Peace Region Forage Seed Association Wildlife Damage Study
Final Report – May 2012

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Background

There are over 200 "fine seed" producers in British Columbia utilizing more than 36,000 ha for grass seed production. Elk numbers in the B.C. Peace region appear to be on the increase as more animals are being seen grazing grass seed fields. These elk are using the grass seed fields in the region as winter and spring pasture. Grazing intensities vary from a few affected plants in a field to large areas of the field having severe grazing damage. The effects of the dormant season grazing of these seed fields are unknown.

A literature review was carried out to assess the research that has been done on the effects of grazing forage seed crops (Appendix 1). There was no published research showing potential yield losses when creeping red fescue is grazed by elk during the dormancy of the grass or in the spring when the grass breaks dormancy and begins spring growth. There have been some trials involving the use of sheep or cattle grazing grasses used for seed production.

Literature suggests (Appendix 1) that the seed yield potential in cool-season perennial grasses is based on the plant development processes that takes place before floral induction (autumn regrowth period). Factors such as plant age, species, fertility, plant development and growing conditions as well as the clipping or grazing of the plant tillers affect the induction process. As much as 92% of the potential seed yield is set before the onset of conditions favoring vernalization (Chastain & Young III, 1998).

The next stage of development is floral initiation which is the transformation of the vegetative growing point to the floral state. Only then can heading and seed development occur (Elliott, 1978). In creeping red fescue this stage occurs shortly after the spring thaw which is earlier than most other grasses (Yoder, 2000). Floral initiation begins with the development of a seedhead at the base of the tiller. As the stem develops and elongates the seedhead emerges and then anthesis (flowering) can occur.

Grazing during the fall, winter or spring may be detrimental to forage seed yields since the sward is reduced and the tillers are clipped which can affect tiller elongation and floral initiation in the spring. Grazing severity of the field and grazing intensities of the plants may determine the severity of seed yield loss.

Pringle et al conducted a trial at Beaverlodge using cattle to graze creeping red fescue to determine the influence of grazing on subsequent plant development and seed yield (Pringle,

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Elliott, & Dobb, 1969). Yearling steers were used to graze a rejuvenated field of creeping red fescue. They found that under fall grazing of moderate intensity, seed yields were reduced by 8%, under fall grazing of heavy intensity seed yields were reduced by 16% and when grazed in the spring and fall, seed yields were reduced by 35%. The high reduction in seed yields from spring grazing was attributed to the removal of plant floral parts by the steers. The reduction in yield from fall grazing was attributed to the removal of fall growth which limited the root reserves and leaf area of the creeping red fescue when flowering was induced.

Nigel Fairey at Beaverlodge studied the effects of post-harvest management on creeping red fescue seed yield (Fairey N., 2006). Three methods of post-harvest management in late September to early October were used: flail mowing, disc mowing and short-duration, intensive grazing by sheep in the fall. Based on one year of assessment Fairey found little difference in the mechanical harvest treatments but found nearly a 50% reduction in seed yield when grazed by sheep. The sheep grazed almost all of the new growth green vegetation but not the stubble from the previously harvested crop. It was felt that the close grazing and the treading by the sheep's hooves removed or damaged the growing points in the crowns of the creeping red fescue. Less intensive grazing may have less of an effect on seed yields.

In 2004 in the Spirit River area of the Peace region of Alberta, Gary Ropchan and Melissa Fuchs with the Central Peace Conservation Society (CPCS) conducted a grazing trial on a creeping red fescue field for seed production. The treatments consisted of no grazing or mowing, fall mowing and early winter grazing by cows. The seed harvest indicated no seed yield difference between the check and the mowed strips but there was a significant seed yield loss of 3.5% on the grazed strips. (Yoder C., 2010)

Research in Great Britain, under different growing conditions than the Peace Region, showed yield losses when grazed at specific times of the year (Green & Evans, 1956). Green et al grazed cattle during the seedling year and had seed yield losses of 24% in cocksfoot (orchardgrass), 18% in red fescue and 7% in tall fescue but in subsequent years found only minor losses in cocksfoot. Red fescue had consistent losses when grazed in the fall and the winter. When grazed in December, February and March, red fescue had seed losses of 26% and when grazed again in April the losses soared to 80% in the first year and were 52% over the three years of the trial. Early flowering species such as red fescue suffered the most when subjected to an April grazing as the authors found a reduced number of fertile tillers following the late grazing. Winter grazing in areas where cool-season grasses can maintain some growth would be much different than in areas where complete dormancy occurs.

