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Clint Miller
City of Boulder Open Space Operations
66 S. Cherryvale Rd.
Boulder, CO 80303

Dear Clint:

Please find enclosed my 1996 report for our diffuse knapweed cattle grazing experiment. I did my best to address each of the reviewer's comments. Some were very useful - particularly those where I failed to express my thoughts such that other could understand (e.g. methodology, especially change is how replications were constructed after the third site turned out to be quite different than the Kelsall and North Boulder sites). I think how we adapted to the third site is more clear. We did not change the experimental design when we could not find a third ranch that was similar to Kelsall and North Boulder Valley ranches - rather, we changed how the data were analyzed. Instead of being a balanced design, it became unbalanced and in each of two different analyses (the all land type and the bottom land) we included in the data sets those properties with similar land types. For example, the all land types analysis was always done using data from Kelsall and North Boulder and included bottom land, hillsides, and hilltops; for the second analysis, i.e., the bottom land analysis, we included data from Kelsall, North Boulder, and Superior only from the bottom land, because that what was common to all sites in this analysis. We used a procedure in SAS 6.11 called Proc Mixed which was created to analyze data sets that are unbalanced.

I am a little surprised that someone did not object to us having only two replications on the hillsides and hilltops at Kelsall and North Boulder - maybe because I did not explain what we did well enough. I intend to visit with our Experiment Station Statistician about this - at least what I have in mind that might help - and with his approval, add another replication (one control exclosure, one treatment exclosure, and two 100 m transects) to the hillsides and hilltops at Kelsall and North Boulder so each would have three replications on each land type. I hope all of this is making sense!

I changed all references to 'ranch' to site or property (site used most often) even though I found this to be rather arbitrary - maybe there is a good reason for this suggestion that I do not understand. We found the baseline site description for Kelsall - I just missed this on the computer. I changed the headings on each of the site descriptions and hopefully these now make sense. A reviewer asked for more information/data on miscellaneous species as well as species composition, or grass cover, for each site and land type. We have not held back any data and what we have appears in the report (obviously excluding those tables without differences due to treatment, etc.). The focus of the study was the effects of cattle grazing on diffuse knapweed and that is what we emphasized. I thought this was clear in the report, but maybe not. Of course, if we find relationships

between grass cover and diffuse knapweed or any other measured variable, we will report it. I am hoping such a relationship will become apparent because it seems logical that if a site is dominated by a healthy grass community that it would be less susceptible to invasion by a plant like diffuse knapweed. However, what seems logical when hypothesizing does not always hold true when the data are analyzed. I have to admit though, that I expect such relationship to materialize over the course of this experiment.

Lastly, I tried to add a little more discussion about grass cover and weedy plants by comparing grass cover at North Boulder to Superior and miscellaneous cover at both locations. For the moment, this is where such a discussion has statistical backing.

Please let me know if there are additional corrections you would like me to make. Thanks for your assistance in preparing this annual report - it should be easier this year. Also, please let me know if you want me to give an oral annual report.

Sincerely,

K. George Beck
Associate Professor

The Influence of Cattle Grazing on the Population Dynamics of Diffuse Knapweed

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Abstract

Diffuse knapweed infests the Kelsall, North Boulder, and Superior Ranches owned by the City of Boulder Open Space Department. Each site was used in an experiment to assess the City's normal cattle grazing management practices on the population dynamics of diffuse knapweed. One or two grazing events per year were compared to no grazing. Diffuse knapweed density and cover before grazing were not different at either ranch among the exclosures and transects constructed to evaluate the effects of grazing. In June, 1996, after two grazing events, diffuse knapweed density was decreased 50 and 33% on bottom land at North Boulder and Superior. Immediately following two grazing events, diffuse knapweed cover was decreased at all sites and land types compared to no grazing. In September, diffuse knapweed density remained decreased 58 and 73% by two grazing events on hillsides and hilltops, respectively, at Kelsall only; on bottom land, each grazing event decreased density incrementally at Superior. Also in September, diffuse knapweed cover remained decreased from two grazing events at all sites and land types except on bottom land at North Boulder. Knapweed height decreased incrementally (from 18 to 39%) as grazing events increased. Cattle readily consumed diffuse knapweed in spring and grazing influenced plant growth. Grazing effects on diffuse knapweed reproduction still are being analyzed.

Objective: The objective of this proposed research was to determine the influence of one v. two cattle grazing events on the population dynamics of diffuse knapweed (*Centaurea diffusa* Lam.) and associated members of the plant community within the constraints of typical grazing practices invoked by the City of Boulder Open Space.

Hypotheses:

Research hypothesis *Ha*: Two cattle grazing events per year will influence the population dynamics of diffuse more than one grazing event per year.

Null hypothesis *Ho*: The population dynamics of diffuse knapweed will be influenced similarly between one and two cattle grazing events per year.

Methodology

Experimental design, site selection, and data collection:

The experiment is a simple randomized complete block design with two treatments; one v. two grazing events invoked in spring. It was conducted in 1996 and will continue in 1997

and 1998. The first grazing event occurred when diffuse knapweed was in the early to mid bolt growth stages and the second grazing event occurred when the grazed plants again were in the early to mid bolt growth stages. Three City of Boulder Open Space properties were selected to use in the experiment and each property was considered a site; i.e.,, the Kelsall site, the North Boulder Valley site, and the Superior site. The original experimental design was to consider each site as a replicate as each site was to have been similar; i.e., each comprised of bottom land, hillsides, and hilltops. The Kelsall and North Boulder sites had all three classifications but the third site, Superior, had only bottom land. The experiment and data collection proceeded as planned but statistical analysis was changed and this explanation is offered below in the Statistical Analysis section. We conducted the experiment within the normal grazing management practices of the City of Boulder Open Space Department.

At the Kelsall and North Boulder sites, pastures were categorized as bottom land, hillsides, and hilltops for data collection purposes as cattle may tend to use these areas differently. The Superior site was categorized only as bottom land. Instead of using sites as replicates as originally planned, replicates were comprised of a control exclosure, a treatment exclosure, and two 100 m transects (Appendix Figure 1). Permanent control exclosures (no grazing) were constructed in each land category; at Kelsall and North Boulder, three control exclosures were constructed on bottom lands and two each on the hillsides and hilltops. At Superior, six control exclosures were constructed. Matching sets of treatment exclosures (one grazing event) were constructed at each site and land categorization after the first grazing event to delineate between one and two grazing events (three treatment exclosures on bottom lands and two each on hillsides and hilltops at Kelsall and North Boulder; six treatment exclosures at Superior). Two 100 m long permanent transects were constructed and paired to each set of exclosures (control and treatment exclosures) and these served to monitor vegetation changes associated with two grazing events (six permanent transects on bottom land and four each on hillsides and hilltops at Kelsall and North Boulder; 12 permanent transects at Superior). Each set of control and treatment exclosures and paired set of 100 m transects at each land category and each site served as a replication; thus, there were three replications on bottom land at Kelsall and North Boulder; two replications each on hillsides and hilltops at Kelsall and North Boulder; and six replications at Superior. Care was taken at each site and land category to assemble exclosures and transects such that the vegetation was representative of the area; however, some differences were detected during baseline analysis.

