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Pinegrass: an important forage in Interior B.C.

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Pinegrass: an important forage in Interior B.C.

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SUMMARY

Pinegrass is a valuable source of forage on forested summer ranges in B.C. It represents about 50% of the forage on these rangelands. At stocking rates ranging from 2 to 20 ha per AUM these ranges provide 100 days of grazing with weight gains of 0.25 kg per day for mature cows to about 1.0 kg/day for calves and 0.8 kg/day for yearlings. As with other forage species, the nutrient value of pinegrass decreases as the season progresses. Pinegrass provides adequate nutrition for moderately high growth rates of yearlings until mid to late July although copper, zinc and selenium levels may be low. Nutritional levels are low for high growth rates of calves or high production levels of pregnant cows nursing calves. With the exception of copper, zinc and selenium levels, pinegrass provides adequate nutrition for maintaining dry cows until the end of August. Nitrogen fertilizer can improve both the quantity and quality of pinegrass, and its effect is enhanced when combined with sulphur fertilization. The morphological development of pinegrass described provides a framework for understanding the nutritional quality and grazing resistance of this important grass. Pinegrass is most sensitive to herbage removal in July when tiller growth is nearly completed. Light to lightly moderate utilization will not cause a pinegrass stand to deteriorate. Moderate to heavy utilization will result in stand deterioration. A complex interaction between cattle and pinegrass during grazing has been documented; cattle pull up entire tillers and initiate new tiller development as well as removing a portion of the existing tillers. The information indicates that grazing studies are required to better define light, moderate and heavy grazing in terms of stocking rates for pinegrass. Recovery is slow, therefore, overgrazing should be avoided.

RÉSUMÉ

Le carex de Pennsylvanie est une importante source de fourrage d'été dans les pâturages boisés de Colombie-Britannique. Cette plante représente environ 50 % du fourrage dans ces grands pâturages. A des densités d'occupation allant de 2 à 20 ha par UAM, ces pâturages ont assuré 100 jours d'alimentation au bétail, le gain de poids étant de 0,25 kg par jour pour les vaches adultes, d'environ 1 kg par jour pour des veaux et d'environ 0,8 kg par jour pour des jeunes d'un an. Comme avec les autres espèces fourragères, la valeur nutritionnelle du carex de Pennsylvanie diminue à mesure qu'avance la saison. Le carex assure une nutrition adéquate à des jeunes d'un an ayant un taux de croissance modérément élevé, jusqu'au milieu ou à la fin de juillet, même si les concentrations de cuivre, de zinc et de sélénium sont basses. Les niveaux nutritionnels sont faibles dans le cas de veaux à croissance rapide, ou de taux élevés de production de vaches en gestation allaitant des veaux. Excepté les concentrations de cuivre, de zinc et de sélénium, le carex de Pennsylvanie assure une nutrition adéquate des vaches sèches jusqu'à la fin d'août. Les engrais azotés peuvent améliorer à la fois la quantité et la qualité du fourrage composé de carex, et leur effet se trouve renforcé lorsqu'on les combine à des engrais soufrés. Le développement morphologique du carex de Pennsylvanie, tel que décrit, nous permet de mieux comprendre la qualité nutritionnelle et la résistance au broutage de cette plante herbacée importante. Le carex de Pennsylvanie est particulièrement sensible à l'enlèvement des herbes fourragères en juillet, époque à laquelle la croissance des talles est presque achevée. Une utilisation légère à modérée ne cause pas la détérioration des peuplements de carex; par contre, une utilisation moyenne à intensive les abîme; on a observé et noté une interaction complexe entre le bétail et le carex durant le pacage; les bovins arrachent des talles entiers et favorisent le développement de nouveaux talles, en même temps qu'ils enlèvent une portion des talles existants. L'information disponible indique la nécessité d'effectuer des études, en vue de définir les taux de pacage légers, modérés et intensifs du point de vue des densités d'occupation du carex de Pennsylvanie. La repousse est lente; par conséquent on doit éviter le surpâturage.

Fig. 1. Demonstration of aspects of pinegrass growth and of pull-up: (A) a cow pulling up pinegrass growing under a tree canopy; (B) grazed pinegrass in the fall on a clearcut; (C) drooping habit of vegetative tillers and previous years' growth lying on forest floor; (D) flowering pinegrass inflorescence; (E) red color of tiller bases; (F)(a) tuft of tillers uprooted during grazing; (b) tillers torn during grazing; (c) tiller bases remaining after tearing; (d) top of the forest floor; (e) top of the mineral soil. (From Stout and Brooke, 1985 b.)

INTRODUCTION

Interior British Columbia has a total of about 7.6 million hectares of range, and of this total, the forested Douglas-fir (Pseudotsuga menziesii) zone occupies about 6 million hectares (McLean, 1967). This zone is up to 320 km wide and is bounded by the Columbia and Rocky Mountains on the east, and by the Coast Mountains on the west. In British Columbia it is bordered by the International Boundary on the south and runs about 640 km north to Prince George and Vanderhoof (Tisdale, 1950). In relation to elevation, the zone lies above the fescue-wheatgrass zone and below the spruce-alpine fir zone (McLean and Tisdale, 1960). The forested range is utilized primarily for summer grazing by cattle. Depending upon tree cover, these forested ranges in B.C. yield from 115 kg/ha to 725 kg/ha of ground cover vegetation annually (Tisdale, 1950). Interestingly, similar annual yields have been reported for such ranges in Oregon: 101 kg/ha under heavy shade and 594 kg/ha under an open canopy (Young et al., 1967b).

Pinegrass (Calamagrostis rubescens Buckl.) provides 50% of the forage yield in the Douglas-fir zone (McLean, 1967), and represents about 80% of the ground cover (McLean, 1972). Although Douglas-fir is the principal climax tree species in the zone, disturbances, such as fire, have resulted in other tree species dominating many areas: lodgepole pine (Pinus contorta), aspen (Populus tremuloides), ponderosa pine (Pinus ponderosa), and species of willow (Salix) (Tisdale and McLean, 1957). Pinegrass is found in association with all of these trees. As well, it persists after the trees have been removed by logging. Although pinegrass is found primarily in the Douglas-fir zone, it is also found in other associations as far south as central California and as far east as Manitoba and northern Colorado (Hitchcock, 1950).

Pinegrass received its common name because of its frequent association with lodgepole and ponderosa pine. Its scientific name originates from Greek and Latin (Hitchcock, 1950). Calamagrostis is derived from the Greek kalamos, a reed, and agrostis, a kind of grass. Members of this genus are often called reedgrasses. Rubescens is Latin and refers to the red or purple hue often observed on flower heads and foliage.

GROWTH OF PINEGRASS

Qualitative Aspects of Growth

Pinegrass is a rhizomatous infrequently-flowering perennial grass. The above ground growth consists of vegetative shoots (or tillers) produced at the end of rhizomes (underground stems). Each year, new tillers can also develop from one or more of the axillary buds at the base of the dead leaves of a preceeding year's tiller. The group of tillers formed in this way constitute a tuft (Fig. 1). The number of tillers per tuft for a given stand is variable: at a typical site near Kamloops it ranged from 1 to 24 tillers with a mean of 6 tillers (Stout and Brooke, 1985b). Annual branching of rhizomes produces a nonuniform stand of tillers and tufts.

The structure of a grass plant is outlined in Fig. 2. Pinegrass leaf sheaths are smooth with a pubescent (hairy) collar (Hitchcock, 1950). Leaves are rolled in the bud-shoot. Leaf blades are erect, 2 to 4 mm wide, flat or slightly involute (both margins rolled inward), scabrous (rough to the touch), and often purplish at the base. When tillers are mature, leaves are flaccid and the tips droop. There are no auricles, but there is a membranous ligule at the junction of the sheath and blade (Clarke and Campbell, 1950).

When culms or flowering stems are present, they are slender and 60 to 100 cm tall (Hitchcock, 1950). The inflorescence is narrow, spikelike or somewhat loose or interrupted, pale or purple, and 7 to 15 cm long. The glumes are 4 to 5 mm long, narrow and acuminate (tapered to a point). The lemma is pale, thin, about as long as the glumes, smooth and the nerves obscure. The awn originates from the base of the lemma. It is geniculate (abruptly bent or twisted), exerted from side of glumes and 1 to 2 mm long above the bend.

Pinegrass rhizomes and roots are located in both the mineral soil and in the accumulation of plant material (forest floor) which ranges from partially decomposed litter at the surface to humus in the lower portion (Klinka et al. 1981). The base of a tiller and therefore its apical meristem are situated in the forest floor.

Pinegrass can reproduce vegetatively by rhizome branching or sexually by seed production. Pinegrass seeds collected in the Kamloops area showed a maximum germination of 38% and showed no evidence of a hard seed coat nor a dormant period (McLean, 1967). Seed production occurs erratically. Pinegrass does not usually flower when growing under a tree canopy. However it has been reported that pinegrass frequently flowers following tree harvest in an area, but the reason for this is not known. Pinegrass tufts were planted at the Kamloops Research Station and grown under irrigation. Most of these transplants flowered in the following year. Perhaps the flowering was related to increased light intensity, increased available water or to injury to the rhizome system during transplanting. Soil disturbance during logging could cause a similar injury to the rhizome system.

Quantitative Aspects of Growth

Pinegrass begins growth following snow melt in early May or earlier and ceases growth in early July (Fig. 3) when soil moisture becomes a limiting factor. In the spring after snow melt, soil water content is at a maximum, and it then decreases throughout the summer. As an example, from June 1 to October 1, soil water decreased from 50% (weight/weight) to 8% at a 5 cm depth, from 40% to 9% at a 10 cm depth, and from 22% to 9% at a 25 cm depth.

