

Vegetative and Reproductive Growth of Bluebunch Wheatgrass in Interior British Columbia

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Abstract

Vegetative and reproductive growth of bluebunch wheatgrass in interior British Columbia has been documented for a 3-year period. Plants began growing immediately after snow melt in the spring, with measurable growth occurring where soils had warmed to $6 \pm 0.5^\circ\text{C}$ at 10-cm depths. Growth ceased from 7 May to 15 July and plants fully matured from 7 July to 10 August with actual dates for each particular site being dependent upon the local microclimate. Fall regrowth was not predictable, occurring only during 1973. Seed production was erratic, unpredictable from our data, and not of sufficient magnitude to sustain the grass population if improper grazing is allowed.

Bluebunch wheatgrass (*Agropyron spicatum*) was the major plant species of the pristine vegetation complex of dry areas from the Canadian Rockies south to the mountain ridges of Mexican Sonora and from the Cascades east to the short-grass prairies (Harris 1967). In British Columbia, this species was the dominant plant on 1,295,000 ha of rangeland in climax condition, contributing 95% of the total yield of herbage from the *Agropyron-Artemisia* community, 74% of the total yield from the *Agropyron-Poa* community, and 34% of the total yield from the *Agropyron-Festuca* community (Tisdale 1947).

In the northwest, bluebunch wheatgrass is of considerable economic importance. As the dominant species on excellent condition ranges, it furnishes spring-fall and often winter grazing for livestock which are a principal industry of the region. If resource managers are to manage the range effectively and maintain sustained optimal production of livestock, they must have an understanding of the key forage species. Because of this, bluebunch wheatgrass has received considerable ecological (Heady 1949, Harris 1969, Benson 1973, Stocker 1975, Daubenmire 1978), manage-

ment (Branson 1956, Wilson et al. 1966, Mueggler 1975, Blaisdell and Pechanec 1949, Rickard et al. 1975, Hormay and Talbot 1961, and others) and physiological (McIlvanie 1942, Anderson and McNaughton 1973, DePuit 1975) attention.

Despite numerous general descriptions, there have been few direct attempts to fully document the phenological development (Sauer and Uresk 1976, Blaisdell and Pechanec 1949) of bluebunch wheatgrass or to explain its growth development (Hyder and Sneva 1963). In all cases, the researcher has to assimilate pieces of information on these two topics from articles concerned with other facets of the autecology of this grass. In this paper, we describe phenology and reproductive growth of bluebunch wheatgrass at two locations in the southern interior dry belt of British Columbia, an area where scant information about the species is available.

Study Area

One of the two sites selected represented the big sagebrush (*Artemisia tridentata*)-bluebunch wheatgrass community and the other represented the lower limit of the bluebunch wheatgrass-rough fescue (*Festuca scabrella*) community or the lower and upper grasslands, respectively. Both sites were located in fenced enclosures, protected from livestock grazing, and were pure stands of bluebunch wheatgrass in excellent condition.

The lower grassland site (Tranquille) was 5 km northwest of Kamloops at 296 m elevation on a Brown Chernozemic sandy loam soil consisting of colluvium over lacustrine deposits. Topography was gently sloping (1 to 3%) to the southeast with good drainage. The site had been fenced for 45 years, being grazed only by wild deer during that time. The adjacent range was in poor condition from heavy grazing. Decreasers of the zone were *Agropyron spicatum* and *Lomatium macrocarpum*. Increasers were *Artemisia tridentata*, *Sporobolus cryptandrus*, and *Chrysothamnus nauseosus*. Invaders were *Bromus tectorum*, *Descurainia sophia*, and *Salsola kali*. The average annual precipitation was 24 cm.

The upper grassland site (Minnie Lake) was 21 km southeast of Quilchena at 1112 m elevation on an eluviated Dark Gray Cherno-

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Table 1. Average air temperature and rainfall for April to October at two sites in interior British Columbia.

