



ECONOMIC ANALYSIS OF CRESTED WHEATGRASS PASTURE REJUVENATION METHODS IN SOUTHWEST SASKATCHEWAN

– TECHNICAL BULLETIN



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Economic Analysis of Crested Wheatgrass Pasture Rejuvenation Methods in Southwest Saskatchewan

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Overview

Crested wheatgrass (*Agropyron cristatum* (Linnaeus) Gaertner) is one of the most recommended tame grass species for Southwest Saskatchewan because of its drought tolerance and ability to withstand heavy grazing (Smoliak et al. 1981). However, productivity of introduced forages can decline over time typically due to diminished soil nutrient availability as the stand ages coupled with poor forage management.

As the productivity of a crested wheatgrass stand diminishes, rejuvenation may offer a solution to improve yield and quality. However, rejuvenation efforts need to be accompanied with good management to reap any benefit (Springer 1999).

Rejuvenation Strategies

Agriculture and Agri-Food Canada (AAFC) scientists at the Swift Current Research and Development Centre have researched a number of rejuvenation methods aimed at addressing soil nutrient deficiency (in particular nitrogen) in pastures including:

- Broadcast application of nitrogen fertilizer
- Break and re-seed the pasture stand
- Sod-seed alfalfa



Crested wheatgrass (photo: cc by-nc-sa 4.0 Stefan Lefnaer)

Although the agronomy of these methods has been assessed, their impact on a producer's pocketbook has not been adequately reviewed. In this bulletin, the agronomic results of each method have been paired with cost and return estimates to assess their respective economic feasibility.

Nitrogen Fertilization

Nitrogen is the most commonly deficient nutrient on pastures, so applying nitrogen fertilizer can have an immediate but short-term impact on pasture productivity (Springer 1999). The advantages of rejuvenation with fertilization are (1) a reduced risk of erosion relative to break and re-seed and (2) the field can be grazed in the year of fertilizer application. However, the short-term effect means that

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periodic reapplication is necessary (Schellenberg et al. 1998). To optimize yield from fertilization, producers will have to apply 100 pounds of actual nitrogen per acre (112 kilograms per hectare) every three years (note: subsequent forage yield is dependent upon available soil moisture).

Break and Re-seed

Complete breaking or cultivating and re-seeding the forage stand is the traditional pasture rejuvenation method. Breaking the sod to suppress the existing forage has the advantage of reducing competition for new seedlings, allowing them to utilize more resources and improve establishment. Additionally, breaking the sod can speed up decomposition of soil organic matter, providing a temporary boost to nitrogen availability (Springer 1999).

There are several challenges with breaking and re-seeding pasture. First, two or three heavy equipment passes are often required, adding greatly to the rejuvenation cost. Second, initial establishment may be poor so re-seeding may be necessary. Third, at least one year of no grazing is required to allow the new forage to become established (Mahli et al. 2004). Fourth, tillage creates a risk for weed seed germination, which can be exacerbated by the boost in soil nitrogen (Smoliak et al. 1981, Springer 1999). Fifth, the most significant risk associated with breaking sod is soil erosion, especially on sandy or rolling landscapes. Despite these challenges, if the goal is to completely change the forage mix, break and re-seed may be better suited than other rejuvenation strategies.

Sod-seeding Alfalfa

Incorporating alfalfa into the forage mix has been shown to improve the productivity of older crested wheatgrass stands. Essentially, alfalfa produces nodules containing nitrogen-fixing bacteria on its roots. Some of the fixed nitrogen leaks into the soil and is taken up by adjacent plants in the stand (Springer 1999). Once established, alfalfa can remain in the stand for several years and continue fixing nitrogen thereby providing a longer term solution to nutrient deficiency than fertilizer application.

Research by AAFC scientists in Southwest Saskatchewan suggests that using an herbicide, sprayed in alternating 20-inch (50-centimeter) strips and direct-seeding alfalfa into the treated strips, is a practical alternative to complete breaking of sod (Schellenberg et al. 1994). The non-selective herbicide glyphosate can adequately suppress existing vegetation so direct-seeded alfalfa has greater access to resources and improves establishment success (Springer 1999). This method leaves the soil largely undisturbed which substantially reduces the risk of soil erosion and soil moisture loss, as well as requiring fewer field operations than completely breaking and reseeding a pasture. Additionally, the crested wheatgrass stand will not be completely killed using this strip spraying method, so grazing will still be available during establishment (Schellenberg and Waddington 1997) (see page 3, How to sod-seed alfalfa into an existing crested wheatgrass stand).

