Rate and Pattern of Vigor Recovery in Idaho Fescue and Bluebunch Wheatgrass

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Highlight: *The rate and pattern of vigor recovery of protected individual Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*) were studied for 5 years after heavy and extreme clipping. Bluebunch wheatgrass was not only more sensitive to clipping, but recovered vigor more slowly than Idaho fescue. Idaho fescue of moderately low vigor required approximately 3 years and bluebunch wheatgrass a projected 6 years to approach normal vigor. Recovery from very low vigor may take more than 6 years of protection for Idaho fescue and 8 years for bluebunch wheatgrass. Maximum leaf length can be used as a reliable index of Idaho fescue vigor. Flower stalk numbers combined with maximum lengths indicate vigor in bluebunch wheatgrass.*

Livestock grazing generally harms to some extent growth and reproduction of utilized plants. Reviews by Ellison (1960), Jameson (1963), and other workers, too numerous to be mentioned here, clearly show that the amount of damage depends primarily upon intensity, frequency, and time of utilization and upon response of individual species to foliage removal. Range scientists and managers are faced with the complex problem of devising grazing systems that (1) permit maximum returns from the forage resource, (2) perpetuate the forage potential, and (3) remain compatible with other resource values (e.g., water, wildlife, and recreation) inherent in a given unit of rangeland. This is truly a perplexing challenge, particularly when we consider the varied palatability and response of plant species to grazing, the competitive interactions between plants, and the mosaic of plant community composition on our native ranges.

Grazing and clipping studies over the past 40 years have contributed substantially to our understanding of the adverse plant response to grazing. Such information is, of course, essential for development of effective grazing systems. However, an understanding of how range plants recover from grazing is also important. The rate and pattern of vigor recovery have received comparatively little attention.

Although bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*) are important forage species on our western ranges (Fig. 1), information related to their ability to regain vigor is meager and is based primarily on comparisons of range areas before and after protection from grazing. Laycock (1967) found that production of bluebunch wheatgrass in southern Idaho increased 76% during 14 years of protection. Canopy cover of this species in two exclosures in the ponderosa pine zone of British Columbia increased from 25% to 55% and from 36% to 45% over 10 years (McLean and Tisdale, 1972). Hormay and Talbot (1961) investigated recovery of vigor in individual Idaho fescue plants that were producing 53% of their former basal area and only 5% as many flower stalks as control plants. After two seasons of rest, production of flower stalks had increased to 27% that of the control plants and had recovered after three seasons of rest. Basal area did not improve even after four seasons of rest, yet the authors somewhat paradoxically concluded that reasonable restoration of vigor in Idaho fescue can be expected from two seasons of rest. Hormay (1970) later generalized that 1 or 2 years of rest usually is adequate to restore plant vigor. Working with Arizona fescue (*F. arizonica*) in Colorado, Smith (1967) found that flower stalk production of grazed plants had almost recovered after 3 years of protection, but that complete recovery of the plants was not apparent even after 9 years of rest.

Need for better understanding of how bluebunch wheatgrass and Idaho fescue recover from grazing, as well as questions concerning the interactions between competition and clipping, stimulated a study designed (1) to determine the influence of competition on the response of these grasses to clipping and (2) to follow subsequent recovery of vigor in clipped plants. Results on the suppressing effects of competition and its interaction with herbage removal have been published (Mueggler, 1970, 1972a). The present paper reports the pattern and rate of vigor recovery observed in plants subjected to different levels of clipping stress. The results are relevant to development of grazing systems based upon physiological requirements of important range plants.

Methods

The study area was a natural mountain grassland on a gently sloping, north-facing swale at 6,000 ft elevation in southwestern Montana. Soils were granitic, fairly deep, and productive. Approximately 70% of the estimated 18 inches of annual precipitation falls from April through September.

The vegetation was dominated by bluebunch wheatgrass, Idaho fescue, and silvery lupine (*Lupinus argenteus*). Secondary species included yarrow (*Achillea millefolium*), cerastium (*Cerastium arvense*), prairiesmoke (*Geum triflorum*), needlegrass (*Stipa occidentalis*), pussytoes (*Antennaria rosea*), sagewort (*Artemisia ludoviciana*), and rabbitbrush

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Fig. 1. *Idaho fescue and bluebunch wheatgrass are major forage species on many mountain grasslands in southwestern Montana.*

(*Chrysothamnus nauseosus*). Vegetation and litter cover were fairly dense; little bare soil was exposed (Fig. 2). The vegetation, conservatively grazed in the years prior to the study, was protected from grazing throughout the study period (1967-1973).