Site	Year	Temperature (°C)							
		Apr.	May	June	Month July	Aug.	Sept.	Oct.	Avg.
Tranquille	1971	10	15	16	22	23	14	8	15
	1972	7	16	18	21	21	13	6	15
	1973	9	15	18	21	20	17	9	16
	Ave.	9	15	17	21	21	14	8	
Minnie Lk.	1971	5	10	11	17	18	8	3	10
	1972	6	10	12	16	16	8	3	10
	1973	6	10	12	16	15	11	4	11
	Ave.	6	10	12	16	16	9	3	
Precipitation (cm)									
Tranquille	1971	0.18	1.91	3.56	1.88	0.91	0.78	0.71	Total 9.93
	1972	0.63	1.37	3.94	2.26	2.87	1.32	1.24	13.63
	1973	0.25	1.60	1.63	0.20	0.51	1.98	2.31	8.48
	Ave.	0.35	1.63	3.04	1.45	1.43	1.39	1.42	10.68
Minnie Lk.	1971	0.79	3.66	4.78	1.19	1.80	2.18	2.87	17.27
	1972	1.47	2.11	6.36	1.52	5.77	1.80	2.31	21.34
	1973	0.58	1.55	2.28	0.36	0.53	2.46	4.06	11.83
	Ave.	0.95	2.44	4.47	1.02	2.70	2.15	3.08	16.81

zemic sandy clay loam soil over glacial till of mixed origin. Topography was a gentle (5%) southeast slope with good drainage. The site, fenced in 1968, was previously used as winter pasture by the Douglas Lake Ranch and had been very lightly grazed by an occasional animal for several years. This zone is characterized by *Festuca scabrella* and *Agropyron spicatum* as decreasers; *Poa pratensis*, *Achillea lanulosa*, and *Antennaria umbrinella* as increasers; and *Bromus tectorum*, *Verbascum thapsus*, and *Eriogon compositus* as invaders. The average annual precipitation was 30.5 cm.

Methods

Fifty plants at each site were randomly selected and identified with coloured stakes. To estimate accumulative phytomass production, 40 of these plants per site were clipped to 5-cm stubble height each week from initiation of growth in April to cessation of growth in the summer, and again in October to killing frost. The clippings were bulked for groups of 10 plants, dried at 80° C and weighed. The ten remaining plants were used as controls from which leaf and culm growth data were gathered. Each plant was hand compressed and measured from the soil surface to determine average leaf and culm lengths. Lengths of outermost leaf sheaths were substituted for culm lengths when culms were not visible. Growth cessation was estimated visually and statistically using Duncan's new multiple range test.

An additional 30 plants per site were identified and used to estimate phenological stages visually. The boot stage was designated as occurring when seed heads were present as a distinct swelling enclosed by the leaf sheath. Early head and full head were considered to be when 10% and 90% respectively, of the heads were out of the boot. Early and late flowering were similarly defined at 10% and 90% levels. At termination of flowering the anthers discoloured and dried up. Culms and spikes were counted for each plant to quantify reproductive potential. Basal areas were taken to determine if size of plant was related to reproduction.

Weather data were collected with thermographs in Stevenson screens and with Victor rain gauges. Soil temperature at 10, 25, and 50 cm depths were taken biweekly April to November and periodically through the winter. Soil samples for gravimetric moisture content determinations were taken biweekly at 5, 10, 25, and 50 cm depths April to November.

Data were analyzed with analysis of variance and Duncan's multiple range test.

Results

Environment

The Tranquille site was 5° C warmer than the Minnie Lake site (Table 1) except for April when there was only a 3° C difference in average temperatures. July and August were the hottest months. The coolest June and warmest July and August occurred in 1971. The coolest August and warmest fall was 1973. Early spring