In Oregon, annual ryegrass was grazed by sheep to determine seed yield response to spring grazing during early stem elongation (Young III, Chilcote, & Youngberg, 1996). Young et al in Oregon determined that there was no seed yield loss in annual ryegrass when grazed in the fall at varying intensities.

Kentucky bluegrass for seed production in Washington was clipped to simulate grazing in the fall and in the spring (Evans, 1975). Evans found that Kentucky bluegrass seed yields increased slightly or remained the same when clipped to simulate grazing throughout the fall, winter and spring.

Clark et al studied the effects of winter grazing by geese and sheep on yields of annual and perennial ryegrass seed production in the Willamette Valley, Oregon (Clark & Jarvis, 1978). Clark et al concluded that geese grazing annual and perennial ryegrass had no effect on yields but when grazed with sheep, there were occasional yield losses.

The majority of the literature published on the effects of grazing on seed yields is from the north western United States, Great Britain and the Peace region of Alberta. None of the trials involved the use of elk in their grazing trials although there were some involving sheep and cattle. Elk graze similar to sheep and are able to clip the plant closer to the ground which can cause more damage to the plant (Aasen, 2009).

British Columbia is developing a program to compensate producers for losses to grain crops caused by wildlife. Research is needed to determine losses in forage seed crops to provide similar options to compensate fine seed producers for their losses. The first steps needed to provide an effective wildlife compensation program for fine seed producers in BC is to quantify the severity of the loss and the development of assessment methodologies that effectively and efficiently assess wildlife losses. Our objective for this study is to determine the impact on forage seed yields when wildlife graze creeping red fescue seed fields in the winter and spring.

Materials and Methods

This was a two year study which was started in the fall of 2009 in the Ft. St. John and Dawson Creek regions of British Columbia. Four potential creeping red fescue fields were identified as potential winter and spring elk grazing sites. The fields selected would be producing the first seed crop harvested after the rejuvenation of the seed field. In the fall, prior to the elk grazing, four sets of corral panels were placed in the fields at each site to form four 10’ x 10’ grazing exclosures. The four exclosures were set up randomly in the field to be used as the ungrazed check. At all four fields a square meter sample of the creeping red fescue was clipped near each exclosure to determine the amount of topgrowth available for grazing to the wildlife.

Unfortunately it is impossible to predict exactly which fields or which areas of the fields will be grazed by the elk when selecting creeping red fescue fields. In the spring of 2010, two fields were abandoned because there had been no elk grazing in the fields. Two other creeping red fescue sites were identified as replacement fields for the study. The Osterwalder site was a second year seed field which had been grazed. The other site was situated in the Loewen field where further elk grazing occurred. In each of the fields four corresponding plots which had wildlife grazing damage were paired with the ungrazed treatments in the exclosures and the plots were recorded by GPS and marked by staking. Grazing intensity levels were also noted at this time. One of the trials in the Osterwalder (north) field had elk damage not from grazing but from hoof damage from trampling and bedding spots.

In mid-July when the creeping red fescue had ripened the plots were either harvested using a rice binder or cut by hand. Harvest area was 3m^2 for the plots at the Osterwalder field and 9 m^2 at the Gies and Loewen fields. These samples were bagged and sent to the Agriculture and Agri-Food Canada station at Beaverlodge to be dried and threshed to determine seed yields. Percent dockage (percent clean seed) and seed germinations were conducted on the seed samples.

In the fall of 2010 four fields in the Dawson Creek and Ft. St. John areas were identified as having the potential to be winter/spring grazed by elk and the corral panel exclosures were placed in these fields. In the spring of 2011 these fields were found to have no elk damage from grazing. It was felt that the deep snow in the winter had prevented the wildlife from grazing the fields. There were no fields in these areas having any substantial grazing damage. A suitable field which had been grazed by 300 elk all winter was selected at Sexsmith, Alberta. Three trials were set up in this field using paired plots of grazed and ungrazed areas. One trial was made up of larger plots to increase harvest volume to reduce the error from environmental influences on the yields, with harvest areas varying from 3.6 – 7.5 m^2. The other 2 trials in this field had plots 2.5 m^2 in size. Grazing intensity levels were noted at this time. One of the smaller trials had elk damage not from grazing but from bedding spots. The plots were recorded by GPS and marked by either mowing or staking.

