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Using a marginal criteria to determine optimal fungus-free fescue establishment

Jeffrey L. Adkins

To the Graduate Council:

I am submitting herewith a thesis written by Jeffrey L. Adkins entitled "Using a marginal criteria to determine optimal fungus-free fescue establishment." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Larry Van Tassell, Major Professor

We have read this thesis and recommend its acceptance:

Dan McLemore, Kim Jensen

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Associate Vice Chancellor
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USING A MARGINAL CRITERIA TO DETERMINE OPTIMAL FUNGUS-FREE FESCUE ESTABLISHMENT

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Jeffrey L. Adkins

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DEDICATION

This thesis is dedicated to my parents

Mr. Virgil Edward Adkins

and

Mrs. Carolyn Lee Adkins

who have given me invaluable educational opportunities.

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ABSTRACT

A marginal revenue criteria was used to determine what reduction in average daily gains from fescue toxicity could be tolerated before it was economically profitable to establish endophyte-free fescue pastures. The current expected net revenue from infected pastures was compared with average net revenue generated from the establishment of endophyte-free pastures. Using the marginal criterion, when net returns from the current infected pasture operation are equal to or less than the "average" annual returns anticipated from establishing a fungus-free pasture, fescue renewal is profitable.

A 10 to 15 percent reduction in average daily gain was required under the assumed conditions before pasture renewal was undertaken. When uncertainty of the stand life was incorporated into the analysis, a further 4 percent reduction in average daily gain was required before establishment was profitable. When no value or decreased value was assumed for crops from the establishment of fungus-free pastures, a further reduction in average daily gain was tolerable. The discount rate and planning horizon also influenced the timing of pasture renewal.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

For many years beef producers have noticed wide variations in animal performance when grazing animals on tall fescue (Festuca arundinacea Schreb.) pastures. Recently these variations have been associated with an endophytic fungus (Acremonium coenophialum Morgan-Jones and Gams) found in tall fescue. The fungus is not harmful to the plant (Bacon and Siegel, 1988), but presence of the fungus is associated with substantial reduction in animal performance (Fribourg et al., 1988). The reduction in animal performance has been attributed to decreased dry matter intake but may also be associated with hormonal changes and other factors currently unknown (Crawford et al., 1989). General symptoms of the presence of the fungus on animal health include elevated body temperatures, increased respiration rates, failure to shed winter coat and poor blood circulation in feet and tail (Fribourg et al., 1988). The poor performance results in lower average daily gains (ADG) which affects the profitability of the stocker steer industry. Fertilization, inclusion of legumes in the sod, and appropriate management practices can improve productivity and quality of fescue fields (Fribourg et al., 1988).

Tennessee has over 3 million acres of tall fescue. According to the Plant and Pest Diagnostic Center in Nashville, less than 5 percent of all Tennessee pastures tested have had infestation levels below 10 percent. The average level of infestation has been 74 percent (Chestnut et al., 1990). A study conducted by the University of Tennessee Animal Science Department at the Ames Plantation Research Facility showed that steer ADG and beef production were depressed when as little as 22 percent of the tall fescue-clover pasture was infected with the endophytic fungus (Chestnut, et al., 1990). These figures indicate a substantial problem for Tennessee stocker steer producers. The fescue toxicity problem across the state is costing the beef cattle farmers an estimated 60 million dollars a year due to lower calf weights and fewer calves (Burns, 1989).

There have been several studies pertaining to the effects of endophyte fungus on average daily gains (Crawford et al., 1989; Jackson et al., 1984; Schmidt et al., 1982; Stuedemann and Hoveland, 1988). Generally, steer ADG has been increased from 30 to over 100 percent by shifting from high to low endophyte pastures (Stuedemann and Hoveland, 1988). One study showed that ADG ranged from 1.4 to 1.6 lb/day for low endophyte infected pastures (Schmidt et al., 1982). Another study showed ADG to range between 1.02 and 1.62 lb/day for low levels of endophyte infected pastures (Crawford et al., 1989). These studies reveal variation in average daily gains at the same infestation level.

It also appears that endophyte-free varieties of fescue are more difficult to establish and uncertainty exists concerning how long the new stands will endure before they must be reseeded or reestablished. Small plot observations indicate the potential productivity of endophyte-free tall fescue is lower than other grasses in the lower South (Gates and Wyatt, 1989). Persistence of endophyte-free fescue was also poor in grazed pastures, and stand loss was aggravated by heavier stocking rates. These factors contributed to higher production costs with endophyte-free fescue.

One advantage of the infested fescue pastures is that they are generally more tolerable to stress (Bransby, 1990). Weather conditions in the South can be very stressful due to the hot dry climate. These conditions make endophyte-free fescue more difficult to establish and survive.

The current level of pasture infestation can be determined by laboratory analysis. The level of pasture infestation can be held fairly constant with proper management. Proper management implies implementing practices that prevent the spread of the fescue seed, because it is believed that transmission of the fungus infection occurs only between generations of the plant (Bacon and Siegel, 1988). There are several methods to prevent fescue from regenerating, thereby keeping infestation level constant. One method is to clip the pastures before the plant produces seed heads. Another alternative is to utilize a continuous heavy grazing regime in order to minimize seed head production (Bransby, 1990).

Reduction in ADG from the endophyte fungus decreases the profitability of the stocker-steer producer. While several studies have examined the effects of endophyte fungus on average daily gains, there have been relatively few studies comparing the costs/benefits associated with these effects. Standaert (1987) conducted what may be the most extensive economic study concerning fescue pasture renewal. He examined the economic feasibility of pasture reestablishment and renovation at various levels of infestation for a cow-calf operation in North Carolina grazing fescue over a 216 day season. Per acre gross revenues and "fungus savings" were calculated for two reestablishment options (one with clover and one without) and a renovation option, for alternative levels of initial fungus infestation. Given initial investment costs for each renewal option, a rate of return was calculated at each infestation level. Standaert determined that a positive internal rate of return could be obtained from reestablishing infested pastures when infestation levels were between 20 and 30 percent.

