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Nutrient quality of bluebunch wheatgrass regrowth on elk winter range in relation to defoliation

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Abstract

Effects of defoliating bluebunch wheatgrass (*Agropyron spicatum* [Pursh] Scribn. & Smith) to increase the quality of regrowth available on Rocky Mountain elk (*Cervus elaphus nelsoni* Bailey) winter range were studied from 1988 through 1990. Percent calcium, phosphorus, in vitro dry matter digestibility (IVDMD), and available forage (kg/ha DM) of regrowth present on control, spring-defoliated, and fall-defoliated plots were determined in November of 1988 and 1989, and April of 1989 and 1990. Spring conditioning did not affect the percentage of calcium and phosphorus, or available forage compared to the current year's growth in either November or April. Fall conditioning increased digestibility and increased the phosphorus concentration, but decreased available forage compared to the control and spring-conditioned forage in November. Fall conditioning may create a deficit of forage if regrowth is not achieved. Additional research is needed on defoliation during the early phenological time-period of bluebunch wheatgrass to improve the forage quality of elk winter ranges.

Key Words: bluebunch wheatgrass, elk, forage conditioning, forage quality, regrowth, winter range

There has been interest in the effects of livestock grazing as a tool to improve the quality of winter range for Rocky Mountain elk (*Cervus elaphus nelsoni* Bailey). Anderson and Scherzinger (1975) hypothesized that livestock grazing can be a tool to improve the quality and quantity of winter range forage. This theory however, lacks quantitative data for support.

Nelson and Leege (1982) suggested that elk have nutritional requirements similar to cattle. Pregnant wintering cattle (454 kg) require 0.18% for both calcium and phosphorus (NRC 1984). A ratio of calcium to phosphorus of 1:2 to 2:1 is needed for optimum absorption of both minerals. Ruminants can tolerate a calcium-to-phosphorus ratio of 1:1 to 7:1 without adverse effects (Simesen 1980).

Pitt (1986) reported that in the second year of clipping, bluebunch wheatgrass (*Agropyron spicatum* [Pursh] Scribn, & Smith) defoliated at the boot stage and control plants contained 0.66% and 0.14% calcium and 0.13% and 0.07% phosphorus, respectively, at the stem-cured stage. Plants defoliated in the boot stage tended to be lower in quality than plants clipped at emergence, flowering, or seed formation; it was suggested that clipping at the boot stage allowed for regrowth and development similar to undefoliated plants.

At Hanford, Washington, 2 years of moderate spring cattle grazing did not affect the mineral content of bluebunch wheatgrass at the seed-development stage (Uresk and Cline 1976). In central British Columbia, there was no significant difference ($p<0.05$) between fall grazed and ungrazed bluebunch wheatgrass in percent calcium or phosphorus the following spring (Willms et al. 1980).

Forages with low in vitro dry matter digestibility (IVDMD) supply a lower amount of available nutrients, require a longer digestion time, and decrease the daily intake rate, compared to forages with higher digestibilities. Low digestibility also implies that digestible energy and digestible protein may by inadequate in meeting elk requirements.

Our objective was to evaluate the effect of defoliation on percent calcium, phosphorus, IVDMD, and available forage of bluebunch wheatgrass regrowth that would be available to elk during the winter season. Variables analyzed were chosen to compliment an earlier study conducted on the same day study sites with the same clipping treatments (Bryant 1993). Bryant (1993) evaluated bluebunch wheatgrass regrowth for percent crude protein, IVDMD, acid detergent fiber, and lignin. Our hypothesis was that conditioning bluebunch wheatgrass in either spring of fall would improve the nutrient quality of elk winter ranges.

Study Area

The study was conducted near the Starkey Experimental Forest and Range in the Blue Mountains of northeastern Oregon. Two sites, Winter Ridge and McCarty Springs, were selected for study. The climate is continental with cold winters and warm summers. Fall rains stimulated fall regrowth each year of the study. Annual precipitation for 1988 and 1989, respectively, at adjacent weather stations near the study areas was 36 and 45 cm for Ukiah (Fig. 1) and 57 and 57 cm for Starkey (NOAA 1988–1990, Forestry and Range Sciences Laboratory 1988–1990). Elevations were 1,366 m at Winter Ridge and 1,274 m at McCarty Springs.

The plant community classifications was bunchgrass on shallow soil, gentle slopes, GB-49-11 (Hall 1973). Bluebunch wheatgrass, Idaho fescue (*Festuca idahoensis* Elmer), Sandberg bluegrass (*Poa secunda* Presl.), and yarrow (*Achillea millefolium* L.) were the dominant vegetation in this community. Soils at both sites were in the Anatone series.