In late July when the creeping red fescue had ripened the plots were harvested using a rice binder. These samples were bagged and sent to the Agriculture and Agri-Food Canada station at Beaverlodge to be dried and threshed to determine seed yields. Percent dockage (percent clean seed), 1000 kernel seed weights and seed germinations were conducted on the seed samples to determine if the grazing affected seed quality.

In 2010 and 2011, bedding sites and trampled areas were also identified and sampled to determine these effects on seed yields and seed quality. Trampling and bedding sites were identified as another source of wildlife damage that might affect fescue seed production in the Peace Region.

The data was analyzed using a t-test: paired two sample for means in Excel 2007 to determine the significance. The paired t-test was conducted to compare the effects of grazing and no grazing by wildlife. Seed yield, percent dockage, 1000 kernel seed weight and percent germination were used to measure the effects.

Results and Discussion

In the fall of 2010 and 2011 the top growth of the seed field was clipped to determine the amount of forage available for wildlife to graze. The creeping red fescue fields produced an average of 1391 kg/ha of topgrowth which is capable of sustaining on average 174 elk grazing days/hectare (table 1.) in 2010. In 2011 the production was 998 kg/ha which could sustain 125 elk grazing days/hectare. The clippings show that there is sufficient growth in the fall to maintain a significant herd of elk on the fescue fields.

Seed Yields

Predicting potential fields in the fall which the wildlife will use for winter and spring grazing is very difficult. In our trials we identified potential fields in the fall and in 2010 we had to abandon two sites and identify replacement sites in the spring. The sites on Dan Peters creeping red fescue fields had no wildlife damage and were abandoned for a site on Bruno Osterwalder's fescue field. A site at Rick Gies' and two sites at Reuben Loewen's were harvested. The grazing intensity was rated as medium at these sites.

The four sites identified in the fall of 2010 were all abandoned when there was no wildlife damage to the creeping red fescue plants subsequent to the inspection of the fields in the spring of 2011. The exceptional heavy snowfall during the winter of 2010 – 2011 was thought to be too deep for the wildlife to graze in the selected fields. A field on Franklin Moller's farm at Sexsmith, Alberta was selected for our sites since it had had approximately 300 elk grazing on 300 acres of creeping red fescue fields for most of the winter. Three sites were selected in the fields where grazed and ungrazed plots were identified and marked. The grazing intensity on the plots was rated as medium.

In 2010 the ungrazed plots had a higher seed yield than the grazed plots (table 2). The yields of the ungrazed plots were numerically higher but not significantly different than the grazed plots. The ungrazed plots had seed yields up to 111 kg/ha higher than the grazed plots and as low as 89 kg/ha less that the grazed plots. The mean difference was 30 kg/ha higher yields for the ungrazed plots than the grazed plots.

In 2011 the differences between the ungrazed plots and the grazed plots (table 3) were much different. The grazed plots had higher seed yields than the ungrazed plots numerically but again the differences were not statistically significant. The numerical mean in the difference between the treatments was 54 kg/ha more yield in the grazed sites than the ungrazed. The ST site had a 109 kg/ha seed increase in the grazed plots whereas the CA site had only a 12 kg/ha increase in seed yields in the grazed plots.

The seed yields from the grazed and the ungrazed plots at all sites in 2010 and 2011 were shown to have differences but we were unable to show any differences that were significant.

Dockage

Dockage is the amount of empty hulls, chaff and foreign material in the seed sample after threshing and is expressed as a percent. High dockage levels may indicate a high level of unfilled hulls which would affect clean seed yields.

In 2010 (table 4) the samples from the grazed plots had a higher dockage (29.9%) although the difference (4%) was not sufficient to be significant. In 2011 (table 5), there was no difference in the dockages (27.7% and 27.8%) between the grazed or the ungrazed seed plots.