One hundred and thirty-five mature, vigorous Idaho fescue plants and a like number of mature, vigorous bluebunch wheatgrass plants were selected for study. Selection was based on uniformity of size and vigor. Basal diameters of the Idaho fescue and bluebunch wheatgrass plants ranged from 3 to 5 cm and from 5 to 8 cm diameter, respectively. None of the latter had the large, coarse, "wolfish" characteristics sometimes found in more open stands. Selected plants were randomly assigned to nine separate treatments which yielded 15 replications of each species per treatment. Treatments were imposed on the bluebunch wheatgrass plants 1 year after the Idaho fescue plants were treated.

The nine treatments consisted of all combinations of each level of competition (full, partial, and no competition) and each level of clipping (heavy, extreme, and no clipping). Levels of competition were created immediately prior to the clipping treatments.

Only those plants subjected to full and partial competition levels were used for determining recovery of vigor. (Plants without competition showed no reduction in vigor when compared with the untreated control plants [Mueggler 1970, 1972a].) Full competition was achieved by permitting the natural vegetation surrounding the plant selected for treatment to remain undisturbed. Partial competition was effected by clipping to ground level all vegetation within a 60-cm radius of the selected Idaho fescue plants and within a 90-cm radius of the selected bluebunch wheatgrass plants (Fig. 3). Clipped material was removed from the plot without disturbing the soil or directly harming root crowns of competing vegetation, which was then permitted to grow without further hindrance during the course of the study.

Clipping treatments were designed to quickly and markedly reduce the vigor of the test plants. The heavy clipping treatment for Idaho fescue consisted of removal of 75% of the herbage volume at the flowering development stage (July 13) and no further treatment. The extreme clipping level consisted of removing 100% (to a 1-cm stubble) of the herbage volume at flowering, followed by removing 75% of the regrowth when control plants neared the seed-ripe stage (August 8). The heavy clipping treatment for bluebunch wheatgrass was achieved by clipping to a stubble height equivalent to 28% of the plant's total height just before full emergence of the flower stalks (June 25). This removal represented approximately 50% of the total herbage weight (Heady, 1950). Extreme clipping of bluebunch wheatgrass entailed the heavy clipping treatment plus clipping regrowth to a uniform 8-cm stubble height when the control plants were at the seed-in-dough stage of development (July 17). Both Idaho fescue and bluebunch wheatgrass plants were clipped during one growing season only.

Unclipped plants under full competition were used as controls to evaluate natural yearly variations in herbage production, leaf and flower stalk lengths, and flower stalk numbers.

Fig. 2. *Idaho fescue, bluebunch wheatgrass, and silvery lupine, along with numerous other species, form a dense cover of vegetation on the study site.*

Fig. 3. *For the partial competition treatment, vegetation surrounding the test plants was clipped to ground level just before the test plants were clipped to give intensities; all vegetation was then permitted to grow without further hindrance.*

Plant response was measured shortly after flowering each of the 5 consecutive years following treatment. Response of Idaho fescue was determined by measuring live basal area (total area minus unoccupied openings), leaf length (distance from the ground to the tip of the leaf blade), and number and lengths of flower stalks. An index to herbage volume was obtained by multiplying live basal area by average leaf length. Response of bluebunch wheatgrass was determined by counting vegetative and flower stalk culms and by measuring maximum and average lengths of those culms. (Vegetative culm length is the distance from point of emergence on the ground to the most distant leaf tip.) Average weights of individual culms by length classes were determined from samples collected from nearby plants; separate regression equations ($R^2 > .92$) were then derived to obtain foliage and flower culm dry weights from respective culm lengths. These equations were used to compute the dry weight of each bluebunch wheatgrass plant from the number of and the average length of foliage and flower culms for each plant.

Vigor recovery was evaluated by comparing plants subjected to various treatments with the control plants. All data, except those for maximum flower stalk lengths, were subjected to covariance analysis to account for possible response differences attributable to variances in initial plant size. Maximum flower stalk lengths were compared by a group t test for unpaired plots. "Before-treatment" data are included in the tables only to show initial similarity of plants in various treatments. These data were collected about 3 weeks earlier in the growing season than those collected in subsequent years. This difference, along with natural yearly variations in plant production, disallows evaluation of vigor recovery by direct comparison with before-treatment data.

