ECONOMICS INFORMATION REPORT

COSTS AND BENEFITS OF FESCUE PASTURE RENEWAL

By

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ECONOMICS INFORMATION REPORT
DEPARTMENT OF ECONOMICS AND BUSINESS
NORTH CAROLINA STATE UNIVERSITY AT RALEIGH

Economic Information Report No. 76

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October, 1987

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Introduction

Wide variations in animal performance on Tall Fescue pasture and hay have been observed since the inception of the grass in the 1940s. Three animal syndromes have been associated with the consumption of Tall Fescue by ruminants: fescue foot, fat necrosis, and poor animal performance or fescue toxicosis. Poor animal performance can mean lower milk production per cow, resulting in poor weight gain by nursing calves, poor weight gain by grazing calves, and lower breeding performance by cows and heifers. Many of the symptoms of the syndrome are observed during warm weather, although consumption of fescue hay during winter also can lead to poor animal performance.

It is widely believed that fescue toxicosis is associated with a fungus growing inside the fescue plant. The highest concentration of the fungus is found in the plant stems and seedheads. The fungus is apparantly not harmful to the plant itself. It is believed that transmission of the fungus infection is accomplished only between generations of plant, through the seed. Increasing levels of infection have been associated with increasing reductions in animal performance.

It is now possible to test by laboratory analysis for the presence of the fungus in fescue pasture plants, hay, and fescue seed. The test of vegetative tillers can tell a farmer what percentage of the material tested is infected. The seed test has allowed seed vendors to supply the market with adequate quantities of seed certified as fungus free. The availability of fungus-free seed allows production of fescue forage that ruminants can consume without bad effects. The purpose of this bulletin is to provide information that will contribute toward an informed choice among alternative methods of combatting the effects of the fungus in a beef cow-calf operation.

Methods of Combatting the Effects of Fescue Fungus

The first step toward control of the effects of fescue fungus on animal performance is to determine the degree of infestation. This is achieved by sampling each pasture used to produce feed for animal consumption.[1] Once the samples are tested and each field is assigned a level of infection, a pasture (field) renewal plan can be worked out. The renewal plan will include methods to control the presence or effects of the fungus, a schedule of pasture renewal, and interim feed sources for periods while renewal is taking place.

The methods to combat the effects of the fungus are:[2]

1) Destroy the stand of infected fescue, reseed with fungus-free fescue seed and clover.
2) Grow clover with the infested fescue.
3) Minimize animal consumption of fescue plant stems and seeds during periods of highest infestation and animal stress.

Method 1 is called reestablishment. The existing stand may be chemically destroyed in the spring or in late summer. If destroyed in the spring, a summer annual crop may be grown before reseeding. In either case, reseeding is

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[1] Samples may be sent to the Forage Testing Lab in Raleigh. The fee is $15 per sample. Advice on sampling procedures may be obtained from your county agent. If it is necessary to limit the number of samples submitted, try to submit samples from fields in which animal symptoms seem most severe.

[2] See J.T. Green, J.P. Mueller, and L.M. Lewis, "Tall Fescue Endophyte," Forage Crop Production, Forage Memo No. 16, February, 1985, NC Agricultural Extension Service, for a complete description of these methods.

accomplished in the fall and animals that may have been scheduled to graze on this acreage must be diverted to another feed source until the following spring. A schedule of operations for all the methods is presented in Table 1.

Table 1. Fescue Pasture Renewal Options

	Kill Options		No-kill Option
	Spring Kill	Summer Kill	Fall Clover
Season	A	B	C
Spring	Kill Fescue Plant summer crop Graze elsewhere	[----------------2 cuttings of hay-----------------] or graze	
Summer	Grow & Harvest summer crop Graze elsewhere	Kill Fescue June 30th Graze elsewhere	[------1 cutting of----] hay or graze
Fall	[---------------Reseed with clover/fescue mix---------] Graze elsewhere		Renovate with clover Graze elsewhere

Method 2 is called renovation. The existing stand is left intact and overseeded in the fall with clover. Clover is not susceptible to fungus infection and its prescence in the diet dilutes the effects of the fungus-infected fescue. During fall, while the clover is becoming established, cattle should be moved to another feed source. The renovated pasture will become available for grazing the following spring.

Method 3 is a set of management practices that has long been advocated for beef cattle and other ruminants grazing fescue. The set of practices includes 1) limiting summer consumption of fescue, 2) keeping seedheads from forming and 3) keeping the plant in a state in which the ratio of leaves to stems is high, either by frequent clipping, intensive grazing, or application of chemicals. This method is not included in the economic analysis that follows because of the difficulty of estimating costs and benefits. It is recognized that this method of control will be used predominantly for pastures with low levels of fungus infection or for pastures with highly erodible soils for which methods 1 and 2 are impractical, and as an interim technique for use in pastures to be renewed in the future. Elements of this method may continue to be practiced even on fescue pastures that have been renewed because animal performance is still poor on fescue with a high ratio of stems.

The Costs of Pasture Renewal

Establishment Years

When renewing a perennial crop such as Tall Fescue pasture, costs are usually divided into establishment (first-year) costs and maintenance (subsequent-year) costs. Establishment costs for three reestablishment options and a renovation option are shown in Table 2. Cost categories are distinguished by the season in which the cost is incurred and by the operation performed.