Germination

All samples were tested for germination to determine the percent of viable seeds that were produced. In both years (table 4 and 5) the grazed plots had a slight increase in germination but the differences were not significant. Neither treatment could be attributed to any difference in germination.

1000 kernel weight

Thousand kernel weights were only measured in 2011. The mean difference in 1000 kernel weights was only 0.1 gram higher in the grazed site. This difference was not significant which indicates that our measurements could not identify any treatment difference in seed weights.

Bedding and trampling

In 2010 a bedding site with numerous elk beds and elk trampling was identified and sampled in the Osterwalder field. In 2011 a site was selected in the Franklin field at Sexsmith with the same type of damages. Clean seed yield, % dockage, % germination and 1000 kernel weights were measured (table 6). There was no significant difference between these bedding sites and paired sites which had no elk damage.

Conclusion

The wildlife damage study conducted in 2010 and 2011 in the Peace Region of British Columbia and Alberta was not able to show any statistical differences in seed yields between an ungrazed creeping red fescue field and an elk grazed field. The data collected was not able to allow us to conclude that winter or spring wildlife grazing did or did not adversely affect the seed yields, dockage, germination or seed weights of a creeping red fescue field. The variability between treatments from site to site and year to year was too large to enable us to show any statistical differences. It is also possible that the fields were not grazed intense enough to seriously affect stem elongation or floral initiation which would adversely affect the seed yields or seed quality.

Wildlife movement is very hard to predict and field selection for this trial was very difficult to predict in the fall prior to any grazing. The sites selected and field plots selected were dictated to us by the grazing patterns of the elk. Wildlife grazing patterns in the fescue fields during the winter and spring is spotty and uneven. A higher grazing intensity on the seed crop may have given us more consistent differences.

The creeping red fescue fields where the grazing occurred were all rejuvenated fields which had been plowed for rejuvenation. These fields generally have variability in plant cover which increases the risk of sampling errors.

When we review previous trials from published literature we find that results are variable as well. The research which was the most controlled was a trial carried out by Nigel Fairey at Beaverlodge (Fairey N., 2006) who found nearly a 50% reduction in seed yield when grazed by sheep in his research plots. This trial was only carried out for one year. The ideal situation to test for wildlife damage would be to duplicate Dr. Fairey's research using either elk or sheep grazing seeded plots of creeping red fescue for mulitple years.

The published literature suggests that many factors affect the seed production process such as plant age, species, fertility, plant development and growing conditions as well as the clipping or grazing of the plant tillers (Yoder, 2000). We were unable to determine if the timing of grazing, intensity of grazing or the type of damage (grazing, hoof action or bedding) by the elk had an effect on creeping red fescue seed yields. There may be an interaction between these factors which was not evident in our trial results.

It is the opinion of the participants of the study that the variability of the grazing and the variability in the fields was too high to enable us to conclude that wildlife grazing did or did not adversely affect the seed yields, dockage, germination or seed weights of a creeping red fescue field in the Peace Region of British Columbia and Alberta.

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Table 1. Top growth and grazing potential of creeping red fescue seed fields

	Top growth		Elk grazing days*	
2010 Sites	**kg/ha**	**lb/ac**	**per hectare**	**per acre**
Dan Peters (site 1)	1291	1150	161	68
Dan Peters (site 2)	1319	1174	165	69
Reuben Loewen	1564	1393	196	82
Mean	1391	1239	174	73
2011 Sites				
Rick Gies	1074	957	134	56
Dave Wuthrich	818	728	102	43
Reuben Loewen	1334	1188	167	70
Gordon Hill	767	683	96	40
Mean	998	889	125	52

*assuming a cow elk consumes 8 kg (17lbs) per day
Source: Alberta Forage Manual – Aasen & Bjorge; 2010

Table 2. 2010 Clean Seed Yield

	Yield in kg/ha*			Yield in lbs/acre*		
	Ungrazed	Grazed	Diff	Ungrazed	Grazed	Diff
RG	481	388	93	428	345	83
BOS	520	609	-89	463	542	-79
RL1	841	838	3	749	746	3
RL2	841	730	111	749	650	99
mean	671	641	30	597	571	27