Table 1. Idaho fescue: effects of partial competition with heavy clipping (P/H) and with extreme clipping (P/E), and of full competition with heavy clipping (F/H) and with extreme clipping (F/E) on herbage and flower stalk production and recovery during 5 years of protection.[1]

Measurements and treatments	Before treatment	Years after treatment				
		1	2	3	4	5
Herbage volume/plant (cm^3)						
Control	144	257	252	252	346	309
P/H	174	309	283	329	391	248
P/E	161	112*	177+	235	385	297
F/H	156	168*	174	274	390	259
F/E	162	38*	51*	83*	158*	196+
Number of flower stalks/plant						
Control	2.5	10.5	5.8	5.3	11.9	11.8
P/H	3.1	9.4	10.2	5.9	9.0	8.9
P/E	2.8	0.1*	6.4	3.3	8.3	6.2+
F/H	3.4	0.1*	2.5+	8.7	14.0	6.6
F/E	2.2	0.1*	0.3*	0.6*	4.3+	7.2

[1]Data adjusted by covariance to account for differences in before-treatment values. Adjusted means with * superscript and those with + superscript differ from the control in a given year at < .05 probability and at .05 to .10 probability, respectively.

Results

The impact of various treatments upon vigor of Idaho fescue and bluebunch wheatgrass is indicated by the depression of herbage and flower stalk production the first growing season after clipping. Of the four combinations of heavy and extreme clipping under partial and full competition, only partial competition with heavy clipping (P/H) did not significantly reduce production the first year. Initial growth depression was about equal for partial competition with extreme clipping (P/E) and full competition with heavy clipping (F/H). Full competition with extreme clipping (F/E) was extremely detrimental to plant vigor. I intended to subject the plants to varying degrees of vigor reduction, which I accomplished in part; however, I did not anticipate how greatly partial reduction in competition would reduce the effects of heavy clipping. I discussed this interaction between competition and clipping in earlier publications (Mueggler, 1970, 1972a).

Idaho Fescue

The most harmful treatment, F/E, reduced herbage volume of Idaho fescue 85% and virtually eliminated flower stalk production (Table 1). Volume increased consistently under complete protection; yet, after 5 years, these plants still produced less than two-thirds the volume of control plants.

Table 2. Idaho fescue: effects of partial competition with heavy clipping (P/H) and with extreme clipping (P/E), and of full competition with heavy clipping (F/H) and with extreme clipping (F/E) on basal area, leaf and flower stalk heights, and subsequent recovery during 5 years of protection.[1]

Measurements and treatments	Before treatment	Years after treatment				
		1	2	3	4	5
Live basal area/plant (cm^2)						
Control	12.2	14.6	14.0	15.0	19.0	17.1
P/H	14.6	19.8+	16.7	17.6	20.3	14.1
P/E	14.3	9.8*	13.3	13.3	19.5	16.6
F/H	13.8	11.0*	9.7*	15.1	20.1	13.8
F/E	12.7	4.2*	4.0*	6.3*	8.9*	11.7+
Maximum leaf length/plant (cm)						
Control	17.5	23.2	23.6	22.6	24.4	21.8
P/H	17.5	19.7*	21.7	23.0	25.0	21.1
P/E	16.3	15.4*	16.9*	21.4	23.1	20.5
F/H	17.3	19.8*	21.0+	22.9	24.4	21.1
F/E	17.9	14.3*	16.1*	17.7*	21.5*	20.8
Maximum flower stalk length/plant (cm)						
Control	40	58	51	55	58	50
P/H	43	56	50	51	55	47+
P/E	38	–	51	53	53	41*
F/H	40	48	49	54	59	46+
F/E	43	39	37	53	54	48

[1]Data, except length of flower stalks, adjusted by covariance to account for differences in before-treatment values. Adjusted means with * superscript and those with + superscript differ from the control in a given year at < .05 probability and at .05 and .10 probability, respectively.

Under this degree of vigor reduction, recovery of flower stalk production was similar to that of herbage volume (Fig. 4). Extrapolation of these data suggests that complete recovery of Idaho fescue from extremely poor vigor might be expected in from 6 to 7 years.