In Table 2, each acre in the establishment year is charged a cost for killing (spring and summer options), a cost for planting a summer temporary crop (spring option), a charge for seeding with grass or a clover-grass mixture and interest on money invested. In addition, because a cow-calf operator is not likely to sell his cows while renewing his pastures, and because he will not be able to graze the renewed area until the following spring, each acre is charged for the value of temporary feed during renewal. If an operator is understocked on the acres he is not renewing, he may obtain temporary feed cheaply simply by raising the stocking rate on the nonrenewed acreage. If he is correctly stocked on the nonrenewed acreage, he must provide the necessary feed either by renting in more pasture,

Table 2. First-Year Investment Costs for Alternative Fescue Pasture Renewal Options

	Reestablishment						Renovation	
	Spring Kill		Summer Kill				Fall Renovate	
	Plant Clover/Grass		Plant Clover/Grass		Plant Grass		Clover/grass	
Season	Cost Category	Cost ($/ac)	Cost Category	Cost ($/ac)	Cost Category	Cost ($/ac)	Cost Category	Cost ($/ac)
Spring Apr-June	Kill fescue(a)	22.00		0		0		0
	Plant Corn(b)	126.53		0		0		0
	Pasture rent(c)	9.00		0		0		0
	Interest(d)	11.03		0		0		0
	Total Spring	168.56		0		0		0
Summer Jul-Aug	Pasture rent	6.00	Kill fescue	22.00	Kill fescue	22.00		0
	Interest	.24	Pasture rent	6.00	Pasture rent	6.00		0
	Harvest & store Corn Silage(g)	100.00	Interest	1.12	Interest	1.12		0
	Total Summer	106.24	Total Summer	29.12		29.12		0
Fall Sept-Oct.	Sodseed clover & fungus free grass (e)	142.94	Sodseed clover & fungus free grass (e)	142.94	Sodseed fescue grass seed	131.00	Renovate existing fescue stand (f)	133.94
	Pasture rent	6.00	Pasture rent	6.00	Pasture rent	6.00	Pasture rent	6.00
	Interest	2.98	Interest	2.98	Interest	2.74	Interest	2.80
	Total Fall	151.92	Total Fall	151.92	Total Fall	139.74	Total Fall	142.74
	Total Cost A	426.72	Total Cost B	181.04	Total Cost	139.74	Total Cost C	142.74
	Silage Value (h)	252.00		-----		-----		----
	Net Renewal Cost	174.72	Net Renew Cost	181.04	Net Renew Cost	139.74	Net Renew Cost	142.74

(a) 2 applications paraquat.
(b) Variable cost for planting corn from NCSU budget #70-5 + $8.00/acre for sod planter rental.
(c) Charged at $3.00/cow/month with stocking rate of 1 cow/acre.
(d) Interest at 1 percent/month from beginning of period to mid-November.
(e) Variable cost from NCSU budget #87-1 plus $10.00/ac for grain drill rental; also 15 pounds of fescue seed at $1.00/lb. Each treatment contains application of two tons of lime.
(f) Variable cost from NCSU budget #87-3 plus $10.00/ac for grain drill rental; also 15 pounds of fescue seed at $1.00/lb. Includes two tons of lime.
(g) Variable cost for harvest, haul, pack, plus dry matter loss.
(h) Assumes 14 tons of silage/acre at $18/ton (6 bu/ton * $2.50/bu + $3).

buying feed,[3] or adding more nitrogen to increase production on temporary pastures. In Table 2, it is assumed he is able to rent pasture for a portion of the year.

The spring option in the establishment year will produce some feed during the summer before seeding. In the example in Table 2, the crop grown during the summer is corn silage. The value of this crop is assumed to be 14 tons produced per acre at $18/ton. The figure at the bottom of the spring option column in Table 2 is net of this silage value. Under these assumptions it appears that the spring option is less expensive than the summer clover-grass option. This conclusion might change for different corn silage yields or prices.

The longevity of the renewed fescue stand in this analysis is assumed to equal that of the infected stand. There is no research evidence for this assumption, since fungus-free seed has been available only a few years and no long-term experiments have been completed to test for differences in longevity. It is possible that the assumption of equal longevities is wrong, since the presence of fungus in fescue may combat fescue's natural enemies. Loss of the fungus may subject fescue to more continuous defoliation, possibly cutting short its long life.

Maintenance Years

Maintenance-year costs for all renewal options begin the spring following planting. Maintenance-year costs for clover-grass mixtures can be as low as 50 percent of those for grass alone primarily because of savings on nitrogen application. However, lime, phosphorus and potassium requirements are slightly

[3] The cow-calf operator may choose to feed his animals on pasture he already owns or out of reserve hay stocks. In either case, he is giving up something that has another use and so should be charged at the return that other use would have earned.

higher for clover-grass mixtures than they are for grass. In addition, clover may have to be reestablished in a mixed sod as frequently as every two years, although the average stand life may be highly variable. The factors affecting clover stand life are legume species, soil type, weather, and grazing management. It is possible that under adverse conditions, average lifetime maintenance-year costs for clover-grass mixtures will exceed those for grass alone.