RG - Rick Gies
BON - Bruno Osterwalder (south)
RL1 - Reuben Loewen (site 1)
RL2 - Reuben Loewen (site 2)

* not significant at $p \leq 0.05$

Table 3. 2011 Clean Seed Yield

	Yield in kg/ha*			Yield in lbs/acre*		
Site	Ungrazed	Grazed	Diff	Ungrazed	Grazed	Diff
CA	802	814	-12	714	725	-11
ST	665	775	-109	592	690	-97
JS	726	765	-40	646	681	-36
Mean	731	785	-54	651	699	-48

***** not significant at p ≤ 0.05

Table 4. 2010 Percent dockage and germination

	Percent Dockage[1]*			Percent germination*		
	Ungrazed	Grazed	Diff	Ungrazed	Grazed	Diff
RG	27.1	31.1	-4	95.8	97.3	-1.5
BOS	35.4	35.3	0.1	98.8	97.5	1.3
RL1	20.7	27.1	-6.4	98.5	99.5	-1
RL2	20.7	26.2	-5.5	98.5	99.1	-0.6
mean	26.0	29.9	-4.0	97.9	98.4	-0.4

RG - Rick Gies
BOS - Bruno Osterwalder (south)
RL1 - Reuben Loewen (site 1)
RL2 - Reuben Loewen (site 2)

1. percent dockage is the amount of empty hulls, chaff & foreign material in the seed sample
***** not significant at p ≤ 0.05

Table 5. 2011 Percent dockage, percent germination and 1000 kernel weight

	Percent Dockage[1]*			Percent germination*			1000 kernel weight (gms)*		
Site	Ungrazed	Grazed	Diff	Ungrazed	Grazed	Diff	Ungrazed	Grazed	Diff
CA	28.3	27.9	0.4	95	95	0.1	1.1	1.2	-0.1
ST	23.8	24.8	-1.0	96.5	97.6	-1.1	1.2	1.2	-0.1
JS	31.2	30.4	0.8	94.1	97.4	-3.3	1.1	1.1	0.0
Mean	27.8	27.7	0.1	95.2	96.7	-1.4	1.1	1.2	-0.1

1. percent dockage is the amount of empty hulls, chaff & foreign material in the seed sample
***** not significant at $p \leq 0.05$

Table 6. The affect of bedding and trampling on seed yield, dockage, germination and seed weight

	Yield (kg/ha)			Percent Dockage[1]*			Percent germination*			1000 kernel weight (gms)*		
Year	Control	Bedded	Diff	Control	Bedded	Diff	Control	Bedded	Diff	Control	Bedded	Diff
2010	464	450	14	34.8	34.4	0.3	97.3	94.0	3.3	n/a	n/a	n/a
2011	572	419	153	35.5	34.4	1.2	94.7	95.3	-0.7	1.2	1.1	0.0

1. percent dockage is the amount of empty hulls, chaff & foreign material in the seed sample
***** not significant at $p \leq 0.05$

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Appendix 1.

The effects of grazing on cool-season forage crops grown for seed production in the Peace Region of British Columbia and Alberta - a review of published papers showing the effects of grazing on grass seed production.

Arvid Aasen, Forage Consultant, Lacombe, Alberta

Creeping red fescue (*Festuca rubra* L. var. *rubra*) is commonly grown for seed production in the Peace region of British Columbia and Alberta. The crop is traditionally seeded and harvested for two years before rejuvenation is needed to reduce the density of the stand to promote high seed yields. In the last 10 years the wild elk population has increased in the Peace region and are becoming a problem for fescue seed producers. Elk and other wildlife graze the newly rejuvenated creeping red fescue fields from the fall through to spring. It is unknown as to the extent of the damage caused by this grazing. This is a literature review of published papers from studies showing the affects of grazing on seed yields of cool-season grasses.

Grass Seed Physiology

In cool-season perennial grasses, the plant tiller has a sequence of stages which it must go through in the production of seed. After germination or rejuvenation the grass plant produces a shoot that consists of leaves and roots. These shoots have a growing point which continues to produce leaves under favourable growing conditions (Elliott, 1978).