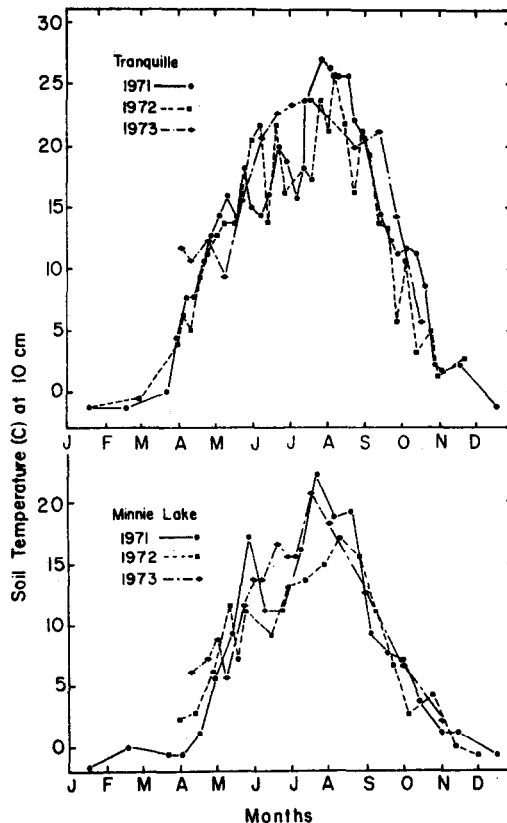


Fig. 1. Soil temperature at a depth of 10 cm at two sites in interior British Columbia

temperatures were variable with 1972 being the coolest April and warmest May at Tranquille while 1971 was the coolest April at Minnie Lake.

Soil temperatures reflected the average air temperatures. The Tranquille site was generally 6°C warmer than the Minnie Lake site April through October (Fig. 1). Soils started warming in April, reached maximum temperatures during late July or early August and cooled rapidly during September and October.

The warmest April and June soil temperatures at 10 cm were in 1973. A temperature lag was apparent at 50-cm depths (data not shown) while soils at 10-cm depths responded rapidly to surface effects from local weather. Temperature profile trend curves, however, closely parallel each other at both depths for each site.

The Minnie Lake site received more precipitation (Table 1) than the Tranquille site. The wettest year was 1972, whereas 1973 was the driest year studied. During 1971, Tranquille was relatively wet from May through July and drier from August through October, while Minnie Lake was wet from May through October.

Despite receiving more precipitation, the Minnie Lake site had less soil moisture at 10-cm depths (data not shown) than the Tranquille site except during early spring. Soil moistures at Minnie Lake were lower than at Tranquille at 25-cm depths during April of 1971 and 1973, during August and September of 1972, and from August through October of 1973. Soils were recharged by spring snow melt to depths greater than 75 cm with the exception of 1973 when moisture penetrated only to a depth of 28 cm at the Tranquille site.

Lower soil moisture content at Minnie Lake can be explained by the presence of more organic material in the surface horizon holding more moisture, thus making it subject to greater evaporation at this windy site. Conversely, the Tranquille site allowed deeper infiltration through sandy and gravelly subsoils, thus water was more readily available at greater depths and persisted in the soil longer.

Vegetative Growth

Cumulative phytomass yields from plants clipped to 5 cm stubble are shown in Figure 3. The Minnie Lake site had an extended growing season in all years and significantly ($P < .05$) greater production than the Tranquille site during 1971 and 1972. Fall regrowth was measurable but not of sufficient magnitude to graph at Tranquille in 1973.

Extrapolation of yield curves to zero production gave growth initiation dates from mid March to 7 April at Tranquille and from 15 April to 28 April at Minnie Lake. Comparison of initiation date to environmental data showed that growth started at soil temperatures of $6.0 \pm 0.5^\circ\text{C}$ at 10 cm depth. Average air temperatures were within 1°C of soil temperatures. Soil moisture at both sites had been recharged from spring thaws.

The exceptional yield (Fig. 3) from the Tranquille site in 1973 was possibly a result of warm soil temperatures enhancing rapid growth during early March. Soil temperatures of 12°C by 1 April, when soil moisture was still available, allowed rapid regrowth between clipping dates and thus a large cumulative yield for clipped plants. In comparison, the total yield from control plants clipped only after growth ceased (28 June) was 2.8 g/plant.

