Ranch Resource Differences Affecting Profitability of Crested Wheatgrass as a Spring Forage Source

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Abstract

A representative cow-calf ranch operation in Elko County, Nev., was modeled using a linear programming procedure to determine effects of selected ranch resource differences on profitability of seeding crested wheatgrass. Net present value (NPV) results suggest seeding crested wheatgrass as a spring forage can be a profitable investment if there are associated increases in calf weaning weights of 9.07 kg and increases in calving rates of 5 percentage points. Amount of meadow hayland, deeded range, and BLM forage available to the representative ranch were increased and decreased 50%. NPV's of the crested wheatgrass investment are greater for ranches with excess meadow hay and excess deeded range. NPV's are lower for ranches with limiting resources of meadow hayland, deeded range, and BLM forage.

Herd size and profit potential on many western ranch operations are limited by availability of high quality, low cost early spring forage. Increased infestation of rangeland with low quality forage species may decrease the amount of spring forage produced. Overgrazing of the perennial grass community during the 1880's destroyed much of the native understory, with degraded stands of sagebrush remaining (Young et al. 1979). Also, domination of rangeland by late maturing range species may delay early spring usage of the range. Given a permanent physical shortage of early spring forage, an operator may choose to buy hay, lease pasture, or graze other forage sources earlier than desired to maintain stand productivity. However, depending on costs and returns, it may be more profitable for the operator to maintain a smaller herd size and have excess ranch forage later in the grazing season.

One possible investment alternative to inadequate spring forage is to remove existing forage and seed the rangeland with an earlier maturing grass. The adaptability of crested wheatgrass *(Agropyron desertorum)* as a forage source on western range operations has been established, as more than 5 million ha have been seeded in the U.S. (Dewey and Asay 1975). Crested wheatgrass has its high-

est nutritional content in early spring (Rauzi 1975) and develops 2 to 3 weeks earlier than native grasses (Frischknecht et al, 1953). Successful crested wheatgrass stands have been established in most western states (Lloyd and Cook 1960, Robertson et al. 1970, Sharp 1970).

Much research has focused on the difference in animal production between grazing native range and grazing crested wheatgrass (Jeffries et al. 1967, Springfield and Reid 1967, Hart et al. 1983). Economic aspects of seeding as a range improvement have also been analyzed. Several studies have estimated returns to seeding based on the value of increased animal gains produced on seeded range versus native range. Kearl and Cordingly (1975), using budgeting techniques, determined that reseeding rangeland is a profitable investment for a cow-yearling operation, assuming increases in weaning weights and calving percentages. Those management practices which influence crested wheatgrass seeding profitability were identified by Godfrey (1975) in a study of various seeding utilization patterns. Relatively high economic returns from increased animal gains made on crested wheatgrass over time have been estimated for most grazing patterns in Idaho (Godfrey et al. 1979). Sonnemann (1982) concluded that seeding crested wheatgrass on a cow-calf operation is profitable even if weaning weights and calving percentages are unchanged, provided excess resources are available to enable cow herd size to increase.

Previous research has concentrated on the impact of various management practices on profitability of crested wheatgrass as a range improvement project. Effects of forage resource quantity differences among ranches upon profitability of removing sagebrush and planting crested wheatgrass have not been evaluated. Objectives of this study are: (1) determine if *ceteris paribus* differences from one ranch to another in amounts of meadow hayland, deeded forage, and public range forage will influence expected profitability of the range investment of seeding crested wheatgrass; and (2) if differences exist, identify factors contributing to increased profitability.

Procedure

Linear programming (LP) ranch models were developed in this study to estimate the effect of different levels of 3 ranch resources

on net returns to seeding crested wheatgrass. LP is frequently used as a research technique to determine economically efficient allocation of range resources (Woodworth 1973, D'Aquino 1974, Torell 1981). The LP technique allows simultaneous examination of resource and activity alternatives in an operation to determine the optimal combination of production activities. This mathematical procedure can maximize returns or minimize costs subject to a set of production constraints. LP has an advantage over total ranch budgeting in the reduced time by which a large number of production alternatives can be evaluated to achieve the single economically optimal solution in ranch resource use.