Literature suggests that the seed yield potential in cool-season grasses is based on the plant development processes that takes place before floral induction (autumn regrowth period) (Chastain & Young III, 1998). Many factors affect the induction process such as plant age, species, fertility, plant development and growing conditions as well as the clipping or grazing of the plant tillers (Yoder, 2000). The basal diameter of vegetative tillers in autumn is related to flowering and seed yield in young stands but not in older stands of creeping red fescue and kentucky bluegrass. Autumn tiller height is related to flowering and seed yield in creeping red fescue and kentucky bluegrass, regardless of the age of the stand. Green leaf number was a poor indicator of seed yield potential in many of the cool-season grasses, including creeping red fescue. As much as 92% of the potential seed yield is set before the onset of conditions favoring vernalization (Chastain & Young III, 1998).

In the fall or early winter the plant undergoes veneralization which is a chemical change in response to low temperatures (Elliott, 1978). This chemical change is called primary induction. In creeping red fescue, primary induction is completed in only those tillers that have had a full season of uninhibited growth.

The next stage of development is floral initiation which is the transformation of the vegetative growing point to the floral state. Only then can heading and seed development occur (Elliott, 1978). In creeping red fescue this stage occurs shortly after the spring thaw which is earlier than most other grasses (Yoder, 2000). Floral initiation begins with the development of a seedhead at the base of the tiller. As the stem develops and elongates the seedhead emerges and then anthesis (flowering) can occur.

Fairey et al conducted trials at Beaverlodge, Alberta to evaluate whether creeping red fescue seed yields could be optimized by manipulating the initial plant density and arrangement of plants (Fairey & Lefkovitch, 1996). Individual plants were transplanted at 7 densities and 3 row spacing in the field. Their findings showed that stands of creeping red fescue should be established to provide an initial density of 12-25 plants/m^2 in rows no wider than 20 cm to optimize seed yields for each of two consecutive crops. When only one harvest year is planned an initial density of 12-100 plants/m^2 on a 20 cm row spacing or 12-50 plants/ m^2 on a 40 cm row spacing is needed to optimize seed yield. When two consecutive harvests are planned, an initial density of 6-25 plants/m^2 on 20 cm row spacing or 6-50 plants/ m^2 on 40 cm row spacing is needed to optimize seed yield over the 2 years.

Fairey et al also studied the reproductive components and seed characteristics of creeping red fescue (Fairey & Lefkovitch, 1996). The natural growth habit of creeping red fescue involves a steady proliferation of tillers which eventually become too dense to form seedheads. The study showed that the seed yield per plant, the number of seedheads per plant and the number of seeds per plant decreased as the density increased. The seed yield was closely correlated with the number of seedheads per square meter which increased with density in the first year but decreased as density increased in years 2 and 3. They conclude that a relatively high density of well spaced plants is required at establishment to optimize seedhead formation in the first crop year but is detrimental to seedhead formation and seed yield in the following years.

Any clipping or grazing during the development process may adversely affect seed production. Clipping or grazing during this period when the growing points are elevated may remove the growing point or seedhead from the plant. This will produce an ineffective tiller which will not produce vegetation or seed. Time of grazing and intensity of grazing are of major concern in grass seed production.

Review of published research

There was no published research showing potential yield losses when creeping red fescue is grazed by elk during the dormancy of the grass or in the spring when the grass breaks dormancy and begins spring growth. There have been some trials involving the use of sheep or cattle grazing grasses used for seed production.

Pringle et al conducted a trial at Beaverlodge using cattle to graze creeping red fescue to determine the influence of grazing on subsequent plant development and seed yield (Pringle, Elliott, & Dobb, 1969). Yearling steers were used to graze a rejuvenated field of creeping red fescue. A control using 1) no grazing - seed harvested was used as a control to evaluate, 2) no grazing - aftermath cut as hay after seed harvest, 3) heavy grazing from seed harvest to freeze-up, 4) medium grazing from seed harvest to freeze-up and 5) spring grazing followed by fall grazing. Fall grazing occurred from early September until early October and the spring grazing took place early to mid May. They found that under fall grazing of moderate intensity, seed yields were reduced by 8%, under fall grazing of heavy intensity seed yields were reduced by 16% and when grazed in the spring and fall seed yields were reduced by 35%. The high reduction in seed yields from spring grazing was attributed to the removal of floral parts by the steers. The reduction in yield from fall grazing was attributed to the removal of fall growth which limited the root reserves and leaf area of the creeping red fescue when flowering was induced.