Vegetation within each land category at each site was characterized by taking cover and density measurements along the permanently marked 100 m long transects. Cover and density of diffuse knapweed and cover of the major grasses and forbs were taken at 5 m intervals along the transects. Repeat measures in time were taken at the same points along the permanent transects. Cover and density measurements were taken within the control and treatment exclosures at 1 m intervals along three transects constructed in each exclosure. Corners of the treatment exclosures were marked at the onset of the experiment to allow cattle to graze the area during the first grazing event then panels were assembled to exclude cattle grazing during the second grazing event. Transects and exclosures were established such that none intersected. Baseline data were taken along all transects before cattle were introduced into the experimental area. Cover and density measurements were taken again approximately 2 weeks following the first grazing event, 2 weeks after the second grazing event, and in September. Data concerning species present, their size, growth stage, and approximate composition of the community at the time data were collected along transects can be found in the appendix tables.

The heights and fresh weights of 20 diffuse knapweed plants were taken along each 100 m transects (approximately 1 to 2 m to the side of each transect) and from up to 10 plants from inside each exclosure. Seedheads were harvested from these plants and number per plant was determined. Currently, germination and tetrazolium analyses are in progress and these data will appended to this report when they become available during winter, 1997. Up to 10 plants in each exclosure and along each transect in each land category were marked with spray paint in September to determine the influence of grazing on the nature of diffuse knapweed to break off at the soil surface and tumble to disperse seed. These data will be collected in April, 1997.

Statistical analysis:

The Colorado State University Experiment Station Statistician was consulted before data analysis because of the change in the original experimental design. Data collected along each transect and within exclosures were averaged then subjected to Proc Mixed within the SAS Statistical Analysis program (SAS 6.11). Two separate analyses were conducted (each using Proc Mixed); the Kelsall and North Boulder sites were complete and the effect of land category was analyzed within these data sets as well as the effect of one or two grazing events; the Kelsall, North Boulder, and Superior sites were analyzed together in the second analysis and only bottom land was used from the Kelsall and North Boulder sites. Thus, both analyses had all grazing treatments present, but the first analysis (the all land types analysis) had all the land categorizations, or types, present while the second (the bottom land analysis) only had the bottom land included as it was the only land type that was common to all three sites. Simple effects and two and three way interactions were evaluated for each analysis.

Results

Baseline data (April, 1996):

Data were collected in April before cattle grazing began to serve as baseline information.

Diffuse knapweed cover: The all land types analysis revealed an effect due to land type and an effect due to grazing (Tables 1a and 1b) before grazing treatments were invoked. The least diffuse knapweed cover was found on hilltops. The effect due to grazing showed that transects constructed to measure the effects of two grazing events had about 8% less diffuse knapweed cover than the exclosures constructed to assess the effects of one grazing event or no grazing.

There were no differences for diffuse knapweed cover among sites, land types, or grazing events when the bottom land analysis was done. The average cover on bottom land at all sites was 22% (data not shown).

Diffuse knapweed density: A difference in diffuse knapweed density was found among the land types when the all land types analysis was conducted. Hilltops at the North Boulder and Kelsall ranches had about half the diffuse knapweed plants per unit area of land compared to bottom land at these two sites (Table 2).

There was no difference in diffuse knapweed density on bottom lands among the three sites and there were an average of 5.3 plants/0.1 m^2 (data not shown).

Perennial grass cover: When the all land types analysis was conducted, a site by land type interaction was revealed indicating that the amount of perennial grass present was dependent upon the site and the land type within that property. The most grass cover at the Kelsall site was found on hillsides whereas hillsides at the North Boulder site had the least grass cover (Table 3). The only difference between the two sites was on hillsides where the Kelsall property had about 38% more grass cover than on the North Boulder hillsides.

Grass cover on bottom lands varied among the sites. The Superior site had over twice as much grass cover than on bottom land at North Boulder and 21% more grass cover than on bottom land at Kelsall (Table 4).

Miscellaneous species cover: The all land types analysis detected a site by land type by grazing interaction for miscellaneous species. No differences in cover for these species were detected among grazing treatments at Kelsall on bottom land or hillsides but, about 24% more miscellaneous species cover was found in no grazing exclosures compared to the other grazing treatments (Table 5a). Also, there was less cover for these species on Kelsall hilltops along the once grazed or twice grazed treatments than on bottom land or hillsides. At North Boulder, there were no differences for cover of miscellaneous species on hillsides or hilltops but on bottom land, once grazed treatment exclosures had 22 and 31% less cover than the twice grazed or no grazed treatments (Table 5b).

The bottom lands analysis detected a difference in miscellaneous species cover among the sites and among grazing treatments. The Superior site had 28 and 35% less cover than Kelsall and North Boulder bottom lands, respectively (Table 6a). The no graze exclosure had 12% more miscellaneous species cover than the twice grazed treatments (Table 6b).

May, 1996; after one grazing event:

Diffuse knapweed cover: When the all land type analysis was conducted, a grazing effect was detected. No difference was found between no grazing and once grazed treatments but twice grazed treatments had about 11% less diffuse knapweed cover than no grazing and once grazed treatments (Table 7). However, this difference may be arbitrary because of the difference among grazing treatments found in the April baseline data; i.e., one would not expect any difference between once grazed and twice grazed treatments after only one grazing event.

The bottom land analysis also revealed an effect due to grazing; there was no difference between no grazed and once grazed treatments nor between once grazed and twice grazed treatments but the latter had 11% less diffuse knapweed cover than no grazed treatments (Table 8). This difference was not arbitrary and was due to grazing as no differences for diffuse knapweed cover were found in the April baseline data on bottom land.

Diffuse knapweed density: The all land types analysis showed no differences for diffuse knapweed density due to site, land type, or grazing treatment. The average density at the Kelsall and North Boulder sites in May after one grazing event was 4.6 plants/0.1 m^2 (data not shown).

Likewise, no difference in diffuse knapweed density was found when the bottom land analysis was done. The average for all sites was 5 plants/0.1 m^2.

Perennial grass cover: When the all land type analysis was done, no differences due to site, land type, or grazing treatment were detected. The average grass cover at the Kelsall and North Boulder sites was 39% (data not shown)

The bottom land analysis detected a grazing effect where 15% less perennial grass cover was found in the once grazed treatments than in the twice grazed treatments (Table 9). No grazed and twice grazed treatments did not differ.

Miscellaneous species cover: The all land types analysis in May did not detect any differences for miscellaneous species due to site, land type, or grazing treatment (data not shown). Miscellaneous species cover averaged 36% on all land types at Kelsall and North Boulder sites.

The bottom land analysis also detected no differences for miscellaneous species cover. Average miscellaneous species cover was 29% for the three sites (data not shown).

June, 1996; after two grazing events:

Diffuse knapweed cover: The all land types analysis detected site, grazing, and land type effects for diffuse knapweed cover after two grazing events. There was 14% more diffuse knapweed cover at Kelsall than North Boulder (Table 10a) and 11% more on bottom and hillsides than on hilltops at both sites (Table 10c). Twice grazed treatments had about 20% less diffuse knapweed cover than no grazed or once grazed treatments (Table 10b). This difference most likely was due primarily to grazing and not the differences among the grazing treatments detected during baseline analysis in April. Diffuse knapweed cover in no grazed and once grazed treatments at Kelsall and North Boulder increased 11% from April until data were taken in June while diffuse knapweed cover in twice grazed treatments increased just 2%.