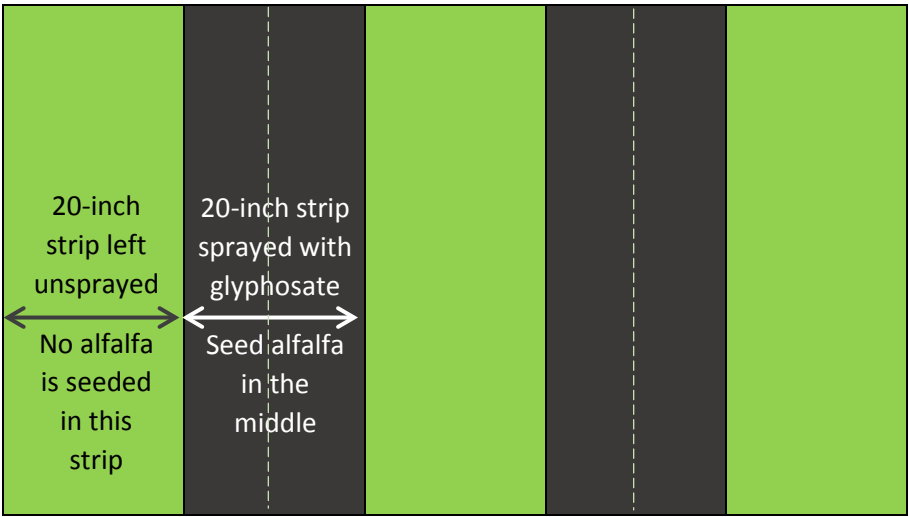
Strips wider than 20 inches (50 centimeters) can increase weedy species invasion. However, narrower strips may allow greater competition from adjacent unsprayed strips, reducing seedling establishment success. Ultimately, the capabilities of the equipment and the manager's goals will determine the width and number of strips; managers will have to weigh the benefits and risks of having strips wider or narrower than recommended (see References Cited: *Sod Seeding: Seeding forages into existing stands using minimal tillage* (Nazarko 2008) for more information on sod-seeding agronomic practices).

Sod-seeding alfalfa into an existing crested wheatgrass stand using chemical suppression and direct seeding overcomes many of the disadvantages of applying nitrogen fertilizer (high cost, reapplication

every three years) and break & reseed (equipment costs, poor establishment [potential], loss of grazing for one year, weed establishment [potential], soil erosion). The following analysis shows which of the three strategies make the most economic sense and under what assumptions.

How to sod-seed alfalfa into an existing crested wheatgrass stand

- Step 1: In early spring, graze the pasture hard (100% of available growth).
- Step 2: Follow grazing with a glyphosate application (2.5 liters per acre) in alternating 20-inch (50-centimeter) sprayed and unsprayed strips (turn off selected sprayer nozzles on the spray boom to produce the unsprayed strips).
- Step 3: After about two weeks, seed alfalfa directly into the sprayed strips using a seeder suited to zero- or no-till with narrow openers. Alfalfa rows should be spaced 40 inches (100 centimeters) apart with each row seeded into the middle of a sprayed strip. Close off runs in a seed-drill to avoid planting alfalfa in the unsprayed strips.



Strip width is key to successfully establishing alfalfa via sod-seeding into an existing crested wheatgrass stand in the Brown soil zone (Schellenberg et al. 1994).

Economic Analysis - Methodology

The economic analysis compared the net present value for three rejuvenation strategies versus business as usual (i.e. no rejuvenation undertaken). Net present value is calculated by deducting incurred costs from the returns received by undertaking a rejuvenation method. After determining costs and returns for a scenario, net returns are adjusted to their net present value. The adjustment requires applying a discount rate (interest rate) to have the future streams of revenue comparable with the up-front costs (investment) in today's dollars (i.e. present value). This adjustment is useful when costs are incurred in one year but returns accrue over multiple years (see page 5, Calculating Net Present Value).

Rejuvenation costs were determined by the agronomic practices associated with each method. Expenses associated with regular pasture maintenance (e.g. fence lines and water sources) were not included in the analysis as these costs would be constant across all scenarios and unaffected by rejuvenation method.

