# RURAL ECONOMY

**Lower Souris Watershed Ecological Goods and Services Pilot Proposal Farm Level Economic Analysis**

**Brad Dollevoet, Stephen Koeckhoven, Scott R Jeffrey and Jim Unterschultz**

**Project Report**

# Project Report

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# Lower Souris Watershed Ecological Goods and Services Pilot Proposal

# Farm Level Economic Analysis

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# Executive Summary

The purpose of this study was to analyze the on-farm economic costs and benefits associated with providing wildlife habitat quantity on a representative mixed farm in the Lower Souris River watershed in south-eastern Saskatchewan. The farm is representative of mixed farms within the Lower Souris River watershed with 116 head cow beef herd, 960 acres of annual crop production and 960 acres of hay, tame pasture and native pasture. A stochastic simulation farm model was developed to estimate the benefits or costs of implementing various Ecological Goods and Services (EG&S) scenarios at the farm level using net present value (NPV) analysis. NPV is a measure of farm wealth in these models. Additional risks in the models were incorporated through varying crop prices, beef prices and weather.

Three general scenarios were modelled in this study to estimate the benefits or costs to the farm. These scenarios were defined as follows:

- a farm operator maintains habitat rather than converting this habitat to cropland, either by draining wetlands or clearing bush;
  - maintain riparian habitat on land instead of converting to cropland
  - maintain riparian habitat on land instead of converting to tame grass
  - maintain forested habitat on land instead of converting to cropland
  - maintain forested habitat on land instead of converting to tame grass
- a farm operator converts cropland to tame grass, through converting a whole field which increases EG&S; and
- a farm operator reduces grazing pressure on pasture lands, through a lower stocking rate or by adding cross fencing and off stream watering.

The base model uses input costs from 2005 although some alternative scenarios using an average of 2007 and 2008 input costs and output prices are presented. Representative farm modeling results are highly sensitive to model assumptions about costs, production and output prices, and these assumptions are described in the main report.

Summarized results are presented in Tables A and B in the executive summary. In general, converting riparian habitat to annual cropland where the converted land is as productive as adjacent cropland provides significant positive benefits to the farm. For example, the model suggests that the benefits may be in the range of $70/acre/year for each acre converted. Hence, where the riparian areas are easily (although not necessarily cheaply) converted, there are significant private benefits to clearing and draining. However if the riparian areas are already being used for grazing, converting the riparian areas to pasture (i.e. clear, break, drain and reseed) may not be economic with the benefits to the farm being a net cost of -$38/acre/year for each acre converted. The additional grazing capacity after conversion is not sufficient to offset the costs of conversion from riparian habitat to pasture. Converting forested habitat to either annual cropland or pasture provides a significant positive benefit to the farm if the converted acres have similar productivity (i.e. yields) to the adjacent cropland (Table A).

The net benefits to the farm of converting existing annual cropland to tame pasture or hay is highly dependent upon annual crop prices (e.g. canola, wheat, barley) relative to calf prices or the price of tame hay. Under the model scenarios evaluated, there may be a small benefit to the farm to convert more crop land to pasture (Table A). However, due to the relatively lower

market price for hay in the model, the benefits of converting annual cropland to hay land are negative at -$49/acre/year of land converted.

Management of existing farm resources such as native pasture and tame pasture carrying capacities are important to the financial health of the business. If the farm pasture carrying capacity were allowed to decline by 20%, this might cost the farm approximately $66/cow/year (Table B). If the pasture is in a reduced carrying capacity, strategies to improve the grazing capacity can be implemented. For example the farm could decrease stocking rates under the assumption that pasture forage production would then increase over time. The economic outcome of this strategy is highly dependent upon how quickly the grazing capacity improves. If capacity improves at 1.5%/year for five years due to a reduced stocking rate, the benefit to the farm may be -$16/cow/year (i.e., a negative net benefit). If the improvement in forage grazing can be 2.5%/year over seven years then the benefit to the farm may be $11/cow/year. Adding cross fencing and off stream waters (e.g. rotational grazing) can provide a small economic benefit to the farm if it results in improved forage production of at least 1%/year for six years (Table B). If adding cross fencing and off stream waters does not increase pasture forage production, this investment will have a negative economic impact on the farm. If management practices are joined with cross fencing and off- stream waters such that forage production can be increased by 7% or more then these investments may have a positive economic impact on the representative farm.

The economic conclusions regarding EG&S farm level costs and benefits in the Lower Souris region are mixed. Farms generally have clear incentives to reduce EG&S habitat (i.e. riparian or forested) when this land can be converted to production of annual crops. In the case of forested land there is also a positive economic benefit to convert this land to pasture. Adding cross fencing and off stream waterers provides an economic benefit to the farm only if the associated pasture management changes (i.e. improved rotational grazing) lead to significant increases in the carrying capacity of the native and tame pasture.

**Executive Summary Table A: Comparing Scenarios of EG&S Retention or Loss**

| **Scenario** | **2005 Cost Assumptions Net Farm Benefit/Acre/Year over number of acres treated** | **2007& 08 Cost and Price Assumptions Net Farm Benefit/Acre/Year over number of acres treated** |
|---|---|---|
| Decreasing Riparian Habitat from 16 acres/crop quarter to 5.3 acres. Habitat converted to annual cropland | $75 | $60 |
| Decreasing Riparian Habitat from 32 acres/pasture quarter to 11 acres. Habitat converted to tame grass | -$47 | Scenario not evaluated |
| Decreasing Forested Habitat from 16 acres/crop quarter to 5.3 acres. Habitat converted to annual cropland | $47 | $33 |
| Decreasing Forested Habitat from 32 acres/pasture quarter to 11 acres. Habitat converted to tame grass | $46 | Scenario not evaluated |
| Converting 144 acres of cropland to tame pasture | $10 | $25 |
| Converting 144 acres of cropland to tame hay | -$49 | -$36 |

**Executive Summary Table B: Alternative Cattle Grazing Scenarios with Decrease or Increase in Forage Production**

| **Scenario** | **2005 Cost Assumptions Benefit/Cow/Year** |
|---|---|
| Overgrazing and decreasing tame and native pasture capacity by 20% (A pasture mismanagement scenario)* (see Table 7-35) | -$66 |
| Starting in overgrazed state and decrease stocking rates to achieve modest rates of improvement in range and pasture capacity (1.5%/year for 5 years) (see Table 7-37) | -$16 |
| Starting in overgrazed state and decrease stocking rates to achieve higher rates of improvement in range and pasture capacity (2.5%/year for 7 years) (see Table 7-39) | $11 |
| Adding cross fencing and offstream waterers with management that improves grazing forage production by 1%/year for 4 years | -$2 |
| Adding cross fencing and offstream waterers with management that improves forage production by 1.5%/year for 4 years | $5 |
| Adding cross fencing and offstream waterers with management that improves grazing forage production by 1%/year for 6 years | $3 |

* Decreasing utilization factor of forage from 50% to 40%.