When the bottom land analysis was conducted, a difference due to grazing was detected. Twice grazed treatments had about 18% less diffuse knapweed cover than no grazed and once grazed treatments (Table 11). This effect was strictly due to grazing and demonstrates the difference between the three grazing treatments on diffuse knapweed plants.

Diffuse knapweed density: The all land types analysis revealed an effect due to grazing after two grazing events. Twice grazed treatments had about half the diffuse knapweed density as no grazed or once grazed treatments (Table 12). It is likely that this effect was in response to cattle hoof action during the additional grazing event.

The bottom land analysis failed to find any differences for diffuse knapweed caused by grazing, ranch location, or land type. Average diffuse knapweed density on bottom land at Kelsall, North Boulder, and Superior was 7.4 plants/0.1 m^2 (data not shown).

Perennial grass cover: No differences were found for perennial grass cover at the Kelsall and North Boulder sites after two grazing events during the all land types analysis. Average grass cover at both sites was 34% (data not shown).

The bottom land analysis revealed a difference due to site after two grazing events. Superior boasted the most grass cover (44%) and had 20% more than the North Boulder site (Table 13). This effect follows the same pattern as that observed when baseline data

were taken in April.

Miscellaneous species cover: The all land types analysis did not find any differences due to grazing, site, or land type for miscellaneous cover after two grazing events. Average cover at Kelsall and North Boulder was about 30% and was comprised mostly of yellow alyssum, Japanese brome, field bindweed, rabbitbrush, yellow sweetclover, and two unknown forbs.

The bottom lands analysis detected a grazing treatment by site interaction after two grazing events. No differences for miscellaneous cover among grazing treatments were found at Kelsall or Superior but the once grazed treatments at North Boulder had about 28% more miscellaneous cover than no grazed or twice grazed treatments (Table 14). The presence of yellow sweetclover only in once grazed treatments could have caused this effect. Also, North Boulder had more miscellaneous cover in no grazed and once grazed treatments than Superior and more than Kelsall in once grazed treatments. Again, yellow sweetclover presence in once grazed treatments at North Boulder probably caused the difference among the three sites for this treatment whereas the generally poorer condition of North Boulder compared to Superior caused the difference in no grazed treatments between these two sites.

September, 1996:

Differences detected by the September data collection period most likely are season-long effects due to grazing.

Diffuse knapweed cover: The all land types analysis revealed a difference for diffuse knapweed cover in September due to grazing. Twice grazed treatments had about half the diffuse knapweed cover as no grazed or once grazed treatments (Table 15). The magnitude of the difference was due at least partially to the difference discovered when baseline data were taken, but a difference due to grazing explains the balance. For example, diffuse knapweed cover increased 2.7 and 2.4 times from April until data were taken in September for no grazed and once grazed treatments, respectively, but cover increased 2.1 times in twice grazed treatments.

A distinct difference due to grazing treatment was detected for diffuse knapweed cover in September when the bottom lands analysis was done. No grazed and once grazed treatments had about 21% more diffuse knapweed cover than twice grazed treatments (Table 16). This effect was due entirely to grazing as there were no differences for diffuse knapweed cover detected in the April bottom lands baseline data.

Diffuse knapweed density: A site by land type interaction was detected during the all land types analysis for diffuse knapweed density data collected in September. No difference was found at Kelsall among the land types but the bottom land at North Boulder had over four times the density of diffuse knapweed than hillsides and hilltops (Table 17). Also, North Boulder had almost twice the density of diffuse knapweed on bottom land than Kelsall. The April baseline data analysis detected a land type difference for both sites but not the interaction detected in the September data. The difference in density found in April among the land types most likely contributed significantly to the difference noted in September. The generally poorer condition of the North Boulder site most likely is the reason for the greater diffuse knapweed density at this site compared to Kelsall.

The bottom land analysis did not detect a difference for diffuse knapweed density due to grazing, site, or land type. The average density on bottom land for the three ranches was 7 plants/0.1 m^2 (data not shown).

Perennial grass cover: A site by land type interaction was found by the all land types analysis for perennial grass cover collected in September. No differences in perennial grass cover occurred at Kelsall among the land types but the North Boulder hilltop had about 16% more grass cover than the hillsides and bottom (Table 18). Also, the Kelsall hillsides had 12% more grass cover than North Boulder hillsides. There were differences for grass cover among land types at Kelsall in the April baseline data set and the lack of differences in the September data set may well imply that cattle grazed the land types equivalently (at least relative to grass cover). Ranking of grass cover among the different land types at North Boulder remained largely unchanged between the April and September data sets.

The bottom lands analysis found that perennial grass cover at Superior in September surpassed that at North Boulder by 14% (Table 19). This is the same general ranking as that found for the April baseline except by September, no difference between Kelsall and Superior was found.

Miscellaneous species cover: The all land types analysis found a difference between Kelsall and North Boulder for miscellaneous species cover in September. North Boulder had 20% greater cover than Kelsall (Table 20) and this difference was most likely due to the more degraded condition at North Boulder compared to Kelsall.

A difference among the three sites for miscellaneous species cover collected in September was found when the bottom lands analysis was conducted. Again, North Boulder had the most ground occupied by miscellaneous species and about 32% more was detected than at Kelsall and Superior (Table 21). As before, the degraded condition at North Boulder most likely was the primary reason for this difference among the sites.

Diffuse knapweed height: Differences due to land type, grazing treatment, and a site by land type interaction were found when the all land types analysis was conducted for diffuse knapweed height data collected in September (grazing and the site by type interactions will be discussed). Diffuse knapweed was tallest in no grazed treatments, was decreased by 9 cm when grazed once and by 15 cm when grazed twice (Table 22a). These data confirm the effect of grazing treatment on diffuse knapweed cover collected in September. Height of diffuse knapweed also varied on the Kelsall and North Boulder sites with land type. Diffuse knapweed on Kelsall hillsides was 6 cm taller than on bottom land whereas diffuse knapweed height on North Boulder bottom land and hillsides was about 25 cm taller than on hilltops (Table 22b). Also, diffuse knapweed was 23 cm taller on Kelsall hilltops than on hilltops at North Boulder. The huge difference found at North Boulder may reflect greater differences in available moisture between the land types at this site compared to Kelsall but this simply is speculation.

Diffuse knapweed height in September was influenced by grazing treatment when the bottom land analysis was done. Areas not grazed had diffuse knapweed 10 cm taller than those grazed once and 17 cm taller than those grazed twice (Table 23). Again, these data support the effect of grazing on diffuse knapweed cover found during this analysis for those data collected in September.

Diffuse knapweed weight: The only difference for diffuse knapweed weight found during the all land types analysis was a difference between sites. Diffuse knapweed was more robust at North Boulder, weighing 5.5 g more on the average than at Kelsall (Table 24). Again, this may reflect a more degraded condition at North Boulder.

The bottom land analysis detected a difference for diffuse knapweed weight among the three sites. Diffuse knapweed at North Boulder weighed over twice that harvested at Superior (Table 25). Greater grass cover at Superior may reflect that more robust grasses at this site competed with diffuse knapweed more effectively for limited resources compared to North Boulder.