Table 3 gives maintenance-year costs for a fescue stand and for a mixed fescue-clover stand. In the maintenance years the fescue-clover stand requires 10 pounds more phosphorus (P_2O_5) and 20 pounds more potassium (K_2O), but requires none of the 150 pounds of nitrogen required by the pure grass stand. Every third year is a liming year for both stands, with lime requirements for the fescue-clover stand double those for the fescue stand. In addition, renovation is assumed to take place every third year. The cash flow difference generated is: first and second years: $27 savings/acre/year to fescue-clover; third year: $36 savings/acre/year to fescue. These cash flows are incorporated in the calculation of Net Present Value of fescue renewal investment in the sections below.

Benefits of Pasture Renewal

A primary benefit of pasture renewal is avoidance of negative animal performance associated with fescue fungus. With renewal, it is expected cows will produce more milk, calves will experience a faster weight gain, and breeding performance may be improved. For pastures with low levels of fungus infestation, the benefits to renewal will be small and for those with high levels, the benefits will be large. In this section, an attempt is made to estimate specific monetary values for renewal of pastures with differing fungus infestation levels. The best use of the pasture is assumed to be for a cow-calf operation regardless of

Table 3. Maintenance Year Costs for Fescue and Fescue/Clover Pastures

Fescue					Fescue/Clover				
Category	Units	Price	Quantity	$/Ac	Category	Units	Price	Quantity	$/ac
Operating Inputs[a]									
0-10-20, bulk	cwt.	7.35	4.00	$29.40	0-10-20, bulk	cwt.	7.35	5.00	$36.75
30 % Nitrogen	cwt.	6.25	5.00	31.25					
Tractor Fuel & lube				4.00	Tractor fuel & lube				2.00
Tractor repair				1.50	Tractor repair				.75
Machinery repair				.90	Machinery repair				.45
Total Yearly Operating Costs				67.05	Total Yearly Operating Costs				39.95
Lime, applied every three years	ton	31.00	1.00	31.00	Lime applied every three years	ton	31.00	2.00	62.00
					Renovation every three years (exclusive of lime)				71.94
Total Triennial Maintenance Costs				98.05	Total Triennial Maintenance Costs				133.94

[a] Costs are at levels that equate hay equivalent productivity of fescue to fescue-clover.

fungus infestation level. In the next section, the stream of benefits flowing from renewal is compared to costs of the various renewal options discussed previously.

Since discovery of fescue fungus has been so recent, much is still unknown about how it affects animals. Scientists are currently conducting experiments that examine how different levels of fungus infestation affect levels of milk production, levels of calf or cow gain, and levels of breeding performance. For instance, it is not known if increasing levels of fungus infestation cause decreasing levels of milk production through reduced feed conversion rates or from reduced energy intake. It is not known whether cows can partially compensate to hold milk production levels constant by obtaining needed energy through reserve stores of body fat. It is not known how much gain depression calves will experience at different levels of fungus infestation. It is not known whether the fungus effects on calf gain increase above some minimum threshold or reach points of diminishing marginal cost as levels of infestation increase above some maximal threshold. There is almost no evidence relating levels of fungus infestation to rebreeding ability, even though it is suspected that poor breeding performance may be a result of the presence of the fungus in the diet.

Another area in which information is lacking is that on the effects of different levels of fescue fungus infestation on animal consumption of the grass. Do animals experience poorer performance on grass with high levels of fungus infestation because they eat less than they would with low levels of infestation? Or is poorer performance attributable to poorer conversion of the nutrients consumed? Or both? These are important questions because their answers will help cow-calf operators plan how they might change their management (i.e., stocking rate, fertilizer amounts) should they decide to renew their pastures. If most of the problem is a result of poor conversion of feed (into beef gain or milk), then lowering the fungus level by renewal will require little change in stocking rates if fertilizer amounts remain the same. If however, most of the problem is the result of an animal "going off feed," then animals consuming a renewed pasture will consume more at a faster pace than they would if the pasture remains in its infested state. It is likely that on renewed pastures stocking rates must be lower, the grazing season shorter, supplements to pasture supplied, or higher rates of fertilizer applied. In any case, the benefits to pasture renewal must be adjusted by the costs these changes in management will impose.

In spite of the lack of knowledge about how fescue fungus affects animal feed consumption and performance, cow-calf operators must make informed choices about pasture renewal based on the information that does exist. The following discussion is based on a review of literature[4] on the effects of fescue fungus on animal performance and consumption.

Effects of Fescue Fungus Renewal on Animal Performance

Relation 1[5]. For every 10 percent decline in the percentage of fescue infested with fungus, calf average daily gains (ADG) increase by 0.1 lb/hd/day for the spring and summer grazing season.

Relation 2. For every 10 percent addition of clover to a grass sod, calf ADG increases by 0.1 lb/hd/day up to a maximum of 0.3 lb/hd/day. The grazing season for which this condition holds is the same as in Relation 1.

Effects of Fescue Fungus Renewal on Animal Consumption

Relation 3. Animals consuming fescue infested with fungus experience poor performance because they consume less.