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# 1. Lower Souris Watershed Ecological Goods and Services Farm Level Economic Problem

The purpose of this study was to analyze the on-farm economic costs and benefits associated with providing wildlife habitat quantity and quality on a representative mixed farm in the Lower Souris River watershed in south-eastern Saskatchewan. Specific agricultural practices are considered that relate to general wildlife habitat quantity and quality in terms of the relevant Ecological Goods and Services (EG&S). The economic analysis was done to determine the direct costs and/or benefits to the producers of implementing these practices for EG&S purposes. In other words, what are the net economic tradeoffs associated with adopting agricultural practices that result in increased EG&S? Are there scenarios where the impact is to generate positive net economic benefits? If not, then what are and in what form are the costs to the producer? This study does not investigate the economic costs and/or benefits to society from wildlife habitat.

The farm modeled and analyzed is representative of a cow/calf farm with crop production (i.e., mixed farm) found within the Lower Souris River watershed. Using the representative characteristics for a farm in the aforementioned area, stochastic simulation was performed to imitate cash flows over time for a net present value (NPV) analysis of alternative production practice scenarios. Replicating cash flows to derive net present values is a capital budgeting technique that allows for comparisons between different best management practices. Various scenarios were modeled and then compared to the base situation. This comparison to a base or reference scenario allowed for a straightforward analysis as to whether a particular change resulted in a net economic benefit or cost. It also provided the opportunity to determine the source of the cost or benefit from implementation as major biophysical and economic relationships were explicitly modeled.

Along with biophysical and economic relationships that occur within the farm operation, relationships and influences external to the farm were also modeled. These relationships contributed stochastic elements that were important drivers behind the profitability of the farm. These stochastic components were crop prices, beef prices and weather, in the form of growing season precipitation and growing degree days. Weather events influenced crop yields over time. The culmination of all the above allowed for an analysis of the economic impact of implementing practices that enhance EG&S production on a representative mixed farm in south-eastern Saskatchewan.

## 2. Background

Agriculture has diverse impacts on the environment, contributing both positively and negatively to environmental quality. Selected agricultural practices cause excess discharge of pollutants and sediment to surface and/or groundwater. Conversely, some agricultural production practices improve or enhance environmental attributes. For example, production of perennial forages contributes to reduced sediment being deposited in waterways.

As well, agriculture is itself affected by environmental quality. Ready access to a reliable source of good quality water is essential for livestock production. Conversely, polluted ground and/or surface water may contaminate crops and transmit disease to consumers. Therefore, undertaking production management practices that are consistent with maintaining or improving environmental attributes is important.

An assessment of interactions between agriculture and the environment often includes discussion of "ecological goods and services". Costanza et al. (1997) describe *Ecological Good and Services (EG&S)* as the benefits derived by humans from ecosystem services, either directly or indirectly. Agricultural producers maintain and manage land for food production and concurrently provide EG&S through the preservation of healthy ecosystems. Examples of ecological goods include clean air and abundant fresh water. Ecological services include purification of air and water, maintenance of biodiversity, pollination of crops and natural vegetation. Given the interaction between agriculture and the environment, some agricultural practices contribute positively in terms of enhancing production of EG&S, while the opposite is true for other practices.

Recently, environmental and producer organizations have become more concerned about the maintaining or increasing production of EG&S on the landscape. This is supported by the emergence of numerous programs designed to study the effect of agriculture on riparian ecosystems and water quality. One such program is the Alberta Riparian Habitat Management Project (Cows and Fish). This program has helped to increase the level of understanding of how improvements in grazing management can enhance the health and productivity of riparian areas while benefiting the producer and surrounding communities. Another related ongoing program of research is Watershed Evaluation of Beneficial Management Practices (WEBs). WEBs is a program of research, funded by the Canadian federal government, that combines biophysical and economic analysis in assessing the impacts of adopting Beneficial or Best Management Practices (BMPs) for riparian areas. Finally, the key example with respect to this study is the proactive approach of the Lower Souris Watershed Committee Inc. to undertake various studies and programs in order to improve water quality.

The focus of this study is on the farm level economic impact of adopting agricultural practices that potentially improve wildlife habitat quantity and quality and provide EG&S. An overview of agriculture in the Lower Souris Watershed region, which is approximated by Saskatchewan Crop District 1 (i.e., represented Crop Districts 1A and 1B), is presented in a separate document (Harper et al 2008)[1]. In summary, the area of farms in Crop District 1 represents approximately 7% of the total area of farms in Saskatchewan. According to Statistics Canada, the total area of farms in Districts 1A and 1B for the 2006 Agricultural Census is 2,687,728 and 2,312,446 acres, respectively. Average farm size in 1981 for the two Districts was 948 acres, and increased to 1402 acres by 2006. The total number of cattle and calves in Crop District 1 has been steadily increasing since the late 1980's. Overall, grain and oilseed production and livestock production (mainly beef cattle) are an important part of agriculture in this region.

## 3. Capital Budgeting and Simulation Analysis

This study incorporates the use of Monte Carlo simulation in conjunction with capital budgeting techniques to study the costs and benefits associated with implementation of agricultural practices that improve wildlife habitat quantity and quality. A theoretical and empirical discussion of capital budgeting is provided in this section. The benefits of using net present value as the capital budgeting approach in this study are discussed. A review of simulation modeling is provided, followed by a presentation of the specific model structure of the representative farm in the Lower Souris River watershed.

[1] At the time the Harper et al (2008) review was initiated, detailed 2006 census data (i.e., on a Rural Municipality basis) were not readily available. As a result, Crop Districts 1A and 1B were used in that document to approximate the relevant area for purposes of the analysis. This region is larger than the area encompassed by the Lower Souris Watershed.

### 3.1. Capital Budgeting

Capital budgeting is a planning tool used to analyze and evaluate long term investments for a firm. The capital budgeting techniques used most frequently are net present value (NPV) and the internal rate of return (IRR). Both NPV and IRR make use of discounted cash flow calculations (Ross et al, 2003). Long term investments are typically characterized by an initial capital outlay (i.e., initial investment), followed by a stream of cash flows, both positive and negative, generated over time. Any method used to evaluate long term investments should incorporate the magnitude and timing of cash flows as well as the time preferences of the decision maker(s). The information provided by the evaluation method should also indicate the potential profitability of the investment relative to the opportunity cost of capital for the decision maker(s). Both NPV and IRR meet these criteria. In this study, NPV is used to evaluate the alternative scenarios modeled for the representative farm. NPV is chosen over IRR due to conceptual and computational advantages (Copeland et al., 2005; Ross et al, 2003). In particular, the NPV approach is consistent with private wealth maximization.

NPV is defined as the present value of future net cash flows, net of the initial investment cost (Ross et al, 2003). Present value takes into account the time value of money and puts a value on a future payment or a series of future payments in terms of its worth at the present time. Present value (PV) is calculated as the value of a future cash stream discounted at an appropriate market rate as shown by the following formula (Ross et al., 2003):

$$\frac{C_1}{(1+r)^1}+\frac{C_2}{(1+r)^2}+\frac{C_3}{(1+r)^3}+\ldots\frac{C_n}{(1+r)^n}$$

where $C_t$ is the net cash flow in time t (t=1, 2, …n) and r is the interest rate, otherwise known as the discount rate. This discount rate is often chosen to be representative of the market interest rate or the rate that is paid on bank deposits or other financial investments. Other approaches to calculating a discount rate may be used that are based on the firm's cost of capital.