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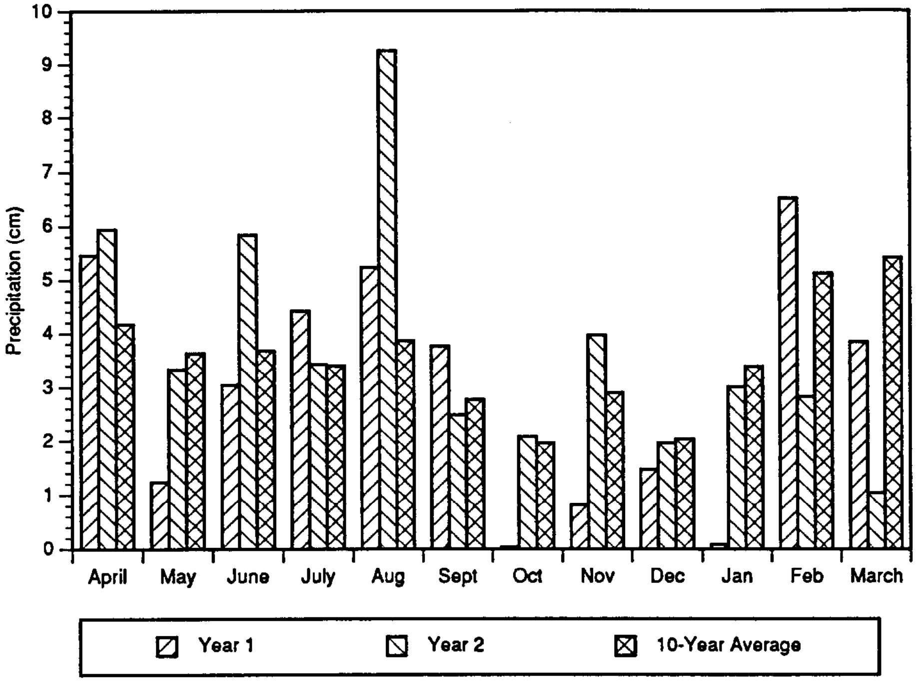

Fig. 1. Monthly precipitation (cm) at Ukiah, Ore. on an April to March basis (NOAA 1989–90).

Methods

Livestock exclosures were established at each site in 1986. Hand-clipping treatments were implemented to condition the forage regrowth beginning in June of 1988. Treatments were spring defoliation (7.6 cm stubble height) in June depending on the phenology of bluebunch wheatgrass, fall defoliation (7.6 cm stubble height) in September before fall rains, and control (i.e., no defoliation).

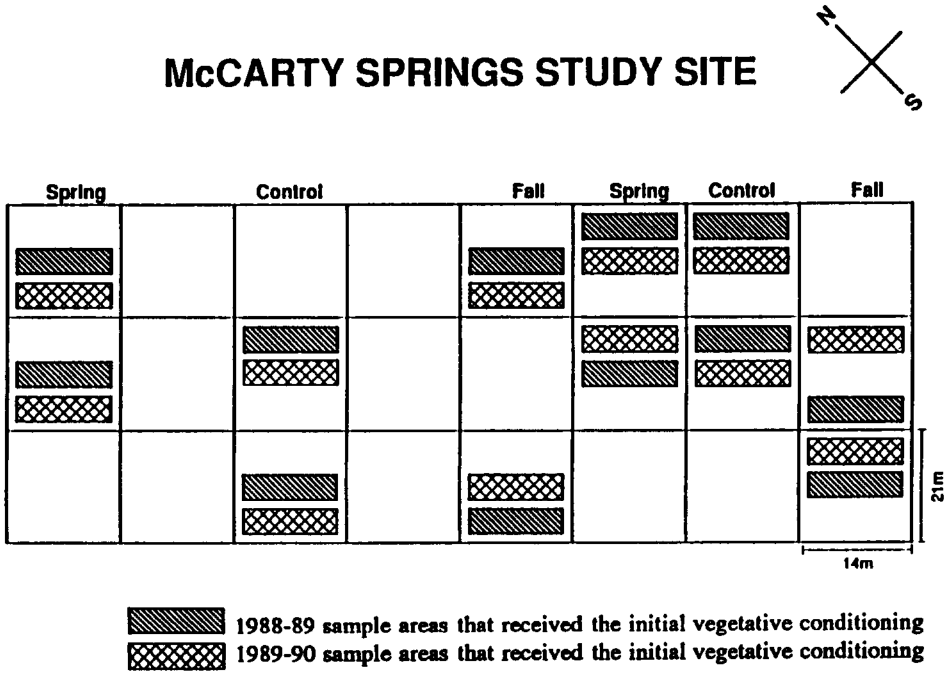

Fig. 2. Split plot design with subunits in strips at McCarty Springs study site in the Blue Mountains, Oregon. Same design was used with different randomization at the Winter Ridge study area.