Diffuse knapweed seedheads: When the all land types analysis was conducted, differences for the number of diffuse knapweed seedheads per shoot due to site and grazing were detected. Diffuse knapweed shoots in the no grazed treatments produced 100 more seedheads per shoot than those that were grazed twice (Table 26a). Diffuse knapweed also produced 107 more seedheads per shoot at North Boulder than at Kelsall. Again this may reflect the difference in general site conditions.

Likewise, the bottom land analysis revealed a difference for number of diffuse knapweed seedheads per shoot due to grazing treatment. Diffuse knapweed plants that were grazed twice produced 81 fewer seedheads per shoot than those that were not grazed (Table 27).

Grazing had obvious effects on the number of seedheads formed per shoot but, seed numbers, % viable seed, and % dormant seed may have been altered to the weed's advantage by compensating for the decreased number of seedheads formed or conversely, we may find that no compensation occurred and that two grazing events is influencing the population dynamics of this weed. These data still are being processed and will be attached to this annual report when they become available later this winter.

Conclusions

At this time, it is ill-advised to make conclusions based on one season's data for a research project of this nature. Many factors can influence results (most notably weather patterns) and conclusions based one season's data may lead to management errors. It is reasonably obvious that cattle readily grazed diffuse knapweed on the three ranches when they were exposed to the plant. It also is obvious that grazing influences knapweed growth and perhaps reproduction. However, data collection and analysis still are ongoing (i.e., seed production, viability, and germination) and possibly these data will reveal a pattern of effect that would compliment current results. Even then, weather patterns may influence the effect of grazing on diffuse knapweed reproduction. For example, we found many more seedhead gall fly larvae (*Urophora* spp.) in seedheads from plants that were grazed once or twice compared to those that were non-grazed. Intuitively, one would anticipate the opposite results that is grazing would negatively influence the number of seedheads predated by the flies. But, weather patterns in 1996 may have altered this effect and results in 1997 may produce exactly the opposite. If the observed effect remains as such in 1997 and 1998 data collection periods, it is possible that developing seedheads not grazed are slightly out of synchronization with the life cycle of the seedhead gall fly but grazed plants are not and this in itself may help explain why knapweed seedhead flies are no more effective than reported. Also, it may be that reduced number of seedheads from grazed plants produce larger, more viable seed because fewer seedheads are a stronger sink for nutrient accumulation and if this is the case, then this could be a compensating

mechanism for our observed effects of grazing on diffuse knapweed plants - i.e., individual plants may be affected by grazing but overall population dynamics may not be altered. A pattern may be detected when data are collected over three consecutive growing seasons.

Regardless of our observed effects due to grazing, one cannot discount the cumulative effects from resting ground from grazing. The effects of not grazing cannot be determined in one growing season and data collected from our no grazed control exclosures may not be indicative of what may be present in spring 1997 much less after two or three years rest. For example, we conducted two experiments in the late 1980's on Boulder Open Space land evaluating different herbicides to control hairy golden aster (*Heterotheca villosa*). We found where several herbicide treatments (most notably those with picloram) controlled about 95 to 100% of the hairy golden aster for the study's duration. We followed the study for three years and fenced it from grazing to prevent confounding our results due to this effect. After three years of no grazing, about 95% of the hairy golden aster was gone from the plots where no herbicide was applied and a dramatic increase in grass cover was observed, which we attributed to causing control.

It is tempting to make an inference relative to site condition about diffuse knapweed cover or density and grass cover or composition. Most striking is the difference between Superior and North Boulder for grass cover (e.g. 54 v 40%, respectively, in September). But, there were no differences for diffuse knapweed cover or density between these sites in 1996. There was however, more miscellaneous species cover at North Boulder than at Superior (e.g. 56 v 21%, respectively in April; 47 v 13% in September) and this coupled with the consistent difference in grass cover is indicative of the range condition differences between the two sites. Most the miscellaneous species were weedy. The differences in how these two properties were managed historically may be the reason for the apparent difference in condition.

It seems most prudent to avoid making strong conclusions at this time and continue the experiment in 1997 and 1998 so that data collected over time may be used to make management implications and change practices if warranted.

Table 1a. Diffuse knapweed cover[1] April, 1996, in different land types before grazing at the Kelsall and North Boulder sites.

Land type	% cover
Bottom	22 a
Hillside	19 a
Top	12 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 1b. Diffuse knapweed cover[1] April, 1996, in assigned grazing treatments but before grazing at the Kelsall and North Boulder sites.

Grazing treatment	% cover
None	21 a
Graze once	20 a
Graze twice	12 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 2. Diffuse knapweed density[1] April, 1996, in different land types before grazing at the Kelsall and North Boulder sites.

Land type	plants/0.1m^2
Bottom	5.0 a
Hillside	3.8 ab
Top	2.7 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 3. Grass cover[1] April, 1996, in different land types before grazing at the Kelsall and North Boulder sites.

	% cover	
Land type	Kelsall	North Boulder
Bottom	34 b A	24 ab A
Hillside	55 a A	17 b B
Top	36 b A	32 a A

[1]Use lower case letters to compare least squares means within a column and upper case letters to compare least squares means within a row. LS means followed by the same letter are not different (P=0.05).

Table 4. Grass cover[1] April, 1996, on bottom land at the Kelsall, North Boulder, and Superior sites before grazing.

Site	% cover
Kelsall	34 b
North Boulder	24 b
Superior	55 a

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 5a. Miscellaneous species cover[1]April, 1996, in different grazing treatments and land types before grazing at the Kelsall site.

	Land type		
Grazing treatment	Bottom	Hillside	Hilltop
	% cover		
No graze	49 a A	26 a A	39 a A
Graze once	53 a A	39 a A	13 b B
Graze twice	46 a A	25 a A	18 b B

[1]Use lower case letters to compare least squares means within a column and upper case letter to compare least squares means within a row. LS means followed by the same letter do not differ (P=0.05).

Table 5b. Miscellaneous species cover[1] April, 1996, in different grazing treatments and land types before grazing at the North Boulder site.

Grazing treatment	Land type		
	Bottom	Hillside	Hilltop
	% cover		
No graze	69 a A	56 a A	62 a A
Graze once	38 b B	40 a AB	66 a A
Graze twice	60 a A	55 a A	62 a A

[1]Use lower case letters to compare least squares means within a column and upper case letter to compare least squares means within a row. LS means followed by the same letter do not differ (P=0.05).

Table 6a. Miscellaneous species cover[1] April, 1996, on bottom land at the Kelsall, North Boulder, and Superior sites before grazing.

Site	% cover
Kelsall	49 a
North Boulder	56 a
Superior	21 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 6b. Miscellaneous species cover[1] April, 1996, on bottom land in the different grazing treatments but before grazing at all sites.

Grazing treatment	% cover
None	47 a
Graze once	35 b
Graze twice	44 ab

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 7. Diffuse knapweed cover[1] May, 1996, as influenced by grazing treatments after one grazing event at the Kelsall and North Boulder sites.

Grazing treatment	% cover
None	22 a
Graze once	19 a
Graze twice	10 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 8. Diffuse knapweed cover[1] May, 1996, on bottom land on all sites as influenced by grazing treatments after one grazing event.