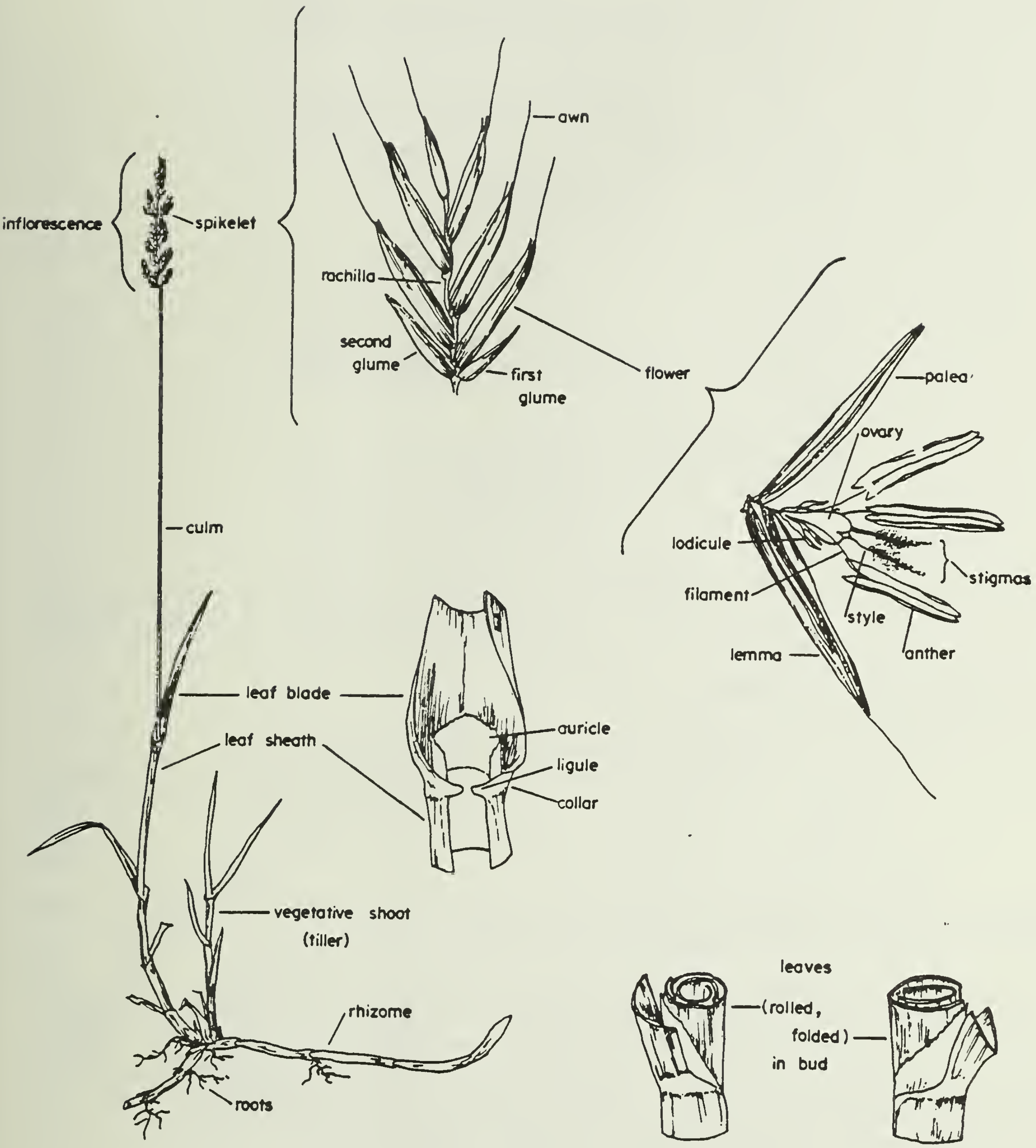

Fig. 2. Characteristic growth of grass plants (adopted from Heath et al. (1973) and Hitchock et al (1969).

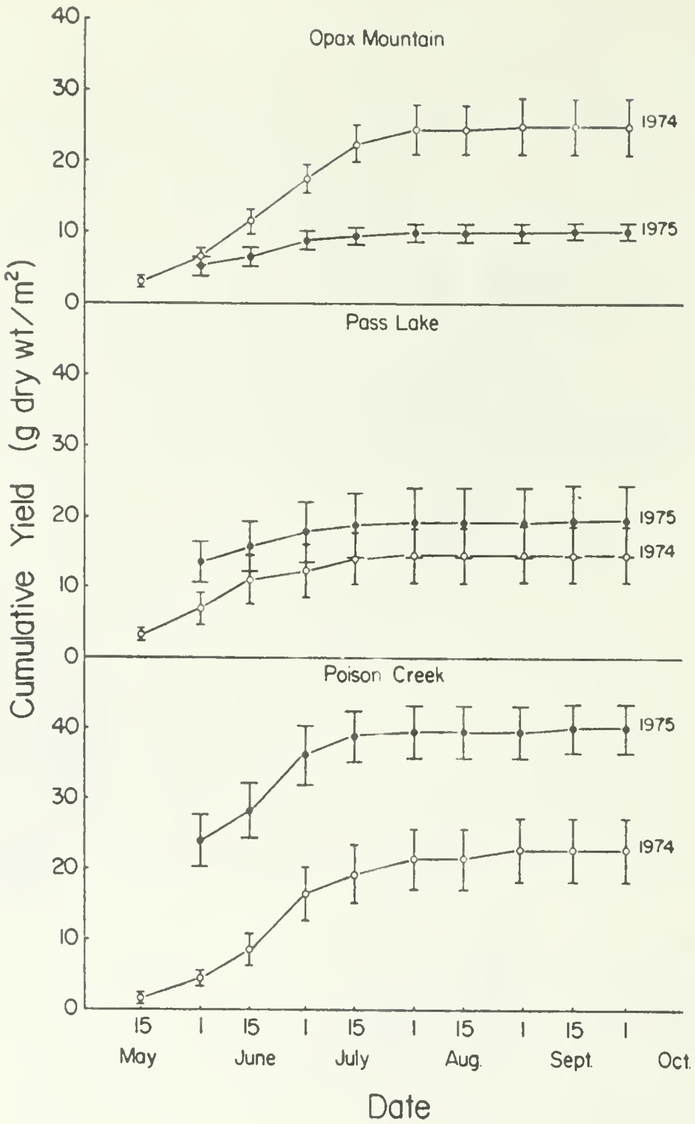

Fig. 3. Growth of pinegrass during the season. The same plots were clipped biweekly to 5 cm. (From Stout et al., 1980.)

Yield of pinegrass from an area of land is related to the number of tillers per unit area and to the tiller size, or weight. The number of tillers per unit area remained constant from May 15 to August 31 (Fig. 4), indicating that tiller emergence is completed early in the spring. Observation of small reddish coloured shoots in the leaf axis during late summer indicates that at least some, if not all, of the tillers that emerge in the spring were initiated the preceeding year (B. Brooke, personal communication). Pinegrass sites are typically snow covered throughout winter and the snow pack flattens the previous years' growth, leaving the new tillers exposed in the spring. Total number of tillers per unit area can change from year to year depending upon environmental conditions. The yield increase during the growing season, as seen in Fig. 3, is related to an increase in size of tillers as reflected in tiller height and tiller weight (Fig. 5). Both height and weight measurements indicate growth cessation in July.

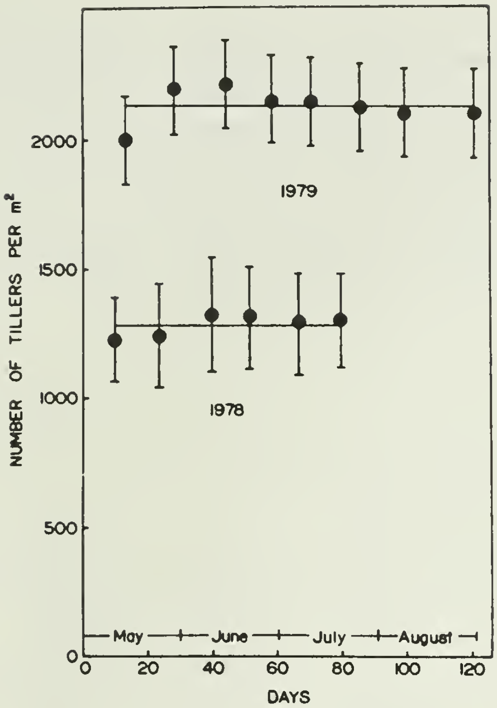

Fig. 4. Number of pinegrass tillers during a growing season. (From Stout and Brooke, 1985a.)

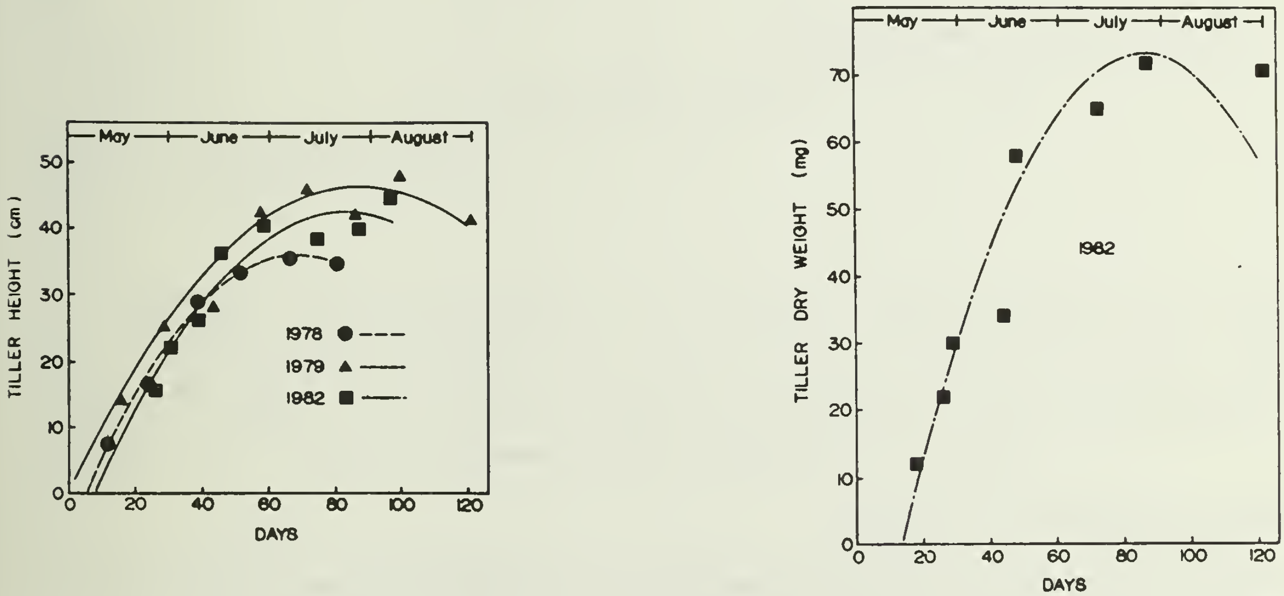

Fig. 5. Pinegrass tiller height and dry weight during a growing season. (From Stout and Brooke, 1985a.)

Pinegrass tillers produced an average of 3.2 leaves that develop sufficiently to produce photosynthetic area and therefore develop into available forage (Fig. 6). The total average number of leaves reaches a maximum by early June. In 1979 leaves began to senesce, or die, in early June (Fig. 6). By the end of August, about 50% of the total leaf area had senesced. The amount of senescence depends upon environmental conditions during the summer. For example, more senescence occurs during a dry year than during a moist year. Nutrition available to the plant, especially nitrogen, will also influence senescence (Milthorpe and Moorby, 1979).