Although plants subjected to the F/H and P/E treatments produced almost no flower stalks the following growing season, they produced considerable herbage and so were probably in a state of intermediate vigor. The F/H and P/E treatments reduced herbage volume 35 and 56%, respectively. Volume apparently recovered under both treatments during 3 years of protection (Fig. 4). During the second year of protection, flower stalk production of plants in the F/H treatment was still less than 50% of the controls, but had recovered under the P/E treatment. Thus, at this intermediate level of vigor, 3 years of protection apparently enables Idaho fescue to produce as much herbage and as many flower stalks as plants of normal vigor. The slight decrease in volume following recovery is probably the result of natural variability; however, the much greater decrease in flower stalk numbers may indicate some instability in apparent recovery of vigor.

Idaho fescue withstood heavy clipping well when competing vegetation was clipped to the same degree (Fig. 4). If anything, these plants were more productive than the control plants for several years. However, both average and maximum leaf lengths were significantly shorter than those of the control plants the first year following treatment (Table 2). These observations suggest that vigor, at least vigor expressed by leaf length, had been affected adversely.

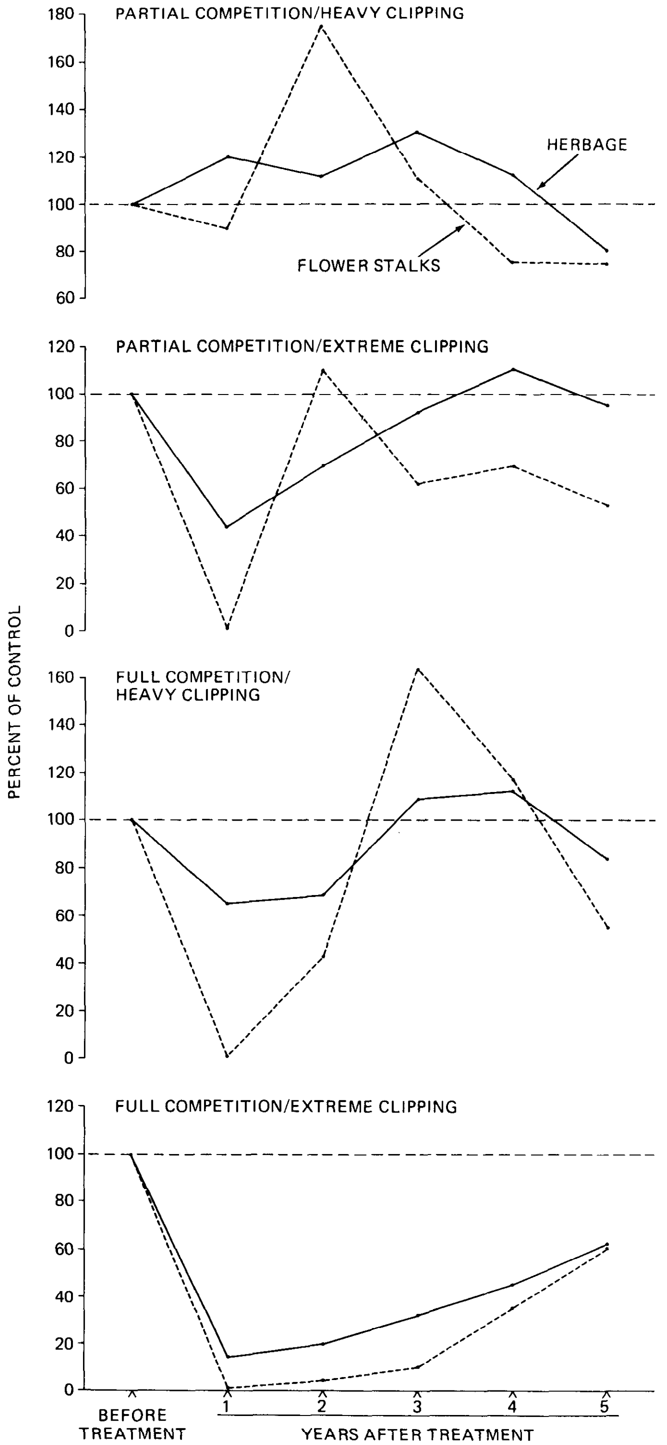

Fig. 4. *Recovery of Idaho fescue flower stalk numbers and total herbage production following heavy and extreme clipping under two levels of competition. Data were adjusted by covariance to before-treatment values and expressed as a percent of the control plants.*

Bluebunch Wheatgrass

Bluebunch wheatgrass vigor was severely depressed the first year after clipping in all treatments except heavy clipping under partial competition (Table 3). As was expected, the combination of full competition and extreme clipping (F/E) was most detrimental; plants so treated produced only about one-fourth as much herbage as the control plants and practically no flower stalks. Full competition with heavy clipping (F/H) and partial competition with extreme clipping (P/E) reduced herbage production to one-half and flower stalk numbers to approximately one-tenth those of the control plants.