Grazing treatment	% cover
None	27 a
Graze once	21 ab
Graze twice	16 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 9. Grass cover[1] May, 1996 on bottom land on all sites as influenced by grazing treatments after one grazing event.

Grazing treatment	% cover
None	42 ab
Graze once	32 b
Graze twice	47 a

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 10a. Diffuse knapweed cover[1] June, 1996, after two grazing events at the Kelsall and North Boulder sites.

Site	% cover
Kelsall	35 a
North Boulder	21 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 10b. Diffuse knapweed cover[1] June, 1996, as influenced by grazing treatment after two grazing events at Kelsall and North Boulder sites.

Grazing treatment	% cover
None	36 a
Graze once	33 a
Graze twice	14 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 10c. Diffuse knapweed cover[1] June, 1996, as influenced by land type after two grazing events at Kelsall and North Boulder sites.

Land type	% cover
Bottom	32 a
Hillside	31 a
Top	20 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 11. Diffuse knapweed cover[1] June, 1996, as influenced by grazing treatment after two grazing events on bottom land at all sites.

Grazing treatment	% cover
None	43 a
Graze once	38 a
Graze twice	22 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 12. Diffuse knapweed density[1] June, 1996, as influenced by grazing treatment after two grazing events at the Kelsall and North Boulder sites.

Grazing treatment	plants/0.1m^2
None	6.9 a
Graze once	6.1 a
Graze twice	3.3 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 13. Grass cover[1] June, 1996, after two grazing events at the Kelsall, North Boulder, and Superior sites.

Site	% cover
Kelsall	31 ab
North Boulder	24 b
Superior	44 a

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 14. Miscellaneous species cover[1] June, 1996, as influenced by grazing treatment after two grazing events on bottom land at the Kelsall, North Boulder, and Superior sites.

Grazing treatment	Kelsall	North Boulder	Superior
None	33 a AB	48 b A	15 a B
Graze once	22 a B	71 a A	20 a B
Graze twice	15 a A	39 b A	17 a A

[1]Use lower case letters to compare least squares means within a column and upper case letter to compare least squares means within a row. LS means followed by the same letter do not differ (P=0.05).

Table 15. Diffuse knapweed cover[1] September, 1996, as influenced by grazing treatments at the Kelsall and North Boulder sites.

Grazing treatment	% cover
None	56 a
Graze once	48 a
Graze twice	25 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 16. Diffuse knapweed cover[1] September, 1996, as influenced by grazing treatments on bottom land at all sites.

Grazing treatment	% cover
None	56 a
Graze once	53 a
Graze twice	34 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 17. Diffuse knapweed density[1] September, 1996, as influenced by land type at the Kelsall and North Boulder sites.

	plants/0.1 m^2	
Land type	Kelsall	North Boulder
Bottom	4.8 a B	9.5 a A
Hillside	7.1 a A	3.2 b A
Top	5.1 a A	1.5 b A

[1]Use lower case letters to compare least squares means within a column and upper case letters to compare least squares means within a row. LS means followed by the same letter are not different (P=0.05).

Table 18. Grass cover[1] September, 1996, as influenced by land type at the Kelsall and North Boulder sites.

	% cover	
Land type	Kelsall	North Boulder
Bottom	47 a A	40 b A
Hillside	49 a A	37 b B
Top	46 a A	54 a A

[1]Use lower case letters to compare least squares means within a column and upper case letters to compare least squares means within a row. LS means followed by the same letter are not different (P=0.05).

Table 19. Grass cover[1] September, 1996, on bottom land as influenced by site.

Site	% cover
Kelsall	47 ab
North Boulder	40 b
Superior	54 a

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 20. Miscellaneous species cover[1] September, 1996, as influenced by site.

Site	% cover
Kelsall	22 b
North Boulder	42 a

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 21. Miscellaneous species cover[1] September, 1996, on bottom land as influenced by site.

Site	% cover
Kelsall	18 b
North Boulder	47 a
Superior	13 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 22a. Diffuse knapweed height[1] September, 1996, as influenced by grazing at the Kelsall and North Boulder sites.

Grazing treatment	cm
None	44 a
Graze once	35 b
Graze twice	29 c

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 22b. Diffuse knapweed height[1] September, 1996, as influenced by land type and site.

	cm	
Land type	Kelsall	North Boulder
Bottom	35 b A	40 a A
Hillside	41 a A	44 a A
Top	40 ab A	17 b B

[1]Use lower case letters to compare least squares means within a column and upper case letters to compare least squares means within a row. LS means followed by the same letter are not different (P=0.05).

Table 23. Diffuse knapweed height[1] September, 1996, on bottom land as influenced by grazing at all sites.

Grazing treatment	cm
None	47 a
Graze once	37 b
Graze twice	30 c

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 24. Diffuse knapweed weight[1] September, 1996, as influenced by site.

Site	g/plant
Kelsall	12.3 b
North Boulder	17.8 a

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 25. Diffuse knapweed weight[1] September, 1996, on bottom land as influenced by site.

Site	g/plant
Kelsall	10.3 ab
North Boulder	17.9 a
Superior	8.5 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 26a. Diffuse knapweed seedheads[1] September, 1996, as influenced by grazing at the Kelsall and North Boulder sites.

Grazing treatment	#/shoot
None	252 a
Graze once	204 ab
Graze twice	152 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 26b. Diffuse knapweed seedheads[1] September, 1996, as influenced by site.

Site	#/shoot
Kelsall	149 b
North Boulder	256 a

[1]Least squares means followed by the same letter do not differ (P=0.05).

Table 27. Diffuse knapweed seedheads[1] September, 1996, on bottom land as influenced by grazing at all sites.

Grazing treatment	#/shoot
None	202 a
Graze once	158 ab
Graze twice	121 b

[1]Least squares means followed by the same letter do not differ (P=0.05).

APPENDIX

Species Key

Bayer code	Latin binomial	Common name
AGRSM	*Agropyron smithii*	western wheatgrass
BOUGR	*Bouteloua gracilis*	blue grama
KOECR	*Koeleria cristata*	prairie junegrass
POAPR	*Poa pratensis*	Kentucky bluegrass
CENDE	*Centaurea diffusa*	diffuse knapweed
ALYAL	*Alyssum alyssoides*	yellow alyssum
CONAR	*Convolvulus arvensis*	field bindweed
MELOF	*Melilotus officinalis*	yellow sweetclover
CHRsp	*Chrysothamnus* spp	rabbitbrush
BROTE	*Bromus tectorum*	downy brome
BROJA	*Bromus japonicus*	Japanese brome
UNKF1		unknown forb # 1
UNKF2		unknown forb # 2
UNKF3		unknown forb # 3
UNKF4		unknown forb # 4
UNKF5		unknown forb # 5

Boulder Open Space
Vegetation growth stage data
Kelsall Ranch
April 24, 1996
Baseline

CENDE - 1st year plants - 3/4 to 2 1/2" diameter rosettes
CENDE - 2nd year plants - 3 1/2 to 5" diameter rosette to early bolt

AGRSM - 3 leaf, 4 to 7" tall
BOUGR - 15% of plants 3 leaf, 1" tall, 85% dormant
POAPR - vegetative, 2 to 4" tall