Net returns from a control or 'business as usual' scenario were used as a comparison to the three rejuvenation strategies – nitrogen fertilization, break and re-seed, and sod-seed alfalfa. The percent yield increase for each rejuvenation method was applied to an estimated long-term average yield for mature crested wheatgrass of 700 pounds per acre (786 kilograms per hectare).ⁱⁱ A forage value of \$0.02 per pound was used for all scenarios (see below, Comparing standing forage prices and daily grazing fees). Revenues for all scenarios were based on a 70% utilization rate (or 30% carryover) of available yield to reflect recommended grazing management practices (Smoliak et al. 1981). The time period used in the net present value calculation differed depending on the rejuvenation method, ranging from six to fourteen years. Grasses have high yields in the first few years after rejuvenation treatment, then drop sharply around the fifth year to reach a long-run equilibrium yield (Looman and Heinrichs, 1973; Tremblay and Kirychuk 2008). The discount rate used was 5%.

Comparing standing forage prices and daily grazing fees

Standing forage valued at \$0.02 per pound (\$0.04 per kilogram) is equal to a daily grazing fee of \$0.70 per cow. Calculation: if a cow weighs 1400 pounds (636 kilograms), and she consumes 2.5% of her body weight in dry matter (DM) each day ($1400 \times 0.025 = 35$ pounds DM [= 15.9 kilograms DM]), then the daily value of grazing is \$0.70/cow/day (35 pounds x \$0.02/pound).

ⁱⁱ Crested wheatgrass starting yield is based on average yield (712 lb per acre; 630 lb per acre median) from 47 published yields for mature crested wheatgrass pastures (Looman and Heinrichs 1973; Power 1980; Lodge, Smoliak and Johnston 1981; Campbell et al. 1986; Schellenberg 1998).

Calculating Net Present Value

The formula for calculating net present value (NPV) takes into consideration the initial investment, returns generated, discount rate and time:

$$NPV = -C_0 + \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \dots + \frac{C_T}{(1+r)^T}$$

Where:

$-C_0$ represents the initial investment

C represents the returns generated (cash flows) for each year from 1 to T

r represents the discount rate

T represents time (in years)

Alternate formula

$$NPV = \sum \{ \text{Cash Flow} / (1+r)^t \} - \text{Initial Investment}$$

Microsoft Excel

Microsoft Excel has a built-in NPV function that simplifies the work of calculating net present value. The function assumes the returns are equally spaced over time and occur at the end of each period, with investment occurring one period before the return. The function takes as input discount rate, initial investment cost (as a negative) and subsequent annual returns to calculate NPV.

Control – ‘business as usual’

This method represents a minimal management strategy (i.e. no rejuvenation = zero rejuvenation costs). For the analysis, it was assumed that an established stand of crested wheatgrass has a long-term average yield of 700 pounds per acre (785 kilograms per hectare) (dry matter basis). Seven years of returns are discounted to present value terms (Table 1) and used as a comparison to the net present values for the rejuvenation strategies.

Table 1. Control scenario: estimated costs, returns and net returns

Returns	Costs
$700 \text{ lb per acre} \times 70\% \text{ utilization}$ $= 490 \text{ lb per acre} \times \0.02 per lb $= \$9.80 \text{ per acre per year} \times 7 \text{ years}$ $= \$68.60 \text{ per acre}$	$\$0.00 \text{ per acre (no rejuvenation undertaken)}$
Apply 5% discount rate $= \$56.71 \text{ per acre}$	
Net Present Value \$56.71 per acre	

Nitrogen Fertilization

The fertilization method assumes 100 pounds per acre of actual nitrogen is applied every three years (twice in a six year period). Jefferson (2010) observed a 439% yield increase in the application year. Related research showed a 15% yield decline in the second year after nitrogen application and a 60% decline in the third year compared to first year results (Schellenberg et al. 1998) (Table 2).