Relation 4. For every 0.1 lb/hd/day increase in daily calf gain, stocking rate (defined as cow-calf units per acre) declines by approximately 3 percent.

The basic model employed is that given in NRC, Nutrient Requirements for Beef Cattle, and is detailed in the Appendix. The basic assumptions are:

1. The dry matter available for consumption per acre per grazing season is constant across all infestation levels and forage species.

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[4] John Steudemann. Unpublished paper presented at North Carolina Cattlemen's Association meetings, February 12, 1986. Raleigh.

[5] Relation 1 is linear throughout the possible range of infestation levels. It is possible and even likely that this assumption is a good approximation only for infestation levels between, say, 30 and 85 percent. Since no evidence exists to define the limits between which the response is linear, this approximation must be accepted with caution.

2. Total consumption per acre per grazing season by the herd is constant across all infestation levels and forage species.

These assumptions imply that it is possible to vary stocking rate continuously. Even though stocking rates cannot be varied that precisely in practice, the purpose behind using these assumptions is to attempt to control for differences in management between improved and unimproved pasture situations. In essence, a comparison is made between a situation in which an infested acre is fully stocked (i.e., all available dry matter is consumed) and one in which a fungus-free acre is fully stocked. Note that these assumptions may bias the results against renewal.

Gross revenue per acre for a cow-calf operation grazing fescue at various levels of fungus infestation is shown in Table 4. Also given are stocking rate, calf sale weights, price assumptions, calving percentage assumptions, and per-cow costs. Stocking rate is expressed as number of cow-calf units per acre over a grazing season. In the example given in Table 4, with a calving percentage of 82 percent, a cow-calf unit consists of 0.82 cow, 0.41 steer calf, 0.41 heifer calf, 0.27 replacement heifer. The grazing season is assumed to begin April 1 and extend through November 3, for 216 days. In the example, beginning weights are steers, 200 lbs; heifers, 180 lbs; replacements, 500 lbs; and cows, 1000 lbs. Season average ADG at zero infestation level is assumed to be: steers, 1.6 lbs/hd/day; heifers, 1.4 lbs/hd/day; replacement heifers, 1.4 lbs/hd/day; cows, 0 lbs/hd/day. Steers, heifers and replacement heifers are assumed to follow the relationship between animal performance and infestation levels. Cows are assumed to maintain body weight throughout the grazing season at all levels of infestation.

While feed demand can be fairly easily characterized, feed supply available to satisfy such demand cannot. An initial assumption is made that 5000 pounds of

Table 4. Savings from Fescue Pasture Renewal, by Fungus Infestation Level. Also Stocking Rates and Net Present of Cash Flows over 20 Year Life of Stand.

						Annual Fungus Savings / Net Present Value		
						Reestablishment		Renovate
Infestation Level[a]		Ending Grazing Weights[c]	Price	Stocking Rate (Cow-Calf units)	Gross Returns per Acre	Clover/grass[d]	Grass	Clover/grass[d]
%		Lbs	$/cwt	CC/ac	$/ac	$/ac %	$/ac %	$/ac %
Initial Investment						$175	$140	$143
Maintenance Year Expenses						$ 40	$ 67	$ 40
Triennial Year Expenses						$134	$ 98	$134
	Steer	654	63					
	Heifer	590	55					
-30	Cow	1000	35	.80	257	---	---	---
	Repl.[b]	910	53					
	Steer	632	63					
	Heifer	567	55					
-20	Cow	1000	35	.83	259	---	---	---
	Repl.	889	53					
	Steer	610	63					
	Heifer	547	55					
-10	Cow	1000	35	.86	260	---	---	---
	Repl.	867	53					
	Steer	589	65					
	Heifer	526	55					
0	Cow	1000	35	.88	266	1.64	---	1.64
	Repl.	846	53			$-29.27		$2.73
	Steer	567	65					
	Heifer	504	55					
10	Cow	1000	35	.91	267	4.21	2.57	2.52
	Repl.	824	53			9.00	-101.72	15.80
	Steer	546	65					
	Heifer	482	56					
20	Cow	1000	35	.94	268	6.37	4.74	2.72
	Repl.	802	53			41.19	-69.59	18.83
	Steer	524	65					
	Heifer	461	56					
30	Cow	1000	35	.97	269	9.64	8.01	8.01
	Repl.	781	53			89.85	-20.88	97.49

Table 4. (Continued)

	Steer	502	65					
	Heifer	439	56					
40	Cow	1000	35	1.00	269	13.30	11.66	9.09
	Repl.	759	53			144.17	33.44	113.53
	Steer	481	67					
	Heifer	418	56					
50	Cow	1000	35	1.04	273	13.26	11.63	6.89
	Repl.	738	53			143.70	32.97	80.87
	Steer	459	67					
	Heifer	396	57					
60	Cow	1000	35	1.07	273	17.11	15.48	7.47
	Repl.	716	53			200.97	90.24	89.48
	Steer	438	67					
	Heifer	374	57					
70	Cow	1000	35	1.11	273	22.14	20.50	8.84
	Repl.	694	54			275.69	164.97	109.89
	Steer	416	67					
	Heifer	353	57					
80	Cow	1000	35	1.14	271	27.65	26.01	14.39
	Repl.	673	54			357.76	247.03	192.42
	Steer	394	69					
	Heifer	331	57					
90	Cow	1000	35	1.18	274	29.88	28.24	12.77
	Repl.	651	54			390.89	280.17	168.29
	Steer	373	69					
	Heifer	310	57					
100	Cow	1000	35	1.22	272	36.56	34.92	14.42
	Repl.	630	54			490.24	379.52	192.91

[a] Negative infestation levels represent the addition of clover to a clean fescue pasture.

