Cows and Fish Report

The Economics of Riparian Area Management

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Alberta Riparian Habitat Management Program   Report No. 015

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Report for the Alberta Riparian Habitat Management Program

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About Cows and Fish

Riparian areas are those areas along rivers, streams, lakes, wetlands, springs, and ponds that are strongly influenced by water and are recognized by water-loving vegetation. Cows and Fish is striving to foster a better understanding of how riparian areas function and how improvements in management strategies in riparian areas can enhance landscape health and productivity for the benefit of livestock producers, their communities and others who value these landscapes.

Cows and Fish Partners: Producers and community groups, Alberta Cattle Commission, Trout Unlimited Canada, Canadian Cattlemen's Association, Alberta Agriculture, Food and Rural Development, Alberta Sustainable Resource Development, Alberta Environment, Department of Fisheries and Oceans, Prairie Farm Rehabilitation Administration, Alberta Conservation Association

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Working with producers and communities on riparian awareness

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Executive Summary

Riparian areas are formed when water, soil, and vegetation interact with one another. The higher water table allows riparian areas to stay greener longer, and produce more forage. If a drought occurred, these areas could serve as a stable source of forage for grazing animals. This study examines producers' knowledge and attitudes toward riparian area management for grazing cattle related to the costs and benefits of various range management scenarios. If beef producers in the province of Alberta have not yet adopted strategies designed to protect riparian areas, there may be a perceived economic barrier to adoption. That is, producers may perceive riparian management strategies as costly, with little or no economic benefit. This study estimates some on-ranch (or on-farm) costs and benefits of various riparian area management schemes for a ranch in Southern Alberta. A Net Present Value (NPV) model is used to quantify the effects of these strategies on a hypothetical Alberta ranch, and the model is used to analyze on-ranch decision-making regarding the grazing strategies.

In Alberta, beef farming is a multi-billion dollar industry. In this industry's cow/calf operations, pasture is usually the major production input. Degradation of riparian pastures occurs through trampling and overgrazing. However, recent research studies have not addressed the economics of riparian area management. Specific costs and benefits have not been analyzed. Programs such as Alberta Riparian Habitat Management Program (also called Cows and Fish) were established to improve the riparian areas and have suggested a number of strategies to improve riparian health. These range from simple animal distribution changes, to more labour-intensive and more costly fencing strategies.

Survey

In order to determine the knowledge level of selected producers, as well as their ideas about riparian management, a questionnaire was developed. It was designed to obtain a qualitative assessment of interested producer knowledge and attitudes. The questionnaire was presented to producers at the 2000 Stockmen's Range Management Course in Maycroft, Alberta. Thus, the survey was not a random sample of managers. Most of the respondents surveyed were ranchers with relatively large operations.

The responses to the initial questionnaire showed that most producers surveyed are knowledgeable about riparian area management. When choosing a strategy for their own ranches, producers would favour lower-cost solutions, such as distributional practices and rotational grazing. However, in the case of a heavily degraded riparian area, many producers chose corridor fencing, the strategy with the highest capital costs. This may be a result of producers looking to the future, and selecting impacts on forage production and quality as the most important factors in their decision-making.

Economic Models and Results

Net Present Value (NPV) models were developed to compare the benefits and costs of selected grazing management strategies. NPV incorporates cash flows and opportunity cost into the analysis. A 10 percent discount rate, the opportunity cost of an investment in the cow-calf business, was used in the analysis. This discount rate incorporates a small

risk premium. The models evaluated the incremental impact of different management strategies on a selected pasture and did not model the entire ranch. NPV does not model ranch profit directly but does allow financial comparisons of alternative management scenarios. Higher NPV numbers are preferred to smaller NPV numbers.

The static ranch NPV models uses six cases and evaluates cash flows over twenty years. A Base Case, Case 1, represents the ranch in a conservative continuous grazing strategy, where extra management is not needed to keep range, a combination of uplands range and riparian range, in good condition. Cases 2 and 3 represent continuous overgrazing strategies. Initial pasture conditions are good in Case 2, poor in Case 3, and the pastures are overgrazed relative to their sustainable carrying capacity. The carrying capacity of the pasture in Cases 2 and 3 was assumed to decrease at 6 percent per year in the uplands and 3 percent per year in the riparian area. Cases 4, 5 and 6, assume the range is in poor condition initially and these cases represent strategies to improve upland and riparian range health. Range was assumed to regenerate (i.e. AU per grazing period increases) under Case 4 (Rotational Grazing with additional fencing and watering costs) and Case 5 (Rotational Grazing with corridor fencing protecting the riparian water way and nearby range) at 2 percent per year on the uplands and 6 percent on the riparian areas. Slightly higher regeneration rates were assumed for Case 6 (Rest-Rotational Grazing where 25 percent of the pasture is rested each year for the first eight years).

The results are highly specific to the assumptions regarding the size of the pasture, the size of the riparian area, and various other assumptions regarding the ranch. In the static model, the Base Case 1 (conservative continuous grazing) NPV is the highest. In Case 2, the pasture was stocked at an unsustainable rate, resulting in a loss of grazing capacity over time. This situation (unsustainable grazing starting with good range health) resulted in the second-highest NPV at the expense of pasture condition. Case 2 generates higher cash flows in the earlier years and lower cash flows in the later years relative to Case 1; yet Case 1 (conservative continuous grazing) is the financially preferred strategy over the long run.

The Rotational Grazing system in Case 4 was implemented to improve the pasture in initial poor condition. Its incremental NPV is almost $100,000 higher than that for Case 3. Both Case 4 and Case 3 were assumed to have started from the same level of degraded pasture condition. In the long-run, it would be a better financial decision for the producer to implement a rotational grazing strategy on poor pasture using the assumptions in this analysis. Initial capital costs are higher in Case 4, but long-run benefits exceed those of an unsustainable continuous grazing strategy such as Case 3. The up front costs of fencing and additional watering for rotational grazing are relatively small compared to the benefits of improved range animal carrying capacity in later years.

Though Corridor Fencing (Case 5) resulted in an NPV that was lower than that for overgrazing from poor condition (Case 3), the riparian area was assumed to be rehabilitated to its Base Case 1 grazing capacity. The grazing livestock were only given limited access to the fenced riparian area in Case 5. Case 5 would be used as a last resort, in order to return a riparian area to health.

Case 6 (Rest-Rotational Grazing) resulted in an incremental NPV of approximately $40,000 more than that for Case 3. As in Case 5, higher initial costs are offset by increased stocking rates on both upland and riparian pastures in later periods.

Study Conclusions

Under the assumptions used, strategies that improve upland and riparian range health (such as rotational grazing) will make a rancher better off (financially) in the long run, when range is already in a degraded condition. Discount rate sensitivity analysis results show that higher discount rates (i.e. 15 percent) will favour strategies that use higher initial stocking rates (Case 2 – overgrazing from good condition), though these strategies lead to lower future stocking rates and cash flows. Lower discount rates (i.e. 5 percent) will favour strategies with lower initial stocking rates, with higher future payoffs (i.e. Case 4 – rotational grazing from poor condition).

The results are also highly sensitive to the rates of pasture degradation and pasture regeneration. The research literature and expert opinion solicited for this study were unable to provide concrete answers on reasonable rates of range degradations and regeneration. The rates used were based on the best guess of experts and were picked from a range of observed or estimated degradation/regeneration rates provided. However there appear to be several general conclusions that this analysis can provide.

1. Long run conservative grazing strategies appear to be financially superior to strategies that overgraze and result in significantly reduced grazing capacity in the future. This result is relatively insensitive to the level of calf prices if calf prices (either low or high) are the same over the entire period of the analysis. However, it should be noted that if initial calf prices are high (i.e. the early years of the analysis), and future prices are expected to be much lower, this may increase the long run financial incentive to overgraze.

2. Long run rotational grazing strategies to improve range capacity (i.e. move range in poor condition to range in good condition) appear to be financially superior to strategies that continue to overgraze and continue to have range in poor condition. This result is relatively insensitive to the up front capital costs of fencing and additional watering facilities for rotational grazing systems. The results are very sensitive to the decreased grazing AU required in the first years of the regeneration grazing strategies (i.e. Cases 4, 5 and 6) to allow the range to improve. That is, the main driver of the results are the reduced cash inflow from fewer cow-calf pairs grazed on the pasture in the beginning years of the strategy.

3. The results are highly sensitive to the rates of range degradation if over grazed and the rates of range regeneration under alternative management strategies. Low rates of range degradations and high rates of regeneration may favour short term overgrazing strategies. Expert opinion suggested that riparian range could regenerate substantially faster than upland range in specific circumstances. Thus, there may be financial incentives to follow strategies that overgraze in the short run when calf prices are high and then follow

strategies that improve range conditions. This conclusion assumes that there are long-run cycles in calf prices that can be forecast by the manager.

4.At higher discount rates, the producer would favour short-term returns, such as those provided by an overgrazing system (e.g., Case 2). At lower discount rates, producers would favour systems that gave them higher returns in the long run, such as the rotational system in Case 4. Individual time preference for cash flows may vary from ranch owner to ranch owner. Higher discount rates model owners that have a higher preference for higher cash flows in nearer time periods. That is, despite the long run financial benefits of the conservative or rotational grazing strategies to the ranch, short run cash flow considerations (i.e. debt payments, family living) may preclude the adoption of these strategies.

Additional Analysis Caveats

Static NPV models were used to evaluate different riparian management strategies. These models focused on a single riparian area. Whole ranch concerns were not modeled. Instead, the model analysis was based on incremental changes to the riparian area and associated uplands range. The incremental NPV model had a number of limitations. The model did not account for over-wintering of cattle. When cattle numbers were reduced due to loss of grazing capacity, these cattle were taken out of the model, without accounting for their whereabouts, sale price (i.e. cull cows), etc. As well, because the model was static, beef prices and costs related to ranch operation were all fixed. One very important variable in most farming situations is the weather. The static model assumed that the effects of weather on year to year range conditions were fixed. That is, all years had "average" weather.

A different model of financial structure may give different results. For example, income taxes could have been included in the model calculations. However, in the static model, whole farm considerations (such as taxes) were left out. Issues such as income tax or cash flow requirements of a ranch are very specific to individual owners and are difficult to incorporate in a general model. The model would also be improved if more information on pasture degeneration/regeneration rates were included. Comprehensive studies on this subject have yet to be performed in the plant science/range science community. The starting range condition and the ending range condition are important, but the rate at which the range degenerates or regenerates is also critical to any long-run financial analysis of range management strategies.

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Chapter 1

Introduction

Riparian areas are formed when water, soil, and vegetation interact with one another. Dickard (1998) stated that riparian areas are often described as groups of plant, animal, and aquatic communities whose presence is directly or indirectly attributed to factors that are related to streams, or stream-induced. Fitch and Adams (1998) noted that riparian areas have different vegetation than uplands. Because the riparian areas represent floodplains, soil moisture is normally higher than upland areas as well (Hawkins, 1994). The higher water table allows riparian areas to stay greener longer, and produce more forage (Fitch and Adams, 1998). If a drought occurred, these areas could serve as a stable source of forage for grazing animals.

This study will examine producers' knowledge of, and attitudes toward riparian area management. The costs and benefits of various management scenarios intended to better manage riparian areas will be evaluated. A Net Present Value (NPV) model will be used to quantify the effects of these strategies on a hypothetical Alberta ranch, and analyze on-ranch decision-making regarding the strategies. Sensitivity analysis and scenario analysis will be used to analyze results of the NPV model.

1.1 Grazing and Riparian Areas

The effects of grazing cattle in many riparian areas have greatly affected the associated landscapes over the past 100 years (Fitch and Adams, 1998). Stillings (1998) noted that, until recently, traditional ranch management practices did not take the specific needs of riparian areas into consideration. The riparian areas of streams and rivers provide numerous ecological services. The benefits of healthy riparian zones include shelter and forage for wildlife, control of the flow and volume of stream discharge, and filtering of chemicals and sediment in runoff from fields and pastures (Fitch and Adams, 1998).

The riparian zone is usually the most productive zone for forages, as a result of its higher water table (Fitch and Adams, 1998). The economic benefit to ranchers of using this zone can be considerable, and may be necessary for the economic viability of ranch operations. In Alberta, economic viability of ranches is important. In 1999, the provincial cow/calf and feedlot industry had cash receipts of over 3 billion dollars (AAFRD, 2000-c).

The use of riparian areas for grazing can lead to conflict between the public and private interests. For example, in the U.S., questions surrounding the grazing of livestock have spawned legal challenges, political debates, and increased media attention (Adams and Fitch, 1998). Certain watersheds in Alberta exhibit definite damage to riparian zones in that their appearance and vegetation (plant species vigor) are not what would occur naturally (Willoughby and Alexander, 2000). Platts and Wagstaff (1984) stated that range management guidelines suggested separate management schemes for riparian areas. Special protection of these areas means treating them differently from other parts of a ranch's rangeland pasture. However, special treatment for riparian areas could be impractical (both technologically and financially), or difficult to implement (Platts and Wagstaff, 1984).

Sopuck (2001) analyzed the Department of Fisheries and Oceans Canada (DFO) guidelines for protection of fish habitat. Section 35 (1) of the Fisheries Act states that "no person shall carry on any work or undertaking that results in the harmful alteration, disruption, or destruction of fish habitat." DFO (2001) posted the second part of this section on their public website, which states that "no person contravenes subsection (1) by causing the alteration, disruption or destruction of fish habitat by any means or under any conditions authorized by the Minister or under regulations made by the Governor in Council under this Act." The federal government assumed full responsibility for protection of fish habitat after talks with the provinces failed (Sopuck, 2001). The question of whether the provincial governments or local communities have control over their own natural resources has led to some uneasiness concerning possible restrictions placed on private farm operations.

1.2 The Literature

Kauffman and Krueger (1984) reviewed the results of over 100 papers on livestock impacts on riparian ecosystems published between 1940 and 1980. The four major categories outlined were: i) impacts causing changes in streamside vegetation, ii) impacts which changed the shape of the stream channel, iii) impacts which influenced water quality and flow rates, and iv) impacts which changed the soil portion of the streambank (Kauffman and Krueger, 1984). Platts and Wagstaff (1984) stated that the previous literature had established the fact that grazing animals do have negative effects on riparian areas. The presence of grazing cattle can also negatively affect wildlife. Negative effects include direct competition and alterations to the habitat necessary to support wildlife (Kauffman and Krueger, 1984).

1.2.1 *Problems with the Literature*

Existing literature does provide good coverage of the physical effects of grazing cattle in riparian areas. However, recent work suggests that the quality of the science in the studies regarding cattle grazing impacts is insufficient. Larsen et al. (1998) compiled a literature review of over 1500 articles about livestock influences on riparian zones and fish habitat. The authors classified the articles into 3 groups; papers with original data, commentary papers, and reports about methodology. Of the total papers reviewed, 428 were directly related to riparian zones and fish habitat, but only 89 were classed as experimental. Larsen et al. (1998) concluded that many studies in this area have inadequate descriptions of grazing management practices, weak study designs, and lack of pre-treatment data.

There are also studies that outline actual or assumed changes to the environment when cattle grazing is modified, either by complete or seasonal exclusion. However, some recent studies suggest that the environmental impacts from grazing are highly variable, and depend mainly on geographical location, the soil and water component of the range, and the grazing management system used (e.g., Clark, 1998). These studies rarely discuss environmental costs associated with overgrazing riparian areas. More information is also needed on the economic benefits to the environment, through the protection riparian areas.

Literature on the economics of riparian management is very scarce. Platts and Wagstaff (1984) outlined many of the costs involved in fencing riparian areas. Fencing costs are important, as many management strategies require the use of fences. However, management strategies in general have not been discussed in detail in the literature. Adams and Fitch (1998) make reference to a number of strategies in *Caring for the Green Zone*, the guidebook for managing riparian areas. Other authors make references to rotational grazing, without explaining the details of the strategy or strategies involved.

General economic concepts are described, but actual costs and benefits, in terms that are of interest to producers, are left to further study. This study will address some of the missing economic information.

1.3 Research Problem

The purpose of this study is to analyze various riparian management strategies. Some analyses of producer costs and benefits will be performed through the use of Net Present Value calculations. Net Present Value calculations will facilitate discounting the net revenue of a cow/calf operation over a period of time. The purpose of these analyses is to determine whether or not suggested riparian management strategies will benefit beef producers in Alberta. If beef producers in the province have not yet adopted strategies designed to protect riparian areas, there may be a perceived economic barrier to adoption. That is, producers may perceive riparian management strategies as costly, with little or no economic benefit. This study estimates some on-ranch (or on-farm) costs and benefits of various riparian area management schemes.

Chapter 2 will give the reader an introduction to Alberta's cattle industry. It will discuss rangeland management in the province. After discussing overall management, riparian area management will be discussed. The chapter will close with a discussion of different riparian management strategies. Chapter 3 will present the methodology of an initial questionnaire, presented to a group of producers in Southern Alberta. The purpose of this questionnaire was to analyze producer knowledge and perceptions of riparian area management. The results of the questionnaire will follow.

Chapter 4 will present the fundamentals of NPV analysis. The static NPV model used in this research to analyze riparian management strategies will be presented. The scenario and sensitivity analysis used for the model will be explained. Results and discussion of the model analysis will be presented in Chapter 5. Chapter 6 will present conclusions to the research. These will be followed by a discussion of ways to improve the economic models used in riparian management research.

Chapter 2

2.1 Alberta's Cattle Industry

2.1.1 *Alberta's Farms and Land Use*

According to the 1996 Census of Agriculture (Statistics Canada, 1997), there were 54,626 farms in Alberta, of which 24,718 were classified as cattle (beef) operations. Alberta has 16,347,251 acres of natural land for pasture, and 4,731,087 acres of tame or seeded pasture. Alberta farmers own 31,344,893 acres of land, and rent or lease 20,619,467 acres from others. Alberta farmers also rent or lease 10,131,862 acres of land from the provincial government (Statistics Canada, 1997).

2.1.2 *Types of Cattle Operations*

There are different types of commercial beef operations in Alberta. Some producers supply breeding stock to other commercial producers. These are *purebred* or *seedstock* operations (AAFRD, 1998-a). These producers market animals with specific traits. These traits can range from low birth weight to superior carcass quality. Some producers operate *cow/calf* farms. These operations maintain cows, and raise calves until they are weaned (generally at six to eight months of age, and 500-600 pounds of weight) (AAFRD, 1998-a). *Backgrounding lots* feed or pasture calves in order to add size and weight. Generally, they will send the calves to *finishing feedlots* at 800-950 pounds. *Finishing feedlots* feed yearling and backgrounded calves to weights of 1000-1400 pounds, when they are ready for slaughter. Cattle are sent to *packers* for slaughter, and the meat to *wholesalers* and *retailers* for sale to consumers (AAFRD, 1998-a).

2.1.3 *Alberta's Cow/Calf Operations*

This research will focus on cow/calf operations. In Alberta, these operations can be large ranches or mixed farms (AAFRD, 1998-a). Large ranches (herds larger than 300 cows) use large areas of grassland for pasture. Most of their revenue comes from the sale of cattle and calves (AAFRD, 1998-a). AAFRD (1998-a) stated that the average land base per operation was 562 hectares. Mixed farms (small herds under 300 head) often use marginal land, and crop residue. Revenue for mixed farms comes from the sale of both cattle and crops (AFFRD, 1998-a). Table 2.1 presents average herd characteristics of Alberta cow/calf operations. The information was obtained by AAFRD through a detailed study of Alberta cow/calf herds, production results, and management practices during the production periods from 1986/87 to 1988/89 (AAFRD, 1998-a).

In 1996, Alberta reported 5,942,257 cattle and calves on-farm (Statistics Canada, 1997). Of these, 2,119,719 were cows (2,016,889 beef cows, 102,830 dairy cows), and 1,858,679 were calves under 1 year of age. Of the animals 1 year and older, 892,696 were steers, and 952,563 were heifers. The number of bulls was 118,600 (Statistics Canada, 1997). In 1998, Alberta reported 5,760,000 cattle and calves on-farm (AAFRD, 2000-a). This included 103,000 dairy cows, and 1,900,000 beef cows. The number of bulls was 108,000. Of the 1,826,000 calves, 45,000 were dairy heifers, 318,000 were beef heifers for breeding, 609,000 were beef heifers for slaughter, and 851,000 were steers (AAFRD, 2000-a). Table 2.1 provides details on these features of the industry.

In 1998, the average annual income for a beef farm operator was $35,513 (AAFRD, 2000-d). Table 2.2 shows the average price (per cwt) from 1988 through 1997. In 1998, the total receipts from the beef industry were $2,748,100,000 (AAFRD, 2000-b). In 1999, the figure was $3,042,200,000. These figures represented more than one third of the total farm cash receipts for Alberta agri-food industries in those years (AAFRD, 2000-c).

2.2 Rangeland Management

2.2.1 *Livestock Grazing*

Fitch and Adams (1998) stated that the ecosystems found on the Canadian prairies were shaped over thousands of years by large herbivores, such as bison. Willms et al. (1996) stated that bison grazed the range during winter months (when grasses were dormant), allowing the range grasses to flourish during the growing season. When Europeans settled the area, they brought a system of sedentary grazing (Adams and Fitch, 1998). Willoughby and Alexander (2000) noted that, in the late 1800's, livestock grazing was unregulated and open-range along the eastern slopes of Alberta's Rockies. Though barbed wire fences (which marked pasture units) defined later ranches, there were no range management guidelines at the time (Fitch and Adams, 1998).

2.2.2 *Stocking Rate*

According to Willms et al. (1985), the most critical decision that must be made by beef producers is the stocking rate they should use on their rangeland. Stocking rate is the number of animals per unit area of land. Willms et al. (1985) expressed stocking rate in Animal Unit Months (AUM) per hectare. One animal unit month is generally regarded as the amount of dry matter (forage) needed to support one grazing cow and calf pair for one month (Range Management – Public Lands Division, 1990). The choice of a stocking rate can be a difficult decision to make. Parsch et al. (1997) noted that producers must consider the future weather patterns in their decisions. Weather patterns (specifically precipitation levels) can determine how much forage is available to grazing livestock. In addition to weather patterns, Parsch et al. (1997) noted that the stocking rate also has an effect on the amount of forage available.