Table 2. Nitrogen fertilization scenario: estimated costs, returns and net returns

Returns	Costs
$700 \text{ lb per acre} \times 439\% \text{ yield increase} \times 70\% \text{ utilization}$ $= 2151 \text{ lb per acre} \times \$0.02 \text{ per lb} \rightarrow \43.02 in Year 1 $+ 1828 \text{ lb per acre}^{\dagger} \times \$0.02 \text{ per lb} \rightarrow \36.56 in Year 2 $+ 860 \text{ lb per acre}^{\ddagger} \times \$0.02 \text{ per lb} \rightarrow \17.20 in Year 3 $+ 2151 \text{ lb per acre} \times \$0.02 \text{ per lb} \rightarrow \43.02 in Year 4 $+ 1828 \text{ lb per acre}^{\dagger} \times \$0.02 \text{ per lb} \rightarrow \36.56 in Year 5 $+ 860 \text{ lb per acre}^{\ddagger} \times \$0.02 \text{ per lb} \rightarrow \17.20 in Year 6 $= \$193.56 \text{ per acre over 6 years}$	$\$0.60 \text{ per lb of nitrogen} \times 100 \text{ lb applied}$ $+ \$7.95 \text{ per acre for broadcast application}^*$ $= \$67.95 \text{ per acre in Year 1}$ $+ \$67.95 \text{ per acre in Year 4}$ $= \$135.90 \text{ per acre over 6 years}$
Apply 5% discount rate $= \$165.86 \text{ per acre}$	Apply 5% discount rate $= \$123.85 \text{ per acre}$
Net Present Value \$42.01 per acre	
\dagger (15% yield decline from year 1) \ddagger (60% yield decline from year 1) * Western Beef Development Centre 2016	

Break and Re-Seed

This scenario assumes completely killing off the existing stand using glyphosate and cultivation, then replacing it with a crested wheatgrass and alfalfa seed mix. Starting in the fall prior to seeding, the stand is sprayed with glyphosate then disced twice. In spring, the stand is cultivated and then seeded. The recommended pasture seeding rate in the Brown soil zone is one pound (0.45 kilograms) alfalfa and three pounds (1.36 kilograms) crested wheatgrass per acre (Saskatchewan Ministry of Agriculture 2014). Cover crops are not recommended in the Brown soil zone because of the limited soil moisture and nutrient availability resulting in zero forage yield in the establishment year. The yield response in Year 2 is 307% above the starting yield (Schellenberg et al. 1998). The yield was assumed to decrease 17% per year to level out at 700 pounds per acre after seven years of benefit (i.e. in year 8 in this scenario) (Table 3).

Table 3. Break and re-seed scenario: estimated costs, returns and net returns

Returns	Costs
<p><i>No returns in Year 1 (establishment year)</i></p> <p><i>700 lb per acre x 307% yield increase x 70% utilization</i></p> <p><i>= 1504 lb/ac x \$0.02/lb → \$30.09 in Year 2</i></p> <p><i>+ 1248 lb/ac[†] x \$0.02/lb → \$24.97 in Year 3</i></p> <p><i>+ 1036 lb/ac[†] x \$0.02/lb → \$20.73 in Year 4</i></p> <p><i>+ 860 lb/ac[†] x \$0.02/lb → \$17.20 in Year 5</i></p> <p><i>+ 714 lb/ac[†] x \$0.02/lb → \$14.28 in Year 6</i></p> <p><i>+ 593 lb/ac[†] x \$0.02/lb → \$11.85 in Year 7</i></p> <p><i>+ 492 lb/ac[†] x \$0.02/lb → \$9.84 in Year 8</i></p> <p><i>= \$128.95 per acre over 7 years</i></p>	<p><i>2.5 liters per acre x \$3.40 per liter for glyphosate*</i></p> <p><i>+ \$5.00 per acre for spraying**</i></p> <p><i>+ \$20.38 per acre x 2 passes of discing**</i></p> <p><i>+ \$9.10 per acre for pre-seed cultivation**</i></p> <p><i>+ \$18.62 per acre for seeding**</i></p> <p><i>+ \$20.75 per acre for seed***</i></p> <p><i>= \$102.73 per acre incurred in Year 1</i></p>
<p><i>Apply 5% discount</i></p> <p><i>\$105.13 per acre</i></p>	
<p>Net Present Value \$2.40 per acre</p>	
<p>[†] Yield declines 17% annually to reach ~490 lb (700 lb x 70% utilization) per acre after 7 years</p> <p>* Western Beef Development Centre 2016</p> <p>** Saskatchewan Ministry of Agriculture 2016</p> <p>*** \$5.50/lb x 3 lb crested wheatgrass + \$4.25/lb x 1 lb alfalfa</p>	

Sod-Seed Alfalfa

This scenario allows for a hard graze (100% of available growth) in early spring followed by a 2.5 liters per acre glyphosate application in alternating 20-inch (50-centimeter) sprayed/unsprayed strips. After two weeks, alfalfa is seeded into sprayed strips at the recommended rate of 2.5 pounds per acre (see page 3, How to sod-seed alfalfa into an existing crested wheatgrass stand,). Research has shown

that yield response from sod-seeding varied with moisture conditions (Schellenberg 1998; Schellenberg and Waddington 1997)ⁱⁱⁱ.