[b] Number of replacement heifers sold is 10 percent of cull cow sales. All cows not producing a calf for sale are culled.

[c] For this example, calving percentage is 82, per-cow costs are $123. Calves are born December-January and sold in November. Grazing season is 216 days; available dry matter per acre is 5000 pounds. Clover stand life is assumed to be three years; fescue stand life (infested or not) is assumed to be twenty years. IRR is computed over a twenty-year year period. Initial weights and rates of gain are: steers(200,1.6), heifers(180,1.4) cows(1000,0), replacement heifers (500,1.4), in pounds and pounds per day.

[d] Fungus savings for clover/grass assumes a 30 percent clover-70 percent grass mixture. Fungus savings listed do not account for differences in maintenance and triennial year costs. However, NPV does.

dry matter are available for consumption and that all of it is consumed. This value is varied in the sensitivity analysis below. The supply of forage available under different fungus infestation levels and for various forage specie types has always posed difficult measurement problems. Lacking more research to explain how availability will vary in these situations, the above assumption will suffice.

At sale time at the end of the grazing season, heavier calves receive lower per-hundredweight prices, with steers receiving $2/cwt. less for every 100-pound increase in sale weight, and heifers (including cull replacement heifers) receiving $1/cwt less for every 100-pound increase in sale weight. Cows not producing a salable calf are culled. Replacement heifers in excess of those required to replace cull cows are sold. Per-cow costs include charges for marketing, labor and management, veterinarian services and medicine, interest and depreciation on capital invested in the cow and her portion of the facilities, and other miscellaneous overhead costs.

In Table 4, note that gross income generated by each acre is similar regardless of infestation level. This is because as infestation levels decrease, increases in calf sale weight per cow are offset by reductions in the number of cow-calf units each acre will support. As infestation levels decrease, the proportion of gross revenues generated by the offspring of the cow increases, whereas the proportion generated by the cow herself decreases. Each cow-calf unit an acre is not required to carry represents a savings in per-head costs (veterinarian services & medicine, labor & management, interest, and other expenses).

Fungus savings per acre per year one may expect from engaging in any of the renewal options is shown in Table 4. Fungus savings for reestablishment of grass with clover-grass at a particular infestation level is defined as the difference between gross returns per acre at that infestation level and gross returns at the -30 infestation level less the difference in per-cow costs per acre for the two levels. Negative infestation levels represent the addition of clover to a grass pasture. For reestablishment with grass, fungus savings is found using the same differences computed at a particular infestation level and at the 0 infestation level. For the renovation option, fungus savings is arrived at using the same differences computed at a particular infestation level and at a level 30 percent less infested. For instance, suppose a grass pasture has a 40 percent infestation level. Adding 30 percent clover to this pasture would make it equivalent to a pasture with a 10 percent infestation level. Fungus savings for this action would be: gross return difference ($267 - $269) less per-head per-acre cost difference ((.91 - 1.00) * $123) = $9.07, which differs from the entry in Table 4 ($9.09) because of rounding error.

Total net return to replacement or renovation of grass with clover-grass is a combination of two savings factors. First, changes in gross revenue minus changes in per-head cost savings represent the net savings to elimination or reduction of the fungus. In addition to this effect on net returns, replacement of grass with clovergrass can create additional savings by curtailing nitrogen purchases. In Table 4, fungus savings does not include additions to net returns from this second source.

The lower number in the three right-hand columns of Table 4 is the Net Present Value (NPV) of investments in reestablishment or renovation. NPV is defined as the sum of disounted values of a stream of income over the life of an investment less the amount of the investment. Defined this way, any NPV above zero indicates a profitable investment, given a suitable discount rate.

The repayment schedule used to compute the NPV includes both fungus savings and nitrogen savings for those renewal options that include clover. For instance, spending $175 to destroy a 20 percent infected stand and establish a clover-grass stand (with a clover life of three years) will set up the following repayment schedule.

Year	Repayment Amount[6]	Explanation
1	($ 6.37 + $27.00)	Fungus savings plus maintenance cost difference.
2	($ 6.37 + $27.00)	Same.
3	($ 6.37 - $36.00)	Fungus savings less triennial cost difference.
4	Same as year 1.	

This pattern is set up to repeat itself seven times over the 20-year expected life of a fescue-clover stand.

Making A Decision Among Pasture Renewal Options

Each acre of renewed pasture will generate greater net returns each year than an acre of nonrenewed pasture. It is out of the enhanced proceeds or cost savings that payment for initial renewal costs must come. If one accepts all the assumptions underlying the calculation of NPV for each renewal option, then one may use this measure to rank renewal options as well as to decide whether to do anything at all.