Within each exclosure, each treatment was randomly assigned to 2 units, and then randomly assigned to 2 of the 3 subunits within the unit. Each subunit was split into 3 sampling areas, in which 1 area was randomly assigned for the defoliation treatment and sample collection in 1988, and a second area assigned for the 1989 treatment and sample collection (Fig 2).

Samples were collected in November of 1988 and 1989, and April of 1989 and 1990. The November (N) collection corresponded to the cessation of fall regrowth, and the time-period when elk first move to winter ranges. The November sample collection consisted of the current year's growth for the control, and current year's regrowth after the spring (June) or fall (September) conditioning, all conditioned to a 2.5-cm stubble height.

The April sample collection corresponded to the time-period just before elk leave the winter range. April samples consisted of current year's spring leaf growth; mature forage was not collected. To assess the effect of multiple defoliation on forage in April, April (W) samples (W = winter defoliated) received 2 defoliation treatments before they were collected. The plants were defoliated during either the spring (June) or fall (September) treatment and also defoliated a second time during the winter (November collections). April (U) samples (U = undefoliated winter samples) were not defoliated in the winter.

Available forage for grazing was calculated for the November

Table 1. Means and standard deviations for the chemical composition of bluebunch wheatgrass regrowth by treatment[1] on study sites in the Blue Mountains, Oregon, 1988-89 and 1989-90.

Sampling period	Nutrient	Year	Control	Spring defoliation	Fall defoliation	Std. error of mean
November	Calcium (%)	1	0.32	0.32	0.39	0.0153
			(0.0298)	(0.0642)	(0.0337)	
		2	0.37	0.32	0.36	0.0144
			(0.0303)	(0.0363)	(0.0492)	
	Phosphorus (%)	1	0.05^{b}	0.05^{b}	0.23^{a}	0.0059
			(0.0180)	(0.0123)	(0.0163)	
		2	0.08^{b}	0.09^{b}	0.14^{a}	0.0093
			(0.01380)	(0.0116)	(0.0278)	
	Digestibility (%)	1	32^{c}	40^{b}	79^{a}	0.8114
			(9.6169)	(5.3835)	(2.3058)	
		2	49^{b}	52^{b}	72^{a}	1.7374
			(4.9464)	(4.9143)	(8.3691)	
	Ca:P ratio[2] (%)	1	6.4:1	6.4:1	1.7:1	
		2	4.6:1	3.6:1	2.6:1	
April (U)	Calcium (%)	1	0.32	0.31	0.34	0.0123
			(0.0328)	(0.0338)	(0.0532)	
		2	0.29	0.30	0.30	0.0079
			(0.0269)	(0.0195)	(0.0292)	
	Phosphorus (%)	1	0.38	0.36	0.36	0.0077
			(0.0194)	(0.0188)	(0.0351)	
		2	0.24	0.25	0.25	0.0061
			(0.0102)	(0.0223)	(0.0252)	
	Digestibility (%)	1	82^{a}	80^{ab}	78^{b}	0.9014
			(2.7425)	(2.0696)	(2.4821)	
		2	85	86	87	0.6619
			(3.0457)	(1.5756)	(2.3052)	
	Ca:P ratio (%)	1	1.0:1.2	1.0:1.2	1.0:1.0	
		2	1.2:1.0	1.3:1.0	1.2:1.0	
April (W)	Calcium (%)	1	0.32	0.31	0.34	0.0136
			(0.0328)	(0.0341)	(0.0698)	
		2	0.29	0.31	0.31	0.0103
			(0.0269)	(0.0206)	(0.0293)	
	Phosphorus (%)	1	0.38	0.36	0.39	0.0115
			(0.0194)	(0.0270)	(0.0293)	
		2	0.24	0.23	0.26	0.0101
			(0.0102)	(0.0337)	(0.0222)	
	Digestibility (%)	1	82^{a}	79^{ab}	76^{b}	1.0041
			(2.7425)	(3.6113)	(5.0188)	
		2	85	85	87	0.8570
			(3.0457)	(3.6438)	(1.8411)	
	Ca:P ratio (%)	1	1.0:1.2	1.0:1.2	1.0:1.1	
		2	1.2:1.0	1.3:1.0	1.2:1.0	

[1] Spring defoliation = hand clipped to a 7.6-cm stubble height in June, Fall defoliation = hand clipped to a 7.6-cm stubble height in September, Control = no defoliation. April (U) = undefoliated winter samples. April (W) = plants were defoliated during either the spring or fall treatment and also defoliated a second time during the winter (W), before samples were collected in April. The standard error of the mean was used to determine significant differences, n = 8 for each treatment. Means within rows with different letters differ significantly at $p<0.05$. Rows with no letters indicate no overall treatment effects.