ALYAL - bud to early flower, 2 to 3 1/2" tall
BROTE - post flower, 2 to 3" tall
UNKF3 - vegetative, 3 to 5" tall

Species Composition

Bayer Code	Common Name	Composition (%)
AGRSM	Western wheatgrass	35-60
BOUGR	Blue grama	40-60
KOECR	Prairie Junegrass	<5
POAPR	Kentucky bluegrass	5-15
ALYAL	Yellow alyssum	35-50
BROTE	Downy brome	10-25
CENDE	Diffuse knapweed	60-75
CONAR	Field bindweed	15-25
UNKF3	Unknown forb #3	20-30

Boulder Open Space
Vegetation growth stage data
Kelsall Ranch
May 15, 1996

Once and twice grazed areas

CENDE - 1st year plants - 1 ½ to 3" diameter rosettes
CENDE - 2nd year plants - 3 to 5" diameter rosette to early bolt, grazed to a 1 1/2-2" height

AGRSM - 3 to 4 leaf, 4 to 6" tall, grazed lightly
BOUGR - 60% of plants 3 leaf, 1/2 to 1 1/2" tall, very light grazing pressure, 40% of plants dormant
POAPR - vegetative, 1 1/2 to 2" tall, very heavy grazing pressure

ALYAL - post flower, 2 to 3" tall
BROTE - vegetative to early flower, 1 1/2 to 3" tall, light grazing pressure

Nongrazed area (Control Exclosures)

CENDE - 1st year plants - 1 to 3" diameter rosettes
CENDE - 2nd year plants - 4 to 8" diameter rosette to bolting, bolting plants 6 to 10" tall

AGRSM - 4 leaf, 5 to 10" tall
BOUGR - 40% of plants 3 leaf, 1 to 2" tall
60% of plants dormant
POAPR - late boot to early flower, 3 to 7" tall

ALYAL - 2 to 3 1/2" tall, post flower
BROTE - late boot to early flower, 2 to 3" tall
UNKF3 - vegetative, 4 to 6" tall

Comments:

Grazed area outside exclosures tends to have fewer first year CENDE plants. This and miscellaneous species loss is possibly due to trampling and utilization by cattle. Kelsall ranch appears to have moderate grass cover and range condition of the three ranches in the study.

Species composition of grass cover is as follows:

BOUGR 40-60%, AGRSM 35-60%, POAPR 5-15%, KOECR <5%

Boulder Open Space
Vegetation growth stage data
Kelsall Ranch
June 12, 1996
Bottom

Twice grazed area

CENDE - 1st year plants - 3 1/2-5" diameter rosettes
CENDE - 2nd year plants - grazed to 3-5" tall, 4-6" diameter, bolting
1-4 base branches originating from single grazed root

AGRSM - 70% of plants 4-6" tall, 30% of plants grazed to 2-4" height
BOUGR - 1 1/2-2 1/2" tall, nongrazed
POAPR - 90% vegetative, grazed to 1-3" height, 10% early flower 2-4" tall

ALYAL - post seed set, 1 1/2-2" tall
BROJA - flower, 4-5" tall
CHRsp - 6-10" tall
UNKF3 - 85% grazed to 2½-5" tall, 15% nongrazed to 5-6" tall
UNKF4 - 75% grazed to 2½-3" tall, 25% nongrazed to 5-6" tall, bud

Once grazed area (Treatment Exclosures)

CENDE - 1st year plants - 3-5" diameter rosettes
CENDE - 2nd year plants - 8-14" tall, 7-14" diameter, bolt to early bud
2-4 shoot base branches originating from single root (from grazing)

AGRSM - 4-7" tall vegetative
BOUGR - 1-2" tall, vegetative

ALYAL - post seed set, 1-2" tall
BROJA - flower, 4-5" tall
CONAR - vegetative, 3-5" shoots
UNKF3 - early bud, 5-10" tall

Nongrazed area (Control Exclosures)

CENDE - 1st year plants - 3 1/2-5 1/2" diameter rosettes
CENDE - 2nd year plants - bud, 12-24" tall, 4-12" diameter

AGRSM - 7-10" tall, vegetative
BOUGR - 1 1/2-2 1/2" tall, vegetative
POAPR - 4-12" tall, vegetative to early flower

ALYAL - 1½-2½" tall, post seed set
BROJA - flower, 4-8" tall
CHRSP - vegetative, 7-10" tall
UNKF3 - bud, 7-12" tall
UNKF4 - flower, 4-6" tall

Boulder Open Space
Vegetation growth stage data
Kelsall Ranch
June 12, 1996
Hillside

Twice grazed area

CENDE - 1st year plants - 3 1/2-7" diameter rosettes
CENDE - 2nd year plants - grazed to 7-13 1/2" height, 5 1/2-8" diameter, bolting
1-8 base branches originating from single grazed root

AGRSM - vegetative, 5-12½" tall
KOECR - anthesis, 6-14½" tall, 15% grazed
POAPR - 75% vegetative, grazed to 3 1/2-7" height, 25% early flower 3 ½-7" tall

ALYAL - post seed set, 1 1/2-4" tall
BROJA - flower, 3½-6" tall"
CHRsp - 3-6" tall
UNKF3 - 85% grazed to 2½-5" tall, 15% nongrazed to 5-6" tall

Once grazed area (Treatment Exclosures)

CENDE - 1st year plants - 3-6 1/2" diameter rosettes
CENDE - 2nd year plants - 7 1/2-15" tall, 5 1/2-10" diameter, bolt to ebud
1-5 shoot base branches originating from single root (from grazing)

AGRSM - 4 1/2-12" tall vegetative
KOECR - 4-8½" tall, vegetative to anthesis
POAPR - 3 ½-5½" tall, vegetative to early flower

ALYAL - post seed set, 1-3" tall
BROJA - flower, 3-8 1/2" tall
CHRsp - vegetative, 4-6" tall
UNKF3 - flower, 5-8" tall

Nongrazed area (Control Exclosures)

CENDE - 1st year plants - 3 1/2-4 1/2" diameter rosettes
CENDE - 2nd year plants - bud, 6-15 1/2" tall, 3 1/2-11" diameter

AGRSM - 5-11" tall, vegetative
KOECR - 5½-9" tall, anthesis
POAPR - 6-13" tall, vegetative to early flower

ALYAL - 1-3½" tall, post seed set
BROJA - flower, 3-4 1/2" tall

Boulder Open Space
Vegetation growth stage data
Kelsall Ranch
June 12, 1996
Hilltop

Twice grazed area

CENDE - 1st year plants - 2 1/2-5" diameter rosettes
CENDE - 2nd year plants - grazed to 3 1/2-11" height, 2 1/2-11" diameter, bolting
1-4 base branches originating from single grazed root

AGRSM - vegetative, 4 1/2-8" tall, 35% grazed
KOECR - vegetative to anthesis, 5-8" tall, 25% grazed
POAPR - 3-6" height, 85% grazed
BOUGR - 1-3½" tall, vegetative

ALYAL - post seed set, 1-3 1/2" tall
CHRsp - 4-8" tall, vegetative
UNKF3 - 4 ½-14" tall, vegetative to early flower

Once grazed area (Treatment Exclosures)