Jacobs (1983) conducted a study comparing potential gains from grazing endophyte-free fescue to the cost of reestablishment. Jacobs computed the net present value of future income streams resulting from gains associated with the establishment of endophyte-free fescue to compare with a one-shot initial cost of obtaining an endophyte-free stand of fescue. Jacobs concluded that a positive net present value could be realized for Missouri farmers, under the assumption that a 30 percent improvement in animal gain could be made.

CHAPTER II

OBJECTIVES

The objectives of this study were: 1) under assumed conditions, determine what reduction in average daily gain from endophyte infestation was permissible before it was economically profitable to establish endophyte-free pastures for a stocker steer operation; 2) examine what effect a shortened stand life for endophyte-free fescue had upon the profitability of establishment; 3) examine how sensitive the profitability of establishing endophyte-free pastures was to a change in steer price and the cost of reestablishment; 4) examine the sensitivity of different planning horizons on the profitability and timing of establishment; and 5) examine how sensitive the profitability of establishing endophyte-free pastures was to a change in discount rates.

CHAPTER III

METHODOLOGY

To determine the profitability of establishing an endophyte-free pasture, Jacobs (1983) and Standaert (1987) used a net present value criteria. They projected income streams over a ten year horizon for the infected and non-infected levels and determined the net present value and/or internal rate of return for the two pastures. The net present value (NPV) of an investment refers to the sum of net cash flows from expected future earnings, discounted to present dollars. This approach considers both the magnitude and the timing of cash flows over a progect's entire expected planning horizon. The basic principle behind the net present value approach is that a dollar is worth more today than tomorrow. Such things as inflation, the uncertainty of the investment, and a person's desire to have a dollar to spend today versus having that same dollar to spend in the future enter into this concept. With the net present value method, the net revenues obtained each year of the planning horizon are "discounted" by a persons "discount rate" (can be thought of in the same terms as an interest rate) so that these future income flows may be presented in terms of their current value. The discount rate is often thought of as the minimum acceptable rate of return for investment projects. This discount rate is an personal decision and will vary between individuals.

An alternative method for determining the optimal replacement point is to use a marginal criteria (Faris, 1960; Chisholm, 1967; Perrin, 1972). This criteria states that the optimum replacement point occurs when the marginal net revenue from the present enterprise or production period is equal to the highest amortized present value of anticipated net revenue from the following enterprise or production period (Winder and Trant, 1961). For this study, marginal revenue (MR_i) is denoted as "current net revenue" and is defined as the net revenue that is expected in the current year given the endophyte status of the pasture. Average revenue is then defined as the amortized net present value of income flows which would occur over a specified planning horizon if the current pasture was replaced with an endophyte-free fescue grass. Using the above definition of average revenue, it would not be proper to compare the current net revenue to the expected net present value obtained from pasture renewal because the expected net present value is composed of income accruing over the entire planning horizon, whereas the expected current net revenue includes only one year's revenue. To compare the net present value of income flows with the current net revenue, the expected net present value is multiplied by an amortization factor to express the expected net present value on an average yearly net income basis. This configuration of average revenue can be symbolized as:

(1) $$AR_n = \left[\sum_{k=1}^{n} \frac{Y_k - V_k - F_k}{(1+r)^k}\right] * \left[\frac{r(1+r)^n}{(1+r)^n - 1}\right]$$

where AR_u = amortized net present value (average net revenue), Y_k = gross revenue in year k, V_k = variable costs in year k, F_k = fixed costs in year k, n = number of years in the planning horizon, and r = the discount rate. The first part of equation 1 represents the expected net present value of income flows over the planning horizon considered.

When net returns from the current infested pasture are greater than the average annual returns from the establishment of an endophyte free pasture, the current operation should be continued. When net returns from the current infested pasture operation are equal to or less than the average annual returns anticipated from establishing a fungus-free pasture (i.e., $MR_i \leq AR_u$), fescue renewal is profitable. To carry the present (current) operation beyond this point would yield additions to net revenue less than the average returns anticipated in the future (Faris, 1960). Paraphrasing Perrin (1972), the infected pasture should be left in use for another year if the additional net returns are greater than the average annual returns from establishing an endophyte free pasture.

The market rate of interest is commonly used as a proxy for a person's discount rate because it represents an oppoutunity cost for the use of the person's funds (Doll and Orazem, 1978). Because inflationary effects were assumed to be nonexistent in this study, real rates of interest were used for discount rates. Real rates of interest are defined as the nominal rate minus the expected inflation rate. Atwood (1990) recently obtained a short-term real savings rate of 3 percent by assuming an inflation rate of 5 percent. To determine the sensitivity of a person's discount rate upon the profitability of fescue reestablishment, discount rates of 3 percent and 5 percent were used in this study.

The average net revenue must take into consideration the timing of cash flows over a specified planning horizon associated with the establishment of an endophyte-free pasture. While it could be assumed that the income stream from establishing a fungus-free pasture extends into perpetuity, a farmer may not wish to consider an income stream of that length for a variety of reasons including the uncertain stand life of the fescue, alternative crop enterprises planned in the future, or length of tenure. A planning horizon of ten years was chosen by Standaert (1987) and Jacobs (1983) and used as the base scenario in this study. To determine the sensitivity of the profitability of establishing an endophyte-free pasture to the length of planning horizon, average revenues were also calculated for the stocker steer enterprise assuming five and fifteen year planning horizons.