Phytomass production ceased 9 May to 16 May at Tranquille and 24 June to 6 July at Minnie Lake. Growth of bluebunch wheatgrass at Tranquille started 24 ± 3 days earlier than Minnie Lake and lasted 35 to 45 days. In contrast, Minnie Lake with cooler temperatures and more surface moisture produced growth over a 60 to 75-day period. Environmental factors affecting growth cessation were not clearly defined. For example, at growth cessation soil temperatures at 10 cm depths ranged from 12°C to 15°C at Tranquille and from 11°C to 15°C at Minnie Lake; air temperatures ranged from 12°C to 16°C at Tranquille and from 13°C to 15°C at Minnie Lake. Soil characteristics prevented comparison of percent soil moisture between sites, although it was noted that at growth

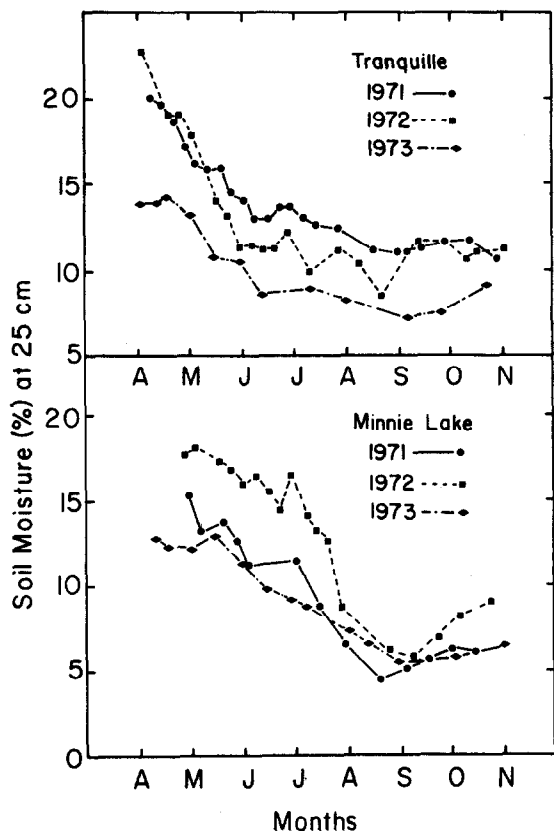


Fig. 2. Soil moisture at a depth of 25 cm at two sites in interior British Columbia.

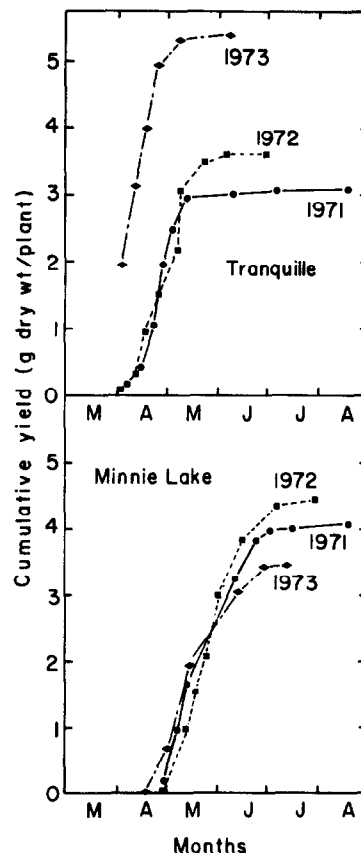


Fig. 3. Cumulative phytomass yield of bluebunch wheatgrass at two sites in interior British Columbia.

cessation moistures at 25 cm depths in 1971 at Tranquille and in 1972 at Minnie Lake were still above early April levels for 1973. Thus moisture was not considered to be the controlling factor. This appears to contradict studies demonstrating a correlation between yield of crested wheatgrass (*Agropyron desertorum*) and previous moisture (Currie and Peterson 1966). However, when considering the extremes of summer temperature, winter temperature and drought that typically occur on bunch grass ranges, the yield for any given year is likely to be controlled by an interaction of factors although precipitation may be the dominant factor over long periods of time.

The leaf curves (Fig. 4) were more difficult to extrapolate to zero. However, leaf growth initiation was observed to be in mid March at Tranquille and mid April at Minnie Lake. Snow patches were still present on the sites one week previously and soil temperatures at 10 cm depths were only slightly above freezing.