2.3 Riparian Management

2.3.1 *What Is a Riparian Area?*

Riparian areas are the zones adjacent to streams, rivers, and wetlands (Wagstaff, 1986). Riparian areas have different vegetation than uplands, stay greener longer, and produce more forage (for grazing livestock) because of their higher water table (Stillings, 1997). Adams and Fitch (1998) noted that riparian areas play important roles as buffer zones. If a drought or flood occurs, these areas serve as an "insurance policy" for ranchers. Droughts are offset by a higher water table, while the effects of floods are lessened by deep-rooted riparian vegetation (Stillings, 1997).

Riparian areas have higher humidity, higher rates of transpiration, more shade, and increased air movement (Fitch and Adams, 1998). Animals are attracted to riparian areas for water, shelter, and forages (Stillings, 1997). Wildlife supported by riparian areas can attract human use. These uses include hunting and fishing (Hawkins, 1994). In Alberta and the northwestern United States, riparian areas often flow through rangeland and support herds of beef cattle (Adams and Fitch, 1998).

2.3.2 *Physical Effects of Livestock on Riparian Areas*

Fitch and Adams (1998) listed the eight hydraulic variables most important to riparian form and function. They were: 1) stream discharge, 2) stream gradient, 3) sediment load, 4) bank and bed resistance to moving water, 5) vegetation, 6) temperature, 7) geology, and 8) human activity. This last variable is important because it includes agriculture. Throughout history, agriculture has been based in riparian ecosystems

(Krueger, 1994). Inputs from agricultural activities can seriously degrade riparian systems' natural processes.

Clary and Kinney (2000) simulated trampling of stream banks by cattle to show that, in riparian areas, livestock cause significant physical damage. Degradation can also include pollution through deposition of animal wastes and leaching. Krueger (1994) reported that 64% of non-point pollution in US river systems was attributed to agriculture. Another effect of livestock grazing is a change in plant species number and composition. Livestock may also consume species of plants eaten by other riparian species, such as the beaver (Wuerthner, 1990). When forage on rangeland is scarce, livestock may compete for food with wild species such as antelope (Wuerthner, 1990). The human activity variable can affect the other seven variables, upsetting an existing equilibrium.

2.3.3 *Livestock Effects on Vegetative Ecology*

Another aspect of range health that livestock can influence is vegetative ecology. Willms et al (1985) described a study at the Agriculture Canada Research Substation at Stavely, Alberta. The study concerned the effects of stocking rate on Rough Fescue (*Festuca scabrella*) grassland vegetation. The pasture had been moderately grazed by cattle between 1884 and 1908, and by horses between 1908 and 1920 (Willms et al, 1985). The area was again used for summer grazing of cattle until 1943, with heavy grazing during the drought of the 1930's. In 1949, four fields were fenced to form enclosures (Willms et al, 1985). It was within these enclosures that the study was performed.

Using a recommended stocking rate for the area of 1.6 AUM per hectare, the study modeled light stocking (1.2 AUM/ha), moderate stocking (1.6 AUM/ha), heavy stocking (2.4 AUM/ha) and very heavy stocking (4.8 AUM/ha) (Willms et al, 1985). Initially, all test sites had Rough Fescue as the dominant species, with Parry Oat Grass (*Danthonia parryi*) as the co-dominant species (Willms et al, 1985). The authors found that, with a move from light to moderate grazing, the amount of Parry Oat Grass increased. As grazing intensified, Rough Fescue declined (Willms et al, 1985). The composition of forbs generally increased with stocking rate, while no effect was noted on shrubs. In a similar study, Willoughby and Alexander (2000) noted that heavy grazing allowed Kentucky bluegrass (*Poa pratensis*) to become dominant. Invader species, like Kentucky bluegrass, can change the nature of plant community ecology.

Platts (1990) noted that improper livestock grazing could also diminish plant vigor, and reduce or destroy streamside vegetative cover. This often leads to a change in species composition, as noted above by Willms et al. Platts (1990) stated that, on rangeland in the western United States, "high-quality fibrous root plants" were replaced by "shallow-rooted annual species, or tap-rooted forbs," which could survive in dry, prairie conditions. Platts (1990) suggested that managing riparian areas differently from uplands could result in a more stable plant community.

2.3.4 *Cows and Fish Project*

In 1992, the Alberta Riparian Habitat Management Project (also called Cows and Fish) was established (CWS, 1999, AAFRD, 2000-e). It was a partnership between the Alberta Cattle Commission, Trout Unlimited Canada, the Canadian Cattlemen's Association, Alberta Environmental Protection, Alberta, Agriculture, Food, and Rural Development (AAFRD), and Fisheries and Oceans Canada (AAFRD, 2000-e). Eleven southern Alberta ranches assisted with the project. They applied riparian grazing strategies to restore riparian condition, or developed existing successful practices to share with project coordinators (AAFRD, 2000-e).

The initiators of the project stated that the knowledge and experience existed to recognize and correct grazing impacts on riparian areas (Fitch and Adams, 1998). In order to realize progress, it was accepted that a number of partners would have to cooperate on the project (hence, the large number of collaborators above). The Cows and Fish program was built on the basis that the functions of riparian systems must first be understood in order to develop suitable strategies for grazing (AAFRD, 2000-e). Range management principles were then applied to develop riparian grazing strategies. Thus, the point of the Cows and Fish Project was to create awareness and "understanding of the linkages between livestock grazing, riparian vegetation health, and stream channel dynamics." (Fitch and Adams, 1998)

Before the inception of Cows and Fish, the Alberta Cattle Commission and the Canadian Cattlemen's Association declared that cattlemen had ownership of the riparian grazing issue (CWS, 1999). Riparian areas had been identified as an area of concern by the Commission's environmental risk assessment. Once the aforementioned partners had come together, they consulted technical data and chose options for the project. Demonstration sites were set up on ranches, and workshops concerning riparian management were held (AAFRD, 2000-e). Local community leaders (including producers), land management agencies, and other groups and organizations performed dissemination of riparian management knowledge (Fitch and Adams, 1998).

2.4 Riparian Management Strategies

The following section presents different riparian management strategies. Adams and Fitch (1998) described many of these strategies in the Cows and Fish guide book "*Caring for the Green Zone: Riparian Areas and Grazing Management*". These strategies have been applied to various test ranches and landscape areas in Alberta where ranching is common. The strategies range from low cost (herd distribution practices), to high cost (corridor fencing). The strategy chosen depends very much on the individual ranch and its associated strengths and weaknesses.

Strategies for managing riparian areas cannot be generalized due to the site-specific nature or riparian areas (Krueger, 1994). A site that is naturally stable will be able to respond well to stress. In fact, Krueger (1994) stated that riparian systems must have disturbances at some points to maintain natural processes. Disturbances can be natural (fire, flooding) or man-made (grazing). A lack of disturbances reduces the ability of a riparian system to provide clean water, good fish and wildlife habitat, etc. (Krueger, 1994). However, excessive removal or alteration of riparian vegetation can cause riparian area degradation (Adams and Fitch, 1998).

2.4.1 *Season-Long Grazing*

Continuous (or season-long) grazing represents the status quo. AAFC (2001-c) stated that this is still the most common grazing strategy in use by many cow/calf producers. If the number of grazing animals exceeds a pasture's carrying capacity, this type of grazing is considered to be a poor management choice for rangelands (Fitch and Adams, 1998). AAFC (2001-b) stated that livestock usually prefer to graze and loiter in riparian areas. A longer grazing season can lead to damage, as the animals will remain in the riparian area unless moved. AAFC (2001-c) noted that animals would be more selective under this strategy, choosing only the most palatable vegetation. As well, when grazing is intense, there is no rest period for the vegetation, and it will be grazed through its vulnerable periods (AAFC, 1999).

2.4.1.1 Holding Pasture

A variation on this theme is the *holding pasture*. According to Adams and Fitch (1998), a holding pasture is usually a field in which livestock are held for prolonged periods of time. There could be valid reasons for this practice, including winter feeding and calving. Holding pastures can also refer to fields where animals are kept in high densities for short periods of time. Some of the problems with holding pastures in riparian areas include trampling of stream banks by livestock, and heavy use of herbaceous and woody plants (Platts, 1990). Adams and Fitch (1998) noted that woody plants are important to riparian health because they will provide cover and shade.

2.4.1.2 Livestock Distribution: Placement of Water and Salt

Livestock distribution practices can be a low-cost method to relieve pressure on riparian areas. If animals prefer to graze in riparian areas, then water should be placed outside of this area (Winward, 1994). Adams and Fitch (1994) noted that these upland "off-stream watering sites" could be effective in relieving grazing pressure on riparian areas. Piping, watering ponds, and troughs developed away from spring sources can provide off-stream water (Winward, 1994). The location of salt can also be important. Winward (1994) stated that ranchers must take care to locate salt blocks away from riparian watering sources, as that is where the animals would then be concentrated.

Dickard (1998) evaluated management strategies involving assessment of off-stream water and salt placement for improved cattle distribution (and subsequent riparian health). Sixty cow/calf pairs were allotted to three pastures, with three grazing strategies: 1) stream access, with access to off-stream water and salt; 2) stream access, with no access to off-stream water and salt; and 3) ungrazed control. No changes were noted for grazing activity, travel distances, forage utilization, or water quality in any of the three treatments (Dickard, 1998). However, Dickard (1998) found that cattle distribution was affected by the presence of off-stream water and salt. Water and salt located away from the stream were successful in relieving pressure on the riparian area.

2.4.2 *Grazing Systems*

Grazing systems specify livestock management and could be the most effective management technique for livestock in riparian areas (Wagstaff, 1986). Unfortunately, these systems are often the most difficult to implement (Winward, 1994). Winward (1994) pointed out that care must be taken to remove all animals from the area to be protected, as remaining animals will focus on riparian vegetation. Grazing systems often involve increased fencing and herding costs for the producer (Wagstaff, 1986). Platts et al. (1989) noted that some grazing systems involve the deferral of animals from grazing specific pastures. This may have a direct effect on revenue for producers.

2.4.2.1 Rotational Grazing

According to AAFC (1999), rotational grazing allows for the best economic return on land, while managing the resource for future years. Normally, the range to be grazed is divided into different pasture units or cells (AAFC, 1999). However, Adams and Fitch (1998) stated that this management scheme could also work with existing pasture units, or through a change in herding practices. A rotational grazing system means that livestock will be grazing available range more evenly (AAFC, 2001-a). If grazing periods are shorter, more rest can be provided to certain areas of the range. This can protect plants at young, vulnerable stages, by allowing them time to establish before grazing (AAFC, 2001-a).

Rest can be provided by deferring grazing (delaying early season grazing, for example), or by resting pastures after grazing. During spring runoff, stream banks are especially vulnerable to trampling (AAFC, 2001-a). Rotational grazing can help a rancher change the season of use, to keep livestock out of riparian areas at this time. When livestock overgraze an area, they have exhausted the young vegetation, and have turned to any forage available, including plant litter (AAFC, 1999). Rotational grazing allows some of this litter to be carried over into another season, which is better for overall range health.

2.4.2.2 Deferred Rotational Grazing

Platts et al. (1989) studied deferred rotation on a ranch on the Henry's Fork River, in Idaho. In 1986, a deferred rotational grazing system was implemented on the ranch. A deferred rotation means that no pasture unit in the rotation is ever grazed at the same time of year, two years in a row (Adams and Fitch, 1998). That is, the sequence of use changes from year to year. On the Henry's Fork pasture, the original pasture was divided into four units, with two chosen for deferral pastures. The animals entered late two years in a row, and another pasture unit was used for rest periods. On the ranch in question, the riparian area showed definite improvement (Platts et al., 1989). The authors reported that the producer could add 25% more livestock than he had before the management change, due to increased forage productivity.

2.4.2.3 Time-Controlled Grazing

Another grazing system is time-controlled grazing. This involves shortening the period of grazing use on riparian pastures, minimizing re-grazing of the required re-growth of plants (Adams and Fitch, 1998). Time-controlled grazing can be used at different stocking rates (light, moderate, or heavy). Adams and Fitch (1998) noted that heavy stocking rates could sometimes be effective in helping producers reach management goals. However, higher stocking rates can mean higher risk of overgrazing in the riparian area. If a rancher wants to restore woody vegetation to a riparian pasture, less selective grazing in riparian zones could hinder this goal (Adams and Fitch, 1998). A rancher must be prepared to move his or her animals, in order to achieve riparian area goals.

2.4.2.3 Rest-Rotation Grazing

Adams and Fitch (1998) described rest-rotation grazing as a conservative grazing strategy. This strategy can be used to assist a rancher in restoring woody vegetation to a riparian area, when it is needed most. Platts and Wagstaff (1984) stated that four or five years of rest could result in a gain of 75% of the original grazing benefits. If woody species do not have time to grow to a height where livestock can no longer browse them, no young trees will survive to replace old, dead trees (Adams and Fitch, 1998). Different types of trees will take longer to regenerate. This must be taken into consideration when planning rest periods.

2.4.2.4 Riparian Pastures

According to Adams and Fitch (1998) riparian pastures represent a landscape approach to riparian area management. This strategy involves defining pastures in such a way as to reduce variation within a field. To do this, a rancher could fence off a riparian area separately from an upland pasture (Adams and Fitch, 1998). Livestock should be grazed in a planned sequence, much like those in a rotational system. The main difference in a riparian pastures system is that pastures are separated according to their landscape type (Adams and Fitch, 1998). The riparian pasture strategy also requires more fencing than other strategies.

2.4.2.5 Corridor Fencing

Platts and Wagstaff (1984) noted that one method of grazing management is to fence the corridor that borders a riparian area. This method eliminates livestock grazing on a narrow fringe of the riparian area. Platts (1990) suggested this method for "high risk" riparian areas that have poor recovery potential. Platts and Wagstaff (1984) noted that this method could provide the most protection for damaged riparian areas. Corridor fencing is very expensive, and can be difficult to maintain (Winward, 1994). The type of fencing chosen will directly affect the costs associated with fencing as well (Platts and Wagstaff, 1984). Platts and Wagstaff (1984) also noted that annual maintenance costs per mile of fencing could be 1 – 3% of the initial fencing cost. Wagstaff (1994) stated that, while expensive, corridor fencing strategies could often be used to improve the management of riparian grazing areas.

2.5 Chapter Summary

In Alberta, beef farming is a multi-billion dollar industry. In this industry's cow/calf operations, pasture is usually the major production input. Studies such as Clary and Kinney (2000) and Willoughby and Alexander (2000) have shown that degradation of riparian pastures occurs through trampling and overgrazing. However, recent studies have not addressed the economics of riparian area management. Specific costs and benefits have not been analyzed. Groups such as Cows and Fish have suggested a number of strategies to improve riparian health. These range from simple distributional changes, to more labour-intensive and costly fencing strategies. This study addresses the economic concerns associated with riparian area management strategies.

2.6 Tables for Chapter 2

Table 2.1 Average Herd Characteristics of Alberta Cow/Calf Producers

Number of herds surveyed	6,249
Cows and heifers in survey	519,979
Total land base per operation (hectares)	562
Cows in herd	72
Replacement heifers in herd	12
Breeding bull/herd	3

AAFRD, 1998-a

Table 2.2 Alberta Beef Cattle at July 1 (Thousands of Head)

Year	Beef Cows	Beef Heifers	Heifers for Slaughter	Calves	Steers	Bulls	Total Beef Cattle	5-600 pound Calves, May Prices, Adjusted for Inflation (1992=100) ($/cwt)
1976	1530	270	368	1435	770	88	4461	116.87
1977	1500	260	318	1315	660	87	4140	102.95
1978	1400	240	320	1239	645	82	3926	159.63
1979	1370	230	325	1205	650	85	3865	256.20
1980	1400	245	306	1290	600	90	3931	150.23
1981	1368	243	325	1300	607	90	3933	137.10
1982	1394	227	320	1260	580	90	3871	125.47
1983	1388	217	300	1235	540	91	3771	122.72
1984	1368	233	298	1255	540	91	3785	116.03
1985	1345	222	264	1245	492	91	3659	105.43
1986	1315	232	255	1252	426	91	3571	113.11
1987	1369	259	271	1297	465	90	3751	138.64
1988	1444	283	287	1351	526	91	3982	134.36
1989	1506	303	319	1421	571	92	4212	120.73
1990	1567	305	320	1478	568	94	4332	115.09
1991	1635	324	330	1560	575	95	4519	113.58
1992	1667	335	348	1581	631	97	4659	106.83
1993	1760	313	410	1666	549	103	4801	123.89
1994	1917	400	359	1818	567	112	5173	131.63
1995	2050	455	374	1910	564	120	5473	105.33
1996	2023	320	459	1945	653	119	5519	70.29
1997	1970	320	550	1830	670	116	5456	99.67

AAFRD, 1998-b (Cattle numbers) and Chase, 2001 (Price data)

Chapter 3

3.1 Initial Questionnaire Methodology

3.1.1 *Introduction*

In order to determine the knowledge level of producers, as well as their ideas about riparian management, a questionnaire was developed. It was designed to obtain a qualitative assessment of producer knowledge and attitudes. Some questions probe the economic importance of management strategies to producers. These attitudes will be tied to economic assessments in later chapters. The questionnaire was presented to producers at the 2000 Stockmen's Range Management Course in Maycroft, Alberta.

The Stockmen's Range Management series is sponsored by: the Alberta Cattle Commission, Alberta Agriculture, Food, and Rural Development, Agriculture and Agri-food Canada, the Prairie Farm Rehabilitation Administration, Alberta Environment, Cows and Fish, and others. This was not a random sample of the population of Alberta ranchers. Forty-two producers and 2 non-producers filled out the questionnaire. The following section briefly describes the survey questions used. The full survey is found in Appendix 1.

3.1.2 *Survey Sections*

The survey (initial questionnaire) was divided into a number of sections. The first section involved an explanation of the various riparian management methods proposed by the Cows and Fish Program. These methods included Distribution Practices, Rotational Grazing, Deferred Rotational Grazing, Time-Controlled Grazing, Rest-Rotation Grazing, Riparian Pastures, Holding Pastures, and Corridor Fencing. As well, respondents were given an idea of the relative cost of each method. These methods are described in Chapter 2, Section 2.4, and in Appendix 1.

Part I

Part I of the survey presented two scenarios to respondents. Figure A (Scenario 1) showed a pasture that had been grazed season-long for 50 years. Figure B (Scenario 2) showed a pasture that demonstrated signs of recovery with a rotational grazing program. Both scenarios asked respondents to choose management strategies to manage the areas shown in the figures. They were asked to rank a list of choices from first to last (1 being the first choice, and 8 being the last). The choices were arranged as they have been discussed in the description section above (see Appendix 1). A section was also provided for respondents to give comments on the section.

The second part of Part I asked respondents how much their management choices were affected by certain factors. The respondents were asked to rate the factors from High Influence to Low Influence, on a Likert scale of 1 to 7 (1 being High Influence, 7 being Low Influence). The factors were arranged as follows:

a) Fencing and other capital costs
b) Management time required
c) Water quality for livestock
d) Water quality for downstream users
e) Effect on public perception
f) Changes in forage production
g) Changes in forage quality
h) Effect on fish and wildlife
i) Impact on short-term grazing
j) Impact on long-term grazing capacity
k) Cows and Fish recommendations
l) Effect on long-term ranch cash flow
m) Other (Examples: fish shelter, stable banks, etc.)

Parts II and III

The second part of the survey involved the respondents' choices of measurement units. That is, when the results of the survey were reported, which units of measurement would the respondents want to see used? The third and final part of the survey collected demographic information from respondents. These parts are presented in detail, in Appendix 1.

3.2 Initial Questionnaire Results

3.2.1 *Demographic Results*

Demographic information was collected from respondents in the third part of the survey. The questions and responses can be found below (See Appendix 2 for more detail). The majority of respondents were ranchers or producers with grazing animals (Table 3.1). Many respondents have large-scale operations, with 88% of them being cow/calf operations (Tables 3.2 and 3.3). 75% of the respondents' operations had a riparian area on site (Table 3.4). These are the producers who will be most affected by this study. 77% of respondents supported the objectives of the survey (Table 3.4). 70%

of respondents thought that a survey was a good way to get information from ranchers (Table 3.4). The two respondents who said no indicated that on-farm visits would be a better method.

3.2.2 *Figure A (Scenario 1) Badly Damaged Riparian Area*

Figure 3.1 Badly Damaged Riparian Area

The badly damaged riparian area picture (Figure A in the questionnaire) can be seen in Figure 3.1. In Scenario 1, many producers favored Distributional Practices as a management choice. Please see tables 3.5 and 3.6 for detailed results. More than half of the respondents ranked it as choice 1 or 2. Only one respondent ranked the Holding Pastures scheme as first choice, while 69% placed it at 7 or 8. Corridor Fencing received an interesting response; 52% of respondents placed it at 7 or 8. However, 27% of respondents ranked it as their first choice.

The producers who responded to this questionnaire seemed to acknowledge the fact that overgrazing pastures can cause severe damage to riparian areas. Respondents recognized that the riparian area was damaged, and did not need increased grazing pressure. As well, there seemed to be a preference for the least expensive strategies. The response for Corridor Fencing was interesting, as it would be the most expensive strategy for beef producers. Even so, 27% of producers ranked it as a first choice. This may suggest that these producers felt that this riparian area was in need of a "last resort" fix.

3.2.3 *Figure B (Scenario 2) Recovering Riparian Area*

Figure 3.2 Recovering Riparian Area

The recovering riparian area (Figure B in the questionnaire) can be seen in Figure 3.2. In Scenario 2, many producers favored Distributional Practices as a management choice. More than half of the respondents ranked it as choice 1 or 2. Please see Tables 3.7 and 3.8 for more information about the results. Rotational Grazing was ranked as a high or "middle ground" choice (36% chose 1 or 2, 35% chose 3 or 4). Only three respondents ranked the Holding Pastures scheme between 1 and 5, while 93% placed it at 6, 7, or 8.

Corridor Fencing was biased toward the lowest rankings, with 87% of respondents choosing 6, 7, or 8. The producer responses to Scenario 2 were much like those for scenario 2. Least-cost scenarios were favoured. Producers seemed to know that this riparian area would not need Corridor Fencing to correct damage to the riparian area, as it was in a recovery stage.

The producers were then asked to rank the factors that would affect their decisions to use each management scheme. Table 3.9 presents the mean rankings of each of the factors. More information on the following results can be found in Appendix 2. The most important factors for producers appear to be *Changes in forage production*, *Changes in forage quality*, *Effects on fish and wildlife*, and *Impact on long-term grazing capacity*. The effects on fish and wildlife will not be addressed in this study, but the other choices will have an impact.