Net present value accounts for any initial capital outlays ($I_0$) that are associated with acquisition of assets that will generate the future cash flows (Ross et al., 2003). The resulting formula for NPV is as follows:

$$NPV=\frac{C_1}{(1+r)^1}+\frac{C_2}{(1+r)^2}+\frac{C_3}{(1+r)^3}+\ldots\frac{C_n}{(1+r)^n}-I_0$$

or

$$NPV = \sum_{t+1}^{N} \frac{C_t}{(1+r)^t} - I_0 \ .$$

The NPV calculation compares the present value of the future cash flow to the initial capital outlay. If the net difference is non-negative, then the investment is earning at least the required rate of return as represented by the discount rate. If an investment's NPV is negative, the present value of cash outflows and/or the initial investment exceed the present value of cash inflows and the investment should not be undertaken as it is not sufficiently profitable. In other words, the return earned is not at least equal to the opportunity cost used in discounting the future cash flows.

An NPV can be converted to an annual benefit or cost using several approaches. The approach used in this report is to convert the NPV to an annualized number using an amortization formula.

$$A = NPV \left[ \frac{r}{1 - \frac{1}{(1+r)^n}} \right]$$

The amortization formula uses a 10% discount rate and a 20 year amortization period which matches the number of years in the cash flow Monte Carlo model.

### 3.2. The Use of NPV

Previous research studies examining similar agricultural investment decisions to the current study have used NPV as an evaluation criterion. For example, Cortus (2005) used simulation and NPV analysis to examine the feasibility of wetland drainage for increased crop production in the district of Emerald in Saskatchewan. Drainage was viewed as an investment decision as capital investments in the form of machinery purchases were needed to undertake drainage activities which in turn impacted cash flows over time. Similarly, in this study investment in materials must be undertaken to implement at least some of the agricultural practices under consideration. In the Cortus study, distributions for NPV resulting from Monte Carlo simulation were compared, and it was concluded that drainage practices were economically feasible under certain conditions in the geographical area considered in the study.

Miller (2002) also used simulation and NPV analysis to evaluate on-farm costs and benefits of various riparian management schemes for a hypothetical southern Alberta ranch. Miller compared the overall feasibility and impact of alternative grazing strategies. These strategies included over-grazing and conservative grazing of pastures, given alternative initial pasture conditions. Monte Carlo simulation was used to generate cash flows over 20 grazing periods for each scenario. NPVs were then calculated for each scenario. From the results it was concluded that on a healthy pasture, a conservative grazing strategy would give the most favourable financial outcome. By conservatively grazing, rather than over-grazing pasture, the productivity would be sustained from year to year allowing for a reliable source of grazing forage over time. Conversely, on range that was in poor condition, overgrazing was the most financially attractive option.

### 3.3. Determining a Discount Rate for Net Present Value Analysis

As noted earlier, the discount rate is used to discount future cash flows to their present values in the calculation of net present value. The discount rate is also known as the required rate of return and its value should represent the rate of return for the best alternative opportunity for using the initial capital outlay (Ross et al., 2003). The choice of discount rate is of importance as it is often a key element in determining whether a NPV is positive or negative. A NPV calculation over an extended time period with large cash flows can very sensitive to the magnitude of the discount rate. The discount rate is determined as described in Koeckhoven (2008) and following a procedure suggested by Copeland and Antikarov (2003). The base rate used is 10%/year.

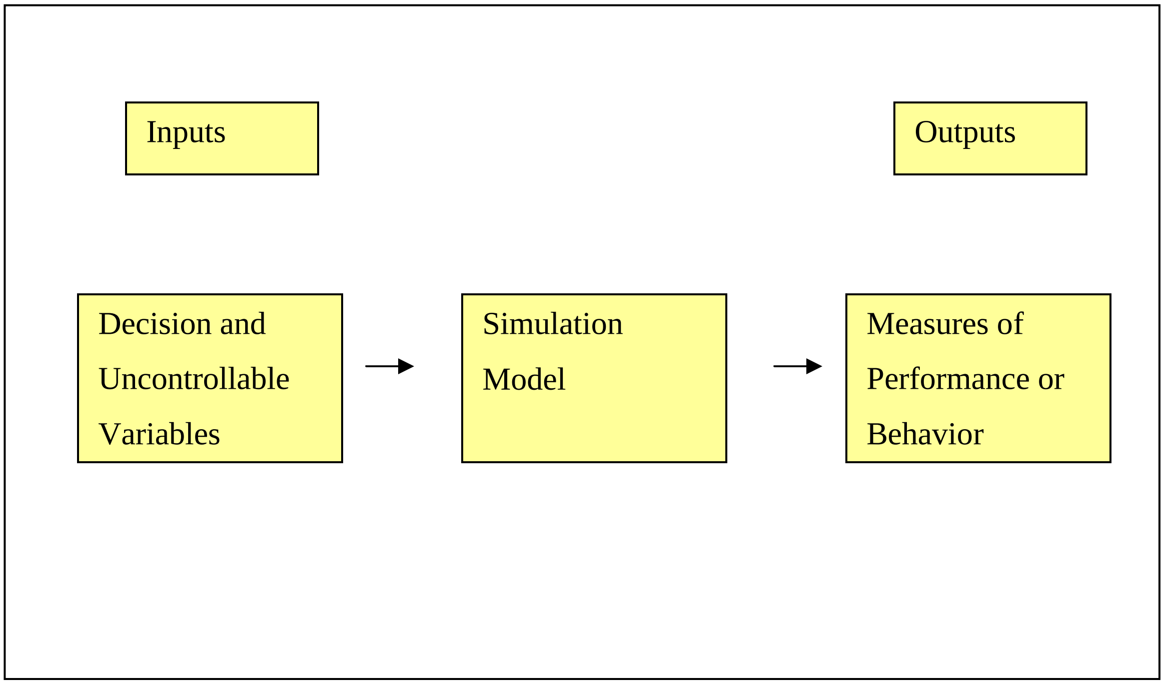
### 3.4. Agricultural Systems Modelling

Simulation modelling is the quantitative tool used in this study to examine the farm level effects of alternative scenarios that potentially enhance EG&S production. Simulation is the process of constructing a model, encompassing relevant variables and relationships that characterizes a real system. This model is then run repetitively to generate a stream of behaviour that, when represented correctly, would be expected from a real system under similar conditions (Babb et al, 1963). A simulation system can be static, which is a representation of a system at a particular point in time, or it can be dynamic in that the model representation evolves over time.

Furthermore, simulation can be deterministic or stochastic in nature. Deterministic models contain no random variables, in contrast to stochastic simulation models that do include random variables. The decision to use static versus dynamic or deterministic versus stochastic models depends on the objectives of the study (Law and Kelton, 2000).

Given the importance of risk in agricultural production decisions, it is appropriate to incorporate stochastic elements in the simulation analysis used in the current study. This is done by utilizing Monte Carlo simulation methods. Monte Carlo simulation is a specific form of simulation that creates "artificial futures by generating thousands and even hundreds of thousands of sample paths of outcomes and analyzes their prevalent characteristics" (Mun, 2006, p.73). This method can be used to determine how random variation, lack of knowledge or error affects the performance, sensitivity and/or the reliability of a system. In a study such as the current one, it can be used to encompass historical data of model inputs to build distributions representing those data in an effort to portray potential distributions of outcomes. Figure 3.1 depicts a general Monte Carlo model process. Selected inputs are represented by distributions of possible values, from which specific values are drawn for use in the simulation calculations. Outputs are also distributions due to the input distributions. In the context of the current study these may include cash flows, net present values, etc. that are used to address the study questions.