Recovery of vigor in these severely affected plants followed generally similar patterns (Fig. 5). Numbers of flower stalks gradually increased with time; however, even after 5 years of complete protection, these plants were able to produce only about two-thirds as many flower stalks as the controls. Changes in herbage production did not follow quite the same pattern as changes in flower stalk numbers. Although initial decreases in total production were not as great as those for flower stalk numbers, subsequent recovery rates were not as rapid either. Consequently, the gap between recovery curves for these two measures tended to narrow with time. By the end of 5 years, total herbage production was only about two-thirds that of the control plants.

The initial reaction of bluebunch wheatgrass to heavy clipping while subjected to partial competition was strikingly different than it was under the other treatments. If anything, both herbage production and number of flower stalks slightly increased rather than decreased the first year after clipping. As with Idaho fescue, the partial reduction in competition apparently offset the adverse effects of heavy clipping. However, even under complete protection, these bluebunch wheatgrass plants produced only about one-third as many flower stalks and five-sixths as much total herbage as the control plants during the second growing season following treatment. Apparently by this time, recovery of competing vegetation was such that the beneficial effects of reduced competition no longer overshadowed the adverse effects of clipping; the net result was an obvious decrease in vigor.

Table 3. **Bluebunch wheatgrass: effects of partial competition with heavy clipping (P/H) and extreme clipping (P/E), and of full competition with heavy clipping (F/H) and extreme clipping (F/E) on herbage and flower stalk production and subsequent recovery during 5 years of protection.**[1]

Measurements and treatments	Before treatment	Years after treatment 1	2	3	4	5
Herbage production (g/plant)						
Control	6.7	7.9	11.4	16.5	11.8	20.9
P/H	7.0	9.9	9.8	12.3	9.3	17.9
P/E	6.5	4.0*	6.4*	7.8*	7.3^{+}	14.3
F/H	6.9	3.9*	7.3*	8.8*	7.2^{+}	13.3
F/E	6.7	2.0*	5.9*	9.1*	6.9*	15.7
Number of flower stalks/plant						
Control	61.7[2]	12.2	17.8	39.4	22.4	40.5
P/H	65.3	13.1	5.7*	24.0^{+}	17.6	27.8
P/E	64.0	1.6*	1.7*	17.3*	13.9	26.8
F/H	62.7	0.6*	7.1*	12.7*	12.3^{+}	23.4
F/E	60.7	0.3*	3.6*	19.4*	12.3^{+}	23.2
Maximum length of flower stalks/plant (cm)						
Control	43[2]	52	70	72	63	66
P/H	44	43*	60*	64*	60	61*
P/E	44	36*	61*	65*	59^{+}	61
F/H	42	37*	67	68^{+}	60	64
F/E	44	38*	64	65*	61	63
Maximum length of foliage culms/plant (cm)						
Control	43[2]	35	40	35	35	34
P/H	44	33	40	37	35	37
P/E	44	31*	36	36	34	34
F/H	42	33	39	37	35	36
F/E	44	31*	37^{+}	35	34	32

[1] Data, except length of flower stalks, adjusted by covariance to account for differences in before-treatment values. Adjusted means with * superscript and those with + superscript differ from the control in a given year at $< .05$ probability and at .05 and .10 probability respectively.
[2] Before-treatment data includes both foliage and flower culms.

Thereafter, the pattern of recovery of these plants paralleled those of plants under other treatments, but at a higher level of productivity.

Recovery of bluebunch wheatgrass of extremely poor vigor does not appear to be as rapid as recovery of Idaho fescue in like vigor. Extrapolation of data in Figure 5 suggests that total herbage production and numbers of flower stalks should return to normal after 8 to 10 years of protection. Even bluebunch wheatgrass at the intermediate level of vigor created by the P/H treatment may require about 6 years of protection to produce as much herbage and as many flower stalks as plants of normal vigor protected from grazing.