CHAPTER IV

DATA AND ASSUMPTIONS

Several of the assumptions concerning a typical stocker steer operation were configured from a study conducted at the Ames Plantation Experiment Station in Tennessee where the performance of steers grazing fescue pasture of varying degrees of endophyte infection were compared (Chestnut et al. (1991); Leeman and Stein (1989)). It was assumed that 400 pound stocker steers were purchased in December, with additional steers purchased in April when fescue growth accelerated. As the summer heat made feed more sparse, some steers were sold in July with the remaining sold near the end of August. Gain per steer on uninfected pastures was rounded to 1.2, 2.0, and 1.0 pounds daily during the winter, spring, and summer periods, respectively. Average stocking rates were 1.0 head per acre for the winter season, 2.0 head per acre for spring season, and 1.5 head per acre for the summer season.

Reduced ingestion has played a major role in the decreased performance of cattle grazing infested fescue pastures (Jackson et al., 1984; Schmidt et al., 1982). Citing several studies, Stuedemann and Hoveland (1989) claimed that intake was 10 to 50 percent higher on low-endophyte compared to high-endophyte hay or seed. Because of the decreased forage intake, more grass is available for grazing and the stocking rate per acre can be increased on infected pastures. This increased stocking rate can partially compensate for the decreased gain per steer and thus must be accounted for in the analysis. Standaert (1987) assumed that for every 0.1 pound increase in daily calf gain, stocking rates would decline by approximately 3 percent. Standaert's adjustment was deemed appropriate during spring and summer grazing periods for this study. Stocking rates were not adjusted for endophyte levels during winter months as toxicity symptoms are less pronounced during cool weather (Stuedemann and Hoveland, 1989).

Prices paid and received for steers were taken from an average of prices received by Tennessee farmers from 1985 through 1989 (Tennessee Agricultural Statistics). Prices used in the base scenario were $78.00 and $82.00 per cwt. for 400-500 pound steers purchased in December and April, respectively. Prices for 600-700 pound steers sold in July and August were $69.00 and $71.00 per cwt., respectively. For the sensitivity analysis average prices from the base scenario were increased by 15 percent to $89.70, $94.30, $79.35, and $81.65 per cwt.. Prices were also decreased by 15 percent to $66.30, $69.70, $58.65, and $60.35 per cwt. for the December, April, July, and August prices, respectively. These ranges closely represented the actual maximum and minimum prices that comprised the five year averages.

Budgets depicting the costs and returns of infested and reestablished pastures were constructed using the Microcomputer Budget Management System (MBMS), developed at Texas A&M University (McGrann et al.,1986).

The level and sequencing of events for the stocker steer budgets and fescue pasture establishment budgets were developed from Burns (1989), Johnson (1989) and Burns (1990). The budgets exclude several costs such as fencing, livestock trailers, and land costs which basically remain constant as endophyte infestation levels change. Fixed costs represent the ownership costs for machinery and equipment used on a typical West Tennessee farm and are allocated to the stocker enterprise based upon their proportional use (Johnson, 1989).

Yearly budgets (Table 1) were used to calculate the economic costs and returns of a stocker steer operation for a typical year when pasture renewal did not occur. Annual income was generated by the sale of stocker steers in July and August. Stocker steers were purchased in December and April. Number of steers sold and months they were sold in depended on the stocking rates between the three grazing seasons. Steers were bought or sold to account for the difference in stocking rates which depended on the season and infestation level. Yearly fertilization rates were included in the budgets along with a pro-rated charge for liming and overseeding with clover. Lime was assumed to be spread every ten years at a rate of two tons/acre. Ladino clover was overseeded every two years on infected pastures and every three years on fungus-free fescue since fungus-free has been found to provide less vigorous competition to the clover (Burns, 1990). With the exception of overseeding of clover, pasture treatment was assumed to be the same for the infected and

Table 1. Sample Budget of the Economic Costs and Returns Per Acre for Stocker Steers[a]

Gross Income Description	Number of Head Sold	Weight Per Head (cwt)	$/cwt	Total
Stocker steer - July	0.50	7.16	69	247.02
Stocker steer - August	1.50	7.21	71	767.87
Death loss[b]				-14.16
Total Gross Income				1000.73
Variable Cost Description				**Total**
Steers				
December purchase				312.00
April purchase				369.00
Veterinarian and medicine				12.00
Salt and minerals				3.63
Marketing (purchase and sell)				23.17
Pasture Maintenance				
Clip				7.20
Spread fertilizer				2.32
Nitrogen (45 lbs.)				9.45
Phosphorus (45 lbs.)				6.30
Potassium (45 lbs.)				4.20
Lime (400 lbs.)				2.50
Overseed clover				2.77
Interest - Operating Capital				14.74
Total Variable Cost				769.28
Fixed Costs Description				
Machinery and equipment[c]				3.61
Total Costs				772.89
Net Projected Returns				227.84

[a]Does not include several costs which would remain basically constant regardless of infestation level such as fencing, shelter, pickup and trailer, land, and management.

[b]Death loss included two percent of purchase price and one percent of variable inputs.

[c]Fixed Costs included depreciation, interest on investment, taxes, insurance, and storage.

noninfected fescue once the latter was established. Variable costs associated with the number of steers grazing (e.g., marketing, salt, veterinary) were a function of the stocking rates resulting from the various average daily gains examined. The sequence followed in killing the infected fungus and establishing a fungus-free variety is shown in Table 2. The procedure followedto establish an endophyte free pasture was as follows: 1) spray infected fungus with two applications of Paraquat in April or May after either grazing or haying the pasture, 2) rotate to sorghum-sudan during the summer, 3) spray remaining fescue and sorghum-sudan with an application of Paraquat in August, 4) seed with 15 pounds of fungus-free fescue per acre in late September and apply fertilizer, 5) overseed with two pounds of ladino clover in February, and 6) top dress with another 45 pounds of nitrogen in March (Burns, 1989; Burns, 1990). Income was generated from establishment by selling the hay produced form the infected fescue in April and from marketing the sorghum-sudan hay produced as a cover crop during the summer before endophyte-free fescue was planted. Steers were not grazed during the winter period and stocking rates for the spring and summer periods were reduced by 10 percent the year of establishment. This was necessary to allow the endophyte-free fescue to develop a proper stand.