These choices suggest that ranchers surveyed are looking to the future. They are concerned with the supply of quality forage for their livestock, and care about the other animals that inhabit parts of their ranches. These choices also suggest that ranchers also value long-term earnings. The time factor will be addressed in our analysis, as we used 20 years of grazing in our ranch models.

The second part of the survey involved the respondents' choices of measurement units (See Table 3.10 and Appendix 2 for more information). Producers favoured Animal Unit Months (AUM) of grazing, when results are reported (69% of respondents). Many producers felt that Tonnes of Forage per Acre (47%) would also be a good way of showing results. These measurement units go hand in hand, as the amount of forage produced per acre will affect the number of AUM's of grazing possible.

Choices featuring "dollars per acre" (benefit – 29%, cost – 38%, revenue – 24%, and profit – 22%) competed with "pounds of beef per animal" (27%) for the rest of the producers' choices. These go hand in hand as well, since pounds of beef per animal will translate to dollars for producers at the end of a grazing season. The total percentage of responses will not sum to 100%, as respondents were encouraged to choose more than one measurement unit.

3.3 Chapter Summary

Most of the respondents surveyed were ranchers with relatively large operations. Since large cow/calf operations will be modeled in this study, these producers would be most interested in the results. The responses to the initial questionnaire showed that most producers surveyed are knowledgeable about riparian area management. When choosing a strategy for their own ranches, producers would favour lower-cost solutions, such as distributional practices and rotational grazing.

However, in the case of a heavily degraded riparian area, many producers chose corridor fencing, the strategy with the highest capital costs. This may be a result of producers looking to the future, and selecting impacts on forage production and quality as the most important factors in their decision-making. This is further supported by the choices of long-term effects of riparian management on grazing capacity and ranch cash flow as important considerations.

3.4 Tables for Chapter 3

Table 3.1 Part III- Responses to Questions 1 and 2 of the Questionnaire

Question	Response			
	YES		NO	
	Number	Percentage	Number	Percentage
1. Do you farm or ranch?	42	95%	2	5%
2. Do you have grazing livestock such as cattle?	41	98%	1	2%

Table 3.2 Part III – Responses to Question 3a of the Questionnaire

3.a Description of farm type	Response	
	Number	Percentage
Cow/Calf	37	90%
Backgrounding	12	29%
Finishing Cattle	3	7%
Other	7	17%

Rank of 1 is the highest ranking, rank of 8 is lowest ranking

Table 3.3 Part III – Responses to Question 3b of the Questionnaire

3.b Number of Animals per Operation	Number	Percentage
Less than 50	4	10%
50 – 199	11	27%
200 or more	26	63%

Table 3.4 Part III – Responses to Questions 4, 5, and 6 of the Questionnaire

Question	Response					
	Yes		No		No Response	
	#	%	#	%	#	%
4. Do you have a riparian area on your ranch?	33	80%	8	19%	-	-
5. Do you support the objectives of this survey?	34	83%	-	-	7	17%
6. Do you think this is a good way to get information from ranchers?	31	76%	2	5%	8	19%

Table 3.5 Responses to Figure A – Scenario 1 of the Questionnaire

	Distributional Practices		Rotational Grazing		Deferred Rotational Grazing		Time Controlled Grazing	
Rank	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
1	9	22	3	12	4	10	2	5
2	12	30	5	15	3	8	6	15
3	4	10	6	20	11	27	8	20
4	5	12	8	22	10	24	4	10
5	3	7	9	12	5	13	4	10
6	3	7	5	7	5	13	10	23
7	2	5	3	5	2	5	7	17
8	3	7	2	7	0	0	0	0
Mean Rank	3		4		4		4	
SD	2.21		1.86		1.60		1.92	

Rank of 1 is the highest ranking, rank of 8 is lowest ranking
refers to frequency of response, % refers to percentage of respondents choosing the rank

Table 3.6 Continuation of Responses to Figure A – Scenario 1 of the Questionnaire

	Rest Rotation Grazing		Riparian Pastures		Holding Pasture		Corridor Fencing	
Rank	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
1	3	7	9	22	1	3	11	27
2	7	17	6	15	0	0	2	5
3	6	15	2	5	0	0	4	10
4	6	15	5	13	2	5	1	3
5	9	22	9	22	2	5	0	0
6	7	17	3	8	7	18	1	3
7	1	2	4	10	16	39	4	10
8	2	5	2	5	12	30	17	42
Mean Rank	4		4		7		5	
SD	1.86		2.24		1.41		3.13	

Rank of 1 is the highest ranking, rank of 8 is lowest ranking
refers to frequency of response, % refers to percentage of respondents choosing the rank

Table 3.7 Responses to Figure B – Scenario 2 of the Questionnaire

	Distributional Practices		Rotational Grazing		Deferred Rotational Grazing		Time Controlled Grazing	
Rank	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
1	16	39	4	10	6	15	5	12
2	6	15	11	26	7	17	4	10
3	1	2	8	20	11	27	10	23
4	4	10	6	15	11	27	8	19
5	6	15	5	12	4	10	7	17
6	5	12	4	10	1	2	8	19
7	1	2	3	7	0	0	0	0
8	2	5	0	0	1	2	0	0
Mean Rank	3		4		3		4	
SD	2.28		1.78		1.50		1.62	

Rank of 1 is highest ranking, rank of 8 is lowest ranking
refers to frequency of response, and % refers to percentage of respondents choosing the rank

Table 3.8 Continuation of Responses to Figure B – Scenario 2[2] of the Questionnaire

	Rest Rotation Grazing		Riparian Pastures		Holding Pasture		Corridor Fencing	
Rank	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
1	6	15	5	12	0	0	1	2
2	8	19	4	10	0	0	1	2
3	6	15	3	7	1	2	1	2
4	6	15	4	10	0	0	2	5
5	8	19	8	19	2	5	1	2
6	2	5	11	25	6	15	4	10
7	3	7	5	12	21	51	8	20
8	2	5	2	5	11	27	23	57
Mean Rank	4		5		7		7	
SD	2.03		2.07		1.01		1.77	

Rank of 1 is highest ranking, rank of 8 is lowest ranking
refers to frequency of response, and % refers to percentage of respondents choosing the rank

Table 3.9 Mean Ratings of Factors (Part I of the Questionnaire)

Factor Affecting management Choice	Mean Rating	Standard Deviation
Fencing and Other Capital Costs	3	1.46
Management Time Required	3	1.52
Water Quality for Livestock	3	1.43
Water Quality for Downstream Users	3	1.46
Effect on Public Perception	3	1.83
Changes in Forage Production	2	0.93
Changes in Forage Quality	2	1.10
Effect on Fish and Wildlife	2	1.34
Impact on Short-term Grazing Capacity	4	1.69
Impact on Long-term Grazing Capacity	2	1.20
Cows and Fish Recommendations	3	1.04
Effect on Long-term Ranch Cash Flow	3	1.50

1 is the highest rating, and 7 is the lowest rating

Table 3.10 Measurement Units Chosen (Part II of the Questionnaire)

Measurement Unit	Percentage of Responses
Tonnes of Forage per Acre	47%
Animal Unit Months of Grazing	69%
Net Dollars Benefit per Acre	29%
Pounds of Beef per Animal Grazed	27%
Cost ($) per Acre	38%
Revenue ($) per Acre	24%
Profit ($) per Acre	22%

Chapter 4

Introduction

This chapter presents simplified overviews of risk, discount rates, and Net Present Value analysis, as they relate to models used in this study. Section 4.1 is a technical discussion of investment analysis. Net Present Value (NPV) analysis, as it relates to cow/calf operations, is discussed. Next, the theory of risk premia and the Capital Market Line (CML) are presented. These concepts relate to the choice of a discount rate for a cow/calf operation. The key assumptions used in each of the model's range management cases are described in section 4.2. These assumptions determine the results from the static NPV analysis.

4.1 Theoretical Framework

4.1.1 *Capital Budgeting: Net Present Value (NPV)*

Farm models developed in this study are analyzed using an incremental Net Present Value (NPV) analysis. This type of analysis is often used to analyze capital investments. A producer may invest in capital that will have value for more than one period. That is, the time value of money must be taken into consideration. The time value of money is one of the most important concepts in farm (and corporate) finance (Ross et al., 1999). Money received today is more valuable than money received tomorrow (AAFRD, 1995). That is, the longer a person must wait for money, the less it is worth to that person today.

The *future value* or *compound value* of money is the value of a sum after investing for one or more periods (Ross et al., 1999). For example, if one were to invest 10,000 dollars today at a 12% interest rate (annual compound rate), it would be worth 11,200 dollars after one year [10,000 x 1.12 = 11,200], and 12,544 dollars after two years [11,200 x 1.12 = 12,544]. That is, the future value is written as:

$$FV = C_0 \times (1 + r)^T \tag{4.1}$$

where C_0 is the cash invested at time 0, r is the interest rate, and T is the number of periods over which the cash is invested (Ross et al., 1999).

Another way to show the time value of money is *present value*. This type of analysis tells an investor how much money he or she must invest today, in order to make a specific amount in the future (Ross et al., 1999). Using numbers from the above example, the present value of 11,200 dollars one year from now, at a 12% rate, is 10,000 dollars. An investor would know the amount of money to invest today, at a 12% rate, in order to receive 11,200 dollars in one year [11,200 / 1.12 = 10,000]. In the case of present value, the interest rate is referred to as the *discount rate* (Megginson, 1997). The equation for Present Value can be written as:

$$PV = \frac{C_t}{(1+r)^t} \tag{4.2}$$

where C_1 is the cash flow at time period 1 and r is the interest (discount) rate.

Damodaran (1997) described a *discount rate* as a rate at which present and future cash flows are traded off. This rate calculates the present value of future cash flows (Ross et al., 1999). The discount rate includes the following elements:

1) preference for current consumption
2) uncertainty in future cash flows.

That is, if there is higher risk, there will be a higher discount rate. As well, if one has greater preference for current consumption, the discount rate is higher (Damodaran, 1997). The discount rate is discussed further in section 4.13.

The expected net cash flow produced by an investment can be presented as a single figure, known as the Net Present Value (NPV) (AAFRD, 1995). The NPV is adjusted for risk, inflation, and the time value of money. In order to understand the computation of a NPV, a simple example adapted from Ross et al. (1999) will be used. A company has the choice of investing $100 in a riskless project. The project has a cash flow of $107 after one period. The company can choose to invest the $100 today, and pay the $107 as a dividend after one period. On the other hand, the company can forego the project, and pay out the $100 as a dividend now. If the interest (discount) rate is 6%, the NPV of the project would be the $107 dividend, divided by 1.06 (interest rate), minus the $100 initial payment (107 ÷ 1.06 – 100). The result is $0.94. When an NPV is positive, a company will generally accept a project (Ross et al., 1999).

The above example could be applied to many situations. An agricultural producer faces a variety of investment decisions that affect his or her operation. The NPV method has three main attributes. The first attribute is that NPV uses cash flows. Other methods use earnings, which are artificial accounting constructs (Ross et al., 1999). Earnings do not represent cash, as cash flows do. NPV also uses all of the cash flows of a project, instead of ignoring cash flows after a specific period (as other methods, such as Payback do). NPV analysis also discounts cash, relying on the time value of money (Ross et al., 1999). These elements can be seen in the NPV formula, for multiple periods, shown below:

$$NPV = C_0 + \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_n}{(1+r)^n} = \sum_{i=0}^{n} \frac{C_i}{(1+r)^i}$$

(4.3)

where C_i represents the net cash flow for each period i, n represents the life of the project (last period), and r represents the risk-adjusted discount rate.

Other than NPV, there are a number of methods (rules) used to analyze investments. The first of these rules is the *Payback Period Rule*. The payback period is the amount of time required to recover the initial investment in a project, taking into account projected cash inflows (Megginson, 1997). When the amount to be received exceeds the initial investment, then the investment is recovered. In the case of a two-year cutoff period, an investment project that has a payback period of two years or less will be accepted (Ross et al., 1999).

There are some problems with the payback period method. First, the timing of the cash flows is not considered. That is, they are not discounted properly (as they would be in NPV analysis) (Ross et al., 1999). A second problem is that the method does not include payments that occur after the payback period (Megginson, 1997). A project that has a positive cash flow after the payback period would definitely be preferred to one that does not. There is also a problem with the choice of a payback period. Using the Payback Period Rule, the choice is arbitrary (Ross et al., 1999). A method such as NPV has a standard for choosing important aspects of financing, such as discount rates.

Another rule noted by Ross et al. (1999) is the *Average Accounting Return* (AAR). This method is defined as “the average project earnings after taxes and depreciation, divided by the average book value of the investment during its life” (Ross et al., 1999). Projected net incomes for each year in the life of the project, divided by its life span, are summed to find average net income (Ross et al., 1999). The expected values of an investment over the life span are summed, then divided by the life span to get average investment (Ross et al., 1999). The AAR can then be calculated by dividing the average net income by the average investment. The resulting percentage is the AAR (Ross et al., 1999).

One major flaw of the AAR method is the fact that accounting values (net income, book value of investment) are used to judge the value of the investment. A better analysis of the investment could be performed using the cash flows associated with a project (as in NPV) (Ross et al., 1999). Also, as in the case of the Payback Period Rule, the AAR method does not take timing of cash flows into consideration. The AAR method also requires an arbitrary cutoff date to be chosen (Ross et al., 1999).

The *Internal Rate of Return* (IRR) method (the most important alternative to the NPV approach) is used to find a single number that explains the benefits of a project (Ross et al., 1999). The number is an *internal* rate of return because it does not depend on the prevailing interest rate in the capital market. If NPV for a one-period project is written as:

$$NPV = Initial\ Investment + \frac{First\ Period\ Cash\ Flow}{1+r} \tag{4.4}$$

where *r* is the discount rate, the IRR is the rate *r* at which NPV will equal zero (Ross et al., 1999). The company or producer will accept the project if the discount rate is above the IRR, and vice-versa. This is the standard IRR rule (Ross et al., 1999).

Problems associated with IRR are not as apparent as problems with other methods. Consider two types of project. If a company pays money first, and receives money later, this is an investing-type project. If a company receives money first, and pays money later (e.g., conference attendees paying fees in advance), this is a financing type project (Ross et al., 1999). A financing-type project can reverse the standard IRR rule (see above). This can be a problem, unless it is fully understood (Ross et al., 1999). A project’s cash flows may also exhibit two or more changes of sign for the net cash flows n different periods (e.g., -$100, $200, -$150). A project such as this may exhibit more than one IRR, due to the “flip-flops” in sign (Ross et al., 1999).

Aside from the mathematical properties mentioned above, Megginson (1997) pointed out that NPV analysis uses a more conservative and realistic investment rate. The NPV approach implicitly assumes that intermediate cash flows generated by an investment will be reinvested at the discount rate (Damodaran, 1997). The IRR approach assumes reinvestment at the IRR of the project (Megginson, 1997). Megginson (1997) noted that the IRR rate is often higher than the discount rate (which is often a reasonable reinvestment rate).

Theoretically, NPV is a better approach for investment analysis (Megginson, 1997). However, many businesses (including farm businesses) often use the accounting approach or IRR to evaluate choices. This may be because the IRR can summarize a project into a simple rate of return (Ross et al., 1999). Freeze et al. (1999) used an accounting approach to evaluate beef feedlot composting. Unterschultz and Quagrainie (1996) used investment analysis in their study of agri-food ventures. However, Mumey and Unterschultz (1996) used concepts of NPV analysis in a study of risk premia in combines and tractors. Risk premia are discussed in section 4.1.3. Applying the reasoning discussed above, future analyses of riparian management would benefit from NPV analysis.

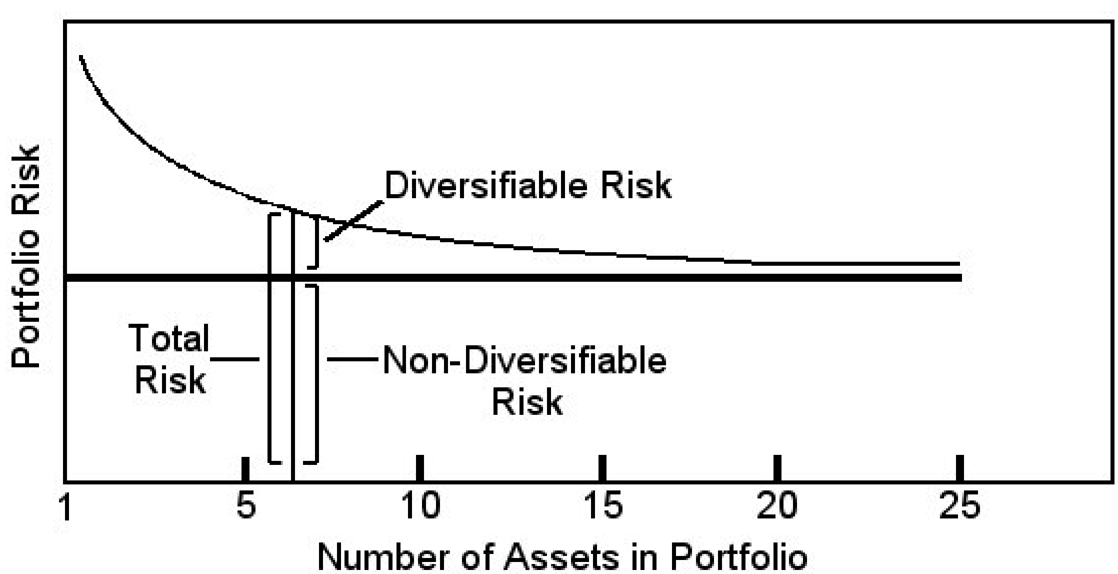
In order to use NPV analysis in our riparian management model, certain information is needed. Production data and relationships are needed for the model, a cow/calf operation. These provide a function for converting raw materials into a finished product. In the case of a cow/calf operation, it is the conversion of forages into 500-600 pound beef calves. As well, the revenue generated by the sale of finished products is needed. Capital and operating costs for the operation are needed in order to calculate of net cash flow (revenue – cost). Incremental analysis evaluates the changes between different scenarios. This simplifies the analysis while maintaining the rigour of NPV analysis.

4.1.2 *Project Risk*

Every project will have a certain amount of uncertainty associated with it. This uncertainty is referred to as risk. Megginson (1997) stated that investors wish to maximize returns for a given amount of risk. According to Unterschultz and Quagrainie (1996), investment projects can have two types of risk associated with them. These risk types are termed *unique risk* and *systematic risk*. Unique risk is risk that is specific to the investment project. Systematic risk is covariance risk between the investment project and the total market (Unterschultz and Quagrainie, 1996). If an investor can diversify his or her investment portfolio (i.e., hold more than one investment in a portfolio at one time), unique risk could be reduced to the point that it will not affect the overall value of a portfolio (Damodaran, 1997).

The standard financial approach to portfolio risk and diversification can be seen in Figure 4.1. It shows that as securities or assets are added to a portfolio, the total portfolio risk decreases. Total portfolio risk is measured as the standard deviation of portfolio returns (σ_{Rp}). However, businesses such as cow/calf operations are usually non-diversified. Therefore, both unique and systematic risk (total portfolio risk) must be considered when analyzing a farm's financial situation.

Figure 4.1 Portfolio Risk and Diversification[1]



[1]modified from Megginson (1997)

4.1.3 *Finding a Risk Premium and Discount Rate for an NPV analysis*

In this study, we wish to obtain a risk measure (discount rate) to use in the Net Present Value analysis of non-diversified investments. First, risk as it applies to diversified investment portfolios will be discussed. Though unique risk can be eliminated in most investment situations through diversification, systematic risk will continue to affect investors. According to Megginson (1997), this means that investors will demand a premium for holding more risky assets. The higher the systematic risk, the higher the expected rate of return will be. Investors must find a trade-off between risk and return. Damodaran (1997) stated that, if an investor specifies the amount of risk he or she is willing to accept, then the portfolio is optimized when expected returns are maximized subject to this level of risk. The dual approach suggests that, if an investor specifies his or her desired level of return, then the portfolio is optimized when variance (risk) is minimized, subject to this level of return (Damodaran, 1997).

Risk minimization can be written as:

$$\text{Min}: \sigma_p^2 = \sum_{i=1}^{i=n} \sum_{j=1}^{j=n} w_i w_j \sigma_{ij}$$

(4.5)

Subject to:

$$E(R_p) = \sum_{i=1}^{i=n} w_i E(R_i) \geq E(\hat{R})$$

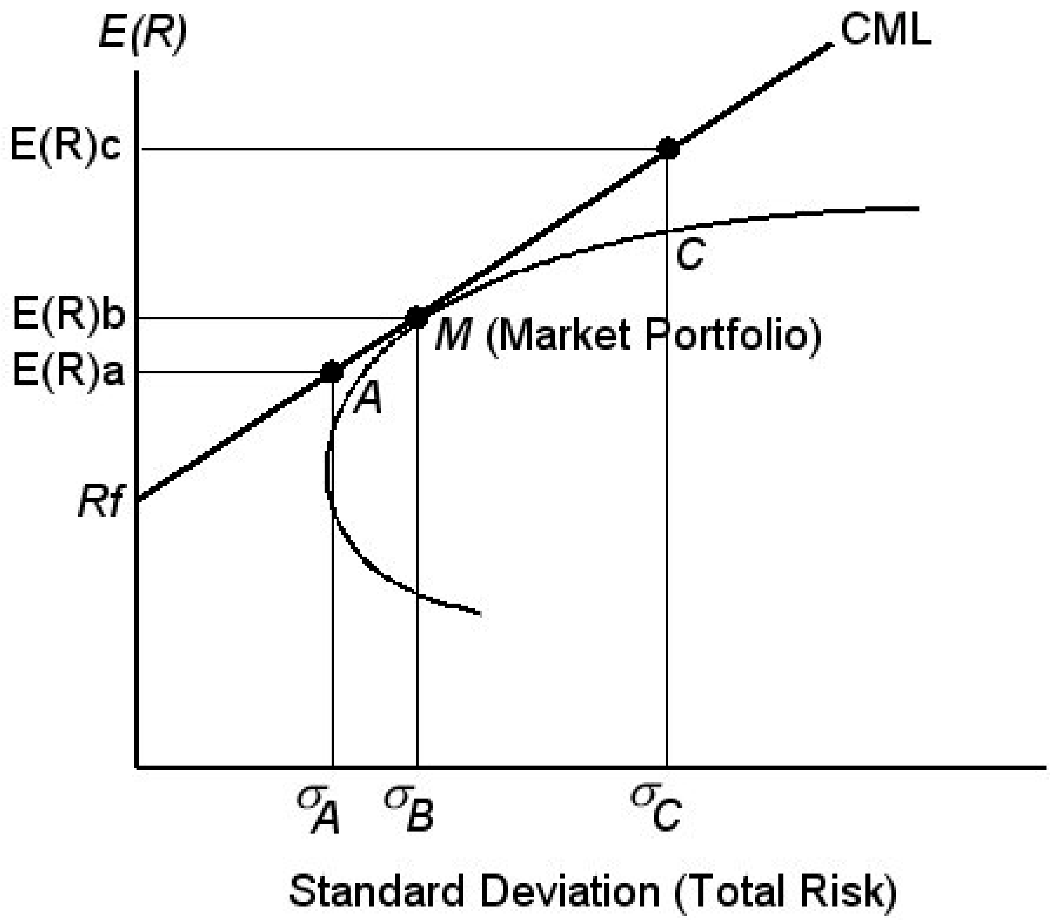
(4.6)

Where σ^2_p is the variance of the portfolio, w_i and w_j are portfolio weights on assets, σ_{ij} is the covariance between returns, $E(R_p)$ is the expected return on the portfolio, n is the number of assets, w_i is the profile weight on an asset, $E(R_i)$ is the expected return on an asset, and E(R) = Investor's desired expected returns.