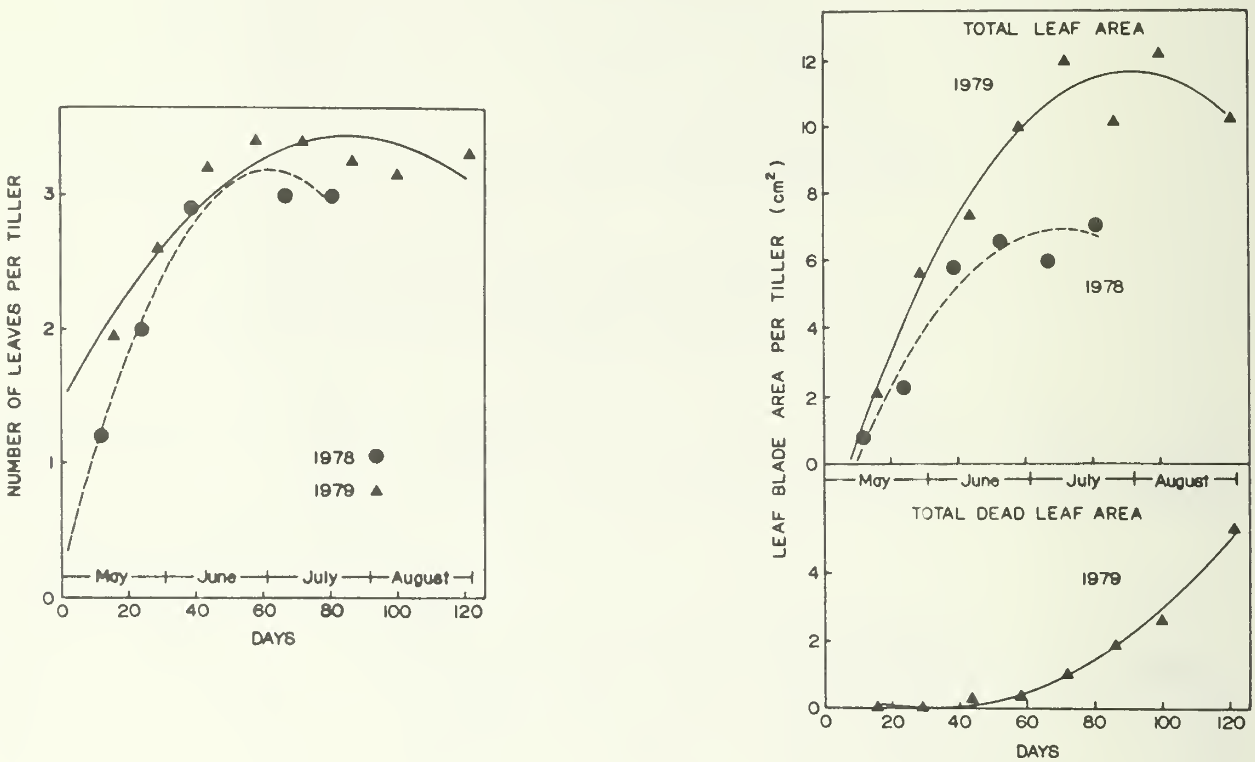

Fig. 6. Number of leaves and total leaf area during a growing season for leaves with a length greater than 1 cm. (From Stout and Brooke, 1985a.)

GROWTH OF PINEGRASS AND ENVIRONMENTAL FACTORS

Light and Growth of Pinegrass

The growth of pinegrass is inversely related to overstory shading. At an unlogged open site, in Oregon, pinegrass yielded 292 kg/ha, and at an unlogged heavily shaded site, pinegrass yielded only 67 kg/ha (Young et al., 1967b). However, grasses respond to shading differently than do forbs. The yield of grasses and forbs decreased as tree canopy increased, but the rate of decrease was greater for grasses than for forbs (Fig. 7). At very high tree cover, forbs did better than grasses, and at very low tree cover, grasses did better than forbs. McConnell and Smith (1965) reported that pinegrass populations increased more rapidly after tree thinning than did some other grasses and the forbs. They suggested that pinegrass may have a competitive advantage because of its ability to spread by rhizomes. Shrubs respond to shading differently than do either grasses or forbs, growing best at intermediate light levels (Fig. 7).

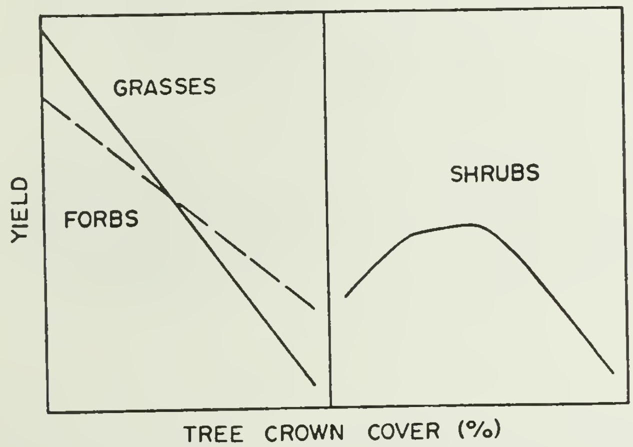

Fig. 7. Response of grasses, forbs and shrubs to tree-crown cover. The trends demonstrated for grasses and forbs are based on the work of McConnell and Smith (1965). The trend for shrubs is based on the work of Young et al. (1967b).

A study in British Columbia, on pinegrass dominated range, revealed that yield of total understory vegetation is inversely related to overstory shading (Fig. 8). When the tree crown cover increased from 0% to 50%, the yield of understory vegetation decreased from 100% to 60%. This relationship held at different sites even though the sites differed in total potential yield; a Williams Lake site consistently outyielded two Kamloops sites.

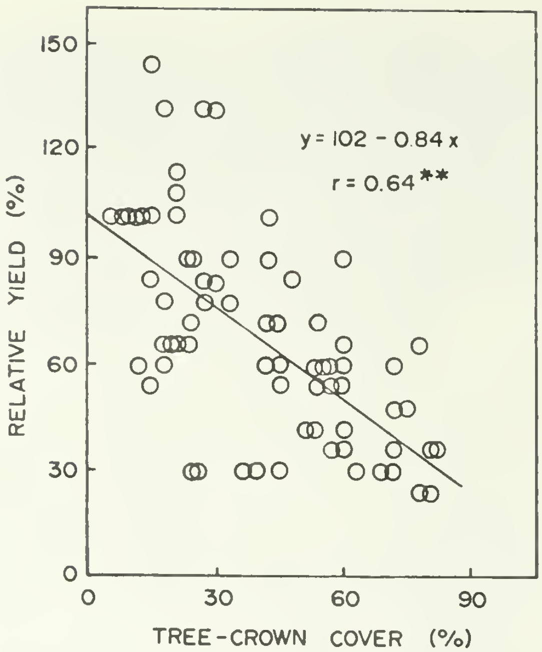

Fig. 8. Yield of understory vegetation as influenced by tree-crown cover. Relative yield was calculated from data by Dodd et al. (1972). Relative yield at a particular site was calculated by assigning a value of 100% to the sample with the lowest tree-crown cover since no data existed for a tree-crown cover of 0%.

Fertilization and Growth of Pinegrass

Soils of the Douglas-fir/pinegrass communities are mainly Luvisols or Brunisols (A.L. van Ryswyk, personal communication). These soils often have a high percentage of parent rock fragments in the profile (Tisdale and McLean, 1957). Decay of the organic forest floor layer produces weak acids that solubilize organic matter and clay particles allowing them to be leached along with soluble nutrients to lower levels or out of the soil profile. In Luvisol soils, leaching of clay is the dominant and distinctive process. The clay is deposited in a lower layer (Table 1) above the location of leached soluble salts. This clay layer can restrict root growth and prevent roots from reaching the soluble nutrients below. Brunisols form on coarser textured parent material and do not form a distinctive clay layer (Table 1). Because Luvisols contain more clay than Brunisols, they have a higher water holding capacity. Leaching causes the rooting zone of both Luvisols and Brunisols to be low in nutrients.

The organic forest floor contains coniferous vegetation in an undecayed peat-like mass that is often called duff (Allison, 1973). The duff contains leaves, needles, cones and twigs. Debris from coniferous trees is less easily broken down by microorganisms than is debris from deciduous trees. In addition, needles and cones are a poor food for earthworms and therefore earthworms do not carry it into the soil as they do leaves from deciduous vegetation.

Table 1. Example of some physical and chemical characteristics of Gray Luvisol and Brunisol soils.

Horizon	Depth cm	Texture	Organic C %	pH	S (ppm)
		Orthic Gray Luvisol (1030 meters)			
L-H	5-0		60.0	3.9	63
Ae1	0-12	gravelly loam	0.6	5.2	5
Ae2	12-25	gravelly loam	0.4	5.1	4
ABgj	25-32	gravelly loam	0.3	5.0	4
Btgj	32-50	gravelly clay loam	0.4	5.1	5
BC	50-85	gravelly clay loam	0.3	6.0	6
C1	85-	gravelly clay loam	---	6.7	4
		Orthic Dystric Brunisol (880 meters)			
L-H	5-0	sandy loam	58.0	4.1	---
Bm	0-17	gravelly sandy loam	1.0	4.9	4
Bc	17-28	sandy fine gravel	---	5.0	2
IIc1	28-50	sandy fine gravel	---	5.1	2
IIc2	50-	---	---	5.1	2

(Data from Lord and MacKintosh, 1982.)

Spring application of 100 and 200 kg N/ha as ammonium nitrate (NH_4NO_3) increased pinegrass yield during the year of application by factors of 1.25 and 2.25, respectively (Freyman and van Ryswyk, 1969). During the second year after application, pinegrass yield for the 100 and 200 kg N/ha applications was increased by factors of 1.8 and 2.9, respectively. Soil NO_3^- measurements indicated that the applied N remained in the top 10 cm of the soil or was leached to depths greater than 30 cm (the lowest depth sampled). Soil NO_3^- measurements indicated that the added N fertilizer was depleted by the fall of the second year. However, only about 14% of the added N was recovered by pinegrass. Therefore a large part of the fertilizer N was either used by associated plants, soil flora, or soil fauna; or was lost by leaching or volatilization. It is not known if more of the applied fertilizer N would be recovered by pinegrass as soil organic matter was mineralized. On grassland sites in interior B.C., nitrogen fertilizer can affect yield for six years (Hubbard and Mason, 1967).

Sulfur (gypsum) fertilization alone had no effect on pinegrass yield, however, it improved the response of pinegrass to nitrogen (Freyman and van Ryswyk, 1969). In contrast, sulfur fertilization increased the yield of alfalfa on Gray Luvisol soils (Chapman et al., 1972). Since legumes such as alfalfa fix nitrogen, an external source of nitrogen was not required.

In a pot trial with pinegrass and Gray Luvisol soil, Freyman and van Ryswyk (1969) found no effect from added phosphate, potash or micronutrients on pinegrass yield. Plant tissue in interior British Columbia has low Cu and Zn concentrations, in terms of livestock nutritional requirements (Fletcher and Brink, 1969), but apparently the soil levels of these micronutrients are not always low enough to limit plant growth.

Young et al. (1967b) reported that disturbance of surface soil during logging increased herbage production compared to when no soil disturbance occurred during logging. This is likely related to "natural fertilization". Disturbance results in aeration of the soil causing increased breakdown of organic matter (Buckman and Brady, 1964). This breakdown of organic matter releases nutrients. Subsoil disturbance however decreased herbage production. It is likely that low fertility subsoil brought to the surface buried the organic matter and therefore prevented its breakdown.

Temperature, Water and Growth of Pinegrass

No definitive studies have evaluated the effects of temperature and water on pinegrass growth. Pinegrass tillers are present immediately after snow melt, therefore, they are able to grow at quite low temperatures with the probability that some tiller development occurs under the snow. Cessation of growth in the summer is believed to be a dormancy related to a lack of available water rather than to high summer temperatures. While regrowth may occur following fall rains (Fig. 3), this was not always observed. It was not determined if this fall regrowth was due to resumption in growth of existing tillers, or was due to growth of new tillers. Pinegrass is considered to be a drought-tolerant plant.

FOOD RESERVE STORAGE PATTERNS

As pinegrass tillers live only 1 year, pinegrass must store "food reserves" to accomodate growth in the spring until the new tillers are able to conduct photosynthesis. Food reserves may also help the plant recover from herbage removal by grazing during the summer. These food reserves provide the energy and the building blocks required for maintenance and for new growth. Carbohydrates, fats, oils and proteins all make up food reserves. Carbohydrates are generally considered to be the major reserve substance (Trlica, 1977). Nevertheless, proteins cannot be ignored since they are the source of reduced nitrogen that is required for synthesis of new proteins (enzymes).

Food reserves of grasses can be stored in two basic types of below-ground tissue: (1) rhizomes plus roots, or (2) crowns (tiller bases) (Trlica, 1977). Rhizomes plus roots of pinegrass contribute the greatest proportion of the plant's dry weight (Table 2), making them the major storage site.