CENDE - 1st year plants - 1 1/2-7" diameter rosettes
CENDE - 2nd year plants - 7-14" tall, 4-12" diameter, bolt to ebud
1-6 shoot base branches originating from single root (from grazing)

AGRSM - 5-12" tall vegetative
KOECR - 4-14" tall, vegetative to anthesis
POAPR - 3½-8" tall, vegetative to early flower

ALYAL - post seed set, 1-4" tall
BROJA - flower, 3-6" tall
UNKF3 - vegetative to early flower, 5-10" tall

Nongrazed area (Control Exclosures)

CENDE - 1st year plants -3½-5½" diameter rosettes
CENDE - 2nd year plants - bolting to bud,7½-16" tall, 3-8 1/2" diameter
single shoot from root base

AGRSM - 5 1/2-8" tall, vegetative
KOECR - 7-13" tall, anthesis
POAPR - 4 ½-8" tall, vegetative to early flower

ALYAL - 2-4½" tall, post seed set
UNKF3 - 5-14" tall, vegetative to early flower

Boulder Open Space
Vegetation growth stage data
North Boulder Ranch
April 22, 1996
Baseline

CENDE - 1st year plants - 1 ½ to 3" diameter rosettes
CENDE - 2nd year plants - 3 1/2 to 5" diameter rosette to early bolt

AGRSM - 3 leaf, 4 to 6" tall
BOUGR - 30% of plants 3 leaf, 1" tall, 70% dormant
POAPR - vegetative, 2½ to 3" tall

ALYAL - bud to early flower, 2 to 4" tall
MELOF - vegetative, 1½ to 2" tall
UNKF1 - early bud, 3 to 5½" tall

Species Composition

Bayer Code	Common Name	Composition (%)
Bottom		
AGRSM	Western wheatgrass	60-90
BOUGR	Blue grama	10-40
POAPR	Kentucky bluegrass	30-50
Hillside and Hilltop		
AGRSM	Western wheatgrass	10-30
BOUGR	Blue grama	60-80
POAPR	Kentucky bluegrass	20-30
Bottom, Hillside, and Hilltop		
ALYAL	Yellow alyssum	20-40
BROTE	Downy brome	5-15
CONAR	Field bindweed	60-80
MELOF	Yellow sweetclover	10-30
UNKF1	Unknown forb #1	30-60

Boulder Open Space
Vegetation growth stage data
North Boulder Ranch
May 15, 1996

Once and twice grazed areas

CENDE - 1st year plants - 1 ½ to 3" diameter rosettes
CENDE - 2nd year plants - 4 to 7" diameter rosette to early bolt, grazed to a 1-3" height

AGRSM - 3 leaf, 2 to 4" tall, moderately grazed
BOUGR - 40% of plants 3 leaf, 1 to 2" tall, very little grazing pressure
- 60% of plants dormant
POAPR - vegetative, 1/2 to 2" tall, very heavy grazing pressure

ALYAL - post flower, 2 to 4" tall
BROTE - vegetative to early flower, 1 to 2" tall, some grazing pressure
CONAR - vegetative, 1 to 2" long liters, heavy grazing pressure
MELOF - vegetative, 1 to 2" tall, heavy grazing pressure
UNKF1 - 2 to 4" diameter rosette, moderate grazing pressure

Nongrazed area (Control Exclosures)

CENDE - 1st year plants - 1 to 3" diameter rosettes
CENDE - 2nd year plants - 5 to 8" diameter rosette to bolting, bolting plants 4 to 10" tall

AGRSM - 3 to 4 leaf, 6 to 8" tall
BOUGR - 40% of plants 3 leaf, 1 to 2" tall
60% of plants dormant
POAPR - vegetative to early flower, 4 to 6½" tall

ALYAL - 3 to 5" tall, post flower
BROTE - late boot to early flower, 2 to 4" tall
CONAR - vegetative, 2 to 6" shoots
MELOF - vegetative, 6 to 10" tall
UNKF1 - vegetative, 3 to 5" diameter rosette

Comments:

Grazed area outside exclosures tends to have fewer first year CENDE plants. This and miscellaneous species loss is possibly due to trampling and utilization by cattle. North Boulder ranch appears to have the lowest grass cover and range condition (especially on bottom) of the three ranches in the study. Fair condition on top of mesa.

Species composition from grass cover is as follows:

Bottom: AGRSM 60-90%, BOUGR 10-40%, POAPR 30-50%
Hillside and hilltop: AGRSM 10-30%, BOUGR 60-80%, POAPR 20-30%

Miscellaneous species composition:

Top and bottom: ALYAL 20-40%, BROTE 5-15%, CONAR 60-80%, MELOF 10-30%, UNKF1 30-60%

Boulder Open Space
Vegetation growth stage data
North Boulder Ranch
June 12, 1996
Bottom

Twice grazed area

CENDE - 1st year plants - 1-3" diameter rosettes
CENDE - 2nd year plants - grazed to 5-7" height, 3-7" diameter, bolting
1-4 base branches originating from single grazed root

AGRSM - 4-12" tall, vegetative
POAPR - grazed to 4-6" height, vegetative
STICO - grazed to 6-7" tall, vegetative

BROJA - 6-11" tall, flower
CONAR - 5-8" shoots, early flower to flower
UNKF4 - grazed to 9-13" height, vegetative
UNKF5 - 2-4" tall, early flower to flower

Once grazed area (Treatment Exclosures)

CENDE - 1st year plants - 2-6" diameter rosettes
CENDE - 2nd year plants - 8-12" tall, bolt to early bud, 3-6" diameter
1-4 shoot base branches originating from single root (from grazing)

AGRSM - 4-6" tall, vegetative
POAPR - 4-6" tall, vegetative

CONAR - 6-14" shoots, vegetative to early flower
MELOF - 8-10" tall, vegetative to early flower
UNKF3 - vegetative to early bud, 8-10" tall
UNKF4 - 3-6" tall, flower

Nongrazed area (Control Exclosures)

CENDE - 1st year plants - 1-4" diameter rosettes
CENDE - 2nd year plants - bud, 12-20" tall, 3-6" diameter
single shoot from root base

AGRSM - 4-6" tall, vegetative
CONAR - 6-14" shoots, vegetative to early flower
POAPR - 4-6" tall, vegetative
UNKF4 - 8-10" tall, vegetative to early bud
UNKF5 - 3-6" tall, flower

Boulder Open Space
Vegetation growth stage data
North Boulder Ranch
June 12, 1996
Hillside

Twice grazed area

CENDE - 1st year plants - 2-4" diameter rosettes
CENDE - 2nd year plants - grazed to 5-8" height, 7-9" diameter, bolting
1-4 base branches originating from single grazed root

AGRSM - 6-8" tall, vegetative
BOUGR - 1-2" tall, vegetative
POAPR - 4-8" tall, vegetative
STICO - 6-8" tall, vegetative

UNKF4 - grazed to 2-4" height, vegetative

Once grazed area (Treatment Exclosures)

CENDE - 1st year plants - 4-6" diameter rosettes
CENDE - 2nd year plants - 8-16" tall, bolt to late bolt
1-4 shoot base branches originating from single root (from grazing)