The elliptical line shown in Figure 4.2 is referred to as the Efficient Frontier. This line is the result of varying E[R] in equations (4.5) and (4.6). Standard Deviation of Returns, σ_p, represents risk. Risk increases from left to right in the figure. The points on the efficient frontier represent combinations of risk (X-axis) and expected return (Y-axis). For example, point M would have a risk associated with it of σ_B and an expected return of $E[R_B]$.

Megginson (1997) stated that investors could choose to invest in risky assets (i.e., common stocks) or risk-free (riskless) assets (i.e., government treasury bills). With risky assets, the returns vary depending on the assets. A riskless asset has an actual return equal to the expected return (Damodaran, 1997). That is, the investor knows what the return will be at the time of the investment. Damodaran (1997) noted that, when investors have the choice of a riskless asset to invest in, the absence of variance in this asset makes it uncorrelated with the returns on any risky assets. Combinations of risky assets with a riskless one will give linear results for the standard deviation (Damodaran, 1997).

Figure 4.2 Capital Market Line (Risky Portfolio with Riskless Asset)[1]



[1] adapted from Damodaran (1997)

The linear relationship that exists between the standard deviation of the overall portfolio and the proportion invested in a risky asset is depicted in Figure 4.2. Megginson (1997) refers to the line from R_f through point *M* as the Capital Market Line, or CML. This line represents portfolios formed by combinations of the risk-free asset and the portfolio of risky securities, *M,* on the efficient frontier. *M* could be a portfolio composed of 30% in Bell Canada Enterprises (BCE, 45% in Canadian Imperial Bank of Commerce (CIBC, and 25% in Canadian Marconi (Ross et al., 1999). *M* is usually considered to be a large portfolio of financial assets. The CML is the efficient set of both risky and riskless assets. Points between R_f and *M* are portfolios in which some money is invested in the riskless asset and the rest is invested in *M*. Points past *M* are obtained by borrowing at the riskless rate, in order to buy more of *M*.

In this example, σ_A, σ_B, and σ_C represent the risk levels of projects. The standard deviation of returns (risk) increases from left to right (Megginson, 1997). That is, the Standard Deviation (X-axis) gives a Total Measure of Risk. Investor A could choose to invest in *A*, a point on the CML between R_f and M. Ross et al. (1999) stated that a more risk-averse investor might choose this point. A person with less risk aversion might choose a point closer to, or even beyond *M*, like point C. The return is maximized at a combination of the riskless asset and the risky portfolio at *M*, tangent to the riskless asset (Damodaran, 1997).

Portfolios on the CML dominate all other possible portfolios (Megginson, 1997). Ross et al. (1999) noted that, with riskless borrowing and lending, an investor's portfolio of risky assets would always be at point M. An investor would never choose another point on the efficient frontier, regardless of his or her tolerance for risk. In the same manner, the investor would also choose not to invest in a portfolio within the feasible region, below the efficient frontier (Ross et al., 1999). The more risk-averse investor would combine the securities of *M* with riskless assets. The less risk-averse investor would borrow the riskless asset to invest more in *M* (Ross et al., 1999). The insight that investors will always choose some combination of the riskless asset and the tangent portfolio is referred to as the *separation theorem*, or *two-fund separation* (Damodaran, 1997).

The CML provides an investment alternative, or a comparison to other investments for non-diversified investment portfolios. The equation for the Capital Market Line would be:

$$R_f + \sigma_B\left[\frac{R_M - R_f}{\sigma_M}\right] = E[R_B]$$

(4.7)

where R_f is the risk-free rate, σ_B is the risk associated with the asset B, R_M is the expected market return, σ^2_m the market risk, and $E[R_B]$ is the individual expected asset return. The

Capital Market Line can lead to the choice of a discount rate for a project that is a large portion of the investor's portfolio. Mumey and Unterschultz (1996) stated that the discount rate is composed of a *riskless (risk-free) base rate* and a *risk premium*. A *risk-free rate* is the current rate of return for a one-year Treasury bill (Ross et al., 1999). Changes in capital supply and demand, as well as inflationary expectations can cause this rate to rise and fall (Mumey and Unterschultz, 1996).

A *risk premium* is the difference between the rate of return on a risky investment and the interest rate. In Figure 4.2, the difference between the expected return on the market portfolio, $E(R)_M$, and the risk-free rate gives the market risk premium and this premium can be used to calculate the risk premium for the risky investment. Rearranging equation 4.7 above, the risk premium would be:

$$E[R_B] - R_f = \sigma_B \left[\frac{R_M - R_f}{\sigma_M} \right] = \text{Risk Premium}$$

(4.8)

This means that $E[R_B]$ in equation (4.7) is a combination of a risk-free rate plus a risk premium. Therefore, the expected rate of return would become the discount rate.

According to Ross et al. (1999), the standard deviation of annual returns on a market portfolio (1948-1997) was 16.45% for Canada. From 1973 -1997, the standard deviation of Canadian Common Stocks was 16.36% (Ross et al., 1999 p.254). The market risk premium was calculated to be 7.04% (Ross et al., 1999). Munro (1993) calculated the risk on an Alberta calf feeding operation's annual returns. With a routine hedge, the risk for 550-pound calf enterprise was calculated to be 14.63%. The current (August 22, 2001) 91-day average Treasury Bill rate in Canada is 3.95% (Royal Bank, 2001). This is used as the risk-free rate. Our calculation of the Capital Market Line, using equation 4.7 would be:

$$3.95 + 14.63 \left[\frac{7.04}{16.45} \right] = 10.21$$

(4.9)

The result of this equation is the expected return on the cow/calf operation, given the risk level on the cow-calf portfolio. This expected return is the discount rate chosen for the cow/calf operation. In this case, the discount rate was found to be approximately

10%. This was the discount rate used for the cow/calf analysis in the static ranch model, described below.

4.2 Ranch Model Assumptions

In this section, the static ranch models will be discussed. The discussion will present the key assumptions used in the NPV analysis of various riparian management strategies. These models deal with incremental analysis. Therefore, only the changes in the riparian area pasture were modeled. Income tax and other whole ranch considerations were not considered. The model involved the examination of a pasture containing one riparian area. Variables such as weather, calf prices, and land values were held constant. Once the base case was created, certain initial conditions were varied, to compare the costs of a status quo system to a new riparian management system. Model assumptions can be found in Table 4.1. Incremental changes are outlined in Table 4.2.

The main variable used in the model was the stocking rate per period, which was defined as the number of Animal Units (AU) per acre of pasture per grazing season. In this model, an implicit assumption is that one AU is equivalent to a 1000-pound cow, with a calf by her side (Range Notes, 1990). One grazing season amounts to 5.5 months in the case of the static model.

The carrying capacity, or sustainable carrying capacity, refers to the number of Animal Unit Months (AUM) a pasture can provide in one grazing season. An AUM refers to the amount of forage consumed by an Animal Unit (AU) in one month. This amount is approximately 1000 pounds of dry matter (forage) (Range Management – Public Lands Division, 1990). Carrying capacity is also referred to as grazing capacity. If a pasture is overgrazed, carrying capacity is exceeded, and a lower future stocking rate must be chosen to restore range health (Wroe et al., 1988). In the model, if livestock degraded the pasture in a season, the number of AUM per acre in the following grazing period was reduced in accordance with the new, degraded carrying capacity. Various scenarios were designed based on variations in carrying capacity.

4.2.1 *Herd Assumptions*

The herd assumptions for all models were as follows. The gain per calf per day was assumed to be 2.2 pounds (1 kilogram) (Adams et al., 1991). The price for a 500-600 pound calf was $1.53 per pound (data provided by AAFRD). It was assumed that the market weight of a calf would be 550 pounds (chosen from an AAFRD beef market report, listing 500-600 pound calf sales). The death rate for calves was assumed to be 2%.

4.2.2 *NPV Calculations*

NPV calculations for all models were as follows. A discount rate of 10% was chosen. The calculation of this rate was discussed in the section 4.1.3. Calculations for the model were made over 20 grazing periods. An adjustment was made to the model to include net revenue beyond year 20 (twenty[1]). The net cash flows were discounted, using the 10% discount rate. The equation for each period was:

$$DCF = NC / (1 + r)^t \tag{4.10}$$

where DCF is the discounted cash flow, NC is net cash, and r is the discount rate, and t is the period number. The discounted cash flow was calculated for each period in the model. The DCF values for the twenty periods were then summed to get the Net Present Value (NPV) for the cow/calf operation. That is:

$$NPV = \sum_{i=0}^{20} (DCF_i) \tag{4.11}$$

4.2.3 *Base Case – Conservative Continuous Grazing*

In the base case, a producer grazes a sustainable level of animal units in a continuous grazing system. That is, the producer chooses a stocking rate which matches the sustainable carrying capacity for the pasture. The animals are continuously grazed for a period of 5.5 months in each grazing season. There are 20 grazing season periods in total. This scenario was chosen to highlight a continuous grazing system in which pasture is not degraded. That is, it does not need a change in management strategy in order to improve. All other scenarios used this base case, with modifications in management and fencing.

4.2.3.1 Field Assumptions

The base case assumed an 1800-acre pasture, hypothetically situated in the Porcupine Hills of Southern Alberta. This pasture is part of a larger ranching operation.

[1] A simple perpetuity calculation was added to capture all benefits beyond year 20.

This is an area of the province where many beef operations are situated. The pasture area was broken down into 500 acres of riparian area, and 1300 acres of upland. 1800 acres translates to 3 sections of land placed end to end, minus 120 acres. A section is measured as one square mile of land. It is equivalent to 640 acres. Assuming a rectangular shape, the pasture was 14,817 feet in length and 5,280 feet (one mile) in width. It was assumed that the outside perimeter of the pasture was previously fenced (Figure 4.3).

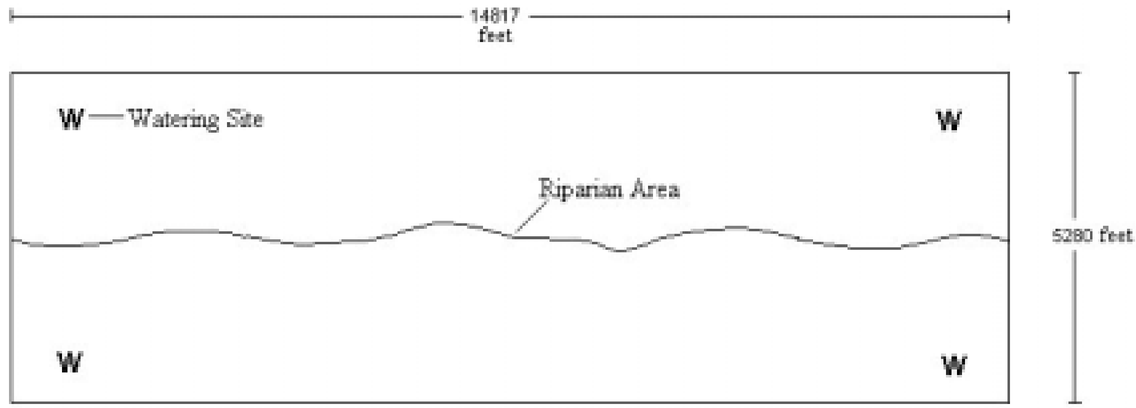
For convenience, the stream and accompanying riparian area ran down the center of the pasture. The maximum width of any one meander of the stream was 250 feet. In order to keep livestock well distributed, it was assumed that the producer had previously added two watering sites to the pasture. Each watering site fed water to both sides of the pasture. This assumption regarding the location of the riparian area, while simplifying the analysis, represents a very idealized type of riparian system. The list of key assumptions for this model is found in Table 4.1.

4.2.3.2 Grazing Capacity and Stocking Rate

It was assumed that the pasture was of the Foothills Grassland range type, in the 18-22 inch (annual) precipitation zone, and the range condition was in the "Good" class (Adams et al., 1991). Adams et al (1991) stated that upland pasture in Good condition could support a stocking rate of 80 AUM/quarter section. Adams and Ambrose (2001) suggested that the riparian area could support double this rate, or 160 AUM/quarter section. When the upland and riparian pasture areas (in quarter sections) were multiplied by the stocking rates, it was found that the upland pasture had a carrying capacity of 650 AUM, and the riparian pasture had a capacity of 500 AUM.

This translated to an initial uplands stocking rate of 0.5 AUM per acre per grazing period (5.5 months), and a riparian area stocking rate of 1.0 AUM per acre per grazing season. The stocking rate is the carrying capacity in AUM (650 or 500), divided by the pasture size in acres (1300 or 500). This equates to 118 cow-calf pairs on the uplands pasture and 91 cow-calf pairs on the riparian pasture each grazing period. Since these levels of grazing were sustainable for the pastures, the producer had no loss in grazing capacity over the 20 periods.

Figure 4.3 Hypothetical Pasture and Riparian Area



4.2.3.3 Incremental Revenue

Incremental revenue was derived from the weight gain of calves while they were on pasture. It was referred to as the total value of calves attributed to pasture. The total weight gain per calf attributed to pasture was found by multiplying the daily gain per calf (in pounds) by the grazing season (in months) by 30 days in one month. The total value of calves produced (attributed to pasture) was calculated by multiplying the total weight gain per calf by the price of a finished 5-600 lb calf by the total number of animal units grazed (minus the death loss). The sale of cull cows was calculated each period by multiplying the number of cows culled by a standard cull cow weight, then multiplying by the price per pound for cull cows. All incremental changes are found in Table 4.2. The daily rate of calf gain was never varied in any of the scenarios.

4.2.3.4 Incremental Costs

In the base case, the stocking rate was sustainable for each of the 20 periods. As no new management strategies were needed maintain the health of the riparian area, there were no incremental costs incurred in this scenario.

4.2.4 *Case 2 - Unsustainable Continuous Grazing from Good Condition*

The second case is one in which the pasture is overgrazed and the range starts in an initially good pasture condition. The stocking rate exceeds the sustainable carrying capacity for the pasture. This case is used to illustrate the incentive (if any) to overstock a pasture. It illustrates the effects of unsustainable stocking rates on pasture. Animals are still grazed for 5.5 months per grazing season, for twenty years.

4.2.4.1 Field Assumptions

The pasture in case 2 is the same as the one used in the base case. It appears in Figure 4.3. Assumptions for this case can be found in Table 4.1.

4.2.4.2 Grazing Capacity and Stocking Rate

Initially, as in the base case, the pasture is in the Good range condition class. The initial stocking rates are 30% higher than in the base case. The uplands are stocked at 0.65 AUM per acre per period (154 AU per period), and the riparian area at 1.3 AUM per acre per period (118 AU per period). That is, the stocking rate exceeded the sustainable grazing capacity by 30%. The stocking rate was decreased slightly over time, as the carrying capacity was reduced, to simulate lost grazing potential through range deterioration. The overgrazed pasture had an assumed capacity decrease of 6% per period on the uplands (i.e., $AUM_t = (1\text{-}0.06)\ AUM_{t\text{-}1}$), and 3% per period on the riparian area, until period 14.

After period 14, it was assumed that grazing capacity in the uplands reached a steady state of 0.273 AUM/acre, or a stocking rate of 65 AU grazed per period. The riparian area, with its lower degradation rate did not reach the steady state. In period 20, the riparian area had a carrying capacity of 0.729 AUM/acre, and a stocking rate of 66 AU grazed per period. Adams et al. (1991) and personal communication with Adams (2000) were used as a basis for the choice of deterioration rate. Rates in the literature varied from pasture to pasture. The rate in this model was chosen because it would reduce the pasture's carrying capacity by slightly more than half after twenty grazing periods (assuming the steady state for upland range after period 14).

4.2.4.3 Incremental Revenue

Incremental revenue was found in the same manner as in the base case. Incremental changes are found in Table 4.2. Incremental revenue in case 2 is higher in earlier periods than the in the base case. However, in later periods, it falls below that of the base case, due to degradation of pasture and lower stocking rates.

4.2.4.4 Incremental Costs

Though the carrying capacity of the pasture was allowed to decrease in this model, no new management strategies were put in place. Therefore, no incremental costs were incurred. Note that only incremental costs on the riparian pasture are included. Potential costs (of reduced carrying capacity) to the whole ranch are not included.

4.2.5 *Case 3: Unsustainable Continuous Grazing from Poor Condition*

The third case is one in which a previous owner overgrazed an initially Good condition pasture for ten years, as in the first ten grazing periods of Case 2. This assumed overgrazing has left the pasture in Poor range condition class (initially). Subsequently, the producer in Case 3 overgrazes it. This model is used to set up a comparison for Case 4, rotational grazing.

4.2.5.1 Field Assumptions

The pasture in Case 3 is the same as the one used in the base case. However, it is in poor pasture condition when the overgrazing begins in this model. The pasture appears in Figure 4.3. Assumptions for this model are found in Table 4.1.

4.2.5.2 Grazing Capacity and Stocking Rate

Adams et al. (1991) stated that in order to sustainably graze pasture in poor condition, 50% fewer AUM per quarter section should be grazed than the stocking rate for good condition grassland. As we wanted to simulate overgrazing on this pasture, the stocking rates used were the rates from Period 11 in Case 2. That is, the initial uplands stocking rate in Case 3 was 0.35 AUM per acre, or 83 AU grazed per period. On the riparian area, the rate was 0.959, or 87 AU grazed per period. As in Case 2, the stocking rate was decreased slightly over time (because the sustainable carrying capacity was reduced) to simulate lost grazing potential through range deterioration.

As in Case 2, the overgrazed uplands pasture had an assumed capacity decrease of 6% per period, until period 14. The riparian area had a capacity decrease of 3% per period. Because the pasture begins in a degraded condition, the uplands pasture reaches a steady state (0.273 AUM/acre per period, 65 AU grazed per period) by Period 5. The riparian area degrades to a carrying capacity of 0.537 AUM/acre per period, or a stocking rate of 49 AU grazed per period, by period 20. The Sensitivity Analysis (Section 4.42) includes a variation on this scenario.

4.2.5.3 Incremental Revenue

Incremental revenue was found in the same manner as in the base case. Incremental changes are found in Table 4.2.

4.2.5.4 Incremental Costs

Though the carrying capacity of the pasture was allowed to decrease in this model, no new management strategies were put in place. Therefore, no incremental costs were incurred.

4.2.6 *Case 4: Rotational Grazing from Poor Condition*

Case 4 has the same initial pasture conditions as Case 3. Ten years of overgrazing by a previous owner is assumed. The pasture is in poor condition. In this case, the rancher implements a rotational grazing strategy. Rotational grazing strategies were ranked highly by respondents to the initial questionnaire, when asked what riparian management strategies should be used to repair damage to riparian areas (Chapter 3). For this case, it was assumed that management time was available in order to change the riparian management strategy. As well, no additional management costs are added in this case. This model presented an alternative and comparison to the overgrazing strategy seen in Case 3.

4.2.6.1 Field Assumptions

This rotational scheme changed the original pasture. The pasture was divided into four units, by adding three cross fences of one mile in length. Each pasture unit was 5280 feet in length by 3705 feet in width. If each new fence addition (assuming the outside area was previously fenced) was 5280 feet long, then an additional 15840 feet of fencing was required. As well, in order to ensure good livestock distribution, an additional two waterers were added. This pasture can be seen in Figure 4.4. All key assumptions for this model are found in Table 4.1.

4.2.6.2 Grazing Capacity and Stocking Rate

As in the previous case, the pasture started in poor condition due to overgrazing. Because all pasture units were not going to be used at once, the grazing capacity was reduced by a further one third on both the uplands and riparian area. That is, the uplands have an initial carrying capacity of 0.273 AUM/acre (65 AU grazed per period). The riparian area has an initial capacity of 0.671 AUM/acre (61 AU grazed per period). If it is assumed that the animals were rotated through the pastures (using three pasture units at a time), grazing is expected to be more uniform in each pasture they graze. It was assumed that the forage resources in the pasture would begin to regenerate. That is, the rotational system would be better for forage re-growth than the original continuous grazing system.

Correspondence with Barry Adams (2000) and Adams et al. (1991) suggested some pasture regeneration times. Each of these examples involved different ranches and many different restoration strategies. Regeneration in these examples ranged from 3.5% per year to almost 10% per year in one case. However, in another case, Adams (2000) suggested that complete regeneration might take more than a ten to fifteen year period. The grazing capacity in this model was assumed to increase by 2 percent each year on the uplands, and 6% per year on the riparian area. By period 8, the riparian area had leveled off at its sustainable steady-state level, 1 AUM per acre per period, or 91 AU grazed per period. The uplands pasture had been regenerated to a carrying capacity of 0.398 AUM/acre (a stocking rate of 94 AU grazed per period).

4.2.6.3 Incremental Revenue

Incremental revenue was found in the same manner as in the base case. In this case, the gradual increase in carrying capacity means a similar increase in stocking rate, to match the sustainable carrying capacity. This translates to a gradual increase in incremental revenue. Incremental changes for this model are found in Table 4.2.