Table 2. Distribution of dry weight within a mature pinegrass tiller.

Tissue	mg/tiller	% of total	% of top growth
Top tissues			
above 15 cm	25	18.5	39.7
10 to 15 cm	10	7.4	15.9
5 to 10 cm	10	7.4	15.9
1.5 to 5 cm	8	5.9	12.7
Crown	10	7.4	15.9
Rhizome plus roots	71	53.4	---
Total	134	100	100

(From Stout et al., 1983.)

Pinegrass total nonstructural carbohydrate (TNC) consists of the simple sugars sucrose, fructose, and glucose, and the polymers fructosan and starch. The predominant polymer is a long-chain fructosan. TNC of pinegrass rhizomes plus roots decreased during May, reached a minimum during late May to early June, increased until late June, remained constant until late August and then increased until November (Fig. 9). TNC levels of crowns tended to be erratic.

Crude protein (CP) of pinegrass rhizomes plus roots remained relatively constant throughout the season (Fig. 9). However CP of crowns showed a consistent pattern: values were high in the spring and decreased continuously until July, before a gradual increase until November. Because the crown tissue is made up mainly of leaf bases, the crown TNC and CP values seem to reflect the physiological state of the leaves rather than food storage. Therefore, results from pinegrass rhizomes plus roots are the most useful for evaluating food storage patterns.

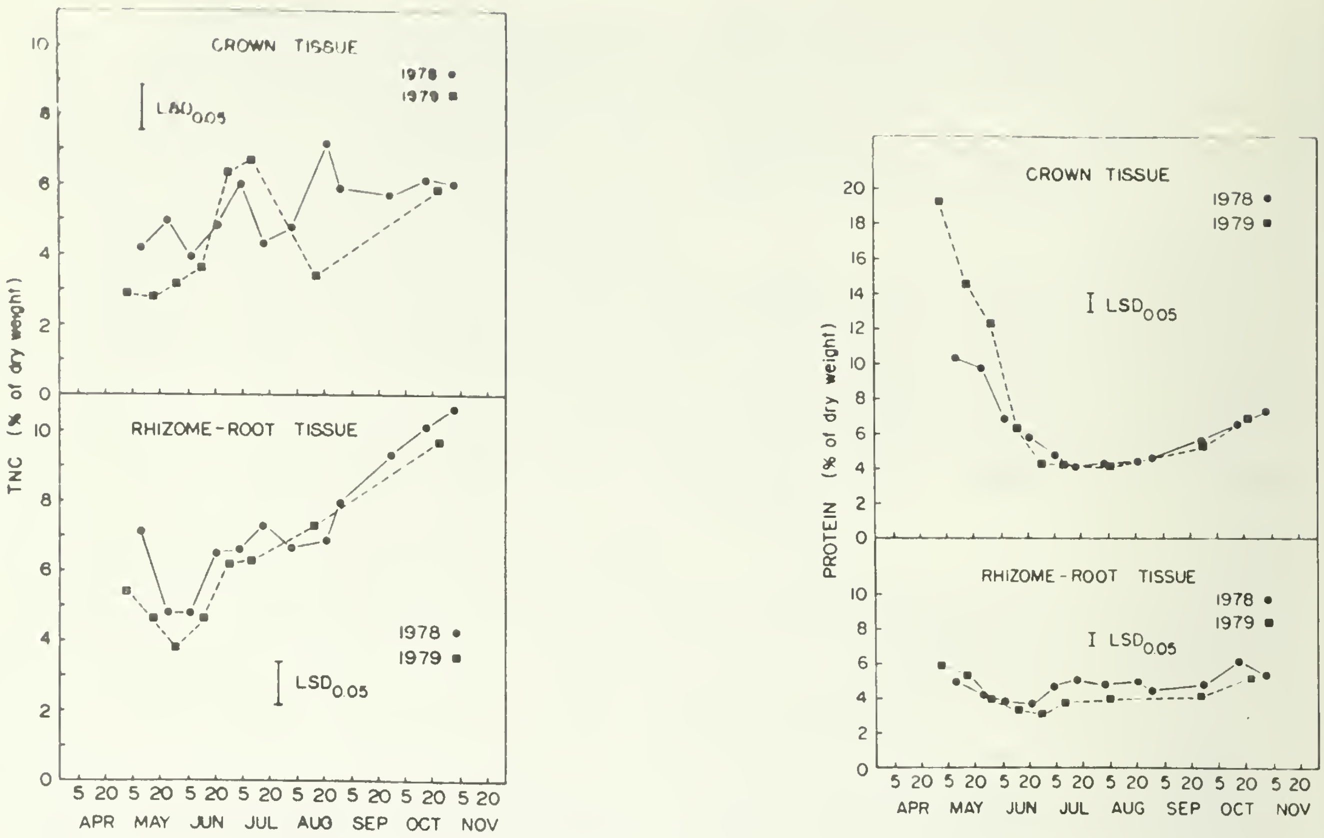

Fig. 9. Seasonal trend of food reserves in pinegrass crowns and rhizomes plus roots. (From Stout et al., 1983.)

EFFECT OF HERBAGE REMOVAL ON PINEGRASS

How Cattle Remove Herbage

In addition to shearing (or cropping) the leaves during grazing, cattle may pull up whole tufts of tillers or the aerial parts of tillers (Fig. 1). Usually the break occurs where the tuft branches from the rhizome (a node) or further along the rhizome. Fibrous roots may also be attached. These "uprooted" portions are pulled away from the network of rhizomes and roots in the forest floor with the break usually occurring at the point of entry into the more dense mineral soil. In addition to the uprooting, some tillers are "torn" when pulled up; the leaves that make up the bulk of the tiller are severed near their bases on the tiller stem.

Cattle normally graze pinegrass to a 15-20 cm stubble height and often do not immediately regraze the same plants. In one experiment, cows removed up to 48% of the tillers during a single pass, and in general, more tillers were uprooted than torn (Table 3). When cattle were allowed to continually graze plots until a stubble height of 5 cm was approached, about 70% of the tillers were pulled-up (Table 4).

Table 3. Tillers pulled up during one grazing pass.

Date grazed	Number of tillers (% of pregrazing count)[1] Torn	Uprooted	Total	Tiller height before grazing (cm)
1980				
August 6	---	---	34	41
1982				
May 31	5	13	18	16
June 29-30	3	27	30	41
July 29	---	---	48	46

[1] Cattle (Herefords, 18 month old heifers and mature cows) were exposed to plots that had not been grazed that season. As soon as the cattle had grazed a plot and then moved to another, the remaining tillers were counted. (From Stout and Brooke, 1985b.)

Table 4. Tiller pull-up and partitioning of tiller pull-up into uprooted and torn during several grazing passes to a 5-cm stubble height.

Year	Date grazed	Number of tillers/m^2 before grazing	Tiller number (% of pregraze count) Torn	Uprooted	Total
1980	June 2-6	1435	---	---	75
	July 3	1535	6	63	69
	August 6	1100	---	---	67
1982	May 31	1135	7	20	27
	June 29-30	1280	9	57	65
	July 29	1215	42	27	69

(From Stout and Brooke, 1985b.)

During grazing, tillers are never cropped to a uniform height, and in fact, some tillers are left ungrazed (Table 5). Pinegrass rhizome connections allow the exchange of food reserves between ungrazed and grazed tillers (Stout and Brooke, 1985c). These rhizome connections may be important in determining the grazing resistance of this grass.

Table 5. Pinegrass stubble height following grazing to an average height of 9 cm.

Stubble height range (cm)	Percentage of stand grazed to each height range
0-5	42
6-10	42
11-15	8
16-20	2
Ungrazed	6

(From Stout and Brooke, 1985b.)

Response of Pinegrass to Grazing

Grazing pinegrass intensively every 2 weeks decreased the next year's yield to approximately one-third of that of ungrazed controls (Table 6). Interestingly, grazing pinegrass intensively only one time in June, July or August also decreased the next year's yield significantly, although to a lesser degree than did biweekly grazing; this indicates that pinegrass may not be an appropriate grass for the high-intensity low-duration grazing system. Grazing had no significant effect on subsequent yield of forbs, shrubs or other grasses.

Clipping decreased the subsequent year's yield of pinegrass to the same degree as grazing did (Table 6). This is surprising in view of the fact grazing pulled-up as much as 70% of the tillers and cropped most of the remaining tillers, whereas clipping only cropped all of the tillers. However, grazing stimulated new tiller production (Table 7). Perhaps these new tillers compensated for the additional herbage removal lost by pull-up during grazing. It is not unexpected that tillering would be related to pull-up, since pull-up is likely to result in removal of apical dominance. Grant et al. (1981) reported that high grazing pressure resulted in more tiller production than medium or light grazing pressure, and that the increased tiller number compensated for a lower production per tiller. They suggested that the increased tiller production could be related to higher light intensity for the high grazing pressure treatment. A light intensity effect likely would not explain the pinegrass results because clipping should eliminate shading in the same way that grazing does.

Table 6. Effect of herbage removal (to a 5 cm stubble height) regime on yield of pinegrass and other species the year following grazing.

		Yield (g dry wt./m^2)			
Experiment	Treatment	Pinegrass	Forbs	Other grasses	Shrubs
1980 - 81	graze biweekly	37.6c	31.5a	19.3a	2.0a
	clip biweekly	34.8c	33.5a	4.7a	4.2a
	control	100.7a	47.7a	12.7a	13.7a
	graze June 2-6	72.1b	51.2a	9.4a	9.4a
	graze July 3	76.6b	37.6a	12.4a	19.1a
	grazing Aug. 6	76.5b	31.4a	16.9a	5.6a
1982 - 83	graze biweekly	18.4d	23.4b	0.3a	14.7a
	clip biweekly	20.2d	62.2a	0.3a	1.8a
	control	61.8a	54.9a	0.1a	9.0a
	graze May 30-31	53.7ab	46.4ab	0.03a	12.1a
	graze June 29-30	39.8c	40.1ab	0.5a	14.0a
	graze July 29	42.1bc	48.0ab	0.1a	6.3a

(Unpublished data.)

Table 7. New tiller production during 2-week periods at Poison Creek during 1982 in response to grazing or clipping.

Tiller production	Number per m^2	
period	Clipped biweekly	Grazed biweekly
June 1-15	8 ± 3	59 ± 13
June 16-28	2.5 ± 1.4	360 ± 145
June 29-July 14	2.1 ± 2.1	N*

* It was not possible to count these because of technical difficulties associated with keeping track of the large number of new tillers that had been produced during this period. However, many more were produced here than in the clipped treatment. (Unpublished data.)

Critical Period for Herbage Removal from Pinegrass

Since clipping was able to simulate the grazing effect on subsequent yield, results from simulated grazing (clipping) can provide useful information. Clipping is a more efficient method of study than grazing, since it requires less labor, land and expense. Nevertheless, extrapolation of results from clipping to grazing must be done with caution since clipping and grazing differ in such things as pull-up and tillering.

Clipping was done to a stubble height of 5 cm at biweekly intervals during six different time periods during the potential grazing season (Fig. 10). Effect on stand density was evaluated by recording tiller number/m^2 in the spring preceeding the first clipping treatment and again in the spring of the year following each treatment year. Five of these treatments consistantly decreased the stand density and the other treatment (Aug. 15 to Sept. 15) decreased the stand density 1 out of 2 years. Clipping from May 15 to September 15, from July 1 to September 15, or from May 15 to August 1 decreased stand density the most. These three treatments have in common the month of July. It is concluded that pinegrass is most sensitive to clipping during July, the time when pinegrass growth is slowing down and summer dormancy is setting in.