[2] Not included in LSD comparisons.

Table 2. Available forage (kg/ha DM) of bluebunch wheatgrass regrowth on study sites in the Blue Mountains, Oregon, 1988–89 and 1989–90.

		Means[1] for untransformed data and std. deviation			Means for untransformed data and std. deviation			
Sampling period	Year	Control	Spring defoliation	Fall defoliation	Control	Spring defoliation	Fall defoliation	Std. erro of mean
		(kg/ha DM)						
November	1	213 (137.79)	143 (90.10)	12 (8.80)	2.263^{a} (.2412)	2.087^{a} (.2564)	0.998^{b} (.2696)	0.0803
November	2	352 (167.65)	188 (64.13)	68 (29.04)	2.505^{a} (.2015)	2.255^{a} (.1304)	1.789^{b} (.2121)	0.0789
April (U)	1	11 (8.65)	7 (4.77)	10 (8.70)	0.965 (.2973)	0.762 (2.660)	0.902 (.2593)	0.1266
April (U)	2	115 (47.94)	74 (28.06)	51 (21.53)	2.023 (.2077)	1.832 (.2051)	1.665 (.2071)	0.0517
April (W)	1	11 (8.65)	10 (11.28)	7 (3.08)	0.965 (.2973)	0.843 (.3186)	0.816 (.2060)	0.1240
April (W)	2	115 (47.94)	55 (15.30)	41 (23.75)	2.023^{a} (.2077)	1.723^{b} (.1229)	1.559^{b} (.2150)	0.0811

[1] Spring defoliation = hand clipped to a 7.6-cm stubble height in June, Fall defoliation = hand clipped to a 7.6-cm stubble height in Sept., Control = no defoliation. April (U) = undefoliated winter samples. April (W) = plants were defoliated during either the spring or fall treatment and also defoliated a second time during the winter (W), before samples were collected in April. Means within rows with different letters differ significantly at $p<0.05$ (n = 8). Statistical analysis was performed on base 10 logarithms. Rows with no letters indicate no overall treatment effects.

and April samples. Forage dry matter was calculated from oven-dried weight of the regrowth clipped to a 2.5-cm stubble height during the sample collection. The clipped area was measured, and kg/ha dry matter (DM) of regrowth produced since the initial defoliation treatment was calculated.

Forage was dried at 50° C until a constant oven-dry weight was reached (48 hours on average), then ground through a 40-mesh screen, and analyzed in duplicate. Calcium was determined by atomic absorption spectrophotometry, and phosphorus by the Vanadomolybdate method of color spectrophotometry (AOAC 1980). In vitro dry matter digestibility was determined by the technique of Tilley and Terry (1963) as modified by Warner (1983). Rumen fluid was from a fistulated cow fed grass hay.

Calcium, phosphorus, and IVDMD were analyzed with the general linear model procedure in the statistical analysis system (SAS Institute Inc. 1987). Separate analyses were performed for each year with an analysis of variance (ANOVA) for a split plot design with subunits in strips (Cochran and Cox 1950: section 7.32). Fisher's protected least significant difference (LSD) test was then used to compare treatment means (Petersen 1985). Statistical significance was inferred at $p<0.05$. Available forage data were transformed using base 10 logarithms to satisfy the constant variance and normality assumptions. The transformed data were analyzed as described above.

Results and Discussion

November Forage Status

Spring conditioning did not affect calcium and phosphorus concentrations, or available forage when compared to the control for November collections (Tables 1 and 2). This indicated that spring conditioning did not have an effect on the quality of bluebunch wheatgrass. In November, the control and spring conditioned forages were low in phosphorus. In the first year, forage was below 50% digestibility thereby indicating that it would be slowly digested. In year 2, the forage was near or above 50% digestibility.

Anderson and Scherzinger (1975) reported a 260% increase in elk numbers on winter range after implemenation of spring cattle grazing in northeastern Oregon. The climax plant community for 60% of the Bridge Creek Wildlife Management Area is a natural grassland dominated by Idaho fescue (Anderson and Scherzinger 1975). In the Blue Mountains of Oregon, bluebunch wheatgrass and Idaho fescue usually are together on deep soils adjacent to coniferous forests (Hall 1973).