Nigel Fairey at Beaverlodge studied the effects of post-harvest management on creeping red fescue seed yield (Fairey N., 2006). Three methods of post-harvest management in late September to early October was used after the first harvest year in 1999: 1) flail mowing to 10 cm and residue removal in the fall after seed harvest; 2) disc mowing to 5 cm and residue removal in the fall after seed harvest and 3) short-duration, intensive grazing by sheep in the fall after seed harvest. These treatments were applied in late September to early October in 1999 and seed yields were determined in the 2000 seed harvest year. Based on one year of assessment Fairey found little difference in the mechanical harvest treatments but found nearly a 50% reduction in seed yield when grazed by sheep. The sheep grazed almost all of the green vegetation but not the stubble from the previously harvested crop. It was felt that the close grazing and the treading by the sheep's hooves removed or damaged the growing points in the crowns of the creeping red fescue. Less intensive grazing may have less of an effect on seed yields.

In 2004 in the Spirit River area of the Peace region of Alberta, Gary Ropchan and Melissa Fuchs with the Central Peace Conservation Society(CPCS) conducted a grazing trial on a creeping red fescue field for seed production. The treatments consisted of a check with no grazing, mowing on November 4th and grazing by cows for 5 days beginning on December 19th. The 2005 seed harvest indicated no seed yield difference between the check and the mowed strips but there was a significant seed yield loss of 3.5% on the grazed strips. (Yoder C. , 2010)

Research in Great Britain, under different growing conditions than the Peace Region, showed yield losses when grazed at specific times of the year (Green & Evans, 1956). Green et al assessed the effect of cattle grazing five grasses – cocksfoot (orchardgrass), meadow fescue, tall fescue, creeping red fescue and perennial ryegrass. The treatments used were: 1) control – no grazing; 2) grazed October; 3) grazed October and December; 4) grazed December; 5) grazed December and February; 6) grazed December, February and March; 7) grazed December, February, March and April. The daily mean temperatures in Berkshire England would be >0°C during these grazing periods which would allow the plants to maintain some growth and development. October grazing during the seeding year reduced cocksfoot yields by 24%, red fescue yields by 18%, tall fescue by 7% and the meadow fescue and ryegrass were unaffected. In the second year after seeding, cocksfoot showed some yield loss with an October grazing but the other grasses were unaffected. An October grazing followed by a December grazing affected the cocksfoot throughout the trial but only had an effect on the other grasses in the initial seeding year with little seed loss over the three years of the trial. The

December grazing only treatment had no significant effect on the seed yields of any of the grasses. When grazed in December and again in February, red fescue had a 29% seed yield loss in year one but over the 3 years of the trial had a 10% loss. The other grasses had little or no seed yield losses over the trial period. When grazed 3 times in treatment 6, the red fescue was affected throughout the trial period with seed yield losses of 26% while cocksfoot and tall fescue showed small losses. When grazed 4 times from December to April, all the species had very significant seed yield losses. Tall fescue and red fescue were the most seriously affected with losses in the first year of 82% and 80% respectively and over the 3 year trial period had losses of 42% and 52% respectively.

Winter grazing in areas where cool-season grasses can maintain some growth would be much different than in areas where complete dormancy occurs. Green et al showed that in most species the initial seeding year responded to grazing differently than the subsequent years. Removal of some of the top growth in years 2 and 3 may have a rejuvenational affect on some of the species as there was little or no yield loss and in many cases there was a yield increase. Early flowering species such as red fescue suffered the most when subjected to an April grazing as the authors found a reduced number of fertile tillers following the late grazing (Green & Evans, 1956).