On average, the yield is estimated to increase 190% from the 700 pounds per acre starting yield to 1,330 pounds per acre. This rejuvenation scenario was analyzed at two different rates of yield decline: 10% per year to reach 700 pounds per acre after seven years of benefit (i.e. in year 8 in this scenario) and 4.75% per year yield decline to reach 700 pounds per acre after fourteen years of benefit (i.e. in year 15 of this scenario). These two rates of decline were used to reflect how different forage management practices can influence stand productivity (Tables 4a and 4b).

Table 4a. Sod-seed alfalfa, seven-year scenario: estimated costs, returns and net returns

Returns	Costs
<p>700 lb/ac x \$0.02/lb x 100% utilization → \$14.00 in Year 1</p> <p>+ 700 lb/ac x 190% increase x 70% utilization</p> <p>= 931 lb/ac x \$0.02/lb → \$18.62 in Year 2</p> <p>+ 838 lb/ac[†] x \$0.02/lb → \$16.76 in Year 3</p> <p>+ 754 lb/ac[‡] x \$0.02/lb → \$15.08 in Year 4</p> <p>+ 678 lb/ac[‡] x \$0.02/lb → \$13.57 in Year 5</p> <p>+ 610 lb/ac[‡] x \$0.02/lb → \$12.22 in Year 6</p> <p>+ 550 lb/ac[‡] x \$0.02/lb → \$11.00 in Year 7</p> <p>+ 495 lb/ac[‡] x \$0.02/lb → \$9.90 in Year 8</p> <p>= \$111.14 per acre over 7 years</p>	<p>2.5 liters per acre x \$3.40 per liter of glyphosate x 0.5^{†,*}</p> <p>+ \$5.00 per acre for spraying^{**}</p> <p>+ \$18.62 per acre for seeding^{**}</p> <p>+ \$5.31 per acre for seed^{***}</p> <p>= \$33.18 per acre in Year 1 only</p>
<p>Apply 5% discount</p> <p>\$91.37 per acre</p>	
<p>Net Present Value \$58.19 per acre</p>	
<p>[†] Cost of glyphosate was halved to reflect nozzles being closed to spray in alternating 20-inch strips</p> <p>[‡] Yield declines 10% annually to reach ~490 lb (700 lb x 70% utilization) in seventh year post-rejuvenation.</p> <p>* Pricing based on invoices received by Western Beef Development Centre 2016; (2.5 x \$3.40) x 0.5 to account for strip spraying</p> <p>** Saskatchewan Ministry of Agriculture 2016</p> <p>*** Based on \$4.25 per lb of alfalfa seed x 2.5 lb per acre seeding rate x 0.5 to account for only sowing into treated 20-inch strips</p>	

ⁱⁱⁱ To account for the varied yield responses, long-term hay yields (1976-2016) for Saskatchewan were analyzed to determine the probability of favorable and poor yield responses. Over the 40-year period, 57% of the years had above average yields and 43% of the years had below average yields. To calculate an average yield response for this rejuvenation strategy, a 57% weighting was applied to the positive yield responses (where treatment yield exceeded control) and a 43% weighting was applied to the poor yield responses (treatment yield below control).

Table 4b. Sod-seed alfalfa, fourteen-year scenario: estimated costs, returns and net returns