Discussion

The delayed response of bluebunch wheatgrass to heavy clipping under partial competition was completely unexpected and partly negates a previous conclusion based upon data for 1 year. I stated in an earlier publication (Mueggler, 1972a) that bluebunch wheatgrass and Idaho fescue apparently can recover rapidly from the adverse effects of heavy clipping if competing vegetation is temporarily suppressed. This observation still appears to hold true for Idaho fescue. Although the maximum length of flower stalks was reduced significantly the first year after clipping, flower stalk numbers and total herbage production of bluebunch wheatgrass were, if anything, slightly greater than those of the control plants; I concluded that plant vigor had not been affected appreciably. However, the sharp decline in flower stalk numbers and herbage production the second year of protection clearly shows that vigor of bluebunch wheatgrass had been reduced considerably. Once competition from surrounding vegetation increased, this reduction in vigor was expressed by reduced production of flower stalks and herbage and continued depression of flower stalk lengths.

Apparently, bluebunch wheatgrass not only is more sensitive to heavy use than Idaho fescue, but is less able to endure competition from surrounding vegetation. This difference is even greater than it may first appear, since heavy

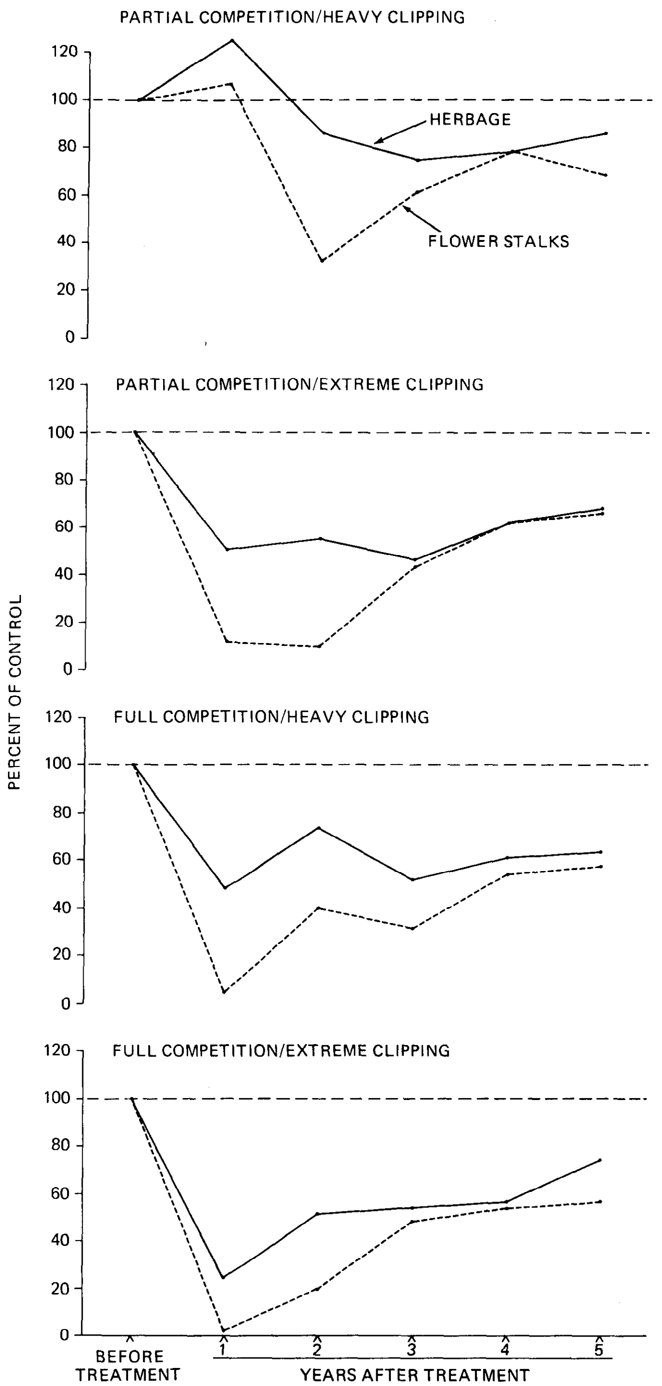

Fig. 5. *Recovery of bluebunch wheatgrass flower stalk numbers and total herbage production following heavy and extreme clipping under two levels of competition. Data were adjusted by covariance to before-treatment values and expressed as a percent of the control plants.*

clipping involved removal of only an estimated 50% of wheatgrass herbage, but 75% of Idaho fescue herbage at supposedly equal periods of sensitivity in their development. Idaho fescue was not affected appreciably by heavy clipping as long as competition was also reduced, but bluebunch wheatgrass was affected adversely by this treatment, even though a smaller percentage of its herbage was clipped.