4.2.6.4 Incremental Costs

This strategy involves adding new fencing to the riparian area. Saskatchewan Agriculture and Food's fencing cost calculator (SAF, 2001) provided costs per mile for different fencing types (barbed, 3- and 4-strand and high tensile, 4- and 5-strand), using new materials prices from UFA. These costs included tractor and post-pounder use, as well as hourly labour. According to the calculator, four lines of standard barbed, 2-strand, all-post fencing would cost a rancher $0.69 per foot. 5 lines of high-tensile, one-strand, all-post fencing would cost $0.65 per foot.

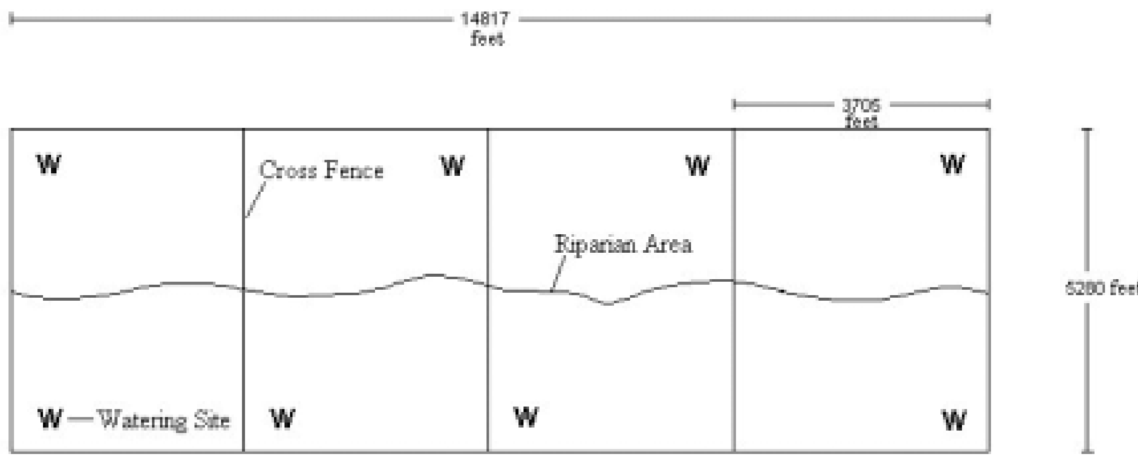
The cost per foot was multiplied by the amount of fencing needed in each scenario, in order to determine total fencing costs for each of the fencing types. The cheaper high-tensile fence was chosen for this model. This scenario required 15,840 feet of additional fencing, at a cost of $10,296. Maintenance costs per period were set at 2.5% of the original cost of fencing. This number was adapted from Platts and Wagstaff (1984). In the rotational scenario, maintenance cost per year was $257. Note that these fencing and maintenance costs could vary depending on the pasture and riparian area in question.

In a conversation with Adams and Ambrose (2001), it was suggested that a watering site, using water from a ranch well, could be put in place for approximately $3500. In the base case, it was assumed that two waterers (serving both sides of the pasture) had been installed previously. In the rotational scheme, there are four pastures in total. That is, another two waterers were needed to improve livestock distribution. The extra cost of these watering sites ($7000) was reflected in the initial costs for this model.

Incremental costs were the differences in costs due to the changes in management strategies. Incremental Costs were divided into Operating Costs and Capital Costs. Operating costs reflected annual payments for such things as upkeep. Capital costs were fixed, one-time costs (in this case in Period 0), such as fencing and waterers. These were updated for each period, depending on when each change took place. In this example, a producer added fencing and waterers in period zero. These capital costs were not repeated in the following period, as no new fencing or water were needed.

However, the 2.5% maintenance cost appeared as an operating cost in the periods following fence construction, as fencing must be kept in good condition each period. Total Incremental Costs were calculated by summing Operating Costs and Capital Costs. Costs are considered a Cash Outflow to a producer. Net Cash for a producer was calculated by subtracting Total Costs from Total Revenue (value of calves produced in a period). Incremental changes for this model are found in Table 4.2.

Figure 4.4 Hypothetical Pasture with Rotational Grazing



4.2.7 *Case 5: Corridor Fencing from Poor Condition*

In this case, the producer implements a corridor fencing strategy, after 10 years of overgrazing by a previous owner (as in Cases 3 and 4). In the responses to the initial questionnaire, 42% of respondents ranked this as choice 1 or 2 for riparian restoration in a highly degraded pasture. The degraded riparian corridor was fenced off, in order to allow for rehabilitation. This case was used as an alternative to the overgrazing strategy of Case 3, and the rotational grazing strategy of Case 4.

4.2.7.1 Field Assumptions

The new corridor fencing takes 100 acres of pasture out of production. That is, the pasture now contains 10 quarter sections, plus 5/8 of another (10.625 quarter sections). The excluded corridor divides the former pasture into two grazeable pastures. By design, this new pasture system also incorporates a rotational strategy, as livestock graze one pasture unit at a time. In order to provide water for the animals, the waterers mentioned in the base case serve the two pastures. The pastures used can be seen in Figure 4.5.

4.2.7.2 Grazing Capacity and Stocking Rate

As in the previous case, the pasture started in poor condition. The grazing capacity for the uplands was the same as that for period 1 in Case 4 (0.273 AUM/acre) to simulate ten prior years of overgrazing. However, because the riparian area is almost taken completely out of production, its initial carrying capacity is half of the initial capacity of Case 4. Its initial carrying capacity is 0.336 AUM/acre, or 31 AU grazed per period. The animals are rotated between the two upland pastures, so grazing is assumed to be more uniform in each pasture they graze. Animals are allowed to minimally graze the riparian corridor.

As in Case 4, it was assumed that the forage resources in the pastures would begin to regenerate. The grazing capacity on the uplands is assumed to increase by 2% per year. On the riparian pasture, the lighter stocking rate contributes to a faster regeneration time, of 10% per period. The corridor fencing reduces the grazeable pasture area, so the stocking rates (in AU grazed per period) are slightly lower than in case 4. By period 13, the riparian area has been regenerated to its base case carrying capacity of 1 AUM/acre (91 AU grazed per period). By period 20, the uplands have been regenerated to 0.398 AUM/acre (94 AU grazed per period).

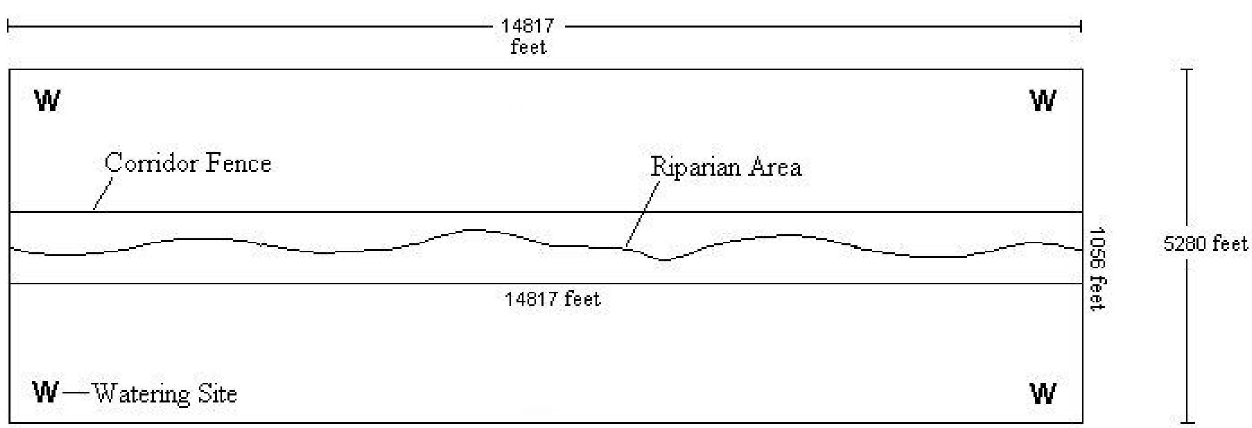
4.2.7.3 Incremental Revenue

Incremental revenue is calculated in the same manner as in the base case. The increase in incremental revenue follows the trend of the rotational grazing system. Incremental changes for this model are found in Table 4.2.

4.2.7.4 Incremental Costs

The fencing costs incurred by this strategy are higher than those for the rotational system, as two lines of fencing, 14817 feet in length, must be constructed. This additional 29,634 feet of fencing added an additional $19,262 of initial cost. The maintenance cost per period was approximately $482 (Table 4.2).

Figure 4.5 Hypothetical Pasture with Corridor Fencing



4.2.8 *Case 6: Rest Rotational Grazing from Poor Condition*

In this case, the producer implements a rest rotation strategy, after 10 years of overgrazing by a previous owner (as in Cases 3 and 4). In the responses to the initial questionnaire, more than a third of respondents ranked this as choice 1 or 2 for riparian restoration in a highly degraded pasture. In this case, the pasture is fenced off for rotational grazing, as in Case 4. For the first 8 years, one pasture is completely rested (no grazing) each period, while the others are grazed. This means that each of the four pastures will be rested twice in the first eight years. After eight years, a regular rotational strategy is employed. This case, like Case 4 and Case 5, was used as an alternative to the overgrazing strategy of Case 3.

4.2.8.1 Field Assumptions

For the first 8 years, one quarter of the original pasture is completely rested each period. Therefore, the grazeable area was reduced by one quarter in both the upland and riparian pastures. The new upland area was 975 acres. The new riparian area was 375 acres. This increases the pasture to its full grazing area, increasing the stocking rate. The increase is depicted graphically in Figure 4.7. As in Case 4, two additional waterers are needed for this strategy, as the pasture has four grazeable areas. The pasture is the same as that for Case 4, rotational grazing, and can be seen in Figure 4.4.

4.2.8.2 Grazing Capacity and Stocking Rate

As in the previous case, the pasture started in poor condition. The initial grazing capacities for the uplands and riparian area were the same as those for period 1 in Case 4 (rotational grazing) (0.273 AUM/acre and 0.671 AUM/acre, respectively) to simulate ten prior years of overgrazing. The animals are rotated through the pastures, so grazing is assumed to be more uniform in each pasture they graze.

It was assumed once more that the forage resources in the pastures would begin to regenerate. Under rest-rotation grazing, the grazing capacity on the uplands was assumed to increase by 4% per year. On the riparian pasture, it increased at 8% per period. After the first eight years, the regular rotational strategy results in the uplands pasture being regenerated at 3% per period, slightly higher than that for Case 4. The riparian area regenerates at 6% per period under regular rotation. By period 7, the riparian area has been regenerated to its base case carrying capacity of 1 AUM/acre (91 AU grazed per period). By period 20, the uplands have been regenerated to their base case level of 0.5 AUM/acre, or 118 AU grazed per period.

4.2.8.3 Incremental Revenue

Incremental revenue is calculated in the same manner as in the base case. The increase in incremental revenue follows the trend of the rotational grazing system. Incremental changes can be found in Table 4.2.

4.2.8.4 Incremental Costs

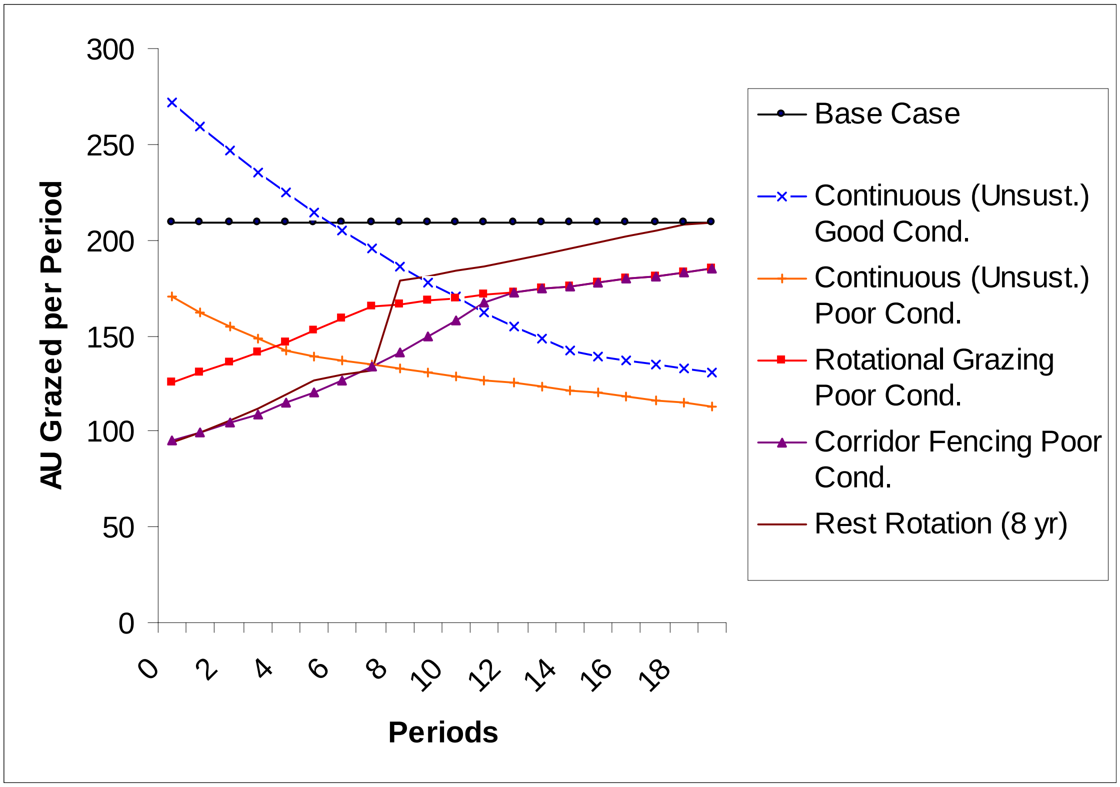
Incremental costs for this case were the same as those for case 4 (Table 4.2).

4.3 Graphical Summary of Grazing Scenarios

Figure 4.6 presents a graphical summary of the grazing scenarios (in AU grazed per Period) discussed above. The Base Case (Conservative Continuous Grazing) is a flat line at 191 AU grazed per period, as there are no changes in carrying capacity. The Unsustainable Continuous Grazing of Case 2 begins at a higher level (272 AU grazed per period), but falls to a final rate of 131 AU grazed per period. Continuously grazing pasture in poor condition at an unsustainable rate (Case 3) showed a decrease in stocking rate from 170 AU grazed per period to 113 AU grazed per period, a level below that of Case 2's final rate (Case 2 began on pasture in good condition).

Using the assumptions of the static NPV model, Rotational Grazing (Case 4) would improve grazing from 126 AU grazed per period to 185 AU grazed per period over a twenty-year time span. Corridor Fencing (Case 5) would improve grazing to the stocking rate of Case 4, on an animal unit grazed per period basis (185 AU grazed per period). For Case 6, Rest Rotational grazing, stocking rate improves from 94 AU grazed per period to the Base Case level of 209 AU grazed per period in period 20.

Figure 4.6 Grazing Scenario Summary for NPV Analysis



4.4 Other Scenarios and Sensitivity Analysis

4.4.1 *Indifference Point Analysis (Scenario Analysis)*

The static models are sensitive to the key assumptions. Some of these assumptions are stocking rate, calf price, and sustainable carrying capacity. The model results were analyzed for sensitivity to changes in price and initial stocking rate. A rancher would be financially indifferent to implementing a rotational grazing strategy over a continuous grazing system at the point where neither system would make the rancher financially better off in the long run. The long run results in the static model relied on incremental NPV as an indication of financial well-being. The "financial indifference point" was the point where the 20-period NPV's of both scenarios were equal.

4.4.1.1 Scenario 1 – Base Case vs. Case 2

The initial uplands stocking rate in Case 2 is allowed to change to the point where the NPV in Case 2 = NPV in Base Case. The riparian area stocking rate was made to increase or decrease proportionally. All other assumptions in the Base Case and Case 2, including pasture degradation rates and subsequent stocking rates, remained unchanged. This determines the point at which a rancher is financially indifferent between a sustainable continuous grazing strategy and a higher (though unsustainable) initial stocking rate. That is, how high must the initial stocking rate in Case 2 be before the unsustainable strategy is the best financial choice? In subsequent discussion, this point is referred to as the "financial indifference point." Calf prices were then allowed to vary (between \$0.80/lb to \$1.60/lb), to see how the financial indifference point changed.

4.4.1.2 Scenario 2 – Case 3 vs. Case 4

Similar to Scenario 1, the financial indifference point is evaluated by finding the initial stocking rate in Case 3 that will equate the NPV in Case 3 to the NPV in Case 4. This is the financial indifference point between unsustainable continuous grazing (Case 3) and implementing a rotational grazing strategy (Case 4). As in Scenario 1, different calf prices (\$0.80/lb to \$1.60/lb) were used to analyze how the financial indifference point changes. Again, all other assumptions were held constant.

4.4.1.3 Scenario 3 – Case 3 vs. Case 5

Similar to Scenario 2, the financial indifference point is evaluated by finding the initial stocking rate in Case 3 that will equate the NPV in Case 3 to the NPV in Case 5. This is the financial indifference point between unsustainable continuous grazing (Case 3) and implementing a corridor fencing strategy (Case 5). As in Scenarios 1 and 2, different calf prices (\$0.80/lb to \$1.60/lb) were used to analyze how the financial indifference point changes. Again, all other assumptions were held constant.

4.4.1.4 Scenario 4 – Case 3 vs. Case 6

Similar to Scenarios 2 and 3, the financial indifference point is evaluated by finding the initial stocking rate in Case 3 that will equate the NPV in Case 3 to the NPV in Case 6. This is the financial indifference point between unsustainable continuous grazing (Case 3) and implementing a rest-rotational grazing strategy (Case 6). As in the above scenarios, different calf prices (\$0.80/lb to \$1.60/lb) were used to analyze how the financial indifference point changes. All other assumptions were held constant.

4.4.1.5 Additional Background on Scenarios 1 through 4

Some of the underlying equations are as follows: In order to determine the value of calves attributed to pasture, a price per pound for 5-600 lb beef calves, P_B, was multiplied by the total pounds of gain per calf attributed pasture, WG_i. The symbol t represents the period number. The equation for the value of all calves attributed to pasture over time was:

$$P_B \cdot \sum_{t=0}^{20} \frac{WG_i}{(1+i)^t}$$

(4.12)

This was the equation for all continuous grazing systems (sustainable and unsustainable, including the base case). In Scenario 1, Equation 4.12 would represent both spreadsheets. This is because there are no incremental costs added to sustainable grazing from good condition (Base Case) or to unsustainable continuous grazing from good condition (Case 2). This means that, regardless of the price per pound of calf ($0.80 - $1.60), the same initial stocking rate for Case 2 will be returned at the point of financial indifference.

For the rotational system, the equation was similar, except that fencing and watering costs, C_i, were included. The equation was:

$$P_B \cdot \underbrace{\sum_{t=0}^{20} \frac{WG_i}{(1+r)^t}}_{\text{Benefits}} - \underbrace{\sum_{t=0}^{20} \frac{C_i}{(1+r)^t}}_{\text{Incremental Costs}}$$

(4.13)

In Scenario 2, equation 4.12 represents Case 3 (no added costs) and equation 4.13 represents Case 4 (added fencing and watering costs). When their NPV's are related, it can be seen that, as the price of calves goes down (in relation to a drop in the price per pound, in this case), the initial stocking rate will change, to offset the effect of fencing and watering costs, C_i, introduced in Case 4 (equation 4.13). The results of the financial indifference point analysis are discussed in the following chapter.

4.4.2 *Sensitivity Analysis*

4.4.2.1 Discount Rate Sensitivity

The research results on an appropriate discount rate for cow/calf operations are not clear. The initial scenarios used a discount rate of 10% (current risk-free rate plus a risk premium for cow/calf operations). In this analysis, the discount rates were changed, in order to see the effect on incremental NPV in each case. This analysis used rates of 5% and 15%, and compared them to that of the initial scenarios. All other assumptions are held constant. The results are presented in the following chapter.

4.4.2.2 Pasture Degradation Rate Sensitivity

Research into pasture degradation rates varied with the scenario and pasture conditions chosen (Adams et al., 1991 and Adams, 2000). An analysis was performed to analyze the sensitivity of cases 2 and 3 to different pasture degradation rates. Initially, both scenarios used degradation rates of 6% (uplands) and 3% (riparian area) per grazing period. For this analysis, rates of 2% (uplands), 1% (riparian area); and 10% (uplands), 5% (riparian area) were used, and compared to the 6% and 3% rates. All other assumptions were held constant. The results are presented in the following chapter.

4.5 Chapter Summary

The static model will be analyzed using Net Present Value (NPV) analysis. NPV models are often used in investment analysis. A cow/calf operation involves investment of the part of a producer, in both time and money. Using risk premia for cow/calf operations in Alberta and the concept of the Capital Market Line (CML) a discount rate for cow/calf operations was chosen. This discount rate will be used in the static ranch model.

The static ranch model uses six cases. A Base Case represents the ranch in a sustainable grazing strategy, where extra management is not needed to keep range in good condition. Cases 2 and 3 represent overgrazing strategies. Initial pasture conditions are Good in Case 2, Poor in Case 3. Cases 4 through 6 represent strategies to improve riparian health. Though costs are higher, these strategies may be needed to keep range productive and healthy. Incremental NPV will be used as an indicator of ranch well-being.

Scenario analyses will be performed to determine the point at which a rancher will be financially indifferent between grazing strategies. The indifference point will be the initial stocking rate at which a producer will be no better off financially, regardless of the grazing strategy chosen. Sensitivity analyses will then be performed to determine how sensitive the model is to changes in the discount rate and pasture degradation rate.