Recursive linear programming (RLP), a variation of linear programming, is the modeling procedure used in this study to enable sequential optimization of the ranch operation throughout the seeding establishment process. An RLP model is constructed and used in the same manner as an ordinary LP model (Day 1963). RLP, however, permits changes in resource levels and technical coefficients from one period to the next. An optimal solution for an unchanging production system is obtained from LP. RLP accounts for system differences between periods by utilizing optimal results from the previous time period. Modification of specified resource levels was thus made in this study during modeled transition periods between the initial operation and the final situation 5 years later, when crested wheatgrass seeding is a forage source and ranch adjustments are complete. Changes between periods in production coefficients, e.g., weaning weights and calving percentages, were also made where appropriate.

The RLP model constructed describes a representative cow-calf operation in Elko County, Nev. Elko County contains some of the State's most productive rangeland. Cost data, resources, and activities for the operation were based on information obtained from a panel of ranchers (Myer and Hackett 1982, USDA 1983). Return data were based on average Kansas City prices received 1979–1981 (Livestock and Meat Situation, USDA, 1979–81). Initial resource levels and activities of the model are shown in Table 1. Initial herd size and production parameters are given in Table 2.

This specific RLP model allocates available forage sources among alternative activities to maximize the objective function of annual net returns to variable costs, calculated as total sales minus

Table 1. Initial resource levels, yield, and grazing periods of representative ranch, Elko County, Nevada.

Resource	Unit of measure	Quantity	Yield
Mechanical harvesting:			
Meadow hayland	ha (acres)	524 (1295)	2470 kg/ha
Dec. 15–Apr. 14			(1.1 tons/acre)
Grazing:			
BLM rangeland:			
Apr. 15–May 14	AUM	532	
May 15–June 14	AUM	563	
June 15–July 14	AUM	780	
July 15–Sept. 14	AUM	900	
Deeded rangeland:			
Apr. 15–May 14	AUM	50	
May 15–June 14	AUM	50	
June 15–July 14	AUM	100	
July 15–Sept. 14	AUM	412	
Sept. 15–Oct. 31	AUM	339	
Meadow pastureland:			
Nov. 1–Dec. 14	AUM	407	2.47 AUM/ha
			(1 AUM/acre)
Meadow hayland aftermath:			
Nov. 1–Dec. 14	AUM	917	1.85 AUM/ha
			(.75 AUM/acre)

Table 2. Stock count table.

Livestock class	Measure	Quantity Before seeding	Quantity After seeding
Weight:			
Heifer weaners	kg (lbs)	161 (355)	170 (375)
Steer weaners	kg (lbs)	180 (395)	189 (415)
Cull cows	kg (lbs)	420 (925)	420 (925)
Cull bulls	kg (lbs)	545 (1,200)	545 (1,200)
Production parameters:			
Weaned calf rate	%	.80	.85
Replacement rate	%	.20	.20
Death loss-cows	%	.03	.03
Death loss-bulls	%	.07	.07
Bull-cow ratio		1:20	1:20
Initial inventory:			
Brood cows	no.		480
12 mo. replacements	no.		125
24 mo. replacements	no.		120
Bulls	no.		30

total variable costs. Table 3 shows per unit variable costs and per unit returns included in the model. Hired labor and operator labor for the ranch were included in the raise-cow-cost activity at $6.00 per hour. An opportunity cost for the operator's management was not included. Other costs not included in the model were costs of horses, depreciation, taxes, interest, and insurance.

Table 3. Costs and returns for major representative ranch activities.