**Figure 3.1 - Illustration of General Structure of Monte Carlo Simulation Mode**




In this study, Monte Carlo simulation methods are used to replicate outcomes for a mixed farm in the Lower Souris watershed in an effort to understand the costs and benefits of implementation of practices that promote wildlife habitat quantity and quality. The specific program used to develop the simulation model is @risk for Microsoft Excel. This software is useful for Monte Carlo simulation in that it expands upon the basic single point estimates calculated within standard Excel spreadsheets. The underlying idea behind the software is that every action in a decision is potentially risky, whether that be an investment decision or otherwise. If risk can be quantified, in terms of determined outcomes and probabilities of occurrence, then a probability distribution can be used to summarize this risk within the spreadsheet (Palisade Corp., 2007).

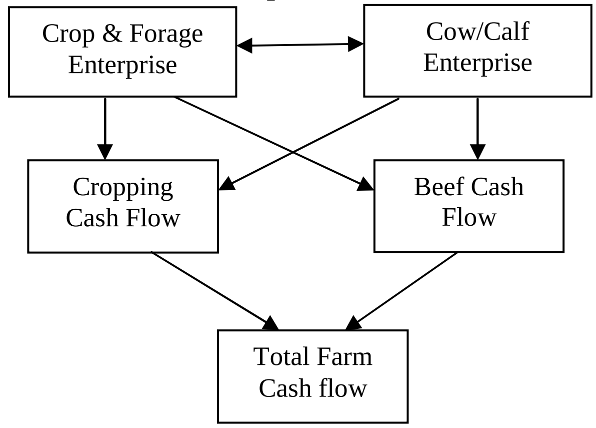
Descriptively, the simulation model developed using this software outlines current operational practices at the farm level and can be manipulated to suggest refinements in practice. Risk analysis is performed through simulating all possible outcomes based upon the sources and magnitudes of risk identified in the spreadsheet. The model is solved iteratively in that the computer recalculates the values in the worksheet repeatedly for different sets of stochastic parameters drawn from the specified input distributions (Palisade Corp, 2007). Each "iteration" produces values for all output variables. After the simulation is complete, the @risk output provides a complete picture of all possible outcomes including the best and worst case scenarios through the distributions of outcome variables. These distributions are then compared between different scenarios to assess the impact of adoption for these practices.

### 3.5. Lower Souris Simulation Model Structure

The first step in the process of understanding the biophysical and economic results of implementing practices that promote EG&S was to build a working simulation model. A model was needed that defined all the basic working relationships within a farming operation. In particular, a requirement of the model was that it be capable of representing a mixed farm with crop, forage and livestock production along with all the relationships or links between the different enterprises. These relationships were both economic and biological in nature.

Economic relationships regarding costs and revenues, which are key components of cash flow calculations, had to be incorporated and linked with production activities. Costs include expenses for inputs such as seed, fertilizer, trucking, labour, etc. Basic revenues are the product of crop and beef production and prices. However, further costs and revenues are realized through participation in farm business risk management programs such as crop insurance and AgriStability. The magnitude of these costs and revenues are dependent upon the biophysical interaction between weather, crop, forage and livestock production. Producer crop revenues are a result of crop yields realized at the end of the growing season and those crop yields are correlated to the weather patterns in that season. Producer livestock revenues are an outcome of calf weights at the end of the grazing season. The length of the grazing season and pasture productivity are also tied to weather. The following diagram, Figure 3.2, shows the general bio-economic simulation structure.

**Figure 3.2 - Model of bio-economic relationships within a mixed farm**



Within Figure 3.2, each enterprise is treated separately in terms of having unique decision variables which are simulated to produce outputs in the form of enterprise revenues and expenses. There are alternative measures which may be used to represent these flows, including gross margin (GM) or net cash flow (NCF). A GM is defined as revenue net of the cost of goods sold. The cost of goods sold are variable expenses directly related to the production of goods sold by a company. Thus the GM represents the margin that remains to contribute towards fixed costs. NCF is the difference between all cash inflows and cash outflows for the enterprise (or business). It includes items that are costs (including some fixed costs) as well as items that are not costs but are expenditures (e.g., principal portion of debt servicing payments). An alternative measure, referred to as modified net cash flow (MNCF), is used in this study. This cash flow measure includes more than would be included in a gross margin calculation but does not cover all expenditures that would lead to a complete net cash flow calculation.

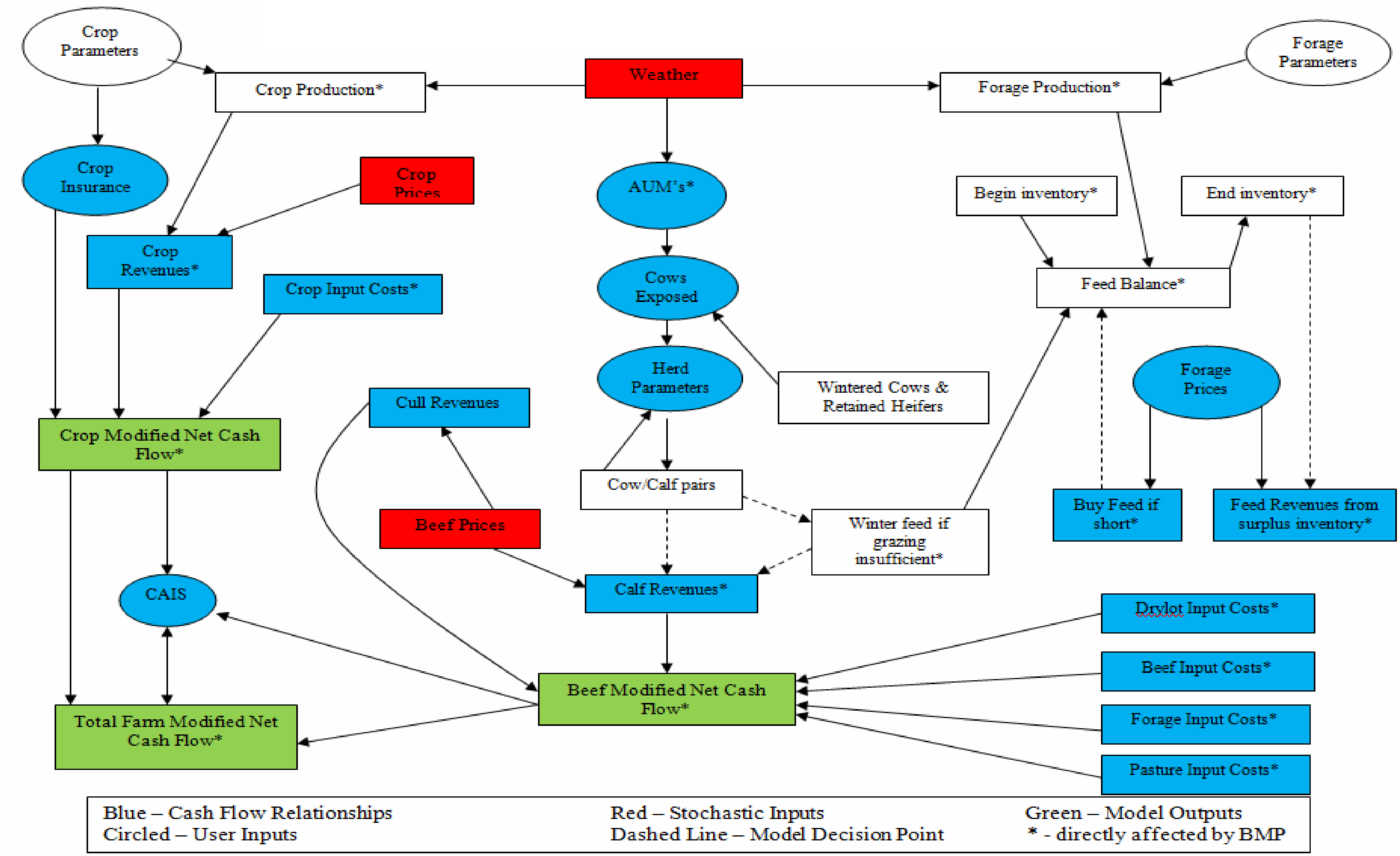
There is also “interaction” between different parts of the model. In particular, individual components of the model affect and are affected by other model components. Within the crop and forage enterprise part of the model, decision variables include what crops and forage to grow, in what rotation and on how much land. These are incorporated into the simulation model and are combined with parameters such as crop prices and weather to produce an economic output. At this level, there are both predefined factors that will impact the farm over the time period and stochastic parameters that are not predefined and change randomly throughout the simulation. The weather and price variables for a particular year are the result of random draws from distributions based on historical data. The weather impacts crop yields to the extent that poor conditions (e.g., a drought or a flood) will decrease yields and good weather will result in better yields. These yields, combined with simulated crop prices, are used to calculate crop revenues, an output that is realized at the end of each year. Forages produced will be used to feed the herd over the winter months. If forage yields are sufficiently high, based on simulated weather, excess inventory can be sold. If the opposite is true, then the beef enterprise is forced to purchase feed from the market.