4.6 Tables for Chapter 4

Table 4.1 Model Assumptions for NPV Analysis

	Base Case: Sustainable Continuous Grazing (from good condition)	Case 2: Unsustainable Continuous Grazing (from Good Condition)	Case 3: Unsustainable Continuous Grazing (from Poor Condition)	Case 4: Rotational Grazing (from Poor Condition)	Case 5: Corridor Fencing (from Poor Condition)	Case 6: Rest Rotational Grazing (from Poor Condition)
Initial Upland Pasture Size (acres)	1300	1300	1300	1300	1300	1300
Initial Riparian Pasture Size (acres)	500	500	500	500	500	500
Outside perimeter fenced	Yes	Yes	Yes	Yes	Yes	Yes
Initial Pasture Condition	Good	Good	Poor	Poor	Poor	Poor
Grazing Period (months)	5.5	5.5	5.5	5.5	5.5	5.5
Gain per Calf per Day (lbs)	2.2	2.2	2.2	2.2	2.2	2.2
Price per Pound (5-600 lb calf)	1.53	1.53	1.53	1.53	1.53	1.53
Market Weight of Calf (lbs)	550	550	550	550	550	550
Death Loss of Calves (%)	2	2	2	2	2	2
Discount Rate (%)	10	10	10	10	10	10
Uplands Degradation Rate (% per period)	NA	6	6	NA	NA	NA
Riparian Degradation Rate (% per period)	NA	3	3	NA	NA	NA
Uplands Regeneration Rate (% per period)	NA	NA	NA	2	2	4/2
Riparian Regeneration Rate (% per period)	NA	NA	NA	6	6	8/6

Table 4.2 Grazing Scenarios for NPV Analysis

	Base Case: Sustainable Continuous Grazing (from good condition)	**Case 2: Unsustainable Continuous Grazing (from Good Condition)**	**Case 3: Unsustainable Continuous Grazing (from Poor Condition)**	**Case 4: Rotational Grazing (from Poor Condition)**	**Case 5: Corridor Fencing (from Poor Condition)**	**Case 6: Rest Rotation Grazing (from Poor Condition)**
Uplands Pasture Used (acres)	1300	1300	1300	1300	1300	975/1300
Riparian Pasture Used (acres)	500	500	500	500	500	375/500
Period 1 Uplands Stocking Rate (AUM/acre)	0.500	0.650	0.350	0.273	0.273	0.273
Period 1 Uplands Stocking Rate AU/grazing period)	118	154	83	65	65	48
Period 20 Uplands Stocking Rate (AUM/acre)	0.500	0.273	0.273	0.398	0.398	0.456
Period 20 Uplands Stocking Rate (AU/grazing period)	118	65	65	94	94	108
Period 1 Riparian Stocking Rate (AUM/acre)	1.00	1.30	0.959	0.671	0.336	0.671
Period 1 Riparian Stocking Rate AU/grazing period)	91	118	87	61	31	46
Period 20 Riparian Stocking Rate (AUM/acre)	1.00	0.729	0.537	1.00	1.00	1.00
Period 20 Riparian Stocking Rate (AU/grazing period)	91	66	49	91	91	91
Uplands Regeneration (Degeneration) Rate (%/yr)	NA	(6)	(6)	2	2	4/2
Riparian Regeneration (Degeneration) Rate (%/yr)	NA	(3)	(3)	6	10	8/6
Extra Fencing Used (feet)	0	0	0	15840	33858	15840
Capital Cost of Fencing	0	0	0	$10,296	$22,007	$10,296
Extra Watering Sites Used	0	0	0	2	0	2
Capital Cost of Watering Sites	0	0	0	$7000	0	$7000

Chapter 5

5.1 Static NPV Model Results

The following section presents results for the static NPV model. Note that the NPV is not the same as ranch profit. It is a method to compare scenarios. However, higher NPV's indicate improved economic benefits for the ranch.

5.1.1 *Base Case – Sustainable Continuous Grazing*

In the base case, a producer continuously stocked a pasture at its sustainable long-run carrying capacity. In this case, the sustainable carrying capacity was 650 AUM per period on the uplands and 500 AUM per period on the riparian area. This translated to a stocking rate of 0.5 AUM per acre, or 118 AU per grazing period on the uplands. On the riparian area, the initial stocking rate was 1.00 AUM per acre, or 91 AU per grazing period.

The value of the 209 calves attributed to the pasture each grazing period was $113,804. This value was the same each period, holding calf prices constant. As no riparian management changes were made, there were no additional costs borne by the producer. The model assumes that initial costs remain constant across different cases. Recall that costs are those for the 500 acre riparian area and 1300 acre upland area only. The resulting Incremental Net Present Value after twenty periods was $1,138,044 (Table 5.1).

5.1.2 *Case 2 – Unsustainable Continuous Grazing from Good Condition*

In case two, the producer grazed the pasture at a stocking rate 30% higher than the field's sustainable carrying capacity level (Section 4.2.4). This resulted in an initial uplands stocking rate of 0.65 AUM per acre, or 154 AU per period. On the riparian area, the initial stocking rate was 130 AUM per acre, or 118 AU grazed per period. In the first period, the value of calves attributed to pasture was $147,945. However, as the stocking rate was reduced each period to match the loss in grazing capacity, this value fell as well. Degradation rates were 6% per period on the uplands, and 3% per period on the riparian area. At period 14, it was assumed that the uplands pasture would reach a steady state of 0.273 AUM per acre, which continued through period 20.

The ending uplands stocking rate (grazing periods 15 through 20) was 0.273 AUM per acre, or 65 AU per grazing period. On the riparian area, the stocking rate fell to 0.729 AUM per acre, or 66 AU per grazing period. The value of calves attributed to the pasture in period 20 was $71,182. The resulting incremental Net Present Value after twenty periods was $1,065,663, which was just over $70,000 less than that for the Base Case (Table 5.1).

5.1.3 *Case 3 – Unsustainable Continuous Grazing from Poor Condition*

In case three, the producer continuously grazed a previously degraded pasture. In order to simulate 10 years of prior overgrazing, the initial carrying capacity was the capacity in year 11 of Case 2 (overgrazing from good condition). That is, the initial upland stocking rate (period 1) was 0.350 AUM per acre, 83 AU per grazing period. On the riparian area, the initial capacity is 0.959 AUM per acre, or 87 AU grazed per period. As in case 2, the stocking rate was reduced by 6% on the uplands until it reached a steady state of 0.273 AUM per acre (65 AU per grazing period). The riparian area, degrading at 3% per period, reached a stocking rate of 0.537 AUM per acre (49 AU grazed per period) by period 20. The value of calves attributed to pasture in period 1 was $92,474. At period 20, this value was $61,713. The incremental Net Present Value after twenty periods was $746,207. This is just over $300,000 less than the incremental NPV found in Case 2 (Table 5.1).

5.1.4 *Case 4 – Rotational Grazing from Poor Condition*

As in Case 3, the initial carrying capacity simulated a degraded pasture condition. The initial stocking rate from Case 3 was reduced by a further 30%, to allow the pasture to regenerate, through the implementation of a rotational grazing system. The initial uplands stocking rate was 0.273 AUM per acre, or 65 AU per grazing period. On the riparian area, the initial stocking rate was 0.671 AUM per acre, or 61 AU per grazing period. Each year, the uplands carrying capacity was assumed to increase by 2%. The riparian area had a regeneration rate of 6%. The stocking rate increased to match the increase in carrying capacity. By period 8, the producer was grazing at the base case rate on the riparian area (1.00 AUM/acre, 91 AU per grazing period). By period 20, the uplands had regenerated to a stocking rate of 0.398 AUM per acre, or 94 AU per grazing period.

The value of calves attributed to pasture in period 1 was $68,325. The value in period 20 was $100,644. The extra capital outlay for fencing in period 0 was $10,296.

The two extra waterers added $7000. A fence maintenance cost of 2.5% per period totaled $257 per period. The incremental Net Present Value after twenty periods was $841,734 (Table 5.1).

5.1.5 *Case 5 – Corridor Fencing from Poor Condition*

Again, initial uplands carrying capacity was 30% lower than in Case 3, simulating degraded pasture condition. The riparian area's initial capacity from Case 4 was cut in half, as grazing on the riparian corridor was very light, in order to encourage regeneration. In the corridor fencing system, the initial uplands stocking rate was 0.273 AUM/acre, or 65 AU per grazing period.   The initial riparian stocking rate was 0.336 AUM per acre, or 31 AU per period. As in the rotational grazing case, uplands pasture quality increased by 2% per period. However, on the lightly grazed riparian area, regeneration occurred at a 10% rate.

By period 13, the riparian steady state of 1.00 AUM/acre (91 AU per grazing period) was reached. The uplands pasture regenerated to a stocking rate of 0.398 AUM per acre (94 AU per grazing period). The value of calves attributed to pasture in period 1 was $51,723. In period 20, the value was $100,644. Extra fencing costs in period 0 totaled $19,262. The maintenance cost per period (2.5% per period) was $481. The incremental NPV after 20 periods was $732,792. This was more than $100,000 less than that for the rotational system. Table 5.1 shows a comparison of the results.

5.1.6 *Case 6 – Rest Rotational Grazing from Poor Condition*

In the rest rotation strategy, the initial stocking rates for the upland and riparian pastures were the same as those for Case 4, rotational grazing. That is, the uplands had an initial stocking rate of 0.273 AUM per acre, or 65 AU per grazing period. The initial riparian area stocking rate was 0.671 AUM per acre, or 46 AU per grazing period. For the first 8 grazing periods, the uplands regenerated at a 4% rate. The riparian area regenerated at a rate of 8%. After period 8, the regular rotational strategy was used again. The uplands then regenerated at a rate of 2%, and the riparian area at 6%.

By period 7, the riparian area had regenerated to its base case stocking rate of 1.00 AUM per acre, or 91 AU per grazing period. By period 20, the uplands had regenerated to 0.456 AUM per acre, or 108 AU per grazing period. The value of calves attributed to pasture in period 1 was $51,243. In period 20, this value was $108,094.

Extra fencing and watering costs were the same as those for Case 4, rotational grazing. The incremental NPV was $786,785. This is approximately $55,000 less than that for rotational grazing (Case 4).

5.1.7 *Comparison of NPV Results*

In the static model, the Base Case NPV is the highest, and the number of AU grazed per period is sustainable (Table 5.1). The number of grazing livestock does not decrease, as it does in the Case 2. The first two cases involve pasture in good condition in period 1. However, in Case 2, the pasture was stocked at an unsustainable rate, resulting in a loss of grazing capacity over time. Case 2 resulted in the second-highest NPV at the expense of pasture condition. Case 3 showed how the unsustainable Continuous Grazing system used in Case 2 would affect a pasture in initially poor condition. The result was a drop in incremental NPV of almost $400,000. This would suggest that, over the long-term, there is no long-run financial incentive to overgraze, given the model assumptions used here.

The Rotational Grazing system in Case 4 was implemented to improve the pasture in poor condition. Using the set of assumptions explained above, this system resulted in an increased grazing capacity over the twenty periods. Its incremental NPV is almost $100,000 higher than that for Case 3. From this, it can be concluded that, in the long-run, it would be a better financial decision for the producer to implement a rotational grazing strategy on poor pasture. Initial capital costs are higher, but long-run benefits exceed those of an unsustainable continuous grazing strategy (like Case 3).

Though Corridor Fencing (Case 5) resulted in an NPV that was lower than that for overgrazing from poor condition (Case 3), the riparian area was rehabilitated to its Base Case grazing rate. The grazing livestock were only given limited access to the fenced riparian area at first. In a real-world case, this strategy would be used as a last resort, in order to return a riparian area to health. This goal was achieved in this strategy by period 13. It is important to note that, as in this case, riparian restoration may not take twenty entire periods. Corridor fencing may work as a risk management scheme, in case of a drought. This is because the riparian area holds moisture, and tends to have better forage. The corridor system appears to have the capacity to give a rancher more financial benefit in the long run (more than 20 periods), when compared to an unsustainable continuous grazing strategy. Higher initial costs (and less grazing capacity) are offset by increased sustainable stocking rates (and hence, increased value of calves attributed to the pasture).

Case 6 (Rest Rotational Grazing) resulted in an incremental NPV of approximately $40,000 more than that for Case 3. As in Case 5, higher initial costs are offset by increased stocking rates on both upland and riparian pastures in later time periods. By Period 9, the riparian area was restored to full health. Though the uplands pasture does not come back to the Base Case level, it ends at a higher level than the uplands pasture in Case 5 did.

5.2 Indifference Point (Scenario) Analysis Results

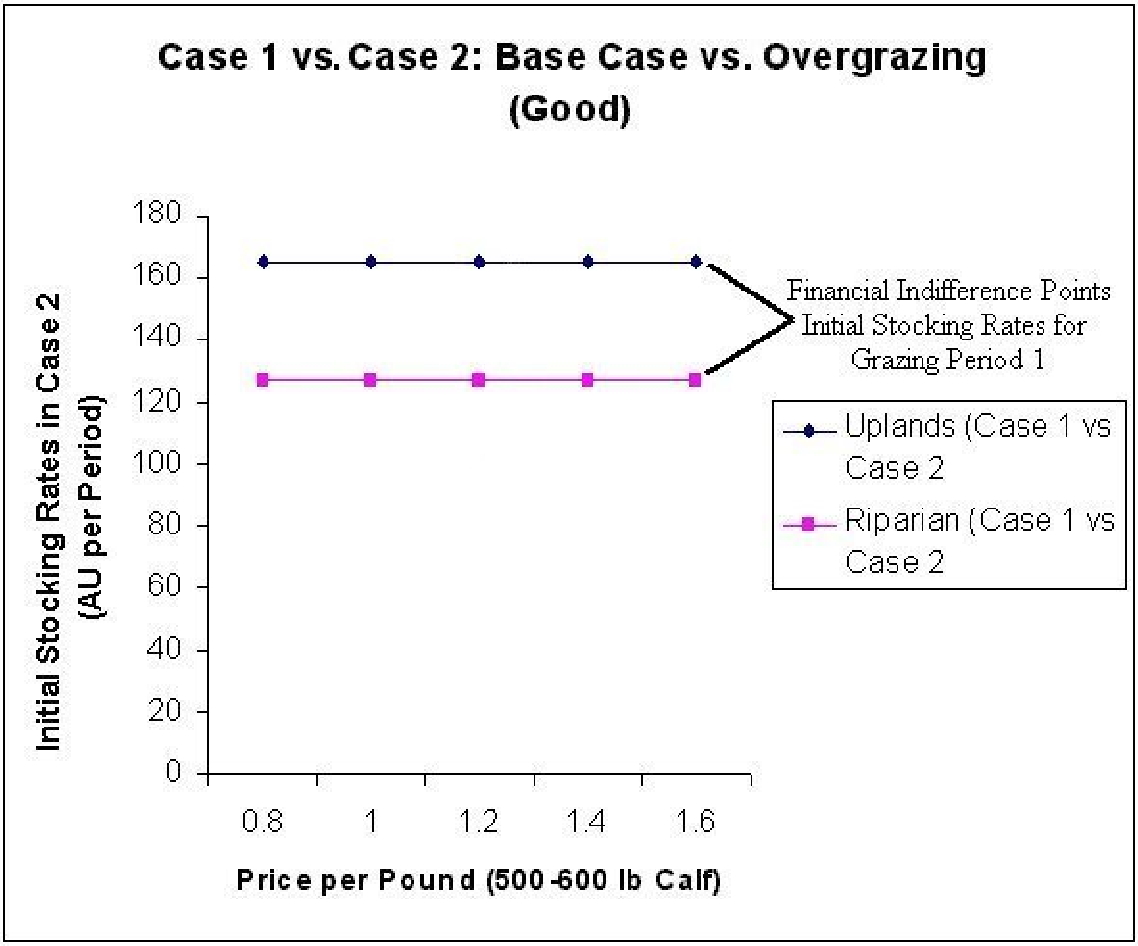
5.2.1 *Scenario 1 – Base Case vs. Case 2*

In this scenario, the producer could choose to graze a pasture at a sustainable level (Base Case), or overgraze the pasture (using a continuous grazing system – Case 2). The uplands stocking rate for Case 2 was allowed to change. The riparian area stocking rate moved in proportion the uplands rate. The new stocking rates were evaluated at 500-600 lb calf price levels ranging from $0.80 per pound to $1.60 per pound. The resulting stocking rates for the first period of Case 2, represented the financial indifference point in grazing period 1 for each of the price points. If the uplands pasture in Case 2 could initially support 0.698 AUM/acre (165 AU per grazing period), and the riparian pasture 1.396 AUM/acre (127 AU per grazing period), the producer would be indifferent between sustainable strategies and overgrazing strategies, at all price points. All other model assumptions, including the pasture degradation rates (Case 2) were held constant.

This result was consistent with the methodology used, as there were no other costs added to either NPV analysis. This suggests that if the pasture were capable of supporting a total of 292 AU per grazing period (or more) in grazing period 1, the producer would financially be better off by overgrazing the pasture. That is, if he or she prefers to receive more economic benefits now, this strategy would be chosen. If the pasture supported a lower capacity in grazing period 1, it would make more economic sense for the producer to graze the pasture in a sustainable manner, and receive more benefits in the future.

Table 5.2 shows the financial indifference point for Scenario 1 when the 292 AU has been spit between the upland and riparian area. If the pastures cannot initially support a total of 292 AU per grazing period or higher, the sustainable grazing strategy (Base Case) is the optimal strategy. Figure 5.1 has a graphical interpretation of this scenario, with the 292 AU split between the upland and riparian areas (indifference point for each pasture shown).

Figure 5.1 Indifference Points for Base Case 1 vs. Case 2



5.2.2 Scenario 2 – Case 3 vs. Case 4

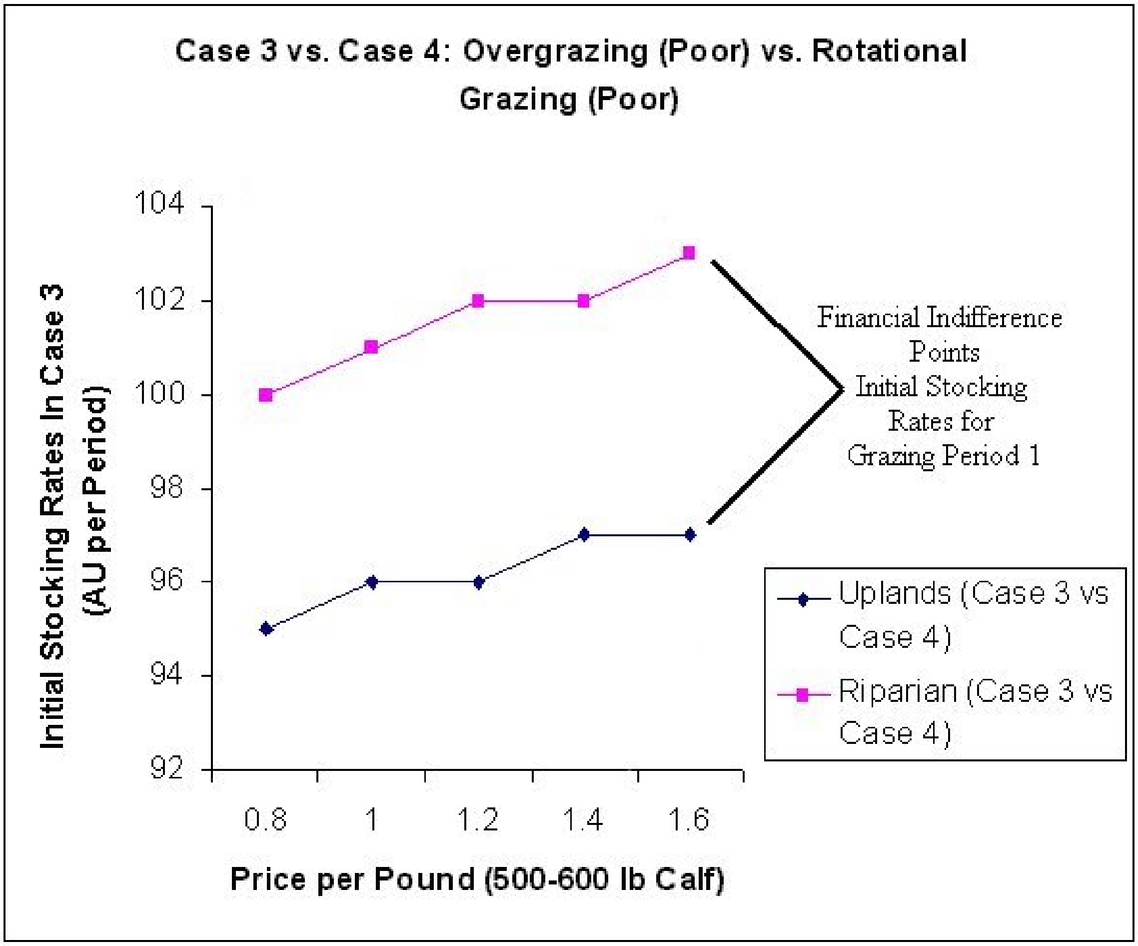
In this scenario, the producer chooses between overgrazing a pasture with a continuous grazing plan (Case 3), and using a rotational grazing strategy (Case 4), with the expectation that the rotational strategy would rehabilitate the pasture. The uplands stocking rate for Case 3 was allowed to change. The riparian area stocking rate was made to move in proportion to the uplands rate. The new stocking rates for Case 3 were evaluated at 500-600 lb calf price levels ranging from $0.80 per pound to $1.60 per pound. Since there were added costs (fencing and watering) in the rotational grazing scenario, there was a slight increase in the financial indifference point in grazing period 1 as calf prices increased.

In Scenario 2, higher calf prices provided slightly more incentive to continue the overgrazing strategy. At $0.80 per pound, the indifference point carrying capacity was 0.4 AUM/acre (95 AU grazed per period) on the uplands, and 1.096 AUM/acre (100 AU grazed per period) on the riparian area (Table 5.3). This result suggested that, at $0.80 per pound, a beef producer would choose a continuous overgrazing stocking rate if the pastures could support more than 195 AU in grazing period 1. Below this carrying capacity, a beef producer choosing a rotational grazing system would be better off (financially) in the long run.

The financial indifference point at $1.00 per pound is 0.405 AUM/acre, or 96 AU grazed per period on the uplands. On the riparian area, the numbers are 1.109 AUM/acre, or 101 AU grazed per period. At $1.20 per pound the indifference point is 0.408 AUM/acre (96 AU grazed per period) on the uplands and 1.118 AUM/acre (102 AU grazed per period) on the riparian area. In Scenario 1, the same change in calf price was applied to both scenarios. There were no incremental costs in either system. Therefore, the financial indifference point remained the same, regardless of calf price. In Scenario 2, Case 4 introduces new fencing and watering costs. However, these costs are offset by pasture that regenerates over the 20 years modeled.

If calf prices increase from $0.80 per pound to $1.00 per pound, the initial stocking rate (uplands plus riparian area) must be approximately 2 AUM higher for the rancher to choose a continuous overgrazing strategy. This is because the slightly higher calf price, and increased carrying capacity through pasture regeneration, will offset the extra cash required for the fencing and watering of the rotational system. This trend continues through price changes to $1.60 per pound. However, the differences in stocking rate become slightly smaller as calf prices increase. Figure 5.2 shows the indifference points split between the upland and riparian pastures (indifference point for each pasture shown).