Returns	Costs
<p>700 lb/ac x \$0.02/lb x 100% utilization → \$14.00 in Year 1</p> <p>700 lb/ac x 190% increase x 70% utilization</p> <p>= 931 lb/ac x \$0.02/lb → \$18.62 in Year 2</p> <p>+ 886 lb/ac[†] x \$0.02/lb → \$17.74 in Year 3</p> <p>+ 845 lb/ac[‡] x \$0.02/lb → \$16.89 in Year 4</p> <p>+ 805 lb/ac[‡] x \$0.02/lb → \$16.09 in Year 5</p> <p>+ 766 lb/ac[‡] x \$0.02/lb → \$15.34 in Year 6</p> <p>+ 730 lb/ac[‡] x \$0.02/lb → \$14.60 in Year 7</p> <p>+ 695 lb/ac[‡] x \$0.02/lb → \$13.90 in Year 8</p> <p>+ 662 lb/ac[‡] x \$0.02/lb → \$13.24 in Year 9</p> <p>+ 631 lb/ac[‡] x \$0.02/lb → \$12.61 in Year 10</p> <p>+ 600 lb/ac[‡] x \$0.02/lb → \$12.01 in Year 11</p> <p>+ 572 lb/ac[‡] x \$0.02/lb → \$11.45 in Year 12</p> <p>+ 545 lb/ac[‡] x \$0.02/lb → \$10.90 in Year 13</p> <p>+ 519 lb/ac[‡] x \$0.02/lb → \$10.38 in Year 14</p> <p>+ 495 lb/ac x \$0.02/lb → \$9.89 in Year 15</p> <p>= \$207.67 per acre over 14 years</p>	<p>2.5 liter per acre x \$3.40 per liter of glyphosate x 0.5^{†,*}</p> <p>+ \$5.00 per acre for spraying^{**}</p> <p>+ \$18.62 per acre for seeding^{**}</p> <p>+ \$5.31 per acre for seed^{***}</p> <p>= \$33.18 per acre in Year 1 only</p>
<p>Apply 5% discount</p> <p>= \$148.74 per acre</p>	
Net Present Value \$115.55 per acre	
<p>† Cost of glyphosate was halved to reflect nozzles being closed to spray in alternating 20-inch strips</p> <p>‡ Yield declines 4.75% annually to reach ~490 lb (700 lb x 70% utilization) in fourteenth year post-rejuvenation.</p> <p>* Pricing based on invoices received by Western Beef Development Centre 2016; (2.5 x \$3.40) x 0.5 to account for strip spraying</p> <p>** Saskatchewan Ministry of Agriculture 2016</p> <p>*** Based on \$4.25 per lb of alfalfa seed x 2.5 lb per acre seeding rate x 0.5 to account for only sowing into treated 20-inch strips</p>	

Net Present Value

The variation in yield response between the three rejuvenation strategies and assumptions about the number of years before the stand reverts to the starting base-line yield of 700 pounds per acre has a large impact on the net returns calculated in this economic analysis. See Table 5 and Figure 1 for the cost return comparisons and the net present value for the five scenarios.

Yield

Nitrogen fertilization produced the largest yield response (439%) while the sod-seeding alfalfa generated the smallest yield response (190%).

Cost

While fertilizer application has the largest yield response, it also has the highest cost at \$135.90 per acre (\$123.85 per acre present value). The lowest cost rejuvenation method was sod-seeding alfalfa, estimated at \$33.18 per acre.

Returns

The highest present value returns (\$165.86 per acre) were generated by nitrogen fertilization, followed by sod-seed alfalfa (\$120.05 per acre: average of seven- (\$91.37) and fourteen-year (\$148.74) scenarios) and break and re-seed (\$105.13 per acre). For all scenarios, forage was valued at \$0.02 per pound; however, it is important to recognize that alfalfa is a protein source which can provide additional value through increased forage quality and improved potential gains for grazing animals.

Present Values

At the conservative \$0.02 per pound valuation of forage, the fourteen-year benefit period of the sod-seeded alfalfa scenario has the highest net present value at \$115.56 per acre followed by the seven-year benefit period of the sod-seeded alfalfa scenario at \$58.19 per acre. The control scenario (\$56.71 per acre) had higher net present value than the nitrogen fertilizer (\$42.01 per acre) and break and re-seed (\$2.40 per acre) scenarios (Table 5).

Benefit-Cost Ratio – Calculating your return for every dollar spent

Benefit-cost ratio is calculated as the total revenue generated from a rejuvenation method divided by its cost in today's dollars (present value). According to the analysis, **sod-seeding alfalfa is the most desirable crested wheatgrass rejuvenation method for producers in Southwest Saskatchewan**. Its benefit-cost ratio is 2.75 for a seven-year life and increases to 4.48 if the yield benefit spans fourteen years. This means for every dollar invested, the rejuvenation method can return \$2.75 for the seven-year scenario – more than double the return of the nitrogen fertilization method.