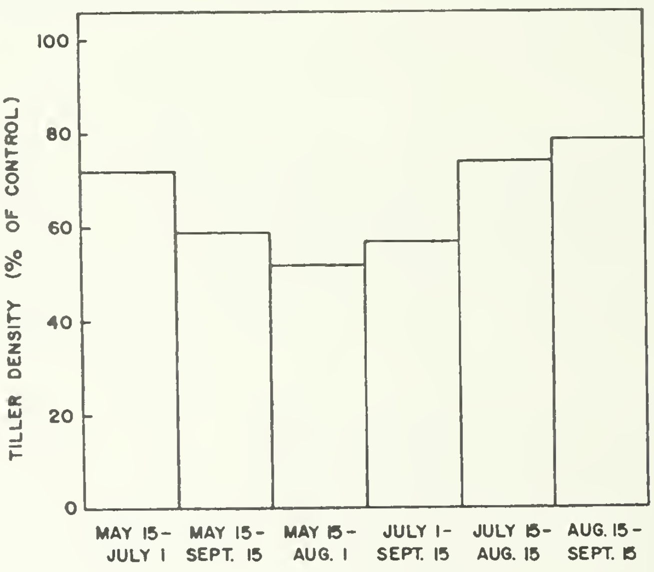

Fig. 10. Influence of clipping biweekly at 5 cm during the indicated period on the average number of pinegrass tillers per square meter at three sites.

Effect of Herbage Removal Intensity on Pinegrass

Pinegrass plots were clipped biweekly during the period May 15 to September 15, to a stubble height of 5, 10 or 15 cm, for 4 consecutive years. These treatments were chosen to simulate heavy, moderate and light continuous grazing. The effect of a particular year of clipping on stand density was evaluated by recording tiller number/m^2 during the spring of the year following the clipping treatment and before beginning the clipping treatment for that year. Stand density decreased ($P \leq 0.05$) with successive years of biweekly clipping to a height of 5 or 10 cm (Fig. 11).

Four years of clipping to 15 cm decreased stand density by about 20%, however the decrease was not significant (Fig. 11). It is likely that clipping to 15 cm does decrease stand density since Freyman (1970) found that, following 3 years of clipping to 15 cm, the dry matter yield of pinegrass was significantly lowered by clipping treatments that included the critical July period.

Clipping intensities could be characterized by the time ($t_{1/2}$) required for the number of tillers to decrease to 50% of the original number: $t_{1/2} = 1$ yr for 5 cm clip; $t_{1/2} = 3.7$ yr for 10 cm clip; and $t_{1/2} = 7.8$ yr for 15 cm clip. To demonstrate the implication of $t_{1/2}$, consider an example where an area of pinegrass having a density of 1000 tillers/m^2 is clipped to 5 cm. After 1 year of clipping, the tiller density would be 500 tillers/m^2 (1/2 x 1000), after 2 years of clipping the density would be 250 tillers/m^2 (1/2 x 500), and after 3 years of clipping the density would be 125 tillers/m^2 (1/2 x 250). Since dry matter yield of pinegrass is correlated with tiller number (Stout et al., 1980), the first year of clipping to 5 cm would decrease the dry matter yield more than would the second and succeeding years. In the foregoing example, number of tillers/m^2 changes by 500 tillers (1000-500) in the first year, but only by 250 tillers (500-250) in the second year. Thus, the first year of heavy grazing would be predicted to cause a larger absolute decrease in carrying capacity than would subsequent years of heavy grazing, but repeated heavy grazing would continue to decrease the productivity and carrying capacity of a pinegrass range by the same proportion each year. Clearly, overuse for even 1 year should be avoided.

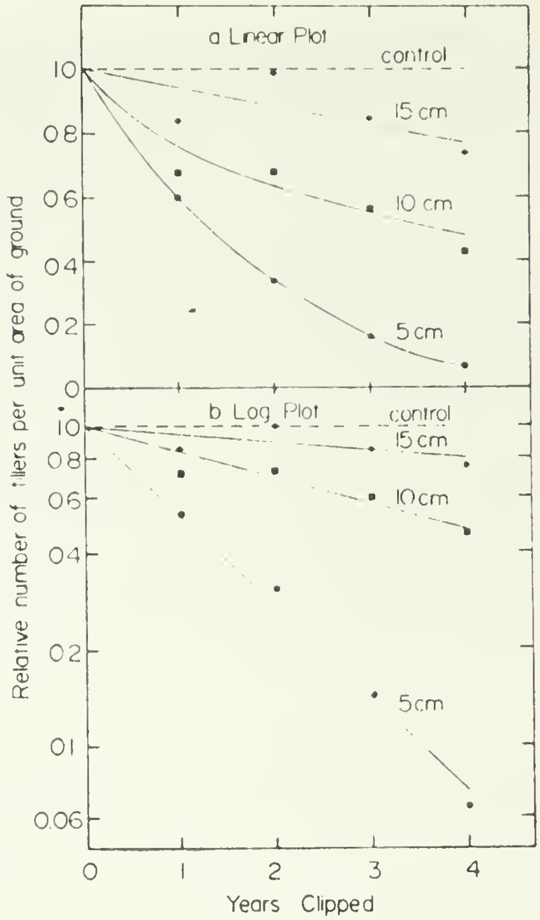

Fig. 11. Stand density as influenced by number of years of clipping (biweekly from May 15 to September 15) at three different intensities. To observe only the effect of herbage removal by clipping on pinegrass vigor, we calculated the relative number of tillers per unit area of ground (RNTA) using the equation:

$$RNTA = (NC_o/NT_o).(NT_y/NC_y)$$

where NC is the average number of tillers/m^2 for control plots before treatments were initiated, NT_0 is the average number of tillers/m^2 for plots receiving a particular treatment before treatments were initiated, NT_y is the average number of tillers/m^2 for plots receiving a particular treatment following (y) years of treatment and NC_y is the average number of tillers m^2 for control plots following (y) years of treatment. Multiplying by the constant NC_0/NT_0 adjusts all treatments to a relative value of one at the start of the experiment. Dividing NT_y by NC_y adjusts for environmental effects and for canopy closure effects on number of tillers, assuming that control and clipped plants are equally influenced by weather. For more details of this study see Stout et al. (1981).

RECOVERY FOLLOWING STAND DETERIORATION

After completion of the herbage removal intensity study (Fig. 11), the plots that had been clipped for 4 consecutive years were left to recover for 6 years. Annual tiller counts were continued during this recovery period. While 1978 was the final year of clipping, no improvement in the stand occurred from 1979 to 1980 (Fig. 12). This delay, or lag, could be due to the remaining pinegrass plants being in a somewhat unhealthy, or low vigor condition following clipping. In support of this, in the fall of a year of herbage removal, rhizomes plus roots have a depressed TNC level (Table 9). However, by the next fall, TNC levels are not depressed (Table 10).

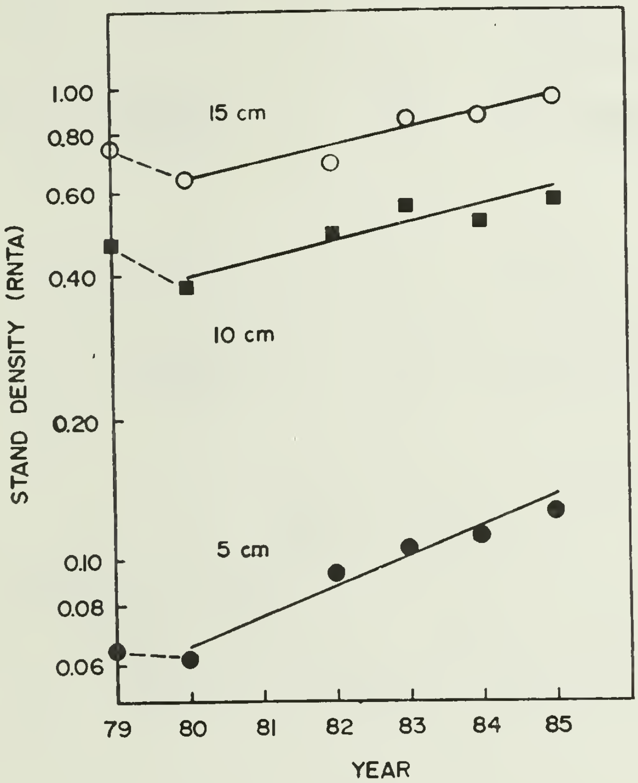

Fig. 12. Recovery of a pinegrass stand density following deterioration caused by consecutive years of clipping to 5, 10 and 15 cm. (Unpublished data.)

Table 9. Influence of clipping treatment on TNC and crude protein concentration of pinegrass rhizomes plus roots during the year of treatment.

Year	Treatment[1]	TNC (% dry wt.)		CP (% dry wt.)	
		Aug. 29	Sept. 25	Aug. 29	Sept. 25
1978	Control	8.0	9.3	4.6	4.6
	Clipped during:				
	spring	5.6	4.5	3.4	4.1
	early summer	6.8	7.2	4.6	4.1
	late summer	---	7.6	---	4.3
1979	Control	6.3	9.2	4.8	4.8
	Clipped during:				
	spring	5.4	5.5	4.4	4.5
	early summer	7.7	7.2	3.9	3.9
	late summer	---	7.9	---	4.5
SE for clipping treatment		0.31		0.21	
SE for harvest date		0.22		0.18	

[1] Tillers were clipped bi-weekly to a stubble height of 5 cm during the period May 18 to June 20 (spring), July 14 to August 15 (early summer), or August 17 to 31 (late summer). (Unpublished data.)

Table 10. Effect of herbage removal on TNC (mg glucose equivalents per g dry wt) of rhizomes plus roots in the year following treatment.

Experiment	Treatment	Date of harvest[1] Summer		Fall
1980 - 81	graze biweekly	52.0bc		62.8abc
	clip biweekly	61.3abc		62.3abc
	control	51.2bc		67.5abc
	graze June 2-6	53.1bc		64.8abc
	graze July 3	49.9c		68.9ab
	graze Aug. 6	52.2bc		73.5a
	SE		5.1	
1982 - 83	graze biweekly	72.8a		62.3a
	clip biweekly	68.3a		71.4a
	control	78.5a		77.4a
	graze May 30-31	77.0a		68.5a
	graze June 29-30	63.0a		77.0a
	graze July 29	59.5a		65.4a
	SE		7.0	

[1] In 1981 the summer harvest was on August 13 and the fall harvest was on October 1. In 1983 the summer harvest was on August 3 and the fall harvest was on October 4. (Unpublished data.)

Following the 1 year lag, number of tillers increased linearly when plotted on a logorithmic scale (Fig. 12). This means that recovery could be characterized by a half-time. As an example, the plots that previously had been clipped to 5 cm had a recovery $t_{1/2}$ of about 4.7 years. For stand deterioration, these plots previously had a $t_{1/2}$ of 1 year. Therefore, the deterioration caused by 1 year of heavy utilization would require 5.7 years of rest to recover (1 year lag plus 4.7 years of tiller increase). Calculation of recovery time in this way assumes that the number of tillers will increase until the stand has recovered. It is predicted that 7 years would be required for recovery following 4 years of clipping to 15 cm, that 13 years would be required for recovery following 4 years of clipping to 10 cm, and that 20 years would be required for recovery following 4 years of clipping to 5 cm.