Figure 5.2 Indifference Points for Case 3 vs. Case 4



5.2.3 *Scenario 3: Case 3 vs. Case 5*

In this scenario, the producer chooses between overgrazing a pasture with a continuous grazing plan (Case 3), and using a corridor fencing strategy (Case 5), with the expectation that the corridor strategy would rehabilitate the pasture. The stocking rates for Case 3 were allowed to change in the same manner as in Scenario 2. The new stocking rates for Case 3 were evaluated at 500-600 lb calf price levels ranging from $0.80 per pound to $1.60 per pound. Since there were added costs (fencing) in the corridor fencing scenario, there was a slight increase in the financial indifference point in grazing period 1 as calf prices increased.

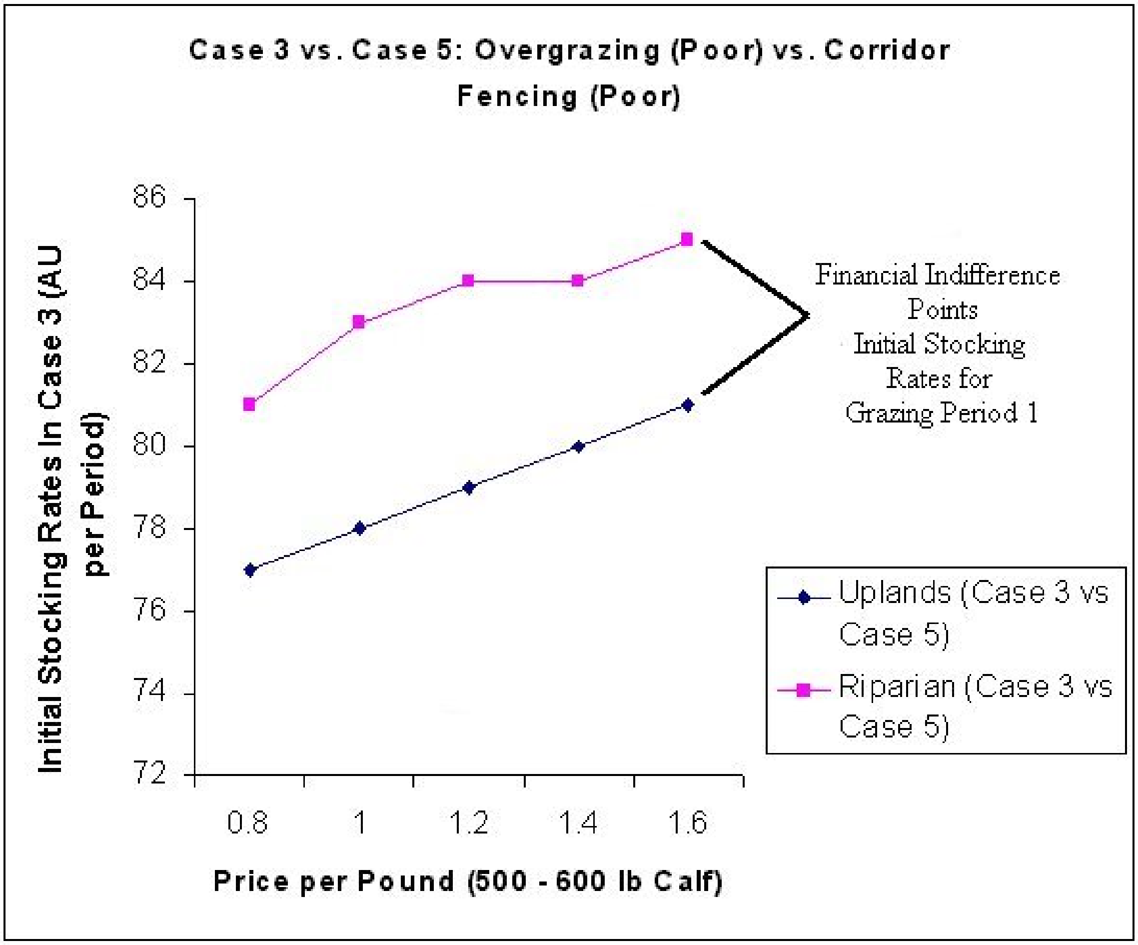
In Scenario 3, higher calf prices provided slightly more incentive to continue the overgrazing strategy, as in Scenario 2. At $0.80 per pound, the indifference point carrying capacity was 0.325 AUM/acre (77 AU grazed per period) on the uplands, and

0.891 AUM/acre (81 AU grazed per period) on the riparian area (Table 5.4). This result suggested that, at $0.80 per pound, a beef producer would choose a continuous overgrazing stocking rate if the pastures could support more than 158 AU in grazing period 1. Below this carrying capacity, a beef producer choosing a corridor fencing system would be better off (financially) in the long run.

The financial indifference point at $1.00 per pound is 0.332 AUM/acre, or 78 AU grazed per period on the uplands. On the riparian area, the numbers are 0.909 AUM/acre, or 83 AU grazed per period. At $1.20 per pound the indifference point is 0.336 AUM/acre (79 AU grazed per period) on the uplands and 0.921 AUM/acre (84 AU grazed per period) on the riparian area. In Scenario 3, as in Scenario 2, Case 5 introduces new costs (fencing). However, these costs are offset by pasture that regenerates over the 20 years modeled.

If calf prices increase from $0.80 per pound to $1.00 per pound, the initial stocking rate (uplands plus riparian area) must be approximately 2 AUM higher for the rancher to choose a continuous overgrazing strategy. This is because the slightly higher calf price, and increased carrying capacity through pasture regeneration, will offset the extra cash required for the fencing of the corridor system. This trend continues through price changes to $1.60 per pound. However, as in Scenario 2, the differences in stocking rate become slightly smaller as calf prices increase. Figure 5.3 shows the indifference points split between upland and riparian pastures (indifference point for each pasture shown).

Figure 5.3 Indifference Points for Case 3 vs. Case 5



5.2.4 *Scenario 4: Case 3 vs. Case 6*

In this scenario, the producer chooses between overgrazing a pasture with a continuous grazing plan (Case 3), and using a rest rotation strategy (Case 6), with the expectation that the rest rotation strategy would rehabilitate the pasture. The stocking rates for Case 3 were allowed to change in the same manner as those in the previous scenarios. The new stocking rates for Case 3 were evaluated at 500-600 lb calf price levels ranging from $0.80 per pound to $1.60 per pound. Since there were added costs (fencing and watering) in the rest rotation scenario, there was a slight increase in the financial indifference point in grazing period 1 as calf prices increased.

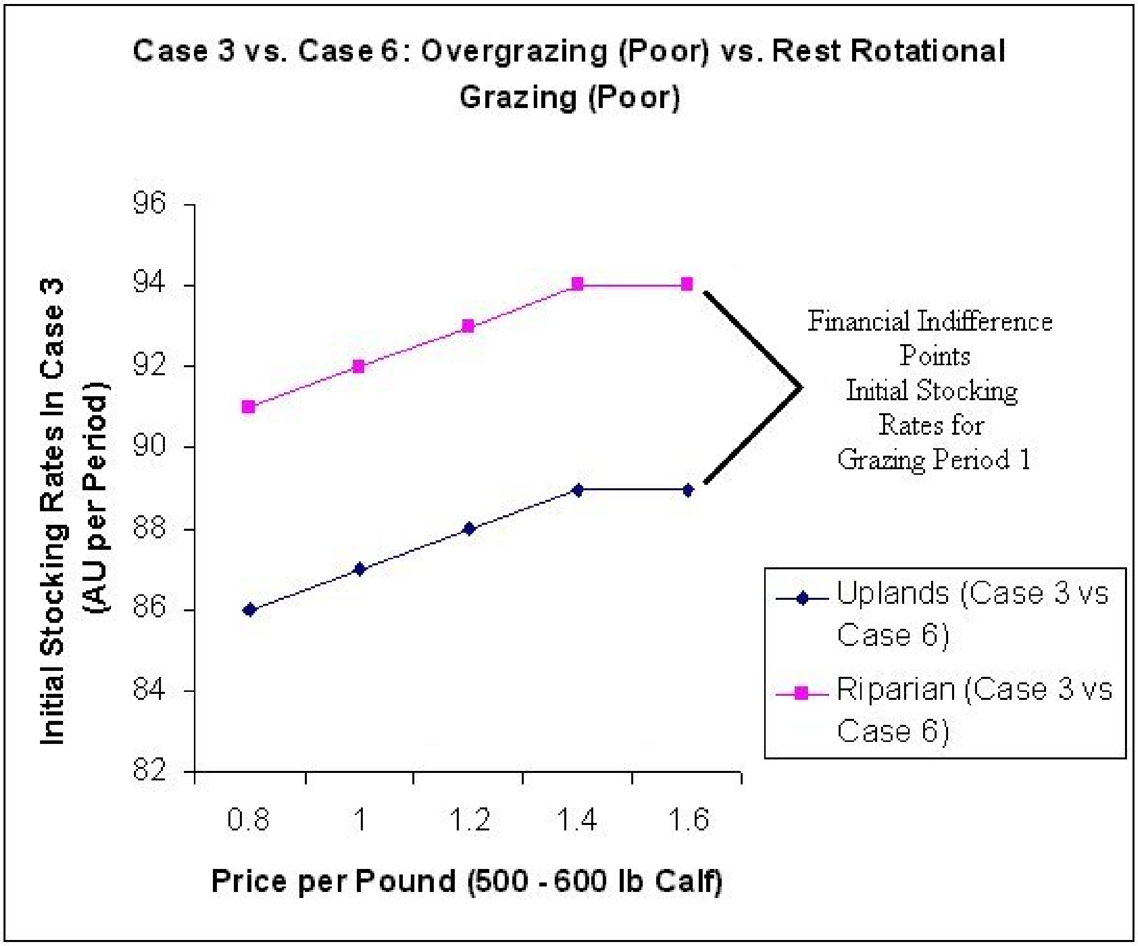
In Scenario 4, higher calf prices provided slightly more incentive to continue the overgrazing strategy, as in Scenarios 2 and 3. At $0.80 per pound, the indifference point carrying capacity was 0.365 AUM/acre (86 AU grazed per period) on the uplands, and

0.999 AUM/acre (91 AU grazed per period) on the riparian area (Table 5.5). This result suggested that, at $0.80 per pound, a beef producer would choose a continuous overgrazing stocking rate if the pastures could support more than 177 AU in grazing period 1. Below this carrying capacity, a beef producer choosing a rest rotation system would be better off (financially) in the long run.

The financial indifference point at $1.00 per pound is 0.370 AUM/acre, or 87 AU grazed per period on the uplands. On the riparian area, the numbers are 1.013 AUM/acre, or 92 AU grazed per period. At $1.20 per pound the indifference point is 0.373 AUM/acre (88 AU grazed per period) on the uplands and 1.022 AUM/acre (93 AU grazed per period) on the riparian area. In Scenario 1, the same change in calf price was applied to both scenarios. There were no incremental costs in either system. Therefore, the financial indifference point remained the same, regardless of calf price. In Scenario 4, as in Scenarios 2 and 3, Case 6 introduces new costs (fencing and watering). However, these costs are offset by pasture that regenerates over the 20 years modeled.

If calf prices increase from $0.80 per pound to $1.00 per pound, the initial stocking rate (uplands plus riparian area) must be approximately 2 AUM higher for the rancher to choose a continuous overgrazing strategy. This is because the slightly higher calf price, and increased carrying capacity through pasture regeneration, will offset the extra cash required for the fencing and watering of the rest rotational system. This trend continues through price changes to $1.60 per pound. However, as in the previous two scenarios, the differences in stocking rate become slightly smaller as calf prices increase. Figure 5.4 shows the indifference points split between upland and riparian pastures (indifference point for each pasture shown).

Figure 5.4 Indifference Points for Case 3 vs. Case 6



5.2.5 *Scenario Analysis Conclusions*

In Scenario 1, the financial indifference point was found at 165 AU per period in the uplands and 127 AU per period in the riparian area, at all calf price points. In the Base Case, it was noted that, in the assumed good pasture condition, the hypothetical pasture could support 209 AU per grazing period. In order for the producer to have financial indifference, the pasture would have to support a much higher initial stocking rate (292 AU per period – addition of upland and riparian areas). This would suggest that, in the case of the good condition pasture (Base Case), the best strategy from a financial point of view would be a sustainable grazing strategy, where the stocking rate matched a pasture's long-run carrying capacity.

In Scenario 2, it was assumed that the pastures were in poor condition in year 1. This meant that the hypothetical pasture (upland plus riparian) was initially stocked at

183 AU per grazing period in Period 1, which was an unsustainable rate. At the initial calf price of $0.80 per pound, the financial indifference point was found where the uplands pasture supported 95 AU per period, and the riparian pasture supported 100 AU per period. Therefore, the producer would have to be able to stock the full pasture (riparian and upland) at an even higher rate than the initial one (183 AU per period – addition of upland and riparian areas), before considering the unsustainable continuous grazing strategy over the rotational strategy. Though the rotational strategy has higher initial capital costs, the pasture health is gradually restored. As calf prices increase, the financial indifference point becomes higher as well. Higher calf prices, as well as pasture restoration, make the rotational grazing strategy appear to be the better choice for the pasture in poor condition at each calf price point.

In Scenario 3, it was again assumed that the pastures were in poor condition in year 1. This meant that the hypothetical pasture (upland plus riparian) was initially stocked at 183 AU per grazing period in Period 1, which was an unsustainable rate. However, the pasture was being compared to a highly degraded pasture in Case 5, which needed a drastic measure (corridor fencing) to restore it to health. In this scenario, at the initial calf price of $0.80 per pound, the financial indifference point was found where the uplands pasture supported 77 AU per period, and the riparian pasture supported 81 AU per period. The producer would consider the unsustainable continuous grazing strategy over the corridor strategy at a lower stocking rate than was originally chosen for Case 3 (Overgrazing from Poor).

However, for a seriously degraded pasture, like that in Case 5, a corridor strategy may be the only choice when a pasture cannot support stocking rates above this level. As in Scenario 2, as calf prices increase, the financial indifference point becomes higher as well. Higher calf prices, as well as pasture restoration, make the corridor fencing strategy appear to be a good choice for the seriously degraded pasture at each price point.

In Scenario 4, it was again assumed that the pastures were in poor condition in year 1. This meant that the hypothetical pasture (upland plus riparian) was initially stocked at 183 AU per grazing period in Period 1, which was an unsustainable rate. At the initial calf price of $0.80 per pound, the financial indifference point was found where the uplands pasture supported 86 AU per period, and the riparian pasture supported 91

AU per period. Again, this combined stocking rate was lower than the 183 AU per period used in Period 1 of Case 3. The pastures in Case 6 (Rest Rotational Grazing) started in a very degraded condition (though not as serious as those in Case 5). Though the rest rotational strategy has higher initial capital costs, the pasture health is gradually restored, as in the previous two scenarios. As calf prices increase, the financial indifference point becomes higher as well. Higher calf prices, as well as pasture restoration, make the rest rotational grazing strategy appear to be the better choice for the pasture in poor condition at each calf price point.

5.3 Sensitivity Analysis Results

5.3.1 *Discount Rate Analysis*

When the discount rate was varied, it changed the incremental NPV (Table 5.6). It can be seen that lower discount rates result in higher incremental NPV's across cases. Higher discount rates reduce the incremental NPV for each case. Results show that higher discount rates will favour strategies that use higher initial stocking rates (Case 2), though these strategies lead to lower future stocking rates. Lower discount rates will favour strategies with lower initial stocking rates and higher future cash flows in later time periods (Case 4).

With higher discount rates, producers who favour early returns might look to the case of overgrazing from good condition (Case 2), where higher returns are seen in the early years of grazing. However, this case will lead to lower returns in the future, as pasture condition is degraded. With lower discount rates, producers with poor pasture might favour a system such as rotational grazing (Case 4), which has higher returns in the later years of grazing. Though a producer starts with a lower initial stocking rate, a rotational system will restore health to a pasture, resulting in higher stocking rates in the future.

5.3.2 *Pasture Degradation Rate Analysis*

Case 2 (overgrazing from good condition), at its initial 6% degradation rate, had its initial uplands stocking rate of 154 AU grazed/period fall to its steady state rate of 65 AU grazed/period (Table 5.7). For the riparian area at 3%, the numbers were 118 AU grazed/period initially, and 66 AU grazed/period in Period 20. At a 2% rate, the uplands final stocking rate is 105 AU grazed/period. For the riparian area at 1%, its period 20 stocking rate was 98 AU grazed/period. At a 10% degradation rate, the uplands hits its steady state rate of 65 AU grazed/period. The final riparian stocking rate at 5% degradation is 45 AU grazed/period. Incremental NPV for Case 2 at the 6% and 3% rates was $1,065,663. At the 2% and 1% rates, the incremental NPV was $1,305,035. At the 10% and 5% rates, the incremental NPV for Case 2 was $940,416.

Case 3 (overgrazing from poor condition), at a 6% degradation rate, had the initial uplands stocking rate of 183 AU grazed/period fall to its steady state rate of 65 AU grazed/period. For the riparian area at a 3% degradation rate, its initial 87 AU grazed/period fell to 49 AU grazed/period. The uplands pasture again reached its steady-state stocking rate (65 AU grazed/period) at a 2% degradation rate. The riparian area, at a 1% rate, had a final stocking rate of 72 AU grazed/period. At a 10% degradation rate, the uplands pasture had the steady-state stocking rate of 65 AU grazed/period in Period 20. The riparian area stocking rate, at a 5% degradation rate, fell to 33 AU grazed/period. Incremental NPV for Case 3 at 6% was $746,207. At 2%, the incremental NPV was $830,502. At 10%, the incremental NPV for Case 3 was $691,709 (Table 5.7).

In Case 2, the first degradation rate increase of 4% results in the NPV decreasing by approximately $250,000 (Table 5.7). However, the next 4% degradation rate increase does not have so large an effect. A similar trend was seen in Case 3, except with smaller amounts. The change appeared to be smaller because Case 3 pastures began in degraded conditions, while Case 2 pastures were in good condition in Period 1. For both Cases, pasture conditions can only degrade to a specific steady state (0.273 AUM/acre). It can be seen that the riparian area never hits its steady state level (25 AU grazed/period), while the uplands pasture hits it in five out of six trials. According to the assumptions made for this model, it may be surmised that the riparian area is highly productive, and can sustain itself longer than uplands pastures.

5.4 Chapter Summary / Summary of Results

In the incremental NPV analysis, sustainable continuous grazing on good condition pasture returned the highest value. However, under the assumptions used, strategies that improve riparian area health (such as rotational grazing and corridor fencing) will make a rancher better off (financially) in the long run, when degraded pasture is being considered. Scenario analysis found the financial indifference points for a producer choosing between sustainable and unsustainable continuous grazing (Scenario 1), rotational grazing and unsustainable continuous grazing (Scenario 2), corridor fencing and unsustainable continuous grazing (Scenario 3), and rest rotational grazing and unsustainable continuous grazing (Scenario 4). It was found that, in the long run, there is no real financial incentive to overgraze pasture. In Scenarios 1 and 2, a pasture would have to be able to sustain a much higher initial stocking rate than the proposed initial rate, in order for a producer to choose an unsustainable grazing strategy. Scenarios 3 and 4 showed the points where it would become necessary to implement more complicated strategies to restore the health of degraded pasture.

Discount rate sensitivity analysis results show that higher discount rates will favour strategies that use higher initial stocking rates (Case 2 – overgrazing from good condition), though these strategies lead to lower future stocking rates. Lower discount rates will favour strategies with lower initial rates, with higher future payoffs (Case 4 – rotational grazing from poor condition). Case 2 (overgrazing from good condition) appears to be more sensitive to increases in the degradation rate than Case 3 (overgrazing from poor condition). This may be due to the “good condition” starting point for the pasture in Case 2.