Table 5. Present value of returns and costs, net present value and benefit/cost ratios for pasture rejuvenation scenarios†

Rejuvenation Method		Present Value Returns (\$/acre)	Present Value Cost (\$/acre)	Net Present Value (\$/acre)	Benefit/Cost Ratio‡
Control		56.71	0	56.71	--
Nitrogen fertilization		165.86	123.85	42.01	1.34
Break and re-Seed		105.13	102.73	2.40	1.02
Sod-seed alfalfa	7-year	91.37	33.18	58.19	2.75
	14-year	148.74	33.18	115.55	4.48

†Returns are based on valuing forage at \$0.02 per pound.

‡Benefit-cost ratio for the control scenario was not estimated given zero costs incurred (no rejuvenation).

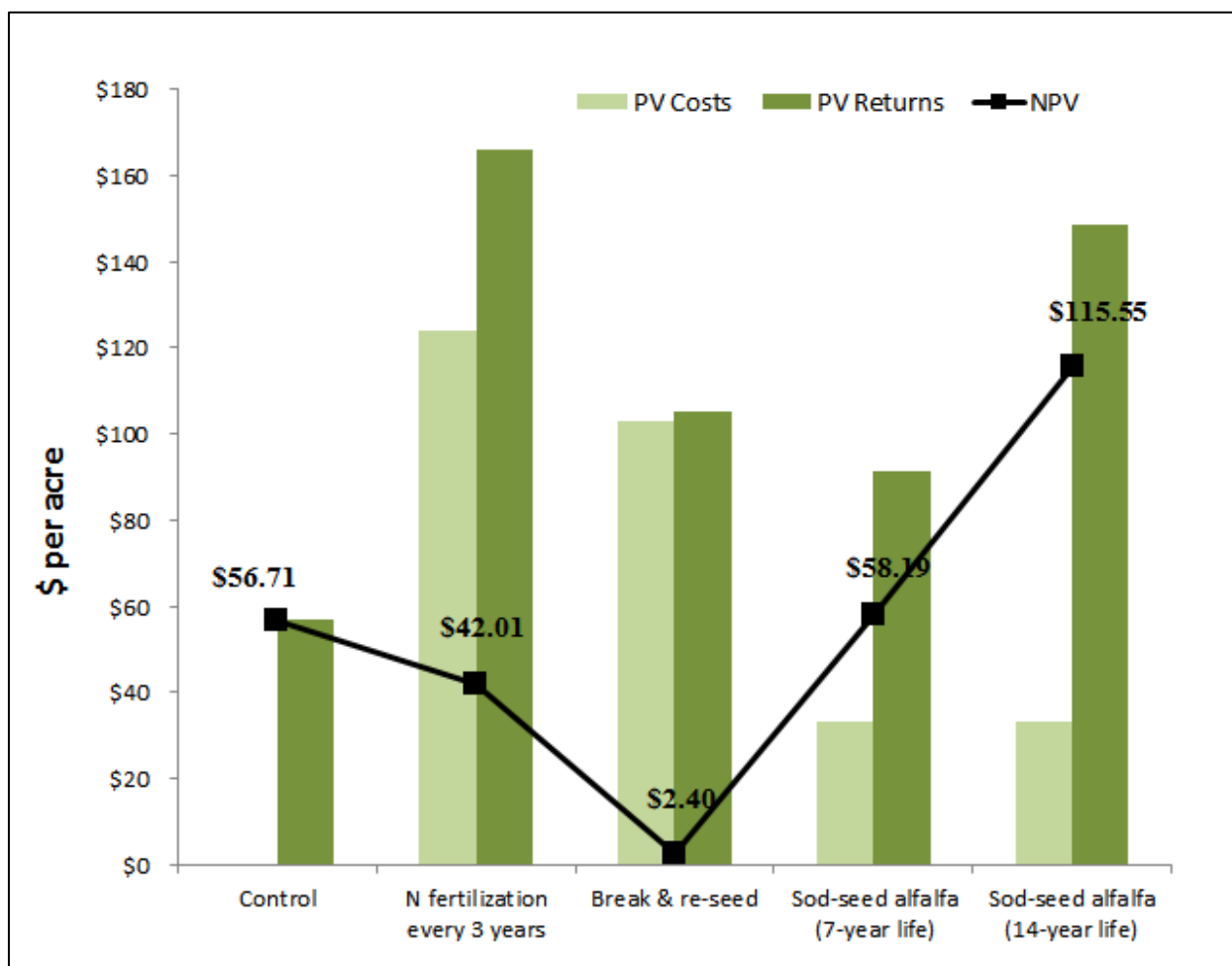


Figure 1. Present value of costs (PV Costs), returns (PV Returns) and net present value (NPV) for four rejuvenation scenarios and one control (no rejuvenation, business-as-usual) using \$0.02 per pound forage valuation.