The beef enterprise includes any process related to raising livestock in a cow/calf production setting. Similar to the crop and forage enterprise, revenues and costs are directly related to predefined and external variables including herd dynamics, beef prices and weather. Weather is simulated and impacts the length of grazing seasons from year to year; that is, weather may shorten or lengthen the grazing season. Any change in the grazing season will affect the amount of forage needed to feed the herd over the winter months. A short growing season will increase the demand for forage and vice versa. This will impact the crop and forage enterprise by decreasing or increasing the inventory that can be sold, thus affecting forage revenues. The two MNCF's for each enterprise are then combined to create a modified net cash flow for the entire operation and this will be used as the comparator in the study.

This study focuses on the economic implications of adopting agricultural practices that promote EG&S production. Therefore the model includes relationships between these practices and farm enterprises. The process is similar to what is described above with the exception that there are additional decision variables for the producer. These decision variables are the specific practices that promote EG&S through wildlife habitat quantity and quality, to be implemented within each enterprise. The options available are dependent on what enterprise is chosen. For example, off-stream watering is an option for the cow/calf enterprise but not for crop enterprises, for obvious reasons. These decisions in turn will affect the separate enterprise decisions. The practice of converting cropland to permanent cover will affect the acreage on which the producer can plant crops.

Figure 3.3 shows the complete simulation model structure including the relationships between all the components of the representative farm. The circled objects represent the predefined variables for both enterprises that are determined and "set" prior to the simulation analysis. Some of these include the crop insurance protection levels, acreage allocated to crop and forage production and the dynamics of the cow/calf herd. Objects shaded in red (i.e. crop prices; cattle prices; weather) are stochastic variables that vary over the different simulation iterations, as defined by probability distributions. Because of the presence of these stochastic parameters, the outputs are calculated and shown as probability distributions. Other shaded objected objects (i.e. blue) generally represent cash flow relationships that are used directly in the calculation of outputs. These outputs are in the form of modified net cash flows which have "modified" in the label (i.e. shaded in green when viewing the colour version of the chart). Objects labelled with an asterisk are directly impacted by implementation of practices that promote EG&S production (labelled as BMP in Figure 3.3). Dashed lines represent model decision points that are dependent on numerous relationships occurring in the model. These are further explained in the following chapter.

**Figure 3.3 – Flow Diagram of Modelled Farm Relationships.**



# 4. Lower Souris Model Description and Results

## 4.1. Representative Farm for Lower Souris Region

A representative farm was constructed for use in the analysis. This farm was developed based on expert opinion[2] and data from the 2006 Canadian Census of Agriculture. Specifically, data for Crop Districts 1A and 1B were examined to establish frequency of general farm types across the watershed. The Regional Municipalities (RMs) of Moosomin (#121), and Redvers (#61) were examined to identify differences between the somewhat moister climate of the north of the watershed (Moosomin) and the less moist climate in the south (Redvers). Table 7-1 summarizes the Census data used, averaged over the total number of farms in the district. These data were used as a reference for developing appropriate farm characteristics.

The land base and amount of acreage allocated to various forms of production were first used to build the representative farm. It was decided that a mixed farm operation (cow-calf and crops) would be best to model since:

a) many farms in the region are of this type (Kyle, Soulodre, 2008), and
b) the scenarios that are required to be modeled for the project include practices related to both crop and livestock production.

Using the Census data in Table 7-1, acreage was allocated for a mixed farm. The resulting representative farm acreage is 1920 acres. The allocation to alternative land uses is shown in Table 7-2.

Land was allocated based on the assumption that the field size is a full quarter section (160 acres). In other words, land was allocated to alternative uses in units of 160 acres. In addition, it was assumed that aftermath grazing would occur on all land dedicated to wheat, barley, and tame hay, for an annual total of 800 acres being aftermath grazed. Use of these crops for aftermath grazing provides significant AUMs and adds to the grazing season length. All acreage dedicated to forage is grown for winter feeding purposes only, while pasture utilization occurred over a 4 month grazing season, from June to September. Aftermath grazing was used during the months of October and November.

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[2] Sheldon Kyle, from the Lower Souris Watershed, and Etienne Soulodre, from the Saskatchewan Watershed Authority, provided expert opinion.

A typical annually cropped quarter section of land in the Lower Souris region has approximately 10% riparian or forested acreage. Thus, the representative farm is assumed to have 144 acres per quarter section of cropland available for growing annual crops. On pasture and forage lands, since the farmer can graze cows within riparian and forested habitat, the full 160 acres per quarter section are assumed to be available for use. However, usually more acres per quarter section would be dedicated to riparian or forested acreage. For modeling purposes, it is assumed that 20% of the acreage is forested or riparian habitat on all quarters utilized for pasture. A higher stocking rate is allowed for riparian areas and a lower stocking rate is used for forested areas, relative to regular upland pasture. The reference farm base case assumes that the farm manager is primarily concerned with wealth maximization and environmental considerations are a lower priority.