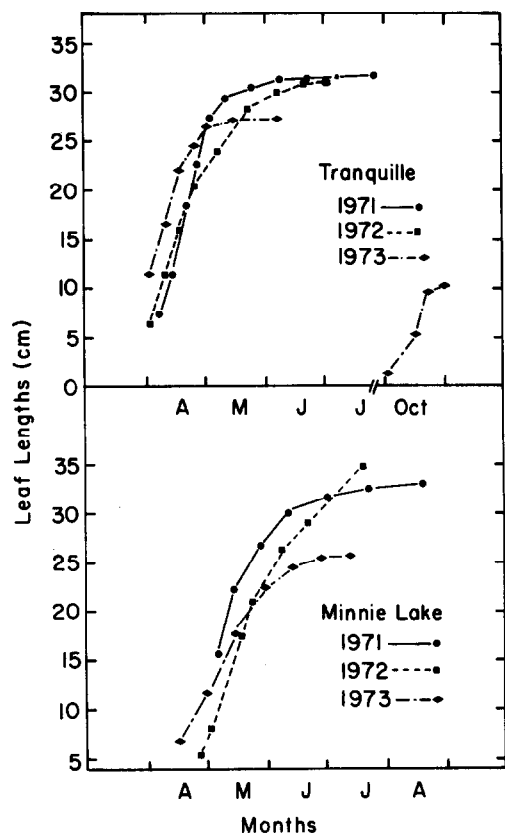


Fig. 4. Leaf growth of bluebunch wheatgrass at two sites in interior British Columbia.

Leaf growth at Tranquille had ceased by 1 June in 1971 and 1972 and by 1 May 1973. Leaf growth ceased at Minnie Lake by 7 July in 1971 and 1972 and by 20 June 1973. Average leaf lengths were 30.5 ± 9 cm at Tranquille and 29.3 ± 10 cm at Minnie Lake. Average air and soil temperatures at this time had not reached optimum of 20°C (DePuit and Caldwell 1975) and percent soil moisture was highly variable.

Culms were longest in 1972 (Fig. 5) when a period of rapid elongation occurred at the latter stages of active growth. Average culm lengths were 18.8 cm and 17.8 cm at Tranquille and Minnie Lake, respectively. The longest and shortest culms were measured at Minnie Lake in 1972 and 1971, respectively.

Fall regrowth of leaves and culms occurred only during 1973, the year of higher than average September and October precipitation and temperatures, in the 3 years of this study (Fig. 4). Where some regrowth was present at Minnie Lake as well as at Tranquille, it was not sufficient to be graphed.

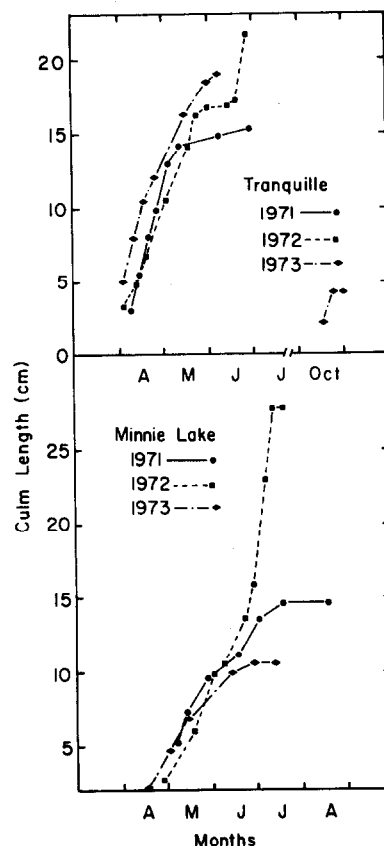


Fig. 5. Culm growth of bluebunch wheatgrass at two sites in interior British Columbia.