BOUGR - 2-3" tall, vegetative
KOECR - 3-5" tall, vegetative to early flower
POAPR - 4-6" tall, vegetative
STICO - 6-8" tall, vegetative to boot

UNKF3 - vegetative to bud, 8-14" tall
UNKF4 - 1-3" tall, bolt

Nongrazed area (Control Exclosures)

CENDE - 1st year plants - 4-6" diameter rosettes
CENDE - 2nd year plants - bud, 18-21" tall
single shoot from root base

AGRSM - 8-12" tall, vegetative
POAPR - 7-14" tall, late boot to early flower

UNKF5 - 3-5" tall, vegetative

Boulder Open Space
Vegetation growth stage data
North Boulder Ranch
June 12, 1996
Hilltop

Twice grazed area

CENDE - 1st year plants - 4-6" diameter rosettes
CENDE - 2nd year plants - grazed to 2-3" height, 4-6" diameter, bolting
1-4 base branches originating from single grazed root

BOUGR - 1 1/2-3" tall, vegetative
KOECR - grazed to 3-4" tall, vegetative
STICO - grazed to 3-6" height, vegetative

UNKF3 - grazed to 6-12" height, vegetative
UNKF4 - grazed to 1-3" height, vegetative
UNKF5 - grazed to 1-4" height, vegetative

Once grazed area (Treatment Exclosures)

CENDE - 1st year plants - 4-6" diameter rosettes
CENDE - 2nd year plants - 8-13" tall, bolt to early bud
1-4 shoot base branches originating from single root (from grazing)

KOECR - 3-5" tall, vegetative to early flower
STICO - 6-8" tall, vegetative to early boot

UNKF3 - vegetative to bud, 8-14" tall
UNKF4 - 1-3" tall, bolt

Nongrazed area (Control Exclosures)

CENDE - 1st year plants - 4-8" diameter rosettes
CENDE - 2nd year plants - bud, 14-18" tall
single shoot from root base

STICO - 6-12" tall, vegetative to late boot

UNKF3 - 7-14" tall, vegetative to early flower
UNKF5 - 3-7" tall, bolt

Boulder Open Space
Vegetation growth stage data
Superior Ranch
April 24, 1996
Baseline

CENDE - 1st year plants - 3/4 to 2 1/2" diameter rosettes
CENDE - 2nd year plants - 3 1/2 to 5" diameter rosette to early bolt

AGRSM - 3 leaf, 4 to 7" tall
BOUGR - 15% of plants 3 leaf, 1" tall, 85% dormant
POAPR - vegetative, 2 to 4" tall

ALYAL - bud to early flower, 2 to 3 1/2" tall
BROTE - post flower, 2 to 3" tall
UNKF3 - vegetative, 3 to 5" tall

Species Composition

Bayer Code	Common Name	Composition (%)
AGRSM	Western wheatgrass	20-50
BOUGR	Blue grama	50-75
KOECR	Prairie junegrass	5-15
POAPR	Kentucky bluegrass	10-30
ALYAL	Yellow alyssum	25-55
BROTE	Downy brome	5-20
CENDE	Diffuse knapweed	40-75
CONAR	Field bindweed	10-30
UNKF3	Unknown forb #3	15-35

Boulder Open Space
Vegetation growth stage data
Superior Ranch
May 15, 1996

Once and twice grazed areas

CENDE - 1st year plants - 1 ½ to 3" diameter rosettes
CENDE - 2nd year plants - 4 to 7" diameter rosette to early bolt, grazed to a 1-3" height

AGRSM - 3 leaf, 4 to 7" tall, very little grazed
BOUGR - 40% of plants 3 leaf, 1 to 2" tall, very little grazing pressure
- 60% of plants dormant
KOECR - vegetative, 1 to 3" tall
POAPR - vegetative to early flower, 1 to 4" tall, 30% of plants grazed

BROTE - vegetative to late boot, 1 to 3" tall, some grazing (0 to 15% of plants
UNKF3 - vegetative, 4 to 6" tall

Nongrazed area (Control Exclosures)

CENDE - 1st year plants - 1 to 3" diameter rosettes
CENDE - 2nd year plants - 4 to 7" diameter rosette to bolting, bolting plants 4 to 7" tall

AGRSM - 3 to 4 leaf, 4 to 8" tall
BOUGR - 40% of plants 3 leaf, 1 to 2" tall
60% of plants dormant
KOECR - late boot, 4 to 6" tall

ALYAL - ¾ to 2" tall, vegetative to late boot
BROTE - vegetative to late boot, 2 to 3" tall
HETVI - vegetative, 3 to 6" tall
UNKF1 - vegetative, 3 to 4" tall
UNKF2 - vegetative, 1 ½ to 4" diameter rosette

Comments:

Grazed area outside exclosures tends to have fewer first year CENDE plants. This and miscellaneous species loss is possibly due to trampling and utilization by cattle. Superior ranch appears to have the highest grass cover and best range condition of the three ranches in the study.

Species composition of grass cover is as follows: BOUGR 50-75%, AGRSM 20-50%, POAPR 10-30%, KOECR 10%. Alyssum is the dominate miscellaneous species.

Boulder Open Space
Vegetation growth stage data
Superior Ranch
June 13, 1996

Twice grazed area

CENDE - 1st year plants - 3-4 1/2" diameter rosettes
CENDE - 2nd year plants - grazed to 3-6" tall, 4½ to 6" diameter, bolting

AGRSM - 85% of plants 4-9" tall with little grazing pressure, 15% of plants grazed to 3-4" height
BOUGR - 3 leaf, 1-2" tall, no grazing pressure
KOECR - vegetative, grazed to 1-3" height
POAPR - vegetative, grazed to 1-3" height
STISP - 35% of plants vegetative, 7-19" tall, 65% of plants late boot grazed to 3-5" height
ALYAL - post seed set, 2-3" tall
BROJA - flower, 4-7" tall
CONAR - vegetative, 2-5" shoots
UNKF3 - vegetative, 3-6" tall

Once grazed area (Treatment Exclosures)

CENDE - 1st year plants - 2 1/2-4" diameter rosettes
CENDE - 2nd year plants - grazed to 7-13" tall, 6-9" diameter, bolt to ebud 1-4 shoot base branches originating from single root (from grazing)

AGRSM - 4-9" tall vegetative
BOUGR - 1-2" tall, vegetative
KOECR - 3-7" tall, vegetative to anthesis
POAPR - 2-5" tall, vegetative to early flower

BROJA - flower, 3-4" tall
CONAR - vegetative, 3-5" shoots
UNKF3 - vegetative, 3-6" tall

Nongrazed area (Control Exclosures)

CENDE - 1st year plants - 2-5" diameter rosettes
CENDE - 2nd year plants - bud, 15-24" tall, 6-12"" diameter

AGRSM - 6-9" tall, vegetative
BOUGR - 1-3" tall, vegetative
KOECR - 3-8" tall, vegetative to anthesis
POAPR - 3-7" tall, vegetative to early
STISP - 7-19" tall, vegetative to late boot

BROJA - flower, 3-6" tall
CONAR - vegetative, 3-5" shoots
UNKF3 - vegetative, 8-12" tall

Figure 1. At each site and land type, a replication consisted of one control exclosure, one treatment exclosure, and two 100 m transects.