Activity	Measure	Cost/unit ($)
Cost:		
Establish crested wheatgrass[1]	ha	$ 46.42
Grow and harvest meadow hay	ha	62.30
Graze BLM rangeland	AUM	1.40
Graze deeded rangeland	AUM	0
Graze meadow pasture	AUM	0
Graze meadow hay aftermath	AUM	0
Purchase grass hay	kg	.09
Raise cow[2]	head	155.11
Lease private range	AUM	5.70
Return:		
Sell weaner heifer[3]	kg	1.34
Sell weaner steer[3]	kg	1.65
Sell cull cow[3]	kg	.95
Sell cull bull[3]	kg	1.17

[1]Variable costs, Sonnemann, et al., 1981.
[2]Includes labor, salt and minerals, veterinary and medicine, fuel (haying not included), accounting, brand inspection, repairs and maintenance (haying not included), fence repairs, marketing, utilities, and protein supplement.
[3]Average price per kg received 1979-1981.

Forage nutrient quality and forage availability from any particular source in each grazing period were accounted for in the model. Seasonal variation in forage quality may be a binding constraint on animal production (Cook and Harris 1968). Total nutrient quality of range forage is highly correlated with the single variable of digestible protein (Cook et al. 1977). Minimum digestible protein requirements for the various livestock classes were included in the model to account for seasonal nutrient variations (National Research Council 1976, Cook and Harris 1968). Metabolizable energy requirements were also incorporated to assure adequate winter feed requirements are met. Maximum daily intake, however, was restricted to 2.3% of body weight to prevent unrealistic livestock feed intake values. After establishment, crested wheatgrass was an early season forage substitute for BLM and deeded native range forage. Unused BLM and deeded native range forage was carried forward in the model one grazing period. For example, 50 deeded AUM's (Animal Unit Months) not consumed 15 May–14 June were available 15 June–14 July but were not available during the 15 June–14 September grazing period.

In the analysis, an LP solution was initially obtained for the representative ranch having an adequate but low quality supply of early spring pasture. Based on activity levels of this solution, constraints for successive models were established. Seeding of crested wheatgrass then occurred on 1,012 ha of private rangeland. Seeding 1,012 ha results in a loss of 125 AUM's for 2 years of deferment following seeding. This 125 AUM's were based on 8.1 ha per AUM (Mitchell and Garrett 1977). Deeded land was assumed to be available for lease during these 2 years at a cost of $5.70 per head per month, an average of values provided by a sample of Elko ranchers. This lease charge was the only additional cost accounted for as a result of seeding.

After successful conversion to crested wheatgrass, the 1,012 ha are assumed to provide 833 AUM's, or 1.24 ha per AUM, April 15–June 14 (a personal communication with R.A. Evans, range scientist, USDA, ARS, Reno, Nev.). A separate constraint was added to the model to account for the crested wheatgrass forage source. A crested wheatgrass stand life of 20 years, with constant annual production, was evaluated. Many factors influence productive life of a stand, but crested wheatgrass seedings have remained in use for 30 years or more (Hull 1972).

If an increase in herd size occurred in the ranch model following establishment of crested wheatgrass, heifer calf sales were reduced in years prior to availability of crested wheatgrass. Fewer weaner heifers were sold during year 2 to adjust herd size to the anticipated increased forage availability. These heifers mature and are productive at the time the seeding is available in year 4.

Permanent increases in weaning weight and calving percentage were assumed to occur following seeding. Weaning weights increase by 9.07 kg (20 lb) per calf in the initial year of crested wheatgrass grazing. Calving percentage increases 5 percentage points during the second year of crested wheatgrass grass availability. These values may be conservative estimates of production increases attainable by seeding crested wheatgrass. Weaning weight increases of 9.08 kg were assumed by Kearl and Cordingly (1975), and pasture research results of 10–16 kg were reported by Cook (1966) and Springfield (1963). Differences in calving percentages between native range and seeded pasture of 10–30% have been reported by Frischknecht (1965) and Houston and Urick (1972). Kearl and Cordingly (1975) assumed an 8% increase.

Although cattle production increases were assumed in this study as a result of improved forage availability, factors other than crested wheatgrass seeding may influence the amount, if any, of these increases. Livestock nutrition in the spring prior to seeding establishment may be at a level such that spring forage from crested wheatgrass will not affect animal production. Increases in calving percentages may result from cows and bulls grazing together in a more concentrated area rather than from the seeded pasture itself (Houston and Urick, 1972). Changes in stocking rates prior to and following seeding may also influence animal production response. For ranchers planning to expand existing range areas of crested wheatgrass, the impact on animal production will likely be less than if cattle change from a native forage only situation to a native forage and crested wheatgrass situation.