For instance, suppose a sample reading indicates that a pasture is 30 percent infested. Scanning across the 30 percent row in Table 4, the renovation

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[6] Fungus savings at 20 percent are $6.37/acre and nitrogen savings for clover-grass relative to grass are $27 in the first and second years. In the third year, clover must be reestablished in the mixture, so costs more than grass alone. See Table 3.

option provides us with the highest Net Present Value, $97.49 per acre. To compare this NPV with that of other uses of our money, both measures must treat inflation in the same way. The calculation of NPV in Table 4 assumes that the amounts in the repayment schedule are adjusted for inflation.

A minimum real discount rate for many investments would probably be in the 3-to-4 percent range for investments of the duration considered here. If 3 percent is used as a minimum, Table 4 indicates that renovation of a pure grass stand by seeding clover into it will always meet that criterion, regardless of infestation level. This does not necessarily mean this option will always dominate the other two options, for Table 4 shows that if sample infestation levels exceed 40 percent, total reestablishment with a clover-grass stand will dominate. The information also indicates that reestablishment with a clean straight fescue stand will never dominate, but will come close to the clover grass reestablishment option at high rates of infestation.

Sensitivity Analysis

The Net Present Value of various fescue pasture renewal strategies is dependent upon choice of beef prices, price discounts for added weight, per head costs, calving rate, gain-infestation relations, initial calf weights, length of grazing season, length of clover life, and fescue life. In modelling the effect of level of infestation on forage consumption and calf weight, the following critical assumptions were made.

1. Dry matter available for consumption per acre per grazing season is constant across all infestation levels and forage species.
2. Total consumption per acre per grazing season is constant across all infestation levels and forage species.

These two assumptions imply it is possible to vary stocking rate continuously. In spite of this dubious implication, the value of the assumptions is that they do not bias upward the Net Present Value of reestablishment or renovation. They probably do in fact bias downward the estimates of NPV of renewal for those operations that typically understock their pastures.

In this section, some of the variables the values of which are least known will be varied to test for sensitivity of Net Present Value. Results of this analysis are shown in Table 5. In addition to the three renewal options, a fourth option is added. This is the option of investing elsewhere and earning a return of at least 3 percent in real (inflation-adjusted) terms. The numbers in Table 5 give the range of infestation levels at which a particular option dominates all other options when the indicated variable is altered. Only one variable is altered at a time. The first line of the table gives the baseline solution.

Pasture Variables

Clover Life. Because of weather, slope, acidity levels, etc., clover stands may not last the three years assumed in the baseline solution. Assuming a two-year life substantially changes cash flows associated with clover maintenance and renovation. In the baseline solution, renewal with a three-year clover crop paid for triennial renovation costs with three years of nitrogen savings. With a two-year clover crop, renovation costs are incurred more frequently and only two years of nitrogen savings are available to pay for renovation. With a two-year clover crop, infestation levels would have to reach at least 30 percent before renewal becomes preferable to investments in other projects earning at

Table 5. Sensitivity Analysis: Effects of changes in key model assumptions on Domination Range of Fescue Pasture Renewal Options.

Variable Changed	Reestablishment Clover-Grass	Reestablishment Grass	Renovation Clover-Grass	Invest Elsewhere (Return 3 %)
	Domination Range, Percent			
Baseline solution	40 - 100	---	0 - 40	---
Pasture Variables				
Clover, 2 yr. life	40 - 70	70 - 100	30 - 40	0 - 30
Grass life, 15 yrs.	60 - 100	---	0 - 60	---
Available Dry Matter (5000+10*i)	---	---	80 - 100	0 - 80
Animal Performance Variables				
Calving %, - 10 %	---	---	30 - 100	0 - 30
Calving %, (.82-.0005*i)	30 - 100	---	0 - 30	---
Gain rule, - 20%	40 - 100	---	0 - 20	20 - 40
Cow gain, (-.005*i)	60 - 100	---	30 - 60	0 - 30
Financial Variables				
Price discount for weight = 0	20 - 100	---	0 - 20	---
Price discount for weight, dbld.	60 - 100	---	30 - 60	0 - 30
Zero fixed costs	---	---	80 - 100	0 - 80
Maint. cost difference, -20%	40 - 100	---	30 - 40	0 - 30
Triennial cost Diff., +20%	40 - 100	---	20 - 40	0 - 20
M & T cost difference = 0	---	40 - 100	---	0 - 40
Discount Rate	40 - 100	---	10 - 40	0 - 10

Variables are altered one at a time.

i is level of infestation expressed in whole numbers, 0 - 100.

least a 3 percent return. At levels of infestation greater than 70 percent, the straight grass reestablishment option is the most preferable.

Grass Life. On the other hand, suppose that fungus-free grass does not have the longevity of infested grass. Suppose that fescue with any positive level of infestation will last only 15 years before requiring reestablishment. This does not affect the NPV of the renovation option but does affect the NPV of each reestablishment option. As a result, the renovation option is dominant up to the 60 percent infestation level.