5.5 Tables for Chapter 5

Table 5.1 Comparison of Static NPV Model Results

	Base Case: Sustainable Continuous Grazing (from good condition)	Case 2: Unsustainable Continuous Grazing (from Good Condition)	Case 3: Unsustainable Continuous Grazing (from Poor Condition)	Case 4: Rotational Grazing (from Poor Condition)	Case 5: Corridor Fencing (from Poor Condition)	Case 6: Rest Rotation Grazing (from Poor Condition)
Initial (Period 1) Uplands Stocking Rate (AUM/acre)	0.500	0.650	0.350	0.273	0.273	0.273
Initial (Period 1) Uplands Stocking Rate (AU/grazing period)	118	154	83	65	65	48
Final (Period 20) Uplands Stocking Rate (AUM/acre)	0.500	0.273	0.273	0.398	0.398	0.456
Final (Period 20) Uplands Stocking Rate (AU/grazing period)	118	65	65	94	94	108
Initial (Period 1) Riparian Stocking Rate (AUM/acre)	1.00	1.30	0.959	0.671	0.336	0.671
Initial (Period 1) Riparian Stocking Rate (AU/grazing period)	91	118	87	61	31	46
Final (Period 20) Riparian Stocking Rate (AUM/acre)	1.00	0.729	0.537	1.00	1.00	1.00
Final (Period 20) Riparian Stocking Rate (AU/grazing period)	91	66	49	91	91	91
Initial Value of Calves Attributed to Pasture (t=1)	$113,804	$147,945	$92,474	$68,325	$51,723	$51,243
Final Value of Calves Attributed to Pasture (t=20)	$113,804	$71,182	$61,713	$100,644	$100,644	$108,094
Incremental NPV	$1,138,044	$1,065,663	$746,207	$841,734	$732,792	$786,785

Table 5.2 Results of Indifference Scenario 1 (Base Case vs. Case 2)

Price ($/lb – 500–600 lb Calf)	Upland AUM/acre	Riparian AUM/acre	Upland AU per Period	Riparian AU per Period
0.80	0.698	1.396	165	127
1.00	0.698	1.396	165	127
1.20	0.698	1.396	165	127
1.40	0.698	1.396	165	127
1.60	0.698	1.396	165	127

Table 5.3 Results of Indifference Scenario 2 (Case 3 vs. Case 4)

Price ($/lb – 500–600 lb Calf)	Upland AUM/acre	Riparian AUM/acre	Upland AU per Period	Riparian AU per Period
0.80	0.4	1.096	95	100
1.00	0.405	1.109	96	101
1.20	0.408	1.118	96	102
1.40	0.41	1.124	97	102
1.60	0.412	1.128	97	103

Table 5.4 Results of Indifference Scenario 3 (Case 3 vs. Case 5)

Price ($/lb – 500–600 lb Calf)	Upland AUM/acre	Riparian AUM/acre	Upland AU per Period	Riparian AU per Period
0.80	0.325	0.891	77	81
1.00	0.332	0.909	78	83
1.20	0.336	0.921	79	84
1.40	0.339	0.929	80	84
1.60	0.342	0.935	81	85

Table 5.5 Results of Indifference Scenario 3 (Case 3 vs. Case 6)

Price ($/lb – 500–600 lb Calf)	Upland AUM/acre	Riparian AUM/acre	Upland AU per Period	Riparian AU per Period
0.80	0.365	0.999	86	91
1.00	0.37	1.013	87	92
1.20	0.373	1.022	88	93
1.40	0.376	1.029	89	94
1.60	0.377	1.033	89	94

Table 5.6 Results of Discount Rate Sensitivity Analysis

Incremental NPV	Base Case: Sustainable Continuous Grazing (from good condition)	Case 2: Unsustainable Continuous Grazing (from Good Condition)	Case 3: Unsustainable Continuous Grazing (from Poor Condition)	Case 4: Rotational Grazing (from Poor Condition)	Case 5: Corridor Fencing (from Poor Condition)	Case 6: Rest Rotation Grazing (from Poor Condition)
5% DR	$2,276,089	$1,864,609	$1,396,223	$1,809,368	$1,671,119	$1,800,133
10% DR	$1,138,044	$1,065,663	$746,207	$841,734	$732,792	$786,785
15% DR	$758,696	$767,800	$518,226	$531,858	$442,923	$473,243

Table 5.7 Results of Pasture Degradation Rate Sensitivity Analysis

Variables at Changing Degeneration Rates	**Case 2: Unsustainable Continuous Grazing (from Good Condition)**	**Case 3: Unsustainable Continuous Grazing (from Poor Condition)**
Initial Uplands Stocking Rate (2%)	154 AU/Grazing Period	83 AU/Grazing Period
Initial Riparian Stocking Rate (1%)	118 AU/Grazing Period	87 AU/Grazing Period
Final Uplands Stocking Rate (2%)	105 AU/Grazing Period	65 AU/Grazing Period
Final Riparian Stocking Rate (1%)	98 AU/Grazing Period	72 AU/Grazing Period
Incremental NPV (2% Up, 1% Rip)	$1,305,035	$830,502
Initial Uplands Stocking Rate (6%)	154 AU/Grazing Period	83 AU/Grazing Period
Initial Riparian Stocking Rate (3%)	118 AU/Grazing Period	87 AU/Grazing Period
Final Uplands Stocking Rate (6%)	65 AU/Grazing Period	65 AU/Grazing Period
Final Riparian Stocking Rate (3%)	66 AU/Grazing Period	49 AU/Grazing Period
Incremental NPV (6% Up, 3% Rip)	$1,065,663	$746,207
Initial Uplands Stocking Rate (10%)	154 AU/Grazing Period	83 AU/Grazing Period
Initial Riparian Stocking Rate (5%)	118 AU/Grazing Period	87 AU/Grazing Period
Final Uplands Stocking Rate (10%)	65 AU/Grazing Period	65 AU/Grazing Period
Final Riparian Stocking Rate (5%)	45 AU/Grazing Period	33 AU/Grazing Period
Incremental NPV (10% Up, 5% Rip)	$940,416	$691,709

Chapter 6

6.1 Conclusions

According to the questionnaire, producers seemed to have good knowledge concerning riparian management. Results of the survey suggested that costs of riparian management strategies would play a role in the management decisions of producers. However, the producers considered the future of ranch operations when making their choices. Grazing systems with higher initial costs would be considered if they were needed to restore pasture health. The producers were also open to suggestions from groups concerned with riparian health, such as Cows and Fish.

Incremental NPV results suggested that overgrazing is generally not a feasible long-term grazing strategy. Grazing strategies that improve range health in the long run would make producers better off financially. Cases 2 and 3 (overgrazing from good condition and overgrazing from poor condition, respectively) were examples of overgrazing strategies. Initial values of calves attributed to the pasture were higher, but these values decreased as pasture condition was degraded. Though their initial costs were higher, the simulated rotational strategy (Case 4) resulted in improved incremental NPV over time, as did the corridor fencing system (Case 5) and the rest rotational system (Case 6).

These conclusions appear to be relatively insensitive to additional costs (Cases 4, 5, and 6) or to calf prices (which were held constant over the 20-year timeline being modeled). If initial calf prices are high, and future prices are expected to be lower, there may be more incentive to overgraze a pasture. By overgrazing in the first few years of grazing, a rancher could capitalize on higher prices, while possibly disregarding future range health. These results are very sensitive to rates of range degradation or regeneration. Low degradation rates (as a result of higher stocking rates and faster regeneration rates) will tend to favour short run overgrazing strategies.

Cases 4, 5, and 6 had stocking rates in their early stages that were much lower than the early stocking rates for the first three cases. The results were very sensitive to the lower initial stocking rates. Though range health improved over time (often improving stocking rates to levels close to the initial stocking rates of the Base Case), the initially diminished numbers of animals on the range (and accompanying loss of cash inflow) kept the final NPV's lower than those for the Base Case and Case 2. If a ranch manager could forecast long-range calf prices, it is possible that a producer would be better off financially by overgrazing in the short term when calf prices are high, then implementing a management strategy that improves range health. This would pre-suppose low degradation rates and high regeneration rates (which riparian area pastures were noted for previously).

Using the same assumptions, indifference point results indicated that producers would opt for grazing strategies that promote forage regeneration. In order to be financially indifferent, a pasture must have the capability to support very high initial stocking rates. However, it should be noted that time preferences for cash flows vary among ranch operators. If initial calf prices are high, and future prices are expected to be lower, this might increase the incentive to overgraze. At higher discount rates, the producer would favour short-term returns, such as those provided by an overgrazing system (e.g., Case 2). A producer in this case may be considering short-term cash flow needs (debts, family considerations, etc.). At lower discount rates, producers would favour systems that gave them higher returns in the long run, such as the rotational system in Case 4. A producer in this case might be considering long-term financial stability for both the farm business and farm family.

Static NPV models were used to evaluate different riparian management strategies. These models were focused on a single riparian area. Whole ranch concerns were not modeled. Instead, the model analysis was based on incremental changes to the riparian area pasture. The incremental NPV model had a number of limitations. The model did not account for over-wintering of cattle. When cattle numbers were reduced due to loss of grazing capacity, these cattle were taken out of the model, without accounting for their whereabouts, sale price (cull cows), etc. As well, because the model was static, beef prices and costs related to ranch operation were all fixed. One very important variable in most farming situations is the weather. The static model assumed that the effects of weather were fixed.

A different model financial structure may give different results. For example, taxes could have been included in the model calculations. However, in the static model, whole farm considerations (such as taxes) were left out. Model results showed that long-run NPV was very sensitive to pasture degeneration and regeneration rates. The model would be improved if more information on these rates were known and included. Comprehensive studies on this subject have yet to be performed in the plant science/range science community. Rates used in the current model were chosen based on examples of previous riparian management strategy implementations (Adams, 2000).

6.2 Further Research

6.2.1 *Data Collection*

As noted in the previous chapter, many assumptions were made considering the use of the riparian area. While data such as fencing and maintenance costs were easily obtained, the biological data were not. For example, the rate of pasture degradation due to overgrazing was an assumption, based on losses seen in earlier riparian management studies (Adams, 2000). Future research would benefit from data collection from multiple pastures, showing rates of pasture degradation at different stocking rates. Though biological processes would vary by pasture, weather conditions, etc., it would also be beneficial to have data on regeneration of forages over time. Regeneration times could then be used in the modeling of systems designed to rest pastures, such as rotational systems. This data, necessary to develop a model through time, was not available.

6.2.2 *Stochastic Modeling*

The model used in this study was static and incremental. The issue of riparian management would benefit from stochastic, or dynamic modeling. Dynamic aspects can be added to a model through the use of stochastic information, such as precipitation levels and cattle prices. While methods exist for predicting both weather and cattle pricing, there is always uncertainty involved. Stochastic models use this uncertainty to allow simulation of random events, such as droughts or sudden increases and decreases in livestock prices. By allowing these data to change over each study period, a level of realism can be added to the simulation of a ranch or farm. The data regarding biological processes (discussed in the previous section) would also improve a stochastic ranch model.

The main focus in this study was the riparian area. A real ranch would have a higher uplands area to riparian area ratio. A further extension of this study would be a "whole-ranch" or "whole-farm" model. That is, the riparian area would be modeled as one piece of the whole ranch. If a riparian area can provide abundant forage resources for a whole ranch, the changes made there would have an effect on the ranch's bottom line. A whole-ranch model would take into account the sources of revenue and the costs involved with the operation of a cow/calf business. For example, factors such as over-wintering of livestock and new livestock purchases were not considered in the riparian-exclusive model. These would become important considerations when modeling an entire ranch operation.

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Appendix 1

Initial Questionnaire

What are the Costs and Benefits of Riparian Grazing Management?

We would like to evaluate the benefits and costs of riparian grazing management strategies. To do this, we need to communicate with you, the producers making changes on the ground. This is the first step in the design of a survey and evaluation. Your help at this stage will allow us to better understand the economic components of riparian grazing management. It will also help us to get this information back to you, the livestock producers making decisions.

Accordingly, we are requesting that you please fill in this brief questionnaire. The questions are about managing riparian grazing areas, and will take fifteen to twenty minutes to complete. Your participation is **voluntary** and all individual answers are confidential. The information gathered from you is confidential. Nothing that identifies the participant by name will be shared with any other participants in the project or with other agencies. The results of the study may be published, but individual responses will remain confidential.

The survey has three parts. After reading through some suggested management practices on the next page, Part I presents two scenarios concerning two unhealthy riparian areas, and requests you rank different practices for managing these areas. Part II requests that you indicate which methods of reporting benefits and costs of different riparian management practices are most useful to you. Part III requests information on whether you have cattle, and manage riparian areas.

This project is funded by the Cows and Fish Program. The evaluation is conducted by researchers from the University of Alberta. Participation in the survey is voluntary.

Contact information for Jamie Miller, Dr. Peter Boxall, and Dr. Jim Unterschultz was presented here.

Part I

1. Distribution Practices

The most basic option is to place cattle attractants in the uplands, away from riparian areas. Things like salt, minerals, upland or off-stream watering sites, oilers or rubbing posts will help draw animals away from riparian areas. With the exception of watering sites, these tend to be low-cost treatments.

2. Rotational Grazing

This strategy allows part of the range to be grazed, while other parts are rested. This normally requires subdividing a ranch into smaller pasture units. It is possible, however, to practice rotational grazing with existing pasture units, or through herding practices. This often means little infrastructure change and capital cost.

3. Deferred Rotational Grazing

Deferral means to delay grazing until a critical growth stage of the plant is passed. Along with moderate stocking rates, deferral promotes the full growth potential of range vegetation. Deferred rotation involves altering the deferral period between pastures. With more pastures, the early graze is alternated or cycled among other pastures from year to year and the harmful effects of early use are reduced.

4. Time-Controlled Grazing

Time-controlled systems minimize regrazing of the regrowth that plants require for rebuilding roots and energy supplies. This strategy involves shortening the period of grazing use on riparian pastures. High stocking rates for short periods can be harmful to woody plant restoration. This may mean moving animals if the strategy is slowing riparian recovery. More management time may be needed than in 1 or 2.

5. Rest-Rotation Grazing

Deferred rotation may not be enough to help restore woody plant growth to a badly damaged riparian area. In this case, more rest may be required. Rest-rotation grazing can involve completely resting a pasture for an entire growing season, or even a number of years. This usually allows woody plants to re-establish and become more resistant to grazing. Taking a pasture out of use for a number of years can be costly.

6. Riparian Pastures

This strategy involves defining fields to reduce variation within fields. This could mean fencing uplands separately from lowland pasture in the floodplain. Though more fencing is required for this strategy, riparian pastures can help to restore woody vegetation.

7. Holding Pastures

Holding pastures are fields where animals are held for long periods of time (winter feeding or calving). Supplemental feeding is usually required. In a riparian area, high stocking rates can be harmful. Off-stream watering sites and careful placement of supplemental feed away from riparian areas may be required. This strategy is difficult to manage and has higher infrastructure costs than other methods.

8. Corridor Fencing

This strategy involves eliminating livestock grazing on a narrow corridor along the riparian area through fencing. This is normally a last resort measure, and can be very expensive.

Please proceed to the scenarios on the following page.

Scenario A

This quarter section-sized pasture (Figure A) has been grazed season-long for 50 years. The lowlands and riparian area are in poor condition. Grazing use is light in the uplands, where there is at least one reliable spring present. Use in the riparian area is heavy. Forage production has declined, and woody species along the stream are absent.

Figure A

If a riparian area on your ranch looked like this, which riparian management strategy would you choose to correct it? Please rank each from first choice to last choice (1-8).

_____ Distributional Practices

Comments?

_____ Rotational Grazing
_____ Deferred Rotational Grazing
_____ Time-Controlled Grazing
_____ Rest-Rotation Grazing
_____ Riparian Pastures
_____ Holding Pastures
_____ Corridor Fencing

_____ Other (Specify) ______________________________

Scenario B

This pasture is showing signs of recovery with a rotational grazing program. Forage production is improving, and young, woody plants are visible. Cattle tend to water at hardened crossings. You would like to make some additional changes to further the regeneration of woody species.

Figure B

Which riparian management strategy would you choose to manage this area? Please rank each from first choice to last choice (1-8).

_____ Distributional Practices Comments?
_____ Rotational Grazing
_____ Deferred Rotational Grazing
_____Time-Controlled Grazing
_____ Rest-Rotation Grazing
_____ Riparian Pastures
_____ Holding Pasture
_____ Corridor Fencing

_____ Other (specify) ___________________________

How much did each of the following factors affect your management choices about Figures A and B?

Please rate them from High Influence (1) to Low Influence (7).

For example, if you chose 1 for letter a), that means that "fencing and other capital costs" highly influenced your decision.

	High Influence						Low Influence
a) Fencing and other capital costs	1	2	3	4	5	6	7
b) Management time required	1	2	3	4	5	6	7
c) Water quality for livestock	1	2	3	4	5	6	7
d) Water quality for downstream users	1	2	3	4	5	6	7
e) Effect on public perception	1	2	3	4	5	6	7
f) Changes in forage production	1	2	3	4	5	6	7
g) Changes in forage quality	1	2	3	4	5	6	7
h) Effect on fish and wildlife	1	2	3	4	5	6	7
i) Impact on short-term grazing capacity	1	2	3	4	5	6	7
j) Impact on long-term grazing capacity	1	2	3	4	5	6	7
k) Cows and Fish Recommendations	1	2	3	4	5	6	7
l) Effect on long-term ranch cash flow	1	2	3	4	5	6	7
m) Other (Examples: fish shelter, stable banks, etc.) ____________________	1	2	3	4	5	6	7

Please proceed to Part II on the next page.

Part II

When reporting the Costs/Benefits of different grazing management strategies, which one of the following measurements/units would you want to see used? Feel free to check more than one.

1. _____ Tonnes of Forage per Acre

2. _____ Animal Unit Months* of Grazing

3. _____ Net Dollars of Benefit per Acre

4. _____ Pounds of Beef per Animal Grazed

5. _____Cost ($) per Acre

6. _____ Revenue ($) per Acre

7. _____ Profit ($) per Acre

8. _____ Other (specify)

***Animal Unit Month (AUM): Amount of forage required (usually 1000 lbs of dry matter) by one AU (1000 lb cow with calf) for a month.**

Part III – Please circle, check or enter your response

1. Do you farm or ranch? Yes No

If no, this survey is complete. If yes, go to 2.

2. Do you have grazing livestock such as cattle? Yes No

If no, this survey is complete. If yes, go to 3.

3. Check the type below which describes your operation:

_____ Cow/Calf	**Number of Animals (1999)**		
_____ Backgrounder	Less than 50	_______ (cows)	
_____ Finishing Cattle	50 - 199	_______ (cows)	
_____ Other (specify) ____________________	More than 200	_______ (cows)	

4. Do you have a riparian area (streamside green zone, or floodplain) on your ranch?

Yes No

5. Do you support the objectives of this survey?

Yes No

6. Do you think that this is a good way to get information from ranchers?

Yes No

Comments

Please feel free to add any additional comments you may have about this survey.

Thank you for your time.

Appendix 2

Responses to Initial Questionnaire

Part I

Table 1: Responses to Figure A (Scenario 1)

	Distributional Practices		Rotational Grazing		Deferred Rotational Grazing		Time Controlled Grazing	
Rank	#	%	#	%	#	%	#	%
1	9	22	3	12	4	10	2	5
2	12	30	5	15	3	8	6	15
3	4	10	6	20	11	27	8	20
4	5	12	8	22	10	24	4	10
5	3	7	9	12	5	13	4	10
6	3	7	5	7	5	13	10	23
7	2	5	3	5	2	5	7	17
8	3	7	2	7	0	0	0	0

Table 2: Continuation of Responses to Figure A (Scenario 1)

	Rest Rotation Grazing		Riparian Pastures		Holding Pasture		Corridor Fencing	
Rank	#	%	#	%	#	%	#	%
1	3	7	9	22	1	3	11	27
2	7	17	6	15	0	0	2	5
3	6	15	2	5	0	0	4	10
4	6	15	5	13	2	5	1	3
5	9	22	9	22	2	5	0	0
6	7	17	3	8	7	18	1	3
7	1	2	4	10	16	39	4	10
8	2	5	2	5	12	30	17	42

Table 3: Responses to Figure B (Scenario 2)

	Distributional Practices		Rotational Grazing		Deferred Rotational Grazing		Time Controlled Grazing	
Rank	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
1	16	39	4	10	6	15	5	12
2	6	15	11	26	7	17	4	10
3	1	2	8	20	11	27	10	23
4	4	10	6	15	11	27	8	19
5	6	15	5	12	4	10	7	17
6	5	12	4	10	1	2	8	19
7	1	2	3	7	0	0	0	0
8	2	5	0	0	1	2	0	0

Table 4: Continuation of Responses to Figure B (Scenario 2)

	Rest Rotation Grazing		Riparian Pastures		Holding Pasture		Corridor Fencing	
Rank	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
1	6	15	5	12	0	0	1	2
2	8	19	4	10	0	0	1	2
3	6	15	3	7	1	2	1	2
4	6	15	4	10	0	0	2	5
5	8	19	8	19	2	5	1	2
6	2	5	11	25	6	15	4	10
7	3	7	5	12	21	51	8	20
8	2	5	2	5	11	27	23	57

Table 5: Factors Affecting Management Choices

	Fencing and other capital costs		Management time required		Water quality for livestock		Water quality for downstream users	
Rank	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
1	9	20	6	14	11	25	10	23
2	11	25	6	14	10	23	4	9
3	11	25	14	31	11	26	13	29
4	7	16	9	20	6	14	10	23
5	3	7	3	7	3	7	5	11
6	3	7	6	14	2	5	2	5
7	0	0	0	0	0	0	0	0

Table 6: Continuation of Factors Affecting Management Choices

	Effect on public perception		Changes in forage production		Changes in forage quality		Effect on fish and wildlife	
Rank	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
1	8	18	13	30	14	32	12	28
2	9	20	12	27	11	25	12	27
3	6	14	18	41	13	30	12	27
4	11	25	0	0	5	11	5	11
5	3	7	1	2	1	2	1	2
6	4	9	0	0	0	0	2	5
7	3	7	0	0	0	0	0	0

Table 7: Continuation of Factors Affecting Management Choices

	Impact on short-term grazing capacity		Impact on long-term grazing capacity		Cows and Fish recommendations		Effect on long-term ranch cash flow	
Rank	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
1	5	11	14	32	4	10	12	27
2	5	11	18	40	12	29	11	26
3	6	14	7	16	12	29	11	26
4	8	18	2	5	13	30	5	12
5	11	26	2	5	1	2	1	2
6	8	18	1	2	0	0	2	5
7	1	2	0	0	0	0	1	2

Table 8: Mean Responses to Factors Affecting Management Choices

Factor Affecting management Choice	Mean Rating
Fencing and Other Capital Costs	3
Management Time Required	3
Water Quality for Livestock	3
Water Quality for Downstream Users	3
Effect on Public Perception	3
Changes in Forage Production	2
Changes in Forage Quality	2
Effect on Fish and Wildlife	2
Impact on Short-term Grazing Capacity	4
Impact on Long-term Grazing Capacity	2
Cows and Fish Recommendations	3
Effect on Long-term Ranch Cash Flow	3

1 is the highest rating, and 7 is the lowest rating

Part II

Measurement Unit	Percentage of Responses
Tonnes of Forage per Acre	47%
Animal Unit Months of Grazing	69%
Net Dollars Benefit per Acre	29%
Pounds of Beef per Animal Grazed	27%
Cost ($) per Acre	38%
Revenue ($) per Acre	24%
Profit ($) per Acre	22%

Part III

Demographics

1. Do you farm or ranch?

Answer	# of Respondents	Percentage
Yes	42	95%
No	2	5%

2. Do you have grazing livestock such as cattle?

Answer	# of Respondents	Percentage
Yes	41	98%
No	1	2%

3. a) Choose the (farm) type below which best describes your operation:

Answer	# of Respondents	Percentage
Cow/Calf	37	88%
Backgrounder	12	29%
Finishing Cattle	3	7%
Other	7	17%

3. b) Choose the number of animals (1999)

Answer	# of Respondents	Percentage
Less than 50	4	10%
50-199	11	26%
More than 200	26	62%

4. Do you have a riparian area (streamside green zone, or floodplain) on your ranch?

Answer	# of Respondents	Percentage
Yes	33	81%
No	3	7%
NA	5	12%

5. Do you support the objectives of this survey?

Answer	# of Respondents	Percentage
Yes	34	83%
No	0	0
NA	7	17%

6. Do you think that this is a good way to get information from ranchers?

Answer	# of Respondents	Percentage
Yes	31	76%
No	2	5%
NA	8	19%