Changes in management practices and cattle production, which were assumed to occur from one year to the next during crested wheatgrass establishment, are shown in Table 4. These livestock production increases were assumed to be maintained throughout the life of the crested wheatgrass stand.

Differences between ranch net returns above variable costs prior to seeding and following seeding were calculated for each year. Present value of added net returns was then calculated to place all current and future costs and incomes on a comparable basis. Costs and incomes were discounted in the year they occurred.

A discount rate (r) of 6% was used. The average yield on U.S. Treasury bonds was approximately 12% (Wall Street Journal, April, 1984). The expected rate of inflation was assumed to be 8% annually with a risk premium of 2% such that:

Table 4. Annual changes/actions made during seeding establishment.

Year	Establishment action
1	Year of seeding 1012 ha (2500) acres of crested wheatgrass; cost of seeding incurred in fall.
2	Private pasture is leased to account for loss of 125 AUM's of deeded range; and, lease cost incurred. If herd size increase is anticipated following crested wheatgrass availability, fewer heifers are sold to build up herd size; lower revenue from heifer sales; and deferment of crested wheatgrazing.
3	Lease cost incurred; increased grazing fees if heifers are being kept to mature as cows in anticipation of crested wheatgrass availability; deferment of crested wheatgrass grazing.
4	Crested wheatgrass available for grazing; cow herd increases (if possible) as heifers not sold in previous years are now mature; increased calf weaning weights of 9.07 kg per head.
5	Full benefits of crested wheatgrass realized as cow calving percentage increase of five percent is attained, along with calf weight increases.

$$r = 12\% - 8\% + 2\%$$
$$r = 6\%$$

This represents a real rate of interest because all per unit income and costs were in constant dollar values. Lower (higher) rates of discount, reflecting lower (higher) levels of risk or higher (lower) rates of inflation will yield higher (lower) net present values (NPV's) than those reported in this study.

Results and Discussion

Based on resource levels obtained from the initial optimal solution, net income impacts of varying resource levels upon profitability of seeding crested wheatgrass were examined. For the representative ranch with adequate spring forage, seeding crested wheatgrass was profitable, assuming calving percentage and weaning weight increases occurred (Table 5). Seeding allows delayed grazing of nonimproved range in a later season. Cow herd size was not expanded, however, because forage sources in other feeding periods were physically limiting and purchase of grass hay was not economical. Crested wheatgrass became an excess range forage source. Ranch net returns increased following seeding because of decreased BLM forage purchased, increased calving percentage, and increased weaning weights.

For comparison, the profitability of seeding crested wheatgrass with no assumed cattle production increases was also examined (Table 5). Seeding with no change in calf weight and calving percentage did not produce a positive NPV. This range improvement project was not profitable because crested wheatgrass was an excess forage source. With no cattle production increases assumed, the project produced no additional revenue, although it did reduce costs by decreasing BLM grazing purchased and hence, decreasing BLM grazing fees paid.

Hayland Resources

Amount of ranch hayland was varied 50% to determine the effect on profitability of seeding ranches that differ in relative quantities available of this forage source. As shown in Table 5, discounted added net returns from seeding were increased 13% on a ranch which has 50% greater meadow hayland (786 ha relative to the representative ranch situation of 524 ha). Ranches with relatively large meadow hayland resource levels have a source of low cost fall and winter forage enabling herd size to expand beyond the size limited in the "just adequate" initial forage case. With a 50%

Table 5. Economic effects of crested wheatgrass seeding with varying forage resource availabilities on a representative ranch, Elko County, Nevada.