To incorporate the uncertainty which exists concerning the stand life of endophyte-free pastures, budgets representing the cost of overseeding to ensure a sufficient stand and the cost of reestablishing the pasture when the first

Table 2. Economic Costs and Returns Per Acre for Endophyte Free Fescue Pasture Establishment

Gross Income Description	Quantity	Unit	$/Unit	Total
Grass hay	1.00	ton	40.00	40.00
Sorghum-Sudan hay	3.00	ton	60.00	180.00
Total Gross Income				220.00

Variable Cost Description	Labor	Machinery	Materials	Total
Spring Kill				
Harvest grass hay[a]	6.64	4.47	0.00	11.11
Kill fescue[b]	1.94	1.38	12.50	15.82
Plant/Harvest Sorghum-Sudan				
Plant[c]	1.75	9.71	20.00	31.46
Spread fertilizer	2.65	1.78	0.00	4.43
Nitrogen (60 + 30 lbs.)			18.90	18.90
Phosphorus (45 lbs.)			9.45	9.45
Potassium (45 lbs.)			6.30	6.30
Lime (400 lbs.)			2.50	2.50
Harvest Sorghum-Sudan[a]	14.73	9.70	0.00	24.43
Kill Sorghum-Sudan[d]	.97	.69	5.00	6.66
Plant Fescue				
Plant[c]	1.75	1.28	23.44	26.47
Spread fertilizer	2.52	1.71	0.00	4.23
Nitrogen (45 + 45 lbs.)			18.90	18.90
Phosphorus (45 lbs.)			9.45	9.45
Potassium (45 lbs.)			6.30	6.30
Overseed with clover	1.02	0.47	6.70	8.18
Interest - Operating Capital				4.67
Total Variable Cost				209.26

Fixed Cost Description	Total
Machinery and equipment[e]	110.15
Total Costs	319.41
Net Projected Returns	-99.41

Table 2 (continued)

[a]Costs associated with this procedure included mowing, raking, baling, hauling and storing.

[b]Two applications of Paraquat (1.5 pints first and 1 pint second application).

[c]Includes cost of renting no-till drill.

[d]One pint of Paraquat required.

[e]Fixed costs included depreciation, interest on investment, taxes, insurance, and storage.

stand did not survive were constructed (Burns, 1990). If a weak stand developed, the pasture was overseeded with 15 pounds of endophyte-free fescue the following September (Table 3). If the fungus-free stand was overtaken by weeds and other grasses, the stand was reestablished by killing the weeds in late August with an application of Roundup followed by an application of Paraquat two weeks later (Table 4). The same procedure for planting the fescue then proceeded as in the original establishment budget.

Experimental work has not been underway long enough to determine the exact stand life of fungus-free fescue when grazed on-farm, and varying success has been achieved in establishing a healthy stand of noninfected fescue. It was felt that a sensitivity analysis which examined what might be classified as a "worst case" scenario concerning stand establishment and stand life would be beneficial. A "worst case" scenario was theorized (Burns, 1990) where a 9 percent probability existed that the established fungus-free fescue would require reseeding and a 16 percent probability existed that it would require reestablishing in the second year. After the stand was established, a 6-year stand life was assumed before reestablishment was again required.

Table 3. Economic Costs Per Acre for Endophyte-Free Fescue Pasture Reseeding

Variable Cost Description	Labor	Machinery	Materials	Total
Reseed				
Plant[a]	1.75	1.28	15.00	26.46
Spread fertilizer	2.65	1.78		4.43
Nitrogen[b] (45 + 45 lbs.)			18.90	18.90
Phosphorus (45 lbs.)			9.45	9.45
Potassium (45 lbs.)			6.30	6.30
Lime (400 lbs.)			2.50	2.50
Interest - Operating Capital				1.29
Total Variable Cost				63.33
Fixed Cost Description				
Machinery and equipment[c]				7.70
Total Costs				77.03

[a]Includes cost of renting no-till drill.

[b]Fall and spring applications.

[c]Fixed costs include depreciation, interest on investment, taxes, insurance, and storage.

Table 4. Economic Costs Per Acre for Endophyte-Free Fescue Pasture Reestablishment

Variable Cost Description	Labor	Machinery	Materials	Total
Fall Kill				
Kill weeds[a]	1.94	1.38	20.50	23.82
Plant Fescue				
Plant[b]	1.75	1.28	23.44	26.46
Spread fertilizer	2.65	1.78	4.43	
Nitrogen[c] (45 + 45 lbs.)			18.90	18.90
Phosphorus (45 lbs.)			9.45	9.45
Potassium (45 lbs.)			6.30	6.30
Lime (400 lbs.)			2.50	2.50
Overseed with clover	1.02	0.47	6.70	8.18
Interest - Operating Capital				1.76
Total Variable Cost				101.81
Fixed Cost Description				
Machinery and equipment[d]				18.04
Total Costs				119.85

[a]One quart of roundup and one pint of Paraquat required.

[b]Includes cost of renting no-till drill.

[c]Fall and spring applications.

[d]Fixed costs included depreciation, interest on investment, taxes, insurance, and storage.

CHAPTER V

RESULTS

Expected net revenue associated with various ADG levels from infected pastures is shown at the top of Table 5 for three cattle price levels. The average daily gain levels presented are incremental reductions from the assumed average daily level associated with noninfected pastures. The net revenue associated with each ADG level can be compared to the expected average net revenue from endophyte-free fescue to determine what reduction in net revenue from infected fescue was required before it was profitable to reestablish infected pastures. The expected average net revenue from endophyte-free fescue pastures is shown at the bottom of Table 5 for several scenarios.