In Oregon, annual ryegrass was grazed by sheep to determine seed yield response to spring grazing during early stem elongation (Young III, Chilcote, & Youngberg, 1996). Young et al studied 4 durations of spring grazing (late February – early April) of annual ryegrass using sheep. Grazing was begun before the onset of stem elongation. Treatments were no grazing (G0), grazing until one-third (G1), two-thirds (G2) or all (G3) primary tillers had their apical meristems removed. The trial period was 2 years and the annual ryegrass was seeded in mid-September each year. In year one the minimum temperature over the trial period was 3°C and the maximum was 22°C, in the second year the temperatures were -4°C and 21°C respectively. Grazing did not affect the number of spikelets per spike or florets per spikelet in the first year but in the second year G2 and G3 reduced spikelets per spike. G2 and G3 affected seed weight in year 1 but not in year 2. The grazing treatments did not affect total herbage dry matter at seed maturity, seed yield or seed quality in either year. Young et al concluded that grazing annual ryegrass in late winter and early spring up to the time when the apical meristem of all primary tillers are removed (G3) does not reduce seed yields.

Kentucky bluegrass for seed production in Washington was clipped to simulate grazing in the fall and in the spring (Evans, 1975). Bluegrass was clipped in late September, early December, early March, late March and early April with various combinations of early and late grazings. Clipping was found to either increase or had no effect on seed yields, panicle numbers or seed weight. Clipping at the onset of panicle development in the spring slightly increased panicle numbers.

Clark et al studied the effects of winter grazing by geese on yields of annual and perennial ryegrass seed production in the Wilamette Valley, Oregon (Clark & Jarvis, 1978). Exclosures were used to compare grazed and ungrazed plots by Canada geese from October 1974 to July 1975. Sheep were used to graze 2 fields as part of this study. The ryegrass was grazed from late October until late April. Although the findings were variable the authors concluded that grazing by geese did not reduce seed yields and in some cases it may increase yields. Grazing by sheep however may occasionally reduce yield.

Discussion

The majority of the literature published on the effects of grazing on seed yields is from the north western United States, Great Britain and the Peace region of Alberta. None of the trials involved the use of elk in their grazing trials but there were some involving sheep and cattle. Sheep are thought to graze more similar to elk.

The research conducted by Pringle et al and Fairey at Beaverlodge in the Peace Region of Alberta, was the only research carried out using cool-season grasses that went into complete dormancy in the fall and resumed growth in the spring. Green et al in Great Britain, Young et al and Clark et al in Oregon used cool-season grasses which continued to be productive during the winter months rather than enter into dormancy. Evans in Washington used cool-season grasses that had a short dormancy period with little or no production in the winter months.

Pringle et al found an 8 – 35% seed yield loss when the creeping red fescue was grazed by cattle. When grazed in the fall and the spring, seed yields were affected the greatest with a 35% yield loss. Fairey realized a 50% seed yield loss with creeping red fescue when grazed heavily by sheep in the fall after the seed was harvested. Ropchan et al found that cattle grazing on creeping red fescue can reduce seed yields by 3.5%. Green et al grazed cattle during the seedling year and had seed yield losses of 24% in cocksfoot, 18% in red fescue and 7% in tall fescue but in subsequent years found only minor losses in cocksfoot. Red fescue had consistent losses when grazed in the fall and the winter. When grazed in December, February and March, red fescue had seed losses of 26% and when again in April the losses soared to 80% in the first year and were 52% over the three years of the trial. Young et al in Oregon determined that there was no seed yield loss in annual ryegrass when grazed in the fall at varying intensities. Evans in Washington found that Kentucky bluegrass seed yields increased slightly or remained the same when clipped to simulate grazing throughout the fall, winter and spring. Clark et al in Oregon concluded that geese grazing annual and perennial ryegrass had no effect on yields but when grazed with sheep, there were occasional yield losses.

Fairey et al showed that plant density had a major influence on creeping red fescue seed yields and densities of 6-25 plants/m^2 on a 20 cm row spacing or 6-50 plants/m^2 on 40 cm row spacing is needed to optimize seed yield over the 2 years of seed production. Elk grazing and elk disturbance may affect plant populations sufficiently to increase or decrease seed yields in a creeping red fescue field.

Conclusion

The published research concludes that there can be seed yield losses in creeping red fescue fields when grazed during the fall, winter and/or spring by cattle or sheep. Similar results can be expected when elk graze during these periods as well. Grazing intensity, time of grazing, forage dormancy, forage species and the age of the forage will all affect the amount of seed yield losses in grasses grown for seed production.

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