Data from the control plants fluctuated considerably between years. This variation can be attributed almost exclusively to yearly weather differences. All data, except before-treatment measurements, were collected in mid-July at approximately the same growth stage each year. Before-treatment data were collected about 3 weeks earlier; consequently, they serve only to initially equate the plants and cannot be used to evaluate yearly differences.

Over the 5 years, natural fluctuations in flower stalk numbers, flower stalk lengths, and total herbage production were considerably greater in bluebunch wheatgrass than in Idaho fescue (Table 1, 2, 3). During the high year, wheatgrass produced 3.3 and fescue 2.3 times as many flower stalks, 1.4 and 1.2 times as long, respectively, as those produced during the low year. Wheatgrass produced 2.7 and fescue only 1.4 times as much total herbage during the high as during the low year. These findings on variations in total herbage production between these two grasses are in line with those previously observed for 5 years on another area (Mueggler, 1972b). On a southwest exposure, bluebunch wheatgrass produced 2.1 and Idaho fescue 1.6 times as much herbage, and on a northeast exposure, 2.6 and 2.1 times as much during the high as during the low year.

This study provided opportunity to examine the usefulness of various characteristics of these grasses for evaluating plant vigor. Vigor usually is described simply as health; most often it is expressed by such variable characteristics as total herbage production, basal area, flower stalk numbers, and leaf and flower stalk lengths. Comparisons of grazed and protected plants usually are based on one or more of these factors. For example, Pond (1960) concluded from comparing plants in grazed pastures with those in exclosures that leaf height, basal area, and herbage weight were of about equal value as vigor measures for Idaho fescue. Similar comparisons by Evanko and Peterson (1955) suggest the same conclusion. Hurd (1959) indicated that maximum leaf height alone appears to be a reliable index to Idaho fescue vigor expressed by production. Numbers of flower stalks have been proposed as a more sensitive indicator of Idaho fescue vigor than leaf length, flower stalk length, or herbage production (Mueggler, 1970).

Although number of flower stalks appears to be a sensitive indicator of initial disturbance to Idaho fescue health, the relatively large variation, compared to that of control plants during vigor recovery (Fig. 4), suggests that flower stalk number alone may not be a reliable means of evaluating degree of recovery. Flower stalk production probably is governed by a number of interacting influences besides plant health, such as weather of the current and the preceding year and even flowering success of the preceding year. Johnston and MacDonald (1967) found that floral initiation and partial development in rough fescue (*F. scabrella*) occur the preceding autumn and that few floral primordia are formed the fall of a good flowering year. They indicate that the same phenomenon may be true for Idaho fescue.

Leaf length is considerably less sensitive than number of flower stalks to disturbance, but appears to be a more consistent indicator of expected trends in Idaho fescue vigor. The first year of vigor recovery, maximum leaf length of clipped plants ranged from 15 to 38% less than that of the controls, depending upon severity of treatment (Table 2). Leaf length gradually recovered over the years at a rate generally consistent with expectations. Trends for average leaf lengths closely paralleled those for maximum lengths; but average leaf lengths were approximately 25% shorter than maximum lengths. Maximum flower stalk length was considerably less useful than leaf length in evaluating recovery of Idaho fescue (Table 2).

Idaho fescue volume, used here as an index of herbage production, was estimated from the product of live basal area and average leaf length. Increased herbage production for plants that received the P/H treatment (Fig. 4) is the result of an increase in basal area that more than offset a significant decrease in average leaf length. The response of live basal area and of herbage volume to various treatments and to subsequent protection was more erratic and less indicative of expected vigor trends than was that of leaf length.

Comparison of these various plant measures (flower stalk numbers and lengths, live basal area, leaf lengths, and herbage volume) shows that maximum leaf length is a simple and relatively reliable index of expected vigor in Idaho fescue. However, the comparatively small differences in maximum leaf length between normal plants and plants of poor vigor could lead to misinterpretations regarding vigor. For example, maximum leaf length of plants of poor vigor (F/E treated) was reduced only 38%, but herbage volume was reduced 85% and flower stalk number, 99%. By the end of 5 recovery years, leaf length was only 5% less than that of control plants, whereas volume and flower stalk number were 37 and 38% less, respectively. Thus, vigor setback and recovery interpreted directly from leaf length suggest a much smaller impact on plant health than that conveyed by herbage volume and flower stalk production.