#### 4.1.1. Crop and Forage Rotation

The simulation uses a six year fixed rotation of wheat, canola, wheat, canola, barley and flax (Table 7-3). This crop rotation was developed based on Census data (Table 7-1) and 2008 survey results of farms in the watershed[3]. The rotations capture elements of the crops grown and reported in the 2006 Census.

The forage stand rotation was developed based on information from Koeckhoven (2008), Entz et al (1995) and expert opinion (Soulodre, 2008). Average forage stand length is seven (7) years and a cover crop (utilized for greenfeed) is usually grown the first year to establish the crop. Thus, the stand rotation used in the simulation analysis is a cover crop and forage establishment the first year followed by seven years of alfalfa-grass mix growth (Table 7-4).

Forage yield changes with the age of the forage stand. Leyshon et al. (1981) studied the effects of seeding rates and row spacing of forage crops in southwestern Saskatchewan. Table 7-5 provides a summary of the results from Leyshon et al., in terms of yield variability over time for a five year, alfalfa grass mix stand. After establishment of the stand, average yields first increase and then decrease later in the life of the stand. This pattern of change in yield over the life of a stand was incorporated into the model.

[3] The Lower Souris Watershed Committee conducted a survey of farms in the watershed during the winter of 2008. The purpose of the survey was to collect data regarding current practices related to production of EG&S. As part of the survey, data on farm characteristics were also collected. The survey results are in Entem et al. (2009).

### 4.1.2. Cow-calf operation

The cow-calf starting herd size was determined based on a four month grazing season and appropriate stocking rates for the area. The herd size of the cow-calf operation was determined by the carrying capacity for 640 acres of tame and native pasture (Table 7-2). Soulodre[4] recommended using a stocking rate of 0.65 AUM per acre for native pasture and 1.3 AUM per acre for tame pasture (Table 7-6). For tame pasture, 1.3 AUM per acre was determined from conversation with Soulodre (2009), who stated that for the first three years of the forage stand stocking rates for alfalfa range from 0.25 AUM per acre to 2.4 AUM per acre, and for meadow bromegrass range from 0.75 AUM per acre to 1.5 AUM per acre. These ranges are first averaged and then summed, due to the assumption of an alfalfa/grass mixture. This results in a stocking rate of 1.7AUM/acre. However, Soulodre (2009) suggested that after seven years of grazing the range of stocking rates changed; specifically, for alfalfa they ranged from 0.25 AUM/acre to 1.2 AUM/acre, and for meadow bromegrass the range was from 0.7 AUM/acre to 0.75 AUM/acre. Again, averaging and summing these ranges resulted in a stocking rate of 0.8 AUM/acre. Calculating a weighted average of 1.7 and 0.8 AUM/acre for a seven year forage stand results in a stocking rate of 1.3 AUM/acre for tame pasture. The stocking rates for riparian and forested zone (Saskatchewan Agriculture 2008-f) are also reported in Table 7-6.

Based on this information, a herd size of 116 cows and calves with a four month grazing season could be supported by the base representative farm. This herd size is slightly smaller than the average herd size for the area reported in the 2006 Census. Aftermath grazing is also utilized by the farm on 800 acres of crop land annually. The average length of time that cows are grazed on aftermath is 57 days. The stocking rate used for aftermath grazing is 0.3 AUM/acre (Koeckhoven 2008; Agriculture and Agri-food Canada 2003).

The herd dynamics are modeled following procedures used by Koeckhoven (2008). The production cycle starts when the cow or heifer is bred, which is followed by calving and then weaning. Table 7-7 shows the basic parameters used for the cow-calf herd in the model (e.g., calf sale weight, weaning rate). The “desired market weight” in Table 7-7 is the target selling weight for weaned animals. If the target calf market weight is not reached by the end of the

[4] Soulodre indicated the information for native pasture stocking rates came from: Saskatchewan Rangeland Ecosystems, Communities on the Sand and Sandy Loam Ecosites – Publication 5, Western Porcupine Grass.

grazing season (pasture and aftermath), the calves are assumed to be fed in a drylot (i.e., winter feeding) until the desired weight is reached.

Culled cows include all cows sold due to disease, inability to conceive, or inability to produce a calf for any other reason (e.g., post-conception problems). The culling percentage for this operation is approximately 16% per year. Based on this culling rate, 19 replacement heifers are kept in the drylot until breeding in order to maintain a steady-state herd size. The number of bulls for the herd is based on having one bull for every 25 – 30 cows, which is typical for an operation in the Lower Souris region (Kyle, 2008; Soulodre, 2008).

Barley greenfeed and alfalfa were assumed to be fed to cattle during the winter season. Demand for winter feed is based on per animal diets and the length of winter season. The winter season is a function of the length of the grazing season, with more days on grazing resulting in fewer days of winter feeding being required. The winter diets (Saskatchewan Agriculture 2008-a, AARD 2007) used are summarized in Table 7-8.

All hay not required for the herd over the winter season is sold at the market price for alfalfa grass hay. Barley grain required to feed market calves is “transferred” from the cropping enterprise. On average 10,100 kg of barley are required by the calves annually. The movement of the hay and barley from the cropping enterprise to the cow-calf enterprise represents a link between the two enterprises in the simulation model.

### 4.1.3. Machinery Complement

The machinery complement required to operate this farm is reported in Table 7-9. It should be noted that the swather and 200-250 hp tractor are required for both the crop and cow/calf enterprises. The operator is assumed to use custom spraying and custom grain handling (trucking), and these costs are included in the input costs for respective enterprises.

Rather than explicitly modeling machinery replacement, an annual “replacement cost” was used instead. The assumption is that the producer allocates funds each year to maintain the initial value of the machinery complement. This amount was calculated to be equal to the annual machinery depreciation cost.

To calculate this depreciation cost, the initial book value of the machinery was required. The value of new equipment was estimated based on information from Saskatchewan Agriculture (2008-b). These values were then are depreciated to 10 years of age using an annual economic depreciation rate of 8%. The resulting depreciated value of approximately $249,342 represented the initial economic value of the machinery complement at the start of the simulation analysis. Applying the 8% depreciation rate on the ten year old machinery complement resulted in an annual cost of machinery replacement (excluding repairs) of $23,700. As noted above, this value was applied as an annual cash outflow to represent machinery replacement in order to maintain the initial machinery economic value.

### 4.2. Model Discussion

The simulation model used in this study was adapted from the model used by Koeckhoven (2008). Koeckhoven's model was developed to simulate performance for a representative mixed beef-crop operation in the Lower Little Bow watershed in southern Alberta. The model was adjusted to represent a mixed farm operation in the Lower Souris. In particular, model parameters were changed and updated to reflect biophysical and economic conditions in the Lower Souris watershed. The model uses Monte Carlo simulation in Excel to simulate the modified net cash flow. The MNCF's are discounted to calculate a net present value (NPV) and used for comparison when changing farm conditions, constraints, and operations.

### 4.3. Stochastic Variables

Parts of the model were specified to be stochastic; specifically, crop and beef prices, weather, and crop yields (e.g., see Figure 3.3). For these parameters, annual values were obtained by randomly drawing from pre-specified distributions. In this manner, the risky elements of farming were modeled.