To determine the reduction in gain permissible before pasture renewal occurred, expected average net revenue from endophyte-free pastures for a particular scenario was compared with the current net revenue. When the current net revenue of infected fescue dropped below the expected average net revenue of endophyte-free fescue, pasture renewal was considered profitable. For a certain stand life, and assuming average steer prices, expected average net revenue for establishing and grazing endophyte free pastures under the base scenario was $176.27 per acre. Current net revenue for the infected

Table 5. Comparison of the Current Expected Net Revenue Per Acre from Infected Fescue Pasture with Average Yearly Net Revenue Per Acre from Establishing Fungus-Free Fescue Assuming a Ten Year Planning Horizon[a]

Current Expected Net Revenue from Grazing Infected Fescue

Average Daily Gain			Current Expected Net Revenue ($) Cattle Price Level		
Winter	Spring	Summer	Average[b]	15% Increase	15% Decrease
1.20	2.00	1.00	227.84	274.13	182.13
1.14	1.90	0.95	210.51	254.04	166.99
1.08	1.80	0.90	192.01	232.94	151.08
1.02	1.70	0.85	172.75	210.98	134.51
0.96	1.60	0.80	152.41	187.77	117.05
0.90	1.50	0.75	131.65	164.09	99.20
0.84	1.40	0.70	109.39	138.70	80.09
0.78	1.30	0.65	86.13	112.15	60.11
0.72	1.20	0.60	62.24	84.88	39.60
0.66	1.10	0.55	36.69	55.73	17.66

Average Net Revenue Expected form Establishing an Endophyte-Free Pasture

	Average Net Revenue ($) Cattle Price Level		
Scenario	Average[b]	15% Increase	15% Decrease
Certain Stand Life[c]			
Base	176.27	214.76	137.78
Decreased crop value	163.75	202.24	125.26
No crop value	151.23	189.72	112.74
Uncertain Stand Life[d]			
Base	142.31	177.70	106.63
Decreased crop value	129.79	165.18	94.91
No crop value	117.27	152.66	81.89

[a]To determine the reduced level of average daily gain required before establishing endophyte-free fescue pastures would be profitable: 1) Determine the scenario and cattle price level of interest from the lower table and obtain the average net revenue located there. 2) Determine the appropriate cattle price level in the top table and search down the "current net revenue" column until the current net revenue $\leq$ the average net revenue. 3) Read horizontally to the three left hand columns of the top table to determine the diminished level of average daily gain required before establishing endophyte-free pastures would be profitable.

Table 5 (Continued)

[b]Average cattle price assumptions: $78.00/cwt and $82.00/cwt for 400-500 pound steers in December and April, respectively; $69.00/cwt and$71.00/cwt for 600-700 pound steers in July and August, respectively.

[c]Certain stand life implies that the endophyte-free pastures did not need to be overseeded or reestablished but maintained productivity levels over the ten-year planning horizon.

[d]Uncertain stand life implies that a 16 percent probability existed that the endophyte-free pasture needed to be overseeded, a 9 percent probably that it needed to be reestablished after the initial year of establishment and an assumption that the stand life was only 6 years after the fescue was productively established.

pasture under the same price assumption equaled expected average netrevenue of the uninfected pasture when ADG fell below 1.08 for winter, 1.80 for spring, and .90 for summer. An approximate 14 percent reduction in ADG could therefore be tolerated before it was profitable to establish endophyte-free fescue under the given assumptions. Crawford et al. (1989) found that for every 10 percent increase in endophyte infection frequency (EIF), ADG decreased by 0.15 lbs./head/day. Using these guidelines, the 14 percent reduction in ADG obtained under the base scenario would relate to an approximate 20 percent infestation level. This infestation level was slightly below that required by Standaert (1987) for an 8 percent return from pasture renewal.

Cost of Establishment Sensitivity

A major assumption in the fungus-free fescue establishment budget was that a return could be realized from haying the infested pasture before the stand was killed, and from the sorghum-sudan summer crop. The hay from the infected pasture may be worth less than was assumed or the stand may be so poor as to not warrant bailing. The revenue generated from sorghum-sudan may also vary depending on procedures used by the farmer and externalities associated with the production of crops. If these returns were not possible, the decrease in ADG before renewal was profitable would increase.

Expected average net revenue was determined under the scenarios that crop values declined by 50 percent and that crop values were equal to zero (Table 5). In the first case, net average revenue declined from $176.27 to $163.75, which decreased the necessary drop in ADG to just below 1.02 in winter, 1.70 in spring, and 0.85 in summer, for an average 17 percent total descent in ADG before pasture renewal was deemed profitable. When crop returns were assumed to be zero, average net revenue deteriorated to $151.23, which required close to a 20 percent deterioration in ADG before renewal. Thus the crop returns associated with endophyte-free fescue establishment affected the profitability of establishment. The higher the crop value the more profitable it was to establish a stand of endophyte-free fescue.

Stand Life Sensitivity

One of the major reasons for the popularity of tall fescue is its ease of establishment and longevity (Stuedemann and Hoveland, 1988). Both of these qualities have been questioned with the new varieties of endophyte-free fescue. To account for the uncertainty associated with establishing fungus-free fescue, a worst case scenario was examined. Using the probabilities of establishment discussed in Chapter 4, the expected average net revenue from establishing endophyte-free fescue pastures was determined (Table 5). For the base assumption of a ten year planning horizon and a 3 percent discount rate, the expected average net revenue dropped from $176.27 to $142.31. In each of the three scenarios (base, decreased crop value, and no crop value), average net revenue was decreased by over $30.00. This drop in revenue was the result of additional costs associated with overseeding and reestablishment of the less stress tolerable fungus-free varieties of tall fescue. This decline interpolated into a additional 5 percent drop in ADG before renewal was profitable.