Reproductive Growth

Phenological stages of vegetative and reproductive growth are shown in Figure 6. The variability amongst years was more compressed for early reproductive growth stages at the Minnie Lake site than for the Tranquille site with comparable phenological stages between the sites being about 1 month apart. As maturity progressed, the variability among years within stages at Tranquille was compressed as were the time intervals between sites for com-

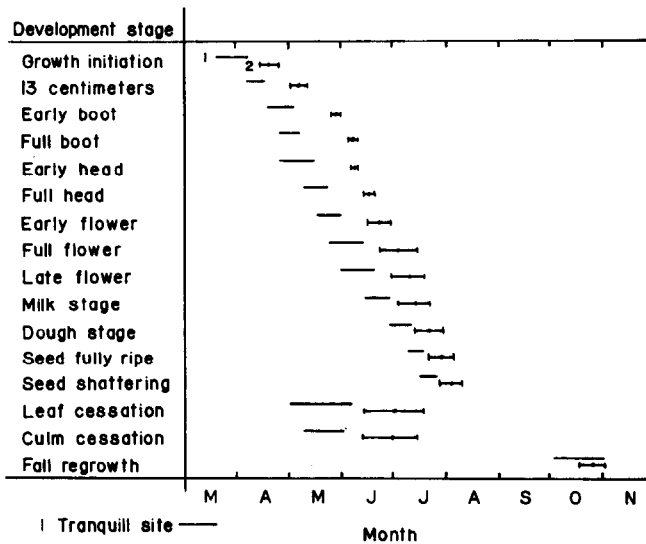


Fig. 6. Phenological stages of bluebunch wheatgrass at two sites in interior British Columbia.

parable stages. Thus the development of reproductive organs occurred later at Minnie Lake but maturity was reached in 59 ± 8 days compared with 77 ± 7 days to reach maturity at Tranquille.

The number of spikes (Table 2) per plant was not significant at either site with the exception of 1973 at the Tranquille site. However, spike production in 1971 and 1973 at Minnie Lake was biologically meaningful since many plants produced a small number of spikes where only the odd plant produced spikes in 1972. This light production of seed could possibly maintain the stand of grass in the absence of use or with optimum management of the use of the grass.

Spike numbers did not correlate well with tiller numbers or with basal areas of the plants (Table 2). The maximum number of spikes (140) at Tranquille was produced by a plant of 63 cm² area having 192 tillers and the maximum number of spikes (15) at Minnie Lake was produced by a 120 cm² plant having 114 tillers. Individual basal areas for plants at Tranquille ranged from 27 cm² to 192 cm² and from 19 cm² to 141 cm² at Minnie Lake. Tillers at Tranquille ranged from 49 to 299 per plant compared with 43 to 325 per plant at Minnie Lake.

Table 2. Average size, numbers of tillers, and number of spikes for bluebunch wheatgrass at two sites in interior British Columbia.

Component	Year	Site	
		Tranquille	Minnie Lake
Avg. basal area (cm ²)	1971	111	90
	1972	61	69
	1973	73	87
Avg. no. of tillers/plant	1971	181	149
	1972	107	173
	1973	163	156
Avg. no. of spikes/plant	1971	0.0	1.9
	1972	0.2	0.6
	1973	46.0	1.6

Discussion

The initiation of growth in bluebunch wheatgrass has not been adequately documented. McIlvanie (1942) in Montana found pale shoots 15 mm long hidden in plant crowns while snow was present and soils were still frozen in March. Supportively, Evans and Tisdale (1972), Hyder and Sneva (1963) in Oregon, Tisdale (1947) in British Columbia, and Wilson et al. (1966) in Washington, report growth starting from the first week to the latter part of March. In contrast, Tisdale (1947) listed bluebunch wheatgrass in the upper grasslands of British Columbia starting to grow on 11 April. April dates are also supported by Blaisdell and Pechanec (1949) at 1675 m elevation in Idaho and by DePuit and Caldwell (1975) in Utah. Blaisdell and Pechanec (1949) further stated that spring growth started 7 days after snow melted and that the previous fall regrowth resumed growth after a winter dormancy. This is supported by Wilson et al. (1966), who reported additional growth of leaves of 2.5 to 5.0 cm by 3 April. Harris (1967) stated that roots remained dormant until soil temperatures reached 8 to 10°C in late April or early May.