#### 4.3.1. Crop Prices

Stochastic crop prices were incorporated into the model. Annual spring wheat and barley Canadian Wheat Board desk prices for the period 1970-2006 (Saskatchewan Agriculture, 2006), and annual prices for flax, oats and canola (CANSIM, Statistics Canada) for the years 1943 to 2006 were obtained and used in the analysis. Prices were adjusted for inflation using the CPI for all products from the CANSIM database. The data were tested for stationarity using Dickey-Fuller tests. Non-stationarity was rejected for all cases without trend. Thus, there was sufficient evidence that stationarity existed in the data. Systems equations (SUR) were estimated following the methods described in Koeckhoven (2008) and Cortus (2005). This approach accounts for possible correlations between crop prices. AIC and BIC criterion (Table 7-11) were used to determine the appropriate lag length in the price forecasting equations for canola, hard red spring wheat, flax and barley (Table 7-12).

The SUR estimation results in a total system $R^2$ of 0.989. Most of the coefficients are significant at the 1% level and individual crop price equation $R^2$ values range from 0.85 to 0.88. These $R^2$ values indicate that most of the variability in historical prices can be explained by these simple time series models.

The crop price equations (Table 7-12) have long-run mean prices that are all significantly lower than the 10 year historical mean. The price forecasting equations were corrected by increasing the constant until the simulated mean in year 20 of the model equalled the 10 year historical unconditional mean (Table 7-13).

The price of forage grown for sale was not included in the SUR estimation. Instead, forage price was modeled deterministically. This was done due to a lack of sufficient data to include forages in the crop price equation estimation process. The market price for any alfalfa/grass hay that was bought or sold was assumed to be $64/tonne. This value was chosen based on determining the long-run average farm price for hay in Saskatchewan for the years 1970 to 2004 (Saskatchewan Agriculture, 2008-c).

### 4.3.2. Cattle Prices

Cattle prices were incorporated into the simulation model in the same manner as crop prices. Prices for animals in various weight ranges (i.e., from 400-500 lb animals up to 800-900 lb animals) were calculated in each year of the simulation. The initial price series used for this estimation was the 500-600 lb weight class. Prices for these animals were obtained from Saskatchewan Agriculture (2008-d). All data were adjusted for inflation. A SUR estimate was developed by first determining the appropriate lag lengths for feeder heifers, feeder steers, and cull cows. The one period lag coefficient was statistically significant at the 1% level in all three equations and the $R^2$ values ranged from 0.69 to 0.75. The system $R^2$ value was 0.82. The data exhibited non-stationarity based on the Dickey-Fuller tests. Nevertheless, stationarity was assumed in the final model simulation. The optimal lag length was determined by AIC and BIC criterion shown in Table 7-14. The parameter estimates for these three equations are reported in Table 7-15.

Due to the stochastic nature of the model, calf weights could be generated that fell outside of the 500-600 lb weight class. For example, a calf could weigh more than 600lbs at the end of the grazing season. To adjust market prices for higher calf sale weights, ordinary least squares (OLS) estimations were run with the prices of other weight classes as the dependent variable and the price for 500-600 lb calves as the independent variable (Table 7-16). The other weight classes used were 400-500 lbs, 600-700 lbs, 700-800 lbs, and 800-900lbs. As with the 500-600 lb weight class, prices were obtained from Saskatchewan Agriculture (2008-d). Most of the coefficients were significant at the 1% level and $R^2$ values ranged from 0.95 to 0.99. These relationships were used to obtain annual prices for the other weight classes by substituting in the price for the 500-600 lb animals, generated from the time series equations.

#### 4.3.3. Weather

For the purposes of this study, and similar to Koeckhoven (2008), it was assumed that weather changes were the greatest driver of yield variability. Therefore, a weather variable was included in estimated yield equations to incorporate the impact of weather on yield variability for crops and forage. As discussed below, this weather variable was calculated using measures of growing season temperature (growing degree days) and precipitation. The growing season was assumed to be from May 1 to October 31, for a total of 185 days. Based on this, total growing season precipitation and growing degree days were determined. Historical daily weather data for the period 1971-2006 were obtained from Environment Canada for the Broadview weather station, located at the northeast edge of the Lower Souris region. This was the nearest weather station to the Lower Souris region that had a complete data set.

Weather distributions were determined from the data set using @Risk distribution fitting functions. Three test statistics, the Chi-Squared statistic, Anderson-Darling statistic and Kolmogorov-Smirnov statistic, were used to determine which distributions best fit the cumulative growing season precipitation (GS) and growing degree days (GDD) data. Table 7-10 provides the “top” three distributions, in terms of fit, based on each of the three test statistics. In each case, the closer the test statistic is to zero, the more confidence can be placed in presuming that the distribution is representative and fits the historical data (Palisade Corporation, 2007). For

GDD, the logistic distribution had the lowest test statistics for all three tests, and so it was used in the simulation. For GS, the log-logistic distribution had the lowest test statistics for all three tests, and so it was used in the simulation.

### 4.3.4. Crop Yields

As noted in the previous section, it was assumed that crop yields were affected by weather variables. As a result, historical crop yields for the area were regressed as a function of the ratio of growing season precipitation (GS) to growing degree days (GDD). Historical yield data for RM# 123, Silverwood, (Saskatchewan Agriculture 2008-e) for the years 1970 to 2007 were used. This RM was located close to the Broadview weather station, as shown in Figure 4.1. The Broadview weather station is the northwest star in the figure, and the RM #123 of Silverwood is southeast of this point.

**Figure 4.1 –** 2008 Southeastern Saskatchewan Weather Stations


Crop inputs were "fixed" in the simulation model; that is, they were assumed to be constant from year to year. As a result, they were not included in the yield equations. The equations used to estimate yields for canola, barley, flax, and wheat are as follows:

$$y_t^C = \alpha_0^C + \alpha_1^C \frac{GS}{GDD} + \alpha_2^C \left( \frac{GS}{GDD} \right)^2 + \varepsilon_t^C$$

The two independent variables represent water availability-water demand ratios (GS/GDD). Greater values of GS obviously represent greater availability of water for use by plants. Greater values of GDD represent warmer growing conditions, resulting in greater demand by plants for water. A squared ratio term was included so that the impact of extreme values could be captured separately from normal growing conditions. Extreme values may have a significant impact on yield. SUR estimation was used again to incorporate the correlation errors between different crops. Results are given in Table 7-17.

The system $R^2$ value is 0.31. Only the model constants showed statistical significance. Farmer yield estimates from the Lower Souris Ecological Goods and Services Pilot survey data (LSEG&S, 2008-a; Entem et al., 2009) were compared to the average yields for RM# 123, Silverwood (Saskatchewan Agriculture 2008-d). In the survey, farmers were asked to estimate their historical yield averages for the years 2003 to 2007 (LSEG&S, 2008-b). Their average yield estimates were significantly higher than estimates from Saskatchewan Agriculture (2008-e). The long run yields in the model simulation were consequently increased by adjusting the equation constants upwards until the model means were equal to the yield estimate means from the survey (Table 7-17).