We might reasonably assume that plant health is adequately defined by an equal combination of herbage and flower stalk production. If so, leaf length can be brought into better perspective as an index of Idaho fescue vigor. This simple measure can be used to estimate the departure of combined herbage and flower stalk production from what is considered normal for a given year (herbage as a percent of normal plus flower stalks as a percent of normal, divided by 2). The following regression equation predicts the percent of normal of combined herbage volume and flower stalk production (**Y**) from the percent of normal of the maximum leaf lengths (**X**):

$$Y = - 131 + 2.3X.$$

This equation was derived from all data in Figure 4 plus similar data for maximum leaf lengths; the correlation coefficient is .72, significant at $< .01$ probability.

Various studies have shown number of flower culms to be a sensitive indicator of vigor in bluebunch wheatgrass (Blaisdell and Pechanec, 1949; Heady, 1950; Mueggler, 1972a). Data presented in Table 3 and Figure 5 substantiate this conclusion. Of the various bluebunch wheatgrass characteristics measured, number of flower stalks was most severely reduced by clipping. In contrast to Idaho fescue, flower stalk numbers of wheatgrass did not fluctuate greatly in comparison to those of the controls during the recovery period.

Whereas neither total herbage nor number of bluebunch wheatgrass flower stalks was decreased initially by the P/H treatment, maximum length of flower stalks was reduced significantly (Table 3). Although depressed only about 30%, at most, flower stalk length may be a more reliable indicator of initial loss in vigor than herbage production or flower stalk numbers.

Total herbage production appeared somewhat inferior to flower stalks in reflecting expected trends in vigor. Maximum length of foliage culms (Table 3) was reduced only 12%, at most, and was by far the poorest expression of expected vigor, an observation that corresponds to conclusions of Blaisdell and Pechanec (1949).

Thus, maximum leaf length appears to be a simple, reliable indicator of Idaho fescue vigor, especially if used to estimate departure of herbage and flower stalk production from normal. Flower stalk numbers used in conjunction with maximum flower stalk lengths appears to be a relatively simple and reliable vigor indicator for bluebunch wheatgrass. Since these characteristics are influenced considerably by yearly weather variations, plants of normal vigor must be used for comparative determinations of vigor in any given year. Additionally, individual plants vary considerably, which necessitates measuring a sufficient number of plants to provide valid means. Assessment of plant-to-plant variability in this study suggests that a sample of 50 Idaho fescue plants should give a 95% probability of falling within ±5% of the mean of maximum leaf lengths. A 50-plant sample of bluebunch wheatgrass should yield equal reliability for estimating maximum flower stalk lengths; however, a sample of from 80 to 100 plants probably will be required to provide 95% probability of falling within ±20% of the mean number of flower stalks.

Conclusions

1) Idaho fescue of moderately low vigor requires about 3 years of protection to regain full vigor. Even then, a residual instability in plant health may remain for several years.

2) Idaho fescue of low vigor produced only two-thirds as much herbage and numbers of flower stalks as normal plants after 5 years of protection; complete vigor recovery can take more than 6 years.

3) Bluebunch wheatgrass of moderately low vigor may require at least 6 years of protection to recover.

4) Bluebunch wheatgrass of low vigor produced only two-thirds as much herbage and numbers of flower stalks as normal plants after 5 years of protection; complete recovery can take more than 8 years.

5) Bluebunch wheatgrass appears to be more sensitive to heavy use than Idaho fescue and recovers vigor more slowly.

6) In any given year, evaluation of vigor requires comparison with protected plants of normal vigor because of natural yearly variations in plant characteristics caused by weather.

7) Although number of flower stalks is a sensitive indicator of initial vigor loss in Idaho fescue, subsequent variations with respect to normal vigor suggest that numbers may not be reliable for evaluating recovery.

8) Maximum leaf length is judged to be a simple and reliable index to Idaho fescue vigor. A reasonable approximation of vigor in Idaho fescue can be obtained by the following steps: (a) determining the average maximum leaf length for 50 normal plants and for 50 plants of reduced vigor; (b) expressing the leaf length of the plants of reduced vigor as a percent of that for plants of normal vigor (**X**); and (c) converting this figure to a percentage of combined herbage and flower stalk production (**Y**) by means of the equation:

$$Y = -131 + 2.3X.$$

9) Bluebunch wheatgrass vigor can be determined by combining numbers of flower stalks with maximum length of flower culms. Means from a sample of approximately 80 to 100 individuals of grazed plants should be compared with those from a like sample of ungrazed plants to yield reasonably valid data.

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