Cattle Price Sensitivity

Sensitivity of the solution to a change in steer prices was examined by both decreasing and increasing the purchase and selling price of steers by 15 percent. Expected average net revenue increased from $176.27 to $214.76 when prices were increased by 15 percent (Table 5). The increased ADG from endophyte-free fescue made it relatively more profitable to reestablish infected pastures when steer prices were higher. The opposite was true when stocker prices were decreased. At a given level of pasture infestation, it was relatively less profitable to reestablish tall fescue than to continue grazing the infected grass. When the base scenario was considered, establishment of endophyte free fescue was profitable when average daily gains fell to levels between 1.08 and 1.02 for winter, 1.80 and 1.70 for spring, and .90 and .85 for summer. When prices were increased and decreased by 15 percent the allowable decrease in average daily gains still fell between these ranges. A reduction in average daily gains of approximately 14 percent was required before pasture renewal became profitable.

Discount Rate Sensitivity

To determine what effects the discount rate had on the reduction in daily gains required from grazing infected fescue before it was profitable to establish fungus-free pastures, revenues were calculated using a base assumption of a 3 percent discount rate (Tables 5-7). These values were then compared to the same revenues usinf a 5 percent discount rate (Tables 8-10). When the discount rate was increased from 3 to 5 percent the average net revenue declined in all scenarios. Comparing values from Table 5 and Table 9, where a ten year planning horizon was assumed, average net revenue declined from $176.27 to $165.67 when the discount rate was changed from 3 percent to 5 percent. The higher discount rate placed a higher value on current income, thereby requiring a higher rate of return from endophyte-free fescue establishment. The required higher rate of return resulted in a larger drop in ADG before endophyte-free pasture renewal became profitable. The outcomes were similar when changing discount rates were examined for the different planning horizons.

Planning Horizon Sensitivity

The length of planning horizon is dependent on the farmer's situation and expectations. Therefore, planning horizons of five, ten, and fifteen years were compared to determine the sensitivity of the planning horizon and the insinuated length of fescue stand life. As the planning horizons increased, the

Table 6. Comparison of the Current Expected Net Revenue Per Acre from Infected Fescue Pasture with Average Yearly Net Revenue Per acre from Establishing Fungus-Free Fescue Assuming a **Discount Rate of 3% and a Five Year Planning Horizon**[a]

Current Expected Net Revenue from Grazing Infected Fescue

Average Daily Gain			Current Expected Net Revenue ($) Cattle Price Level		
Winter	Spring	Summer	Average[b]	15% Increase	15% Decrease
1.20	2.00	1.00	227.84	274.13	182.13
1.14	1.90	0.95	210.51	254.04	166.99
1.08	1.80	0.90	192.01	232.94	151.08
1.02	1.70	0.85	172.75	210.98	134.51
0.96	1.60	0.80	152.41	187.77	117.05
0.90	1.50	0.75	131.65	164.09	99.20
0.84	1.40	0.70	109.39	138.70	80.09
0.78	1.30	0.65	86.13	112.15	60.11
0.72	1.20	0.60	62.24	84.88	39.60
0.66	1.10	0.55	36.69	55.73	17.66

Average Net Revenue Expected form Establishing an Endophyte-Free Pasture

Scenario	Average Net Revenue ($) Cattle Price Level: Average[b]	15% Increase	15% Decrease
Certain Stand Life[c]			
Base	131.54	163.55	99.52
Decreased crop value	108.22	140.23	76.21
No crop value	84.90	116.91	52.89

[a]To determine the reduced level of average daily gain required before establishing endophyte-free fescue pastures would be profitable: 1) Determine the scenario and cattle price level of interest from the lower table and obtain the average net revenue located there. 2) Determine the appropriate cattle price level in the top table and search down the "current net revenue" column until the current net revenue ≤ the average net revenue. 3) Read horizontally to the three left hand columns of the top table to determine the diminished level of average daily gain required before establishing endophyte-free pastures would be profitable.

[b]Average cattle price assumptions: $78.00/cwt and $82.00/cwt for 400-500 pound steers in December and April, respectively; $69.00/cwt and$71.00/cwt for 600-700 pound steers in July and August, respectively.

[c]Certain stand life implies that the endophyte-free pastures did not need to be overseeded or reestablished but maintained productivity levels over the five-year planning horizon.

Table 7. **Comparison of the Current Expected Net Revenue Per Acre from Infected Fescue Pasture with Average Yearly Net Revenue Per acre from Establishing Fungus-Free Fescue Assuming a Discount Rate of 3% and a Fifteen Year Planning Horizon**[a]

Current Expected Net Revenue from Grazing Infected Fescue

Average Daily Gain			Current Expected Net Revenue ($) Cattle Price Level		
Winter	Spring	Summer	Average[b]	15% Increase	15% Decrease
1.20	2.00	1.00	227.84	274.13	182.13
1.14	1.90	0.95	210.51	254.04	166.99
1.08	1.80	0.90	192.01	232.94	151.08
1.02	1.70	0.85	172.75	210.98	134.51
0.96	1.60	0.80	152.41	187.77	117.05
0.90	1.50	0.75	131.65	164.09	99.20
0.84	1.40	0.70	109.39	138.70	80.09
0.78	1.30	0.65	86.13	112.15	60.11
0.72	1.20	0.60	62.24	84.88	39.60
0.66	1.10	0.55	36.69	55.73	17.66

Average Net Revenue Expected form Establishing an Endophyte-Free Pasture

	Average Net Revenue ($) Cattle Price Level		
Scenario	Average[b]	15% Increase	15% Decrease
Certain Stand Life[c]			
Base	191.07	231.71	150.44
Decreased crop value	182.13	222.76	141.49
No crop value	173.18	213.82	132.55

[a]To determine the reduced level of average daily gain required before establishing endophyte-free fescue pastures would be profitable: 1) Determine the scenario and cattle price level of interest from the lower table and obtain the average net revenue located there. 2) Determine the appropriate cattle price level in the top table and search down the "current net revenue" column until the current net revenue $\leq$ the average net revenue. 3) Read horizontally to the three left hand columns of the top table to determine the diminished level of average daily gain required before establishing endophyte-free pastures would be profitable.