Available Dry Matter. Allowing dry matter availability to increase as infestation levels increase causes stocking rates to increase dramatically. Gross revenue per acre rises faster than per cow costs as infestation levels increase. Renovation is the dominant option for infestation levels above 80 percent. Investing funds elswhere dominates for lower infestation levels.

Animal Performance Variables

Calving Percent. A reduction in calving percent raises feed requirements per cow-calf unit because of the extra replacement heifers the unit must carry. Lower calving percent thus means lower stocking rates at each level of infestation. As infestation levels increase, the pounds of calf sold per acre are nearly constant, but the pounds of cow and replacement heifer sold per acre increase. Thus, gross revenues per acre increase with higher infestation levels and at a rate similar to those for per-cow costs. The result is that renovation is the only renewal option that dominates, but it does so only for infestation levels above 30 percent.

When calving percent is allowed to vary negatively with infestation level, the dominating options are very similar to those in the baseline solution.

Infestation-Gain Relationship. The infestation-gain relation was decreased by 20 percent so each 10-percent improvement in fungus infestation level was associated with 0.08 lb/day difference in calf gain. This, of course, reduces some of the benefits to pasture renewal. The result is that the "invest elsewhere" option dominates for infestation levels below 20 percent, the renovation option for levels between 20 and 40 percent, and the clover-grass reestablishment option for levels above 40 percent.

Financial Variables

Price Discounts. Allowing no price discounts for heavier weight calves increases the range over which the clover-grass reestablishment option dominates. Similarly, doubling the discount for added weight causes the "invest elsewhere" option to dominate for infestation levels up to 30 percent. The renovation option dominates for infestation levels between 30 and 60 percent, and the clover-grass reestablishment option dominates for all higher levels.

Zero Fixed Costs. Fixed costs are interest and depreciation on value tied up in every cow-calf unit. If these costs are set at zero, most of the per-cow cost savings associated with lower stocking rates are erased. It makes little sense to engage in any renewal option under these conditions unless infestation levels are very high.

Maintenance Cost Difference. Reducing the cost difference between maintaining fescue-clover and straight fescue by 20 percent shifts much of the advantage that renovation enjoyed in the baseline solution to the "invest elsewhere" option. This reflects the fact that at low levels of infestation, renovation is the dominant option not because of fungus savings but because of savings in maintenance cost.

Triennial Cost Difference. For the same reasons as above, increases in the cost of renovation for three-year clover relative to third-year lime and maintenance costs for straight fescue reduces the range in which the renovation option dominates. When both maintenance and triennial cost differences are set equal to zero, three-year clover in any renewal option loses its dominance at all levels of infestation. The reestablishment of straight fescue dominates for infestation levels above 40 percent.

Discount Rate. Increasing the discount rate reduces the value of future income relative to present income. Raising the discount rate to 4 percent increases the minimum infestation level required for renewal action from 0 to 10 percent.

Future Research

The areas are many for future research of fescue fungus effects on animal performance and consumption. First, it must be determined how ingestion of the fungus affects the animal. Is it a toxic effect that reduces the rate at which the animal is able convert feed into product, or is it an appetite-depressant? How does the fungus affect an animal's ability to rebreed, its fetal growth, and abortion incidence? Do different breeds of animals respond differently to the presence of fungus in fescue material.

Second, how long will fungus-free fescue live under different management regimes? Will fertilizer response be the same for fungus-free grass as that for infested grass? What is the longevity of the plant if attacked by insects? Finally, What is the gain response difference under pasture neglect?

Third, How should management practices be altered in a fungus-free fescue situation? Should fertilizer amounts be increased? What stocking rates should be recommended?

Finally, it appears that farmers are slow to adopt the new fungus-free varieties of fescue. Why? A large part of the savings to be gained from replacement of the older varieties is reduction in per-head fixed costs for renewed acre. A large portion of these per-head costs is the interest and depreciation on the value of the cow. Beef cow-calf producers are notorious for ignoring these costs, or at least they see them as counterbalanced by many of the nonpecuniary benefits associated with producing beef calves. The solution to the baseline model is very sensitive to the level of fixed costs. This is illustrated in Table 5.

Conclusions

Advising beef cattle farmers about investment decisions when it is known their fescue pastures are infested with endophyte is difficult because of the large amounts of money involved, the many years until payback, and the many uncertainties about new varieties of fescue. The conclusions drawn in this paper offer some useful guidelines to those charged with advising farmers. Some general conclusions follow.

1. For areas in which growth can be expected for at least three years or more, results indicate it is always a good idea to use clover in pasture regardless of infestation levels.
2. For beef cow-calf operations with fescue fungus infestation levels above 40 percent, it is economically feasible to destroy infested fescue and replant with fungus-free varieties providing future research shows that new varieties have longevity comparable to that of the older varieties.

3. Operations that produce higher value per acre than do beef cow-calf operations (such as stocker operations or dairies) can probably tolerate lower minimum levels of infestation.

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APPENDIX

The procedure to calculate stocking rates for different levels of fescue infestation is given below. The assumptions are the following:

1) At each level of infestation the pasture is fully stocked. That is, at all stocking rates the pasture will be fully consumed in a given period at all infestation rates.

2) All animals start at a given weight at the beginning of the spring grazing season. This weight is the same for all infestation levels.