GRAZING AND NUTRITIVE VALUES OF PINEGRASS

Cattle Weight Gains

The average daily gain (ADG) of several classes of cattle are given in Tables 11 and 12. The ADG for cows ranged from maintenance in June and September to moderate gains (0.1 to 0.5 kg/day) in July and August. Although the highest ADG (0.55 kg/day) for cows was recorded in July, 1978, August was the only month in which a weight loss never occurred during 7 years of study.

Table 11. Cattle weight gains on forested ranges where pinegrass was the major forage.

Experiment	Class of animal	Grazing information			
		Start dates	Total time (d)	ADG (kg)	AUM (ha)
Kamloops 1960-1964[1]	Yearling steers	June 5-July 6	103	0.80	1.92
Cariboo 1968-1970[2]	Yearling steers	June 4-6	97	0.79	1.84
Cariboo & Kamloops[3]	Cows	---	---	0.32	---
Cariboo & Kamloops[3]	Calves	---	---	0.91	---
Kamloops 1938-1940[4]	2 yr old steers and heifers	late June	70	0.91	---
Kamloops 1938-1940[4]	2 yr old steers and heifers	Sept. 1	30	0.45	---
Oregon 1965-1966[5]	Steers	May 13	105(63)	0.57	---
Kamloops 1977-1983[6]	Cows	June 12-15	92	0.25	9.75[7]
Kamloops 1977-1983[6]	Calves	June 12-15	92	0.97	

1 From McLean, 1967.
2 From McLean, 1972.
3 From A. McLean, personal communication. At the start of the trial cows weighed 400 kg and calves weighed 100 kg.
4 From Tisdale, 1950.
5 From Hedrick et al., 1969. During the second year, grazing was only 63 d because of dry weather.
6 From D. Quinton, unpublished data. At start of trial cows weighed 490 kg calves weighed 134 kg.
7 Cow and calf units.

Table 12. Monthly weight gains (kg/day)[1] of cows and calves grazing pinegrass range near Kamloops, British Columbia.

	June	July	Aug.	Sept.
Cows	0.00	0.10	0.54	0.02
Calves	0.93	0.96	1.04	0.87

[1] Values are means from 7 years (D. Quinton unpublished data).

The ADG of calves nursing cows on pinegrass range averaged 0.97 kg/day. The low ADG (0.87 kg/day) occurred during late August through September. The highest ADG (1.04 kg/day) occurred during August which was also the period of the highest ADG for the dams.

Beef heifers on range had high ADG during early June (1.3 kg/day), moderate ADG during July and only 0.5 kg/day gain during August and September. Similarly, the ADG of steers on pinegrass range in the Cariboo region of British Columbia ranged from 1.18 kg/day during June to 0.3 kg/day during September. Steers on pinegrass range near Kamloops averaged 0.81 kg/day gain in June and early July and showed a consistent though non significant decrease in ADG to 0.77 kg/day in late September when the grazing season ended.

Since the quantity of forage was not limited during the grazing season, it was concluded that the decrease in ADG of growing beef cattle with the passage of time was related to a decrease in forage quality (McLean et al., 1968). Similarly, lactating cows were barely meeting nutritive requirements in June when they were milking heavy. As milk production decreased and calves were eating more forage, the cow weight increased. During late August the forage quality had decreased to where cows were at or below maintenance nutrition.

Cattle diets on pinegrass ranges vary according to the relative climatic condition of the range. Dry (xeric) ranges produce fewer plants which cure earlier in contrast to wetter (mesic) ranges which produce a greater variety and quantity of herbage that remains succulent longer. Cattle diets on xeric ranges average 80% grasses, 10% forbs and 10% shrubs. Forb use increased during June and July when plants were available and browse use increased in early September. The frequency of grass in cattle diets decreased during periods of higher use of other forage (Fig. 13) but there were no dramatic changes in diet as the grazing season progressed (McLean and Willms, 1977). Quinton (unpublished data) found that the diets of cows consisted of from 40% to 66% pinegrass while the total diet of cows on a forested range consisted of 73% to 83% grass.

Pinegrass ranges at lower elevations in British Columbia can be grazed for up to 120 days starting in May or June. Stocking rates range from 1.9 ha per AUM on dense grass stands in smaller pastures to 16 ha or more per AUM depending on such factors as distance from water, accessibility, topography, fencing, crown closure of trees, soils, site productivity, etc. The average range in a Douglas fir - lodgepole pine forest with interspersed openings can be stocked at about 8 ha/AUM in the Kamloops area. Utilization and cattle distribution on the range can be improved by using different classes of cattle, particularly younger animals (Young et al., 1967), judicious salt placement, fencing, trail construction, herding and water development.

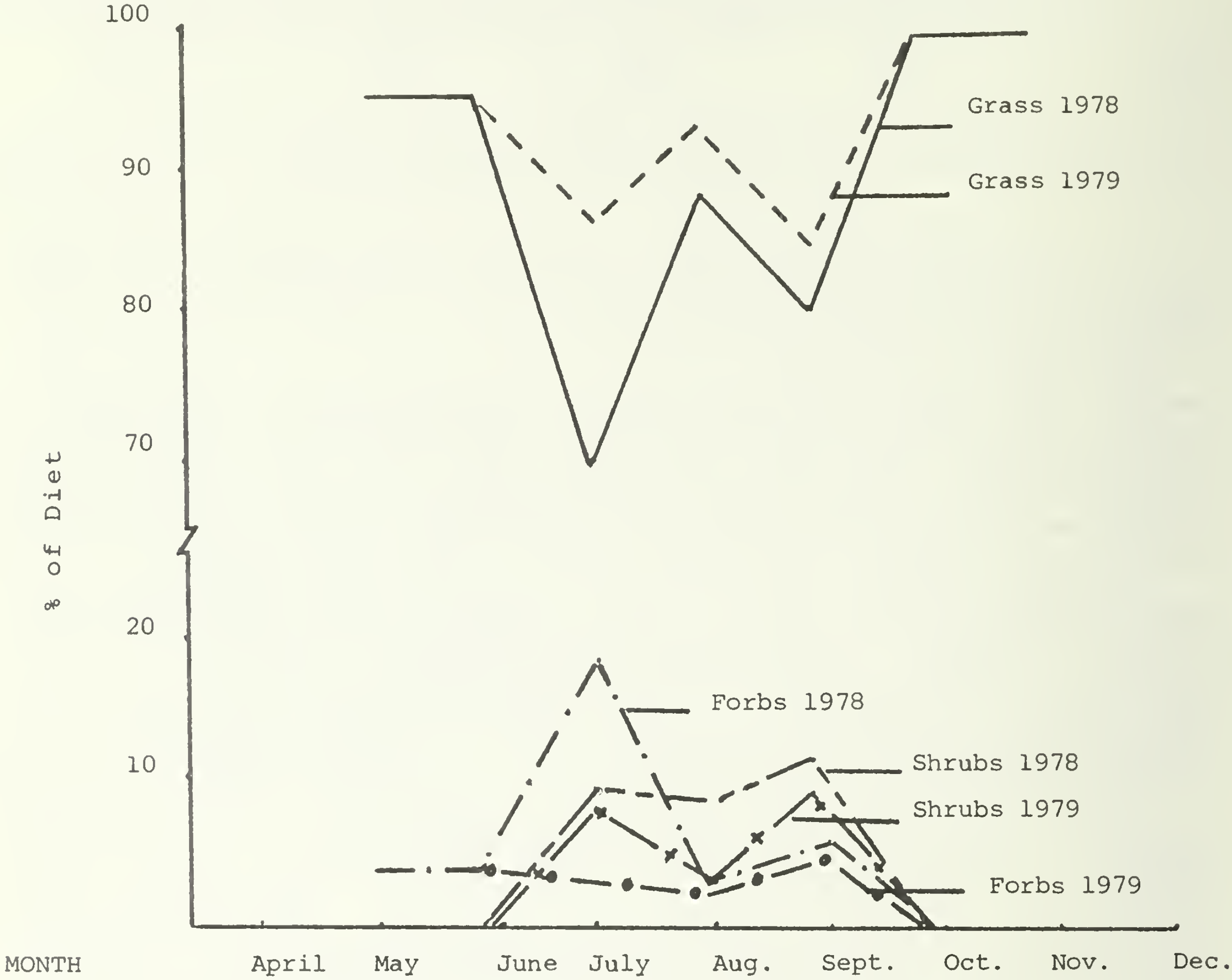

Fig. 13. Use of forages by cattle grazing Wheeler Mountain, Kamloops, B.C. Cattle were on pinegrass range from June to September in 1978 and 1979. (From Quinton, 1980.)

Nutritive Value of Pinegrass

Food quality is the characteristic of forage that is determined by its potential for animal production (G. Fick, personal communication). Factors which determine quality are intake, digestibility, efficiency and antiquality factors, and stages of plant development (McLean and Tisdale, 1960). Nutritive value of range forage must also consider the biomass or quantity of forage available. Intake depends on hunger, palatability, blood sugar levels, gut fill, learned selection, and rate of passage through the digestive tract. The intake of forage minus the amount eliminated as body waste is the digestibility. Efficiency refers to the gain in growth, condition or production per unit of food digested. The efficiency is related to nutritive requirements of the animal which are defined as energy, minerals, protein and water. Antiquality factors may reduce one or several of palatability, intake, digestion and efficiency or may contain toxic factors to a particular kind and class of livestock. Thus forage quality is not defined by a single factor but is determined by an interaction of many factors. However, chemical composition is used as an indicator of forage quality.

Some chemical constituents of pinegrass that are important in animal nutrition are given in Figure 14 and Table 13. Crude protein (CP), phosphorus (P) and the digestible dry matter (DDM) of pinegrass decreased as the growing season advanced. A decrease, to below the requirements of cattle for these constituents, indicates a decrease in the quality of pinegrass for cattle production. The DDM reached a value of 55% and CP reached a value of 8% at Kamloops about August 1. Until this time the ADG of yearlings and calves was about 1 kg/day.

The CP requirement for growth of young stock is 11% of the forage for yearlings and 13% for young calves (National Academy of Science, 1984). Thus the protein content of pinegrass is below optimum for rapid growth for yearlings after July 1 and is never sufficient for optimum growth of calves. Similarly, the CP content of pinegrass may be below optimum for maintenance of weight and milk production by July (Table 13) and below maintenance for dry stock by September. However, the CP content of pinegrass is similar to that of other grasses at comparable stages of development: <u>Agropyron dasystachyum</u>, <u>A. smithii</u>, <u>Elymus condensatus</u>, <u>Festuca scabrella</u> (Johnston and Bezeau, 1962), <u>Agropyron spicatum</u> and <u>Poa</u> spp. (Quinton, unpublished data). Cattle obtain additional CP from other forbs and browse that maintain higher levels of nutrients at this time of year (McLean and Tisdale, 1960). Legumes especially would be expected to have a higher CP content than grasses, and legumes are readily consumed on pinegrass rangelands (McLean and Willms, 1977). Despite cattle seeking more nutritious forage, the main bulk of their diets still consists of grass. Low weight gains (Table 12) indicate a better quality diet is required for rapid growth of young stock and maintenance of mature cows (Fig. 14, Table 12).

Acid detergent fiber, lignin, ash and silica content of pinegrass all increased as the season progressed (Fig. 14). These constituents are considered antiquality factors reducing the palatability, intake and digestibility of pinegrass. Calcium, required for bone, cellular and organ function, also increased as the season progressed.