We found from phytomass production and growth data that production of bluebunch wheatgrass was first measurable from mid March to 7 April in the lower grasslands (396 m) and from mid April to 1 May in the upper grassland (1097 m). We further found that dates of initiation of first leaf growth corresponded to soil temperatures of 0.0 to 2.0°C at 10 cm soil depth and that initiation of measurable production corresponded to soil temperature of $6.0 \pm 0.5^\circ\text{C}$ at 10 cm soil depths, at all sites and dates. Anderson and McNaughton (1973) found that fully grown plants reduced their transpiration and photosynthetic rates 50% and 30%, respectively, when roots were cooled to 3°C. Thus, a plant would be quiescent as temperatures approached zero, producing active growth only

when temperature increased. It is therefore apparent that bluebunch wheatgrass begins active growth as soon as soils warm to 5 to 6°C at 10 cm depths with growth accelerating until the optimum of 20 to 25°C (DePuit and Caldwell 1975) is reached, providing other environmental factors remain favourable.

Growth of bluebunch wheatgrass ceases when moisture becomes limiting and higher temperatures prevail (DePuit and Caldwell 1975). Several researchers (Tisdale 1947, Blaisdell and Pechanec 1949, and Hyder and Sneva 1963, Wilson et al. 1966) found growth ceased in June. However, Heady (1950) at elevations ranging from 800 to 2530 m in Montana found that bluebunch wheatgrass matured 10 July at lower elevations and 19 August at higher elevations, and Sauer and Uresk (1976) in Washington reported active vegetative growth of bluebunch wheatgrass from 15 December to 15 September in an unusually wet year. We found vegetative growth ceased as early as 7 May and as late as 15 July and that plants fully matured from 7 July to 10 August. We further found that fall regrowth of bluebunch wheatgrass at our location is erratic and unpredictable, although common at other sites reported in the literature.

We found seed production to be very poor, especially at the upper grassland site, and to be extremely variable among plants and years with no apparent relationship to tiller numbers or basal areas. No individual plant consistently produced spikes. Since our studies were conducted on protected sites in excellent condition, the vigor of the plants should have been good. Daubenmire (1978) studied variability in flowering of bluebunch wheatgrass in Washington and reported similar erratic results.

From the above discussion, it appears that the growth and development of bluebunch wheatgrass follows a continuum from low to high elevations with growth being dependent on soil temperatures and local weather conditions. Management of the grass for optimum sustained production will thus require specific knowledge of the current year's stage of plant development at each grazing site and flexibility in range and grazing management from range users.

In British Columbia, range readiness traditionally occurs when bluebunch wheatgrass is 15 to 18 cm tall on about 8 April on the lower ranges to 10 May on the upper ranges (McLean and Marchand 1968). This means that grazing will occur during the boot and early flowering stages when the grass is most susceptible to injury (Wilson et al. 1966, McIlvanie 1942, Blaisdell and Pechanec 1949). Since seed production on our ranges is not sufficient to maintain them under continual or improper use, grazing management becomes critical. Early spring grazing and the removal of animals would allow aftermath growth most years and a partial recovery and nutrient storage in the plants. However, unpublished data indicates that aftermath growth is variable and cannot be relied on. The alternatives are then to graze lightly as early as possible in the current growing season for the site concerned, or to delay grazing until plants have become dormant at that site. We recommend a rotation of spring and fall grazing. This will allow spring use of the plants when they are most nutritious and also remove unpalatable mature stems periodically in the fall and in this way avoid continually grazing the same plants year after year, thus improving utilization. Mueggler (1975) estimated that bluebunch wheatgrass subjected to a single clipping at head emergence required 9 years to recover. Our unpublished data and Wilson et al. (1966) support the observation that repeated defoliation to ground level during the boot stage results in complete disappearance of bluebunch wheatgrass from rangeland. Therefore, our management proposals are absolutely necessary to sustain the grass population. Also, heavy fall grazing improves cattle dispersal, results in more uniform utilization during succeeding grazing periods, and reduces interspecific competition. This practice thus alleviates the detrimental effects of grazing on the species (Mueggler 1972).

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