Anderson and Scherzinger's (1975) hypothesis can be applied to grasslands in the Blue Mountains. Their hypothesis was that spring cattle grazing would increase the quality of winter forage. Regrowth would be halted by the increasing temperatures and lack of soil moisture, so that the regrowth would only reach the flower stalk stage of phenology at the end of the growing season. The nutrients would then be stabilized in the above-ground tissue, instead of being transferred to root storage.

Anderson and Scherzinger (1975) did not quantitatively measure nutrient quality, and there are alternative explanations for their results. The increase in elk numbers may have been from increased nutrient quality, increased availability of green leaf material from the removal of old standing litter and increased tillering, or from some other factor such as decreased snowmobile activity.

In this study, plants conditioned before the boot stage (spring-conditioned samples) were similar ($p>0.05$) to the control in quality and quantity (Tables 1 and 2). This indicated that the clipped plants had a sufficient growing season to develop similarly to undefoliated plants. Most spring-conditioned plants did not reach the seed stalk stage, but the regrowth entered summer dormancy and yellowed-leaf stage of plant phenology.

Defoliation before the boot stage did not increase the late season quality of bluebunch wheatgrass. As speculated by Anderson and Scherzinger (1975), and quantitatively shown by Pitt (1986), defoliation after the vegetative stage of plant phenology is needed to increase the winter quality of bluebunch wheatgrass. Bluebunch wheatgrass is a grazing-sensitive species, and defoliation late in the spring but before summer dormancy, can cause damage to the vigor and health of the plant (Stoddart 1946, Wilson et al. 1966, Mueggler 1975, McLean and Wikeem 1985). Research on late-spring grazing is needed that would incorporate cattle grazing after the vegetative stage, and quantitatively measure forage nutrient concentrations, plant vigor, and actual elk use after grazing.

Early spring grazing before the boot stage can be beneficial to elk winter range, even though the increase in forage quality is minimal. Early spring grazing, if controlled, can allow bluebunch wheatgrass to reestablish regrowth and accumulate carbohydrate reserves for the year before dormancy (McIlvanie 1942). Grazing can decrease the amount of old standing material, and increase the availability of the current years growth of forage (Willms et al. 1979, Grover and Thompson 1986).

Bluebunch wheatgrass regrowth from fall conditioning was significantly higher ($p<0.05$) in digestibility and percent phosphorus when compared to the older, mature forage of the control and spring-defoliated samples. Fall-conditioned forage exceeded elk requirements for both calcium and phosphorus. The calcium to phosphorus ratio was near the optimum absorption range. Digestibility was high, suggesting that digestible energy and protein levels should be increased relative to undefoliated forage. The fall-conditioned regrowth can supply the nutrients needed for elk in the winter, whereas the control and spring-conditioned forages are nutritionally deficient.

April Forage Status

In April, forage from all treatments exceeded elk requirements for calcium and phosphorus, and the calcium-to-phosphorus ratio was optimum. In vitro dry matter digestibility was high (76–87%) for forage from all treatments for both years. This indicated that the previous year's defoliation did not affect forage quality the following spring. Fall defoliation did reduce digestibility in year 1 ($p<0.05$) however, this may have little biological impact at digestibilities near 80% (Table 1).

Available Forage

In November, spring conditioning decreased available forage by 33 and 47% when compared to the control for 1988 and 1989, respectively (Table 2). Fall conditioning decreased available forage by 95 and 81% of the control for the 2 years of the study. The increase in digestibility and phosphorus in November is beneficial, assuming that regrowth is attained. Fall rains stimulated fall regrowth each year of this study. If fall precipitation is low, or cool temperatures come early, there may be little or no regrowth after fall-conditioning. Regrowth after fall cattle grazing occurred in only 2 of 5 years in eastern Oregon on crested wheatgrass (*Agropyron cristatum* [L.] Gaertn.) pastures (Hedrick et al. 1969). If the forage is fall-conditioned and regrowth is not achieved, the remaining forage will have the same nutrient quality as undefoliated forage, but the available forage will be greatly reduced. If there is regrowth after fall conditioning, the regrowth will exceed elk requirements for calcium, phosphorus, and digestibility. The nutrient quality will be appreciably higher, but the available forage reduced, compared to undefoliated forage.

The control and fall-conditioned treatments in this study represented opposing levels of forage availability, but actual livestock utilization will generally result in an intermediate level of forage availability. Actual livestock utilization will show much spatial variation resulting in a diverse array of plant structures, such as older, mature vegetation supplying biomass and regrowth supplying high quality forage. Finding the point of balance in plant structures among the large array of potential forage conditions resulting from grazing is where management skill is needed to complement the land manager's scientific knowledge.

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