Calcium, manganese, iron and cobalt levels in pinegrass were above minimum requirements for cattle (Fig. 13; Table 13). The levels of copper, zinc and selenium were low in agreement with Fletcher and Brink (1969) who reported most plants in south central B.C. to be below requirements of copper and zinc for ruminants. Unfortunately studies to determine if mineral supplementation of pinegrass is beneficial have not been performed. However, local ranchers have reported beneficial results from feeding mineral supplements to cattle grazing pinegrass range (McLean and Tisdale, 1960).

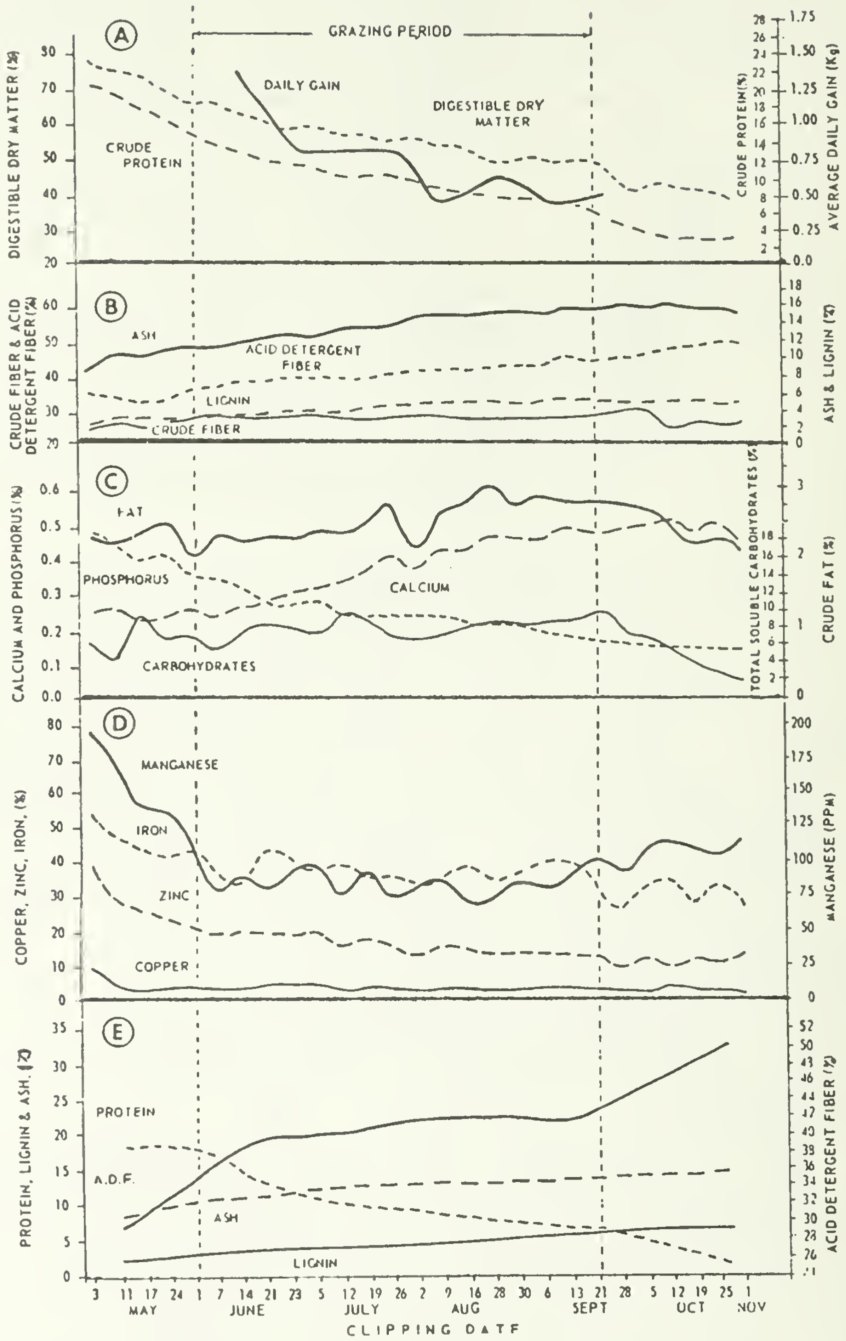

Fig. 14. Chemical composition and digestible dry matter of pinegrass plus average daily gains of yearling heifers. A to D are from Kamloops sites and E is a Cariboo site. (From McLean et al., 1969.)

Table 13. Chemical composition of pinegrass and nutritive requirements of livestock.

	Chemical constituent								
Date	CP[1] %	Ca %	P %	Mg %	Cu ppm[2]	Se ppm	Zn ppm	Co ppm	Grazing System
June 30	8.0	0.41	0.19	0.12	0.9	0.13	13	0.83	continuous
July 30	6.5	0.36	0.20	0.08	1.2	0.07	12	1.20	rotation
	8.5	0.36	0.42	0.10	1.0	0.14	7	0.60	continuous
Aug. 14	6.8	0.49	0.34	0.13	0.7	0.08	14	0.52	rotation
	6.7	0.41	0.21	0.11	0.5	0.02	9	0.40	continuous
Sept. 5	5.2	0.43	0.19	0.15	1.3	0.08	10	0.73	rotation
	8.7	0.35	0.26	0.13					continuous

[1] CP - crude protein, Ca - calcium, P - phosphorus, Mg - magnesium, Cu - copper, Se - selenium, Zn - zinc, Co - cobalt.

[2] ppm - parts per million.

(From Quinton, unpublished data.)

<u>Requirements</u> (From Ensminger and Olentine, 1978.):

	CP %	Ca %	P %	Mg %	Cu ppm	Se ppm	Zn ppm	Co ppm
Growth of yearlings	11.1	0.18	0.18		4	0.1	10-30	.05-0.1
Pregnancy and Lactation	9.2	0.28	0.22	0.18	4	0.1		
Calves[1]	9-13	.19-.53	.18-.41		4	0.1		
Dry cows	5.9	0.16	0.16		4	0.1		

[1] Depends on weight - smaller calves need more.

Management Practices to Alter Pinegrass Quality

Application of nitrogen as ammonium nitrate at 165 kg N/ha and 200 kg N/ha in early May increased the CP content and decreased the silica content of pinegrass during the year of application (Freyman and van Ryswyk, 1969). Sulfur applied as gypsum at 100 kg S/ha greatly enhanced the uptake of nitrogen but gave no other benefit to pinegrass. Improved palatability and utilization of pinegrass was evident when cattle were allowed to graze the fertilized plots.

Silviculture practices can alter the chemical composition of pinegrass. Plants growing in shaded sites under trees have a lower soluble carbohydrate content and a higher CP content than pinegrass growing on exposed sunny sites (Freyman and McLean, 1968). Silica, lignin and acid detergent fiber contents of pinegrass were similar between shaded and open sites. Ranchers report that cattle prefer pinegrass on open logged sites to pinegrass under trees. This response to selection of plants with lower CP by cattle is the opposite to cattle grazing higher CP content plants on fertilized plots reported by Freyman and van Ryswyk. The effect of site and fertilizer on the chemical constituents of pinegrass cannot explain the trends in cattle preference. Preference can be influenced by a combination of nutrients, the amount of forage, learned behaviour, the energy expended to obtain forage, etc. Tree covered sites, with wind falls present, clearly obstruct vision and movement. Further, grass production on treed sites is lower than on open sites. Young et al. (1967) reported that yearling heifers became accustomed to grazing forested sites and would return to those sites after calving while other cows would not.

Treatment of pinegrass with low concentrations of the herbicide Atrazine or Paraquot in the spring resulted in higher CP concentrations from June to October (Freyman, 1970). This shows that chemical curing of pinegrass to increase quality for animal production is possible. However, the nature and extent of pinegrass range, the place of associated plants in cattle diets, and economics make this an unacceptable practice.

Simulated diet samples of pinegrass from a pasture grazed on a continuous basis by cows and calves show a trend of higher protein values than samples from pastures grazed on a rotation system (Table 13). This could be explained by cattle removing the older senescent leaves (Fig. 6) on the first grazing pass over an area thus exposing only the younger leaves that developed after grazing. These new leaves would have a higher protein content and would be subject to subsequent grazing passes by cattle. Also since grazing stimulates new tiller production (Table 7), new young tillers would result in higher CP content of the cattle diet. New tillers do not develop on ungrazed plants. New tiller development in September is also important on rough fescue range. When cattle are moved from forested range to rough fescue range in September their ADG increases (D. Quinton, unpublished data). The nutritional value of mature rough fescue is comparable to pinegrass (Johnston and Bezeau, 1962). In September cattle were selecting new regrowth and thus more nutritious forage.

GRAZING SYSTEMS

Pinegrass ranges in British Columbia have traditionally been grazed using a continuous grazing system starting in June on lower elevation ranges. As the summer progressed the lower range became warmer and drier with the forage maturing and senescing. As a result, much of the cattle herd migrated to higher elevation range until by late summer cattle were dispersed over the entire range. With the advent of cold weather and snow at higher elevations in the fall, a downward migration of cattle to concentrate on the lower elevation range occurred. Cattle herding and fencing were used to compliment or alter this system to adapt it to available forage, use patterns of forage and the overall management plan of the area.

The emphasis on integrated resource management planning and the intensification of ranch management in recent years has resulted in pinegrass rangeland receiving more attention in ranch forage systems. Pinegrass ranges are now grazed under numerous grazing systems: continuous with herding, pasture rotation and deferred rotation schemes are the most prevalent. Most grazing systems were developed in the United States to improve range production while maintaining plant and soil resources (Stoddart et al., 1975). Unfortunately, grazing systems for pinegrass rangeland in British Columbia have not been studied. However, a study directed by Dr. Dee Quinton at the Kamloops Research Station is in progress. Due to the lack of data it is only possible to discuss grazing systems for pinegrass range in a general way using the principles established in the preceeding sections of this bulletin.

A true continuous grazing system holds livestock on an area, either by herding or fencing, for the duration of the grazing season. The stocking rate on such an area should be such that the forage stand is not deteriorated. For pinegrass range, a stubble height of about 15 cm and utilization of 40%, by weight, of pinegrass tillers is the apparent goal to maintain stand productivity. Because of tiller pull up and new tiller initiation with grazing it is not possible to extrapolate from clipping studies and define a specific level of utilization or a specific stocking rate.

If continuous grazing is to be the system used, the range manager must continually monitor the forage use and affect livestock movements that will ensure proper use of the range. The relationship of pinegrass to other forages in the plant community, the fact that livestock uproot entire tillers during grazing, access, and other features of the range must be considered in proper management. Utilization of pinegrass by occasional observation of frequency of cropped tillers and stubble heights is not sufficient. Without some management of livestock and observation of grazing, pinegrass range may (and probably will) be overgrazed with pinegrass being under used. This becomes increasingly possible as pinegrass matures and becomes unpalatable in relation to other forages.

Advantages of continuous grazing are that livestock may retrace their grazing movements over the same area several times during the grazing season. Livestock would thus have access to any new growth since the last grazing pass and would have a more palatable, nutritious diet. This phenomenon could also be detrimental if stocking rates and management were such that overutilization and excess pull up occurred.

Rotation grazing is a system where units of a range are grazed sequentially. Although there are many variations, the two most commonly used with pinegrass range are deferred rotation and alternate rotation. Under rotation grazing schemes each range unit is grazed for only part of the season. Theoretically this can effect better utilization of the forage, give better animal distribution on each unit and may result in an increased stocking rate of livestock as well as resting plants for part of the grazing season. Fencing of the range into units is usually required (Stoddart et al., 1975). Although there are reports indicating increased benefits on some range types, there is no evidence that rotation grazing is any more beneficial than proper continuous grazing on many other range types (Stoddart et al., 1975).