Procedure A: Compute array of daily gains by animal class and infestation (i) level using

$$g_{ji} = g_{j0} - B_j * (i) , \quad (1)$$

where j = steer, heifer, cow, replacement heifer, and i = percent of infestation, i.e., 10, 20,..., and B_j = gain rule for jth animal class, i.e., $B_j = 0.01$, except for cows. Average Daily Gain (ADG) for the jth class of animal grazing at the ith level of infestation is g_{ji} in pounds/hd/day.

Procedure B: Compute array of midweights by animal class and i level using

$$\bar{W}_{ji} = W^0_{ji} + g_{ji} * d/2 , \quad (2)$$

where W^0_{ji}= the initial weight of jth class of animal at beginning of the grazing season, and d is the length of the grazing season in days.

Procedure C: Compute array of Megacalorie requirements for each class of animal at each level of infestation using the net energy system for maintenance and gain.

<u>Maintenance (Mcal/hd/day)</u>

$$NE^{r}_{mji} = .043 * (\bar{W}_{ji})^{.75} \tag{3}$$

<u>Steer Gain (Mcal/st/day)</u>

$$NE^{r}_{gsi} = .000778 * g^{2}_{si} * (\bar{W}_{si})^{.75} + .01322 * g_{si} * (\bar{W}_{si})^{.75} \tag{4}$$

<u>Heifer Gain (Mcal/hf/day)</u>

$$NE^{r}_{ghi} = .001439 * g^{2}_{hi} * (\bar{W}_{hi})^{.75} + .01405 * g_{hi} * (\bar{W}_{hi})^{.75} \tag{5}$$

<u>Pregnancy requirements (Kcal NE^{p}_{m} /cow/day)</u>

$$NE^{p}_{m} = \int_{0}^{N} cw*(.00677-.0000185*t)*exp(.05883*t-.0000804*t^{2})/N, \tag{6}$$

where cw = calf birth weight (lbs), t = days since conception, and N is the last day of gestation that the cow is on pasture. This adjustment is added to maintenance requirements for cows and replacement heifers.

<u>Procedure D</u>: Compute daily intake for each class of animal and each i level using

$$IT_{ji} = (NE^{r}_{gji} / ne^{a}_{g}) + (NE^{r}_{mji} / ne^{a}_{m}) , \tag{7}$$

where ne^{a}_{g} is net energy available for gain per pound of forage dry matter and ne^{a}_{m} is net energy available for maintenance per pound of forage dry matter. IT_{ji} is daily pounds of dry matter intake by the jth class of animal at the ith infestation level.

Procedure E: Compute intake on a cow-calf unit basis, assuming constant herd size and a given calving rate. Compute stocking rate by dividing available dry matter per acre by season-long intake per cow-calf unit. A cow-calf unit is defined as C_i cows, $C_i/2$ steers, $C_i/2$ heifers, and R_i replacement heifers.

$$IT_i = IT_{si} * (C_i/2) + IT_{hi} * (C_i/2) + IT_{ci} * (C_i) + IT_{ri} * (R_i) , \qquad (8)$$

where IT_i is daily intake per cow calf unit at ith infestation level,

C_i is calving rate per cow per year at ith infestation level, and

R_i is the number of replacement heifers held at ith infestation level.

Assume $R_i = (1 - C_i)/(1 - r*(1 - C_i))$,

where r is culling rate for first calf heifers divided by the culling rate for cows. In the example, r = 1.5. Also,

$$S_i = ADM / IT_i \qquad (9)$$

where S_i is season average stocking rate at ith infestation level expressed in cow-calf units per acre and ADM is available dry matter per acre.

Procedure F: Compute Gross Return per acre for each infestation level using

$$GR_i = (C_i/2) * S_i * W_{si} * P_s(W_{si}) + (C_i/2 - R_i) * S_i * W_{hi} * P_h(W_{hi})$$
$$+ (1 - C_i) * S_i * W_{ci} * P_c(W_{oi})$$
$$+ (R_i + C_i - 1) * S_i * W_{ri} * P_r(W_{ri}) \qquad (10)$$

where GR_i = gross return per acre for ith I level,

W_{ji} = ending weight of jth class of animal at ith infestation level, and

$P_j(W_{ji})$ = price function for jth animal at ith infestation level.

The price functions are: for steers, subtract 2 cents/lb for every 100-pound increase in weight; for heifers, the discount is 1 cent/lb; for cows, no discount for added weight.

Procedure G: Compute Fungus Savings for each infestation level relative to the zero infestation level.

$$FS_i = (GR_0 - GR_i) + (S_i - S_0) * H , \qquad (11)$$

where H is per-head costs (\$123), marketing charges (\$10), labor and management (\$21), veterinarian & medicine (\$11), interest and depreciation on a \$500 cow (\$81), and miscellaneous (\$0).

Procedure H: Compute Net Present Value:

$$NPV = -I_k + \sum_{t=1}^{20} [(FS_{ki} + MC_k)/(1+d)^t] , \qquad (12)$$

where I_k is intital investment for the kth renewal option, MC_k is maintenance and triennial cost differences between a treatment containing clover and one not containing clover.

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