[b]Average cattle price assumptions: $78.00/cwt and $82.00/cwt for 400-500 pound steers in December and April, respectively; $69.00/cwt and$71.00/cwt for 600-700 pound steers in July and August, respectively.

[c]Certain stand life implies that the endophyte-free pastures did not need to be overseeded or reestablished but maintained productivity levels over the fifteen-year planning horizon.

Table 8. **Comparison of the Current Expected Net Revenue Per Acre from Infected Fescue Pasture with Average Yearly Net Revenue Per acre from Establishing Fungus-Free Fescue Assuming a Discount Rate of 5% and a Five Year Planning Horizon**[a]

Current Expected Net Revenue from Grazing Infected Fescue

Average Daily Gain			Current Expected Net Revenue ($) Cattle Price Level		
Winter	Spring	Summer	Average[b]	15% Increase	15% Decrease
1.20	2.00	1.00	227.84	274.13	182.13
1.14	1.90	0.95	210.51	254.04	166.99
1.08	1.80	0.90	192.01	232.94	151.08
1.02	1.70	0.85	172.75	210.98	134.51
0.96	1.60	0.80	152.41	187.77	117.05
0.90	1.50	0.75	131.65	164.09	99.20
0.84	1.40	0.70	109.39	138.70	80.09
0.78	1.30	0.65	86.13	112.15	60.11
0.72	1.20	0.60	62.24	84.88	39.60
0.66	1.10	0.55	36.69	55.73	17.66

Average Net Revenue Expected form Establishing an Endophyte-Free Pasture

Scenario	Average Net Revenue ($) Cattle Price Level: Average[b]	15% Increase	15% Decrease
Certain Stand Life[c]			
Base	122.62	153.38	91.86
Decreased crop value	98.42	129.19	67.67
No crop value	74.23	104.99	43.47

[a]To determine the reduced level of average daily gain required before establishing endophyte-free fescue pastures would be profitable: 1) Determine the scenario and cattle price level of interest from the lower table and obtain the average net revenue located there. 2) Determine the appropriate cattle price level in the top table and search down the "current net revenue" column until the current net revenue ≤ the average net revenue. 3) Read horizontally to the three left hand columns of the top table to determine the diminished level of average daily gain required before establishing endophyte-free pastures would be profitable.

[b]Average cattle price assumptions: $78.00/cwt and $82.00/cwt for 400-500 pound steers in December and April, respectively; $69.00/cwt and$71.00/cwt for 600-700 pound steers in July and August, respectively.

[c]Certain stand life implies that the endophyte-free pastures did not need to be overseeded or reestablished but maintained productivity levels over the five-year planning horizon.

Table 9. **Comparison of the Current Expected Net Revenue Per Acre from Infected Fescue Pasture with Average Yearly Net Revenue Per acre from Establishing Fungus-Free Fescue Assuming a Discount Rate of 5% and a Ten Year Planning Horizon**[a]

Current Expected Net Revenue from Grazing Infected Fescue

Average Daily Gain			Current Expected Net Revenue ($) Cattle Price Level		
Winter	Spring	Summer	Average[b]	15% Increase	15% Decrease
1.20	2.00	1.00	227.84	274.13	182.13
1.14	1.90	0.95	210.51	254.04	166.99
1.08	1.80	0.90	192.01	232.94	151.08
1.02	1.70	0.85	172.75	210.98	134.51
0.96	1.60	0.80	152.41	187.77	117.05
0.90	1.50	0.75	131.65	164.09	99.20
0.84	1.40	0.70	109.39	138.70	80.09
0.78	1.30	0.65	86.13	112.15	60.11
0.72	1.20	0.60	62.24	84.88	39.60
0.66	1.10	0.55	36.69	55.73	17.66

Average Net Revenue Expected form Establishing an Endophyte-Free Pasture

Scenario	Average Net Revenue ($) Cattle Price Level		
	Average[b]	15% Increase	15% Decrease
Certain Stand Life[c]			
Base	165.67	202.67	128.68
Decreased crop value	152.11	189.11	115.11
No crop value	138.54	175.54	101.55

[a]To determine the reduced level of average daily gain required before establishing endophyte-free fescue pastures would be profitable: 1) Determine the scenario and cattle price level of interest from the lower table and obtain the average net revenue located there. 2) Determine the appropriate cattle price level in the top table and search down the "current net revenue" column until the current net revenue ≤ the average net revenue. 3) Read horizontally to the three left hand columns of the top table to determine the diminished level of average daily gain required before establishing endophyte-free pastures would be profitable.

[b]Average cattle price assumptions: $78.00/cwt and $82.00/cwt for 400-500 pound steers in December and April, respectively; $69.00/cwt and$71.00/cwt for 600-700 pound steers in July and August, respectively.

[c]Certain stand life implies that the endophyte-free pastures did not need to be overseeded or reestablished but maintained productivity levels over the ten-year planning horizon.