When using an alternate grazing system on pinegrass range the stocking rate and the duration of grazing on each range unit must be controlled to prevent stand deterioration. Pinegrass does not tolerate any degree of heavy grazing, not even one or two days (Table 6). Thus, grazing must be managed to effect no more than light to light-moderate use of pinegrass. Further, although excess herbage removal at any time during the grazing season leads to stand deterioration, pinegrass is most sensitive to grazing in July (Fig. 10) just after growth ceases at the beginning of the summer drought. Therefore, it is especially critical that the grazing intensity during July is managed to give only light to moderate utilization of pinegrass. Freyman (1970b) suggested that the critical period for grazing damage to pinegrass could be avoided by herding cattle onto other range types in the spruce-alpine fir zone during late June and July and returning to pinegrass range in August. A switch back or alternate pasture rotation where livestock are returned to a range unit that was grazed early and has regrowth would provide better quality forage than moving onto a range that has not been used during the current grazing season. Management under this grazing system must insure that only light utilization occurs.

Other schemes can be devised to better manage pinegrass under current grazing practices. The seasonal migration of cattle to higher elevation range is essentially a natural rotation grazing. A moderate amount of forage management with livestock herding can compliment this system. Cattle should be moved to another forage type during July, or where this is not possible, the utilization of pinegrass during July should be kept light.

The rest rotation grazing system, where range units are rested for an entire grazing season, may be optimal for recovery of depleted pinegrass ranges. The apparent lag in pinegrass recovery (Fig. 12) implies that at least a two year, or longer, rest is necessary depending on condition of the stand.

Grazing systems, regardless of type, can be an important tool in range management if and only if managed properly. No one system is appropriate in all situations and each system must be adjusted to apply to a specific range unit in a specific ranching operation. All systems require management, some more than others, which must be "artfully" applied if the desired results are to be attained. When any grazing system is being designed there are constraints which must be applied so the system will complement the overall forage system and operation of the ranch. If pinegrass range is managed to carry only the maximum number of animals the range will support during a poor season and if Bell's (1973) criteria of take half leave half is modified to take 40% leave 60%, the grass stand should persist in good health. This management will protect the grass while allowing the manager flexibility to supplement the permanent herd with additional animals, on a temporary basis only, during good years.

CONCLUSIONS

A knowledge of the growth and development of pinegrass aids in its proper management. For a non-grazed and undisturbed stand of pinegrass, the number of tillers that are going to develop during a given year is established early in the spring, if not during the previous fall. Increase in tiller size then accounts for the growth of the stand during the period May to July. Tiller development can be observed as soon as the snow melts, and growth normally ceases in early July when water becomes limiting. This period of growth cessation is a critical period for stand depletion due to herbage removal. There is no distinct morphological stage of development associated with the critical herbage removal period in early July. Only subtle changes, such as weight gain and protein metabolism, are taking place in tillers during the critical period. Pinegrass tillers arise from rhizomes growing in the duff of the forest floor. Therefore, they are not strongly anchored in mineral soil and so are sensitive to pull-up during grazing. Vegetative production of pinegrass can be substantially increased by thinning out the tree cover. Pinegrass can spread from either rhizomes, seed, or both, thus it is a fairly aggressive plant. However seed production is infrequent on an undisturbed stand. In the Douglas-fir zone of interior B.C., pinegrass responds to nitrogen fertilizer but the residual effect of fast release fertilizers, such as NH_4NO_3 is short. Sulfur increases the effectiveness of nitrogen fertilizer but has no effect alone.

The nutritional and grazing quality of pinegrass decrease throughout the season. For example, protein and phosphorus supplementation is required by August 1 for moderate growth of yearlings or weanling calves. Pregnant dry cows and replacement heifers do not need supplementation until later. In the Kamloops region pinegrass range provides about 100 days of grazing at a stocking rate of 2 to 20 ha per AUM. During this time, yearling steers and calves should gain from 0.8 to 1.00 kg/day. Throughout the season, pinegrass is deficient in copper, selenium and zinc. However feeding studies have not yet been done to determine if supplementing these micronutrients will increase ADG. Because grazing stimulates new tiller production, grazing may increase the forage quality of pinegrass. This may explain why more grass is eaten in August and September under rotation grazing than under continuous grazing.

Grazing removes pinegrass herbage in two ways. First, tillers are cropped; however, cropping height is not uniform. Second, complete tillers, including attached rhizome and roots, can be pulled-up. In fact, up to 48% of the tillers may be pulled-up during a single pass by a cow. During several passes by a cow, when the average stubble height is reduced to 5 cm, up to 75% of the tillers may be removed.

Clipping crops all tillers to a constant stubble height. Despite these differences between grazing and clipping, they both had a similar effect on subsequent yield, at least when intensive herbage removal was practiced. New tillers develop following grazing but not following clipping. Apparently, the new tillers compensate for the removal of total tillers during pull-up. In any case, general conclusions drawn from clipping studies appear to be applicable to grazing. Pinegrass is most sensitive to grazing in July when growth of pinegrass is ceasing. Clipping intensity was evaluated by simulating light (leaving 15-cm stubble), moderate (leaving a 10-cm stubble), and heavy (leaving a 5-cm stubble) herbage removal. A 15-cm stubble represents about 40%

utilization, a 10-cm stubble represents about 56% utilization, and a 5-cm stubble represents about 71% utilization (Stout et al., 1983). Only the moderate and heavy removal significantly decreased the subsequent productivity of a pinegrass stand. However, Freyman (1970) detected a significant pinegrass yield decrease following clipping to 15 cm. Nevertheless continuous light grazing will not harm a stand of pinegrass but the actual definition of light grazing needs to be defined using animal studies. If more intensive herbage removal is practiced, it should be conducted for only a short time, and the stand should be rested. Pinegrass does not appear suitable for the high intensity, short duration grazing system. The cattle weight gain studies by McLean (1967 and 1969) in B.C. used a stocking rate of 2 ha per AUM, but the effect of this stocking rate on the pinegrass stand was not reported. Because of tiller pull-up and tiller initiation during grazing, it is not possible to make a specific conclusion regarding stocking rate and maintenance of the pinegrass stand from the clipping studies. Thus actual grazing studies need to be done to answer this important question. Lastly, pinegrass recovery following excessive herbage removal is slow. Thus overgrazing must be avoided.

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APPENDIXES

1. Principal species associated with Douglas-fir/pinegrass according to Tisdale and McLean (1957).[1]

Category	Common name	Scientific name
Trees	Douglas-fir	Pseudotsuga menziesii
	lodgepole pine	Pinus contorta
	trembling aspen	Populus tremuloides
Shrubs	baldhip rose	Rosa gymnocarpa
	birch-leaved spirea	Spireae betulifolia
	soopalallie	Shepherdia canadensis
	common saskatoon	Amelanchier alnifolia
Dwarf shrubs	kinnikinnick	Arctostaphylos uva-ursi
	northern twinflower	Linnaea borealis
	creeping Oregon grape	Mahonia repens
	dwarf blueberry	Vaccinum caespitosum
Herbs	pinegrass	Calamagrostis rubescens
	blue-leaved wild strawberry	Fragaria glauca
	Richardson's sedge	Carex richardsonii
	showy aster	Aster conspicuus
	heart-leaved arnica	Arnica cordifolia
	large-leaved rattlesnake orchid	Goodyera oblongifolia
	cream-coloured peavine	Lathyrus ochroleuceus
	artic lupine	Lupinus articus
	timber milkvetch	Astragalus serotinus
Mosses and Lichens		Brachythecium spp.
		Cladonia gracilis
		Peltigera spp.

[1] From Tisdale and McLean (1957). Common names are according to Angove (1981).

2. Typical seasonal cattle feeding pattern in southern interior B.C.

In order to put the grazing of pinegrass in the Douglas-fir zone into perspective, the following Table was constructed using information given by McLean and Tisdale (1960).

Grazing or feeding period	Date	Zone used[1]	Major forage species	Dominant soil order, Great group, Subgroup
Spring	mid-April to mid-June	sagebrush-wheatgrass	bluebunch wheatgrass needle-and-thread Sandberg's bluegrass downy brome	Brown Chernozem
		wheatgrass-bluegrass	bluebunch wheatgrass Sandberg's bluegrass needle-and-thread	Gleyed Black Chernozem
		ponderosa pine	bluebunch wheatgrass rough fescue Junegrass	Eutric Brunisol Dark Brown Chernozem
		fescue-wheatgrass	rough fescue bluebunch wheatgrass Kentucky bluegrass Junegrass, asters balsamroot, vetch timber milkvetch geranium	Black and Dark Brown Chernozem
Summer	mid-June to mid to late Sept.	Douglas-fir	pinegrass, lupine vetch, peavine timber milkvetch rose, spirea soopalallie serviceberry, snowberry	Brunisol, Luvisol
		spruce-alpine fir (grazing mainly on meadows and parklike openings)	sedges rushes march reedgrass	Dystric Brunisol to Podsol, Organics and Gleysols
		Alpine	sedges, rushes bluegrass, trisetum kobresia	Sombric and Dystric Brunisol Regosol

continued....

2. Continued.

Grazing or feeding period	Date	Zone used[1]	Major forage species	Dominant soil order, Great group, Subgroup
Fall	Sept. to late Oct. or early Nov.	fescue-wheatgrass		
		wheatgrass-bluegrass		
		ponderosa pine		
		sagebrush-wheatgrass		
Winter	early Nov. to mid-April	sagebrush-wheatgrass		
		lowland riverbottoms	sedges, native and cultivated grasses	Regosol, Gleyed Regosol
		aftermath on cultivated fields	alfalfa grasses	Regosol, Gleysol Brown Chernozem
		following heavy snows or depletion of forage on the above three zones	stored hay	

1 Grazing begins in the spring at the zone of lowest elevation (sagebrush-wheatgrass). Cattle then move upward until the highest elevation zone (spruce-alpine fir) is reached. In the fall, cattle move downwards and graze until available forage is depleted. Stored hay is then fed for 3 to 5 months depending upon elevation of the ranch site. The hay is grown at low elevation during the summer using irrigation. The grazing pattern shown in this Table is theoretical and in practice, many exceptions occur. For example, in the fall cattle may be moved directly from the forest zone to cultivated fields. As well, some ranches are located above the grasslands and thus must feed hay until domestic grasses provide grazing in the spring; cattle are then moved onto pinegrass ranges.

3. Taxaonomy from Hitchcock (1950).

Family:	Gramineae (Poaceae) - grass family
Sub-family:	Festucoideae
Tribe:	Agrostideae
Genus:	Calamagrostis
Species:*	rubescens Buckl. - pinegrass
	canadensis (Michx.) Beauv. - bluejoint or marsh reedgrass
	inexpansa A. Gray - northern reedgrass
	montanensis Schribn. - plains reedgrass
	neglecta (Echrl.) Gaertn. May. and Schrib. - slimstem reedgrass
	purpurascens R. Br. - purple reedgrass

* These six species are listed by A.C. Budd (1957) as growing on the Canadian prairies. (Wild Plants of the Canadian Prairies, Can. Dept. of Agric., Publ. No. 983).

4. Additional references not cited in the text.

The literature for pinegrass is limited. Following are references not cited in the text. The following references plus those cited in the text are believed to represent a large fraction of the total publications dealing with Calamagrostis.

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