Resource quantity relative to initial level	Net Ranch Income ($)		NPV of added net returns @ 6% disc rate (20 Yrs.)	Cow herd size	
	Before seeding	After seeding		Before seeding	After seeding
Seeding:					
With no cattle production increases	$30,721	$31,765	$-39,796	480	480
With cattle production increases	30,721	44,884	60,720	480	480
Meadow hayland:					
+50%	30,721	47,055	68,624	480	505
-50%	16,094	23,351	7,614	240	240
Deeded range:					
+50%	31,482	45,808	62,042	480	480
-50%	20,019	30,924	31,278	317	330
BLM range:					
+50%	30,721	44,884	60,720	480	480
-50%	17,535	37,294	57,969	264	394

increase in meadow hay availability, full use of the seeding, and delayed seasonal use of native range forage enabled complete utilization of all forage resources. The increase in herd size of 25 head contributed to the largest positive NPV of added net returns obtained of investment scenarios examined.

A ranch with 50% less meadow hayland available (262 ha) than the representative operation had the lowest positive NPV of the seeding investment alternatives analyzed (Table 5). In this situation, the reduced amount of low cost fall and winter feed, compared to the representative ranch, resulted in a smaller economically optimal herd size. Smaller herd size created an excess supply of crested wheatgrass and other range forage. Lower returns were obtained because of the smaller number of livestock sold. NPV was positive but low, relative to other alternatives evaluated in the study.

Deeded Range

A ranch with 50% greater deeded range capacity than the representative ranch yielded the second largest added NPV (Table 5). Increased net returns in this model were a result of reduced BLM grazing fees paid as more deeded land was available. Herd size was not increased, however, due to the limited availability of all other forage sources, particularly meadow hayland. Purchase of grass hay was not profitable in this model.

The 50% smaller deeded range capacity yielded lower, but positive added net returns compared to the increased deeded forage operation. Although operations were assumed to have equal maximum quantity of BLM forage available, the smaller amount of available deeded range limited the amount of BLM forage used, causing a smaller optimal herd size. Crested wheatgrass became a complementary forage source for the 50% lower deeded capacity by enabling deferred use of deeded land later in the grazing season. This availability of later forage, with crested wheatgrass providing early season grazing, enabled expansion of herd size by 23 cows (Table 5).

BLM Range

Under model assumptions, 50% more BLM forage available had no effect on NPV of the investment, all else constant (Table 5). No herd size difference existed due to equal hay resources. A larger amount of public rangeland, other forage source quantities equal, did not alter the profitability of crested wheatgrass relative to the representative ranch case. The additional BLM forage was not purchased.

Fifty percent less BLM forage available, accompanied by crested wheatgrass seeding, yielded NPV of added returns slightly less than those obtained in the representative ranch model (Table 5). A herd

size increase of 130 head occurred after the investment was made. Because 32% of the ranch's spring and summer forage was supplied by public range, seeding crested wheatgrass became a profitable complement to this forage source. As in the case of limited deeded range, deferred BLM forage use combined with spring crested wheatgrass availability enabled additional grazing. Herd size expansion was possible because other resources, at the representative ranch level of availability, were in excess supply prior to seeding.

Summary and Conclusions

Based on NPV investment criterion and assumptions made in this study, removing sagebrush and seeding crested wheatgrass was a profitable investment for a representative Elko County, Nev., cow-calf operation. The degree of profitability, however, was influenced by the availability of certain other ranch forage sources. Availability of relatively low-cost winter feed (ranch produced meadow hay) had the largest impact upon profitability of the investment. An excess amount of this resource enables herd size to expand and fully utilize the new forage source. NPV of the investment also increases, if excess deeded range is available.

Increases in calf weaning weights and calving percentages were assumed to occur as a result of cattle grazing the improved forage source. Production increases assumed in this study should be realistic objectives for many cow-calf operators. If high levels of management and nutrition are provided before seeding, these increases in animal production may not be achieved.

An operator considering investment in crested wheatgrass to provide early spring forage should consider herd size adjustments desirable during years of seeding establishment. This analysis assumed additional deeded land was available for lease to maintain herd size prior to availability of the seeding. If additional land is not available, other feed sources may be too costly for crested wheatgrass to be a profitable investment.

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