Table 10. Comparison of the Current Expected Net Revenue Per Acre from Infected Fescue Pasture with Average Yearly Net Revenue Per acre from Establishing Fungus-Free Fescue Assuming a **Discount Rate of 5% and a Fifteen Year Planning Horizon**[a]

Current Expected Net Revenue from Grazing Infected Fescue

Average Daily Gain			Current Expected Net Revenue ($) Cattle Price Level		
Winter	Spring	Summer	Average[b]	15% Increase	15% Decrease
1.20	2.00	1.00	227.84	274.13	182.13
1.14	1.90	0.95	210.51	254.04	166.99
1.08	1.80	0.90	192.01	232.94	151.08
1.02	1.70	0.85	172.75	210.98	134.51
0.96	1.60	0.80	152.41	187.77	117.05
0.90	1.50	0.75	131.65	164.09	99.20
0.84	1.40	0.70	109.39	138.70	80.09
0.78	1.30	0.65	86.13	112.15	60.11
0.72	1.20	0.60	62.24	84.88	39.60
0.66	1.10	0.55	36.69	55.73	17.66

Average Net Revenue Expected form Establishing an Endophyte-Free Pasture

Scenario	Average Net Revenue ($) Cattle Price Level		
	Average[b]	15% Increase	15% Decrease
Certain Stand Life[c]			
Base	179.74	218.78	140.71
Decreased crop value	169.65	208.69	130.62
No crop value	159.56	198.60	120.53

[a]To determine the reduced level of average daily gain required before establishing endophyte-free fescue pastures would be profitable: 1) Determine the scenario and cattle price level of interest from the lower table and obtain the average net revenue located there. 2) Determine the appropriate cattle price level in the top table and search down the "current net revenue" column until the current net revenue $\leq$ the average net revenue. 3) Read horizontally to the three left hand columns of the top table to determine the diminished level of average daily gain required before establishing endophyte-free pastures would be profitable.

[b]Average cattle price assumptions: $78.00/cwt and $82.00/cwt for 400-500 pound steers in December and April, respectively; $69.00/cwt and$71.00/cwt for 600-700 pound steers in July and August, respectively.

[c]Certain stand life implies that the endophyte-free pastures did not need to be overseeded or reestablished but maintained productivity levels over the fifteen-year planning horizon.

expected average net revenue from the endophyte-free pastures increased making pasture renewal more profitable at higher average daily gains. Using Tables 5, 6, and 7, expected average net revenue values for different planning horizons can be compared. The average net revenue for a five year planning horizon was $131.54. When the planning horizon was increased to ten years (base assumption), expected average net revenue increased to $176.27. When the planning horizon was increased to fifteen years, expected average net revenue increased to $191.07. The average net revenue for the five year planning horizon increased the allowable decrease in ADG from infected fescue by over 10 percent, when compared to the base assumption of a ten year planning horizon. When a fifteen year planning horizon was used, the change in average net revenue was not enough to change the point of pasture renewal from the base assumption for the interval examined. When the planning horizon was increased to fifteen years, the decrease in allowable ADG was less than 5 percent. When the planning horizon was decreased from ten to five years, the decrease in allowable ADG was over 10 percent. The same differences occurred when comparing the planning horizon using a 5 percent discount rate (Tables 8,9,and 10).

CHAPTER VI

SUMMARY AND CONCLUSIONS

The problem of fescue toxicity in beef cattle has been observed for many years. The wide variations in average daily gains of cattle grazing fescue infected with an endophytic fungus curtails the profitability of the stocker steer industry. At present, elimination of the negative effects from grazing infected fescue pastures involves the reestablishment of these pastures with a fescue variety that is free of the endophyte fungus. The degree of infestation that can be economically tolerated before pasture renewal is inaugurated is a question that has received relatively little attention. This study utilized a marginal revenue criteria to determine what reduction in average daily gains from fescue toxicity could be tolerated before it was economically profitable to establish endophyte-free fescue pastures. For the base assumptions utilized in this study, maximum profits were achieved by establishing pastures with fungus-free fescue when average daily gains fell below 1.08 lbs/day in winter, 1.80 lbs/day in spring, and 0.90 lbs/day in summer. When average daily gain of the steers on infected pastures reached this level, profits were maximized for the ten year planning horizon by establishing an endophyte-free pasture.

The allowable decrease in ADG was sensitive to the income realized from the hay and sorghum-sudan crops in the year of establishment.

Allowable ADG decreased by 16 to 20 percent when crop values were cut in half or were assumed to be zero. When the uncertainty concerning the longevity of fungus-free fescue was considered, average revenue for the endophyte free pasture decreased, which in turn decreased the level of average daily gain required before renewal occurred. Higher cattle prices also made it relatively more profitable to establish endophyte-free pastures, while the opposite was true when stocker prices were decreased.

Increasing the discount rate lowered average net revenue obtained by establishing a fungus-free pasture. This lower average net revenue lowered the level of average daily gain required before renewal occurred. Using a five year planning horizon made establishment less profitable. Higher revenues generated from increased average daily gains on endophyte-free fescue could not be fully realized in such a short planning horizon. A ten year planning horizon seemed to be an adequate time span to realize gains from increased production rates. Using a fifteen year planning horizon did not change the level of the reduction in average daily gain required before pasture renewal was profitable.

While the question of "if and when" to establish endophyte-free pastures must be made on an individual basis, the results presented in this study not only outline a simple methodology for determining when pasture reestablishment is profitable, but provide general guidelines for scientists and farmers alike. It must be remembered that the results were not without limitations. The assumptions concerning the base ADG and stocking rates obtained on noninfected fescue will change from area to area, as will the operations for and cost of establishing endophyte-free pastures. There are other factors inherent in this study that should be remembered. Management qualities will make a difference in the outcome of this study but were not considered variable. Average daily gain will vary between farmers as will the stand life of the pastures as a result of their management practices. Farmer's individual preferences about their planning horizon and discount rates will also influence the optimal solution.

Although it would be beneficial to relate infestation level to average daily gain the variability of this factor made it unrealistic for this study. When more precise data is available on the relationship between ADG and infestation level an economic study similar to this study could determine the level of endophyte infestation where pasture renewal would be profitable.

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