The resulting yield equations were used to calculate crop yields for each crop in each year of the simulation. In any given year, values from the individual weather variable distributions were first drawn. These were then substituted into the yield equations. An additional stochastic element is incorporated through the random error term in the yield equations, which accounts for yield correlations between crops, to obtain the final yields.

#### 4.3.5. Forage Yields

Forage yields were determined following the approach developed in Koeckhoven, (2008). The covariability between forage yields and other crop yields was established using a correlation matrix from Alberta Agriculture and Rural Development (Kaliel, 2007). The simulation used the correlation between barley grain and forage yields (i.e., greenfeed and alfalfa-grass hay) to establish yields for the forage crops in each year. The correlations used are provided in Table 7-19. For every 1% change in barley yield, a 0.6% change in greenfeed and a 0.3% change in alfalfa-grass hay occurred, from one year to the next. Average yields for greenfeed and alfalfa-grass obtained from Saskatchewan Agriculture (2008-f, and 2008-g) were used as starting values.

### 4.3.6. Pasture Yields

A forage yield index (FYI) model based on Bork et al (2001) was estimated to represent pasture productivity for the Lower Souris region. The Bork et al data are for the upland region of the Boreal grassland region of Alberta, which is similar to the Aspen parkland region of eastern Saskatchewan in terms of precipitation levels and potential pasture grass types. The data consisted of 12 years of forage production, expressed in kilograms per hectare. The FYI model is estimated such that FYI is a linear function of precipitation (PI). The indices were calculated by dividing each annual observation by their sample median and multiplying the result by 100 (Unterschultz et al, 2004). The resulting estimated equation is as follows,

$$FYI_t = \underset{(25.7)}{4.19} + \underset{(0.27)}{1.02PI_t} \quad R^2 = 0.58,$$

where the values in parentheses represent standard errors for the estimates, FYI is the forage yield index and PI is the precipitation index.

Bork's model was calibrated for the current simulation analysis using weather data for the Broadview weather station, given a growing season assumed to last from May to October. Since the median value is the same as the starting value for the first year in the simulation, the starting FYI and PI values are 100. The forage index is converted into AUMs for the simulation following the procedures described in Koeckhoven (2008). Variability in tame pasture yields was modeled in the same manner as greenfeed or alfalfa-grass hay. A correlation value (Table 7-19) that captures tame pasture changes in relation to native pasture was utilized. Table 7-20 gives an example of output of the simulation results for the amount of forage generated per year (given in AUM/acre) and the descriptive statistics for tame and native pasture for one iteration of the model (i.e. one twenty year life of the farm).

## 4.4. Input Costs

Input costs were incorporated into the model (Tables 7-21 and 7-22) and used in calculating enterprise and farm cash flow. Crop enterprise input costs were based on 2005 Saskatchewan producer crop budgets for direct seeding in the Black/Grey soil zone[5]. Custom work costs for

[5] Crop prices in 2007 and 2008 are higher than those used on which the 2005 budgets were based. However, the price forecasting models used in the model are based on historical data and consequently do not generally capture

grain handling and spraying were obtained from Saskatchewan Agriculture (2008-b). Input costs for forages and for pasture came from a variety of sources. Annual input costs per acre for tame and native pasture were based on information received from Alberta Agriculture and Rural Development (Kaliel, 2007). Input costs for alfalfa-grass hay were based on estimates received from Soulodre[6]. Barley greenfeed input costs were based on figures reported by Saskatchewan Agriculture (2008-h). Capital costs per acre were provided by Alberta Agriculture and Food (Kaliel, 2007). Table 7-21 provides a summary of these input costs.

Input costs for the cow-calf enterprise were based on budgets produced by the Western Beef Development Centre (2006). These budgets were used to estimate direct expenses for putting cows on pasture and keeping them over winter (Table 7-22). Direct costs for keeping cows on pasture and winter feeding are included for purposes of calculating NPVs for the beef enterprise. The cost of planting and harvesting forage (i.e., tame hay) is only incorporated in the crop enterprise. Without incorporating this cost, the beef enterprise NPV would be significantly overestimated. For this reason, budget costs for pasture and winter feeding are utilized to determine the NPV for the beef enterprise (Table 7-22). However, in the calculation of the total farm NPV these costs are omitted.

### 4.5. Crop Insurance and AgriStability

The basic structure of crop insurance for Saskatchewan producers was incorporated into the simulation analysis, following the approach taken by Koeckhoven (2008). In the model, if the actual crop yield for a year is below a predetermined level, a payout is triggered based on coverage level, the size of the difference, and the insurance price. The farmer is assumed to use an 80% coverage level for all crops in all years. The price used to calculate payouts was the 2008 Base Commercial Price from Saskatchewan Crop Insurance (2008). These prices were $9.19, $3.27, $11.56, and $5.31 for canola, barley, flax and wheat, respectively.

It is assumed that the mixed farm operation in the simulation analysis participates in AgriStability. AgriStability is the federal/provincial business risk management program (i.e., public safety net) that replaced the Canadian Agricultural Income Stabilization (CAIS) program.

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the recent high prices. Input costs in 2008 were also much higher than historical values. Using input prices from 2005 provided a better match to the price forecasting models for estimating farm modified net cash flows.

[6] Soulodre, Range Agrologist, Saskatchewan Watershed Authority.

AgriStability works in basically the same manner as CAIS, as it protects farmer income (producer margin) from extreme events and risks. AgriStability was incorporated into the simulation model in the same manner as Koeckhoven (2008). In order to determine if a program payment is triggered, the production margin for the current year is compared to the reference margin calculated within the model. With the AgriStability program, the production margin must fall below 85% of the reference margin before a payment is triggered. Payouts from both "tiers" of AgriStability are modeled in the analysis.

### 4.6. Simulation Scenarios

Three general scenarios were modelled in this study. These scenarios were defined as follows:

- a farm operator maintains habitat rather than converting this habitat to cropland, either by draining wetlands or clearing bush;
- a farm operator converts cropland to tame grass, through converting a whole field; and
- a farm operator reduces grazing pressure on pasture lands, through a lower stocking rate or a different management strategy.

Producers can increase the amount of habitat available for wildlife, preserve water quality, and increase carbon sequestration by conserving the riparian and forested areas on their land. However, farm managers may have financial incentives to remove scattered areas of habitat in their fields (e.g., through draining or bulldozing/burning) to increase efficiencies in production. If a farmer preserves habitat areas, however, there are potential foregone returns because the area is not used in agricultural production. The extent of these forgone revenues is undetermined. Therefore, in order to assess the impact of maintaining habitat, one model scenario considered is the conversion of habitat over to agricultural production. This allows an examination of the financial impact of habitat maintenance.

#### 4.6.1. Base Case Scenario

The base case scenario is the farm simulation model run without any environmental or management practice constraints implemented on the farm. The base case scenario is used as a reference for all simulation scenarios to determine the extent to which alternative scenarios change farm wealth. Summary statistics for the base scenario results for the representative farm are used to compare across all scenarios (Table 7-23). Given the stochastic nature of the simulation, mean values are presented, along with standard deviations.

The twenty-year NPV is calculated for the farm operation over the twenty year time horizon of the simulation. Given that the farm would be expected to continue operating beyond the end of the simulation, an NPV is also reported that takes the twenty year NPV and extends it into perpetuity