Sensitivity Analysis – When forage values change

A conservative forage value estimate (\$0.02 per pound) was used in the analysis. Forage values change over time and therefore influence the net returns of each rejuvenation method. Table 6 provides net present values as forage values range from \$0.01 to \$0.045 per pound in half-cent increments. For all valuations, the sod-seed alfalfa scenario (fourteen-year longevity analysis) has the highest net present value. It is important to note that at \$0.02 per pound, the sod-seed seven-year scenario has higher net present value than doing no rejuvenation (control). Forage would need to be valued at \$0.025 per pound before applying nitrogen would yield higher net returns than control and \$0.045 per pound before breaking and re-seeding net returns exceed control.

Table 6. The Effect of Changing Forage Values on Net Present Value (\$/acre) [the outlined row is the forage value and NPV results in this analysis]

Forage Value (\$/pound)	Control	100 pounds nitrogen per acre (apply every 3 years)	Break & re-seed crested wheatgrass + alfalfa	Sod-seed alfalfa (7-year life)	Sod-seed alfalfa (14-year life)
\$0.01	\$28.35	-\$40.92	-\$50.17	\$12.50	\$41.19
\$0.015	\$42.53	\$0.55	-\$23.89	\$35.34	\$78.37
\$0.02	\$56.71	\$42.01	\$2.40	\$58.19	\$115.55
\$0.025	\$70.88	\$83.48	\$28.68	\$81.03	\$152.74
\$0.03	\$85.06	\$124.94	\$54.96	\$103.87	\$189.92
\$0.035	\$99.24	\$166.41	\$81.24	\$126.71	\$227.11
\$0.04	\$113.41	\$207.87	\$107.52	\$149.56	\$264.29
\$0.045	\$127.59	\$249.34	\$133.80	\$172.40	\$301.47

How realistic is a \$0.03 per pound valuation on grazing lands?

At \$0.03 per pound of forage, grazing would be worth \$1.05 per day for a cow in a cow-calf pair consuming 35 pounds forage per day (35 pounds x \$0.03 per pound). This is in line with reported average grazing fees of \$1.09 per cow-calf pair per day in 2016 (Saskatchewan Forage Council 2016), meaning a \$0.03 per pound valuation for grazed forage is realistic.

Conclusion

Millions of acres have been sown to crested wheatgrass in Southwest Saskatchewan since the mid-1930s. Over time, crested wheatgrass yields decline and then plateau. Three rejuvenation methods were analyzed for economic feasibility: nitrogen fertilization, break/re-seed and sod-seed alfalfa.

The analysis showed that with increasing yield response comes increasing cost. Applying nitrogen fertilizer has the highest yield response (439% in year 1), but also requires re-application (every 3 years), which results in the highest cost (\$123.85 per acre). Sod-seeding alfalfa had the lowest yield response (190%) but also the lowest cost (\$33.18 per acre). Breaking and re-seeding provided 307% increase in yield at a cost of \$102.73 per acre. Using a forage value of \$0.02 per pound, the sod-seeding alfalfa rejuvenation method has the highest present value of net returns using the average of seven- and fourteen-year yield benefits ($(58.19 + 115.55)/2 = \$86.87$ per acre average) followed by control (no rejuvenation) at \$56.71 per acre, nitrogen fertilization (\$42.01 per acre) and break and re-seed (\$2.40 per acre). **Based on the benefit-cost ratio, sod-seeding alfalfa is the best overall crested wheatgrass pasture rejuvenation strategy.**

Even though returns were based solely on yield estimates, it is important to remember the additional benefits that can accrue from including a legume (such as alfalfa) in a pasture stand. The incorporation of a legume has been shown to improve stand productivity and forage quality. Keep in mind that as forage value changes, so will the ranking of which rejuvenation method generates the best net returns. Pasture rejuvenation is not without risks: producers must evaluate their own unique situation to determine the appropriate method for their operation. However, the chances of a generating positive return on investment are higher when pasture rejuvenation is followed by on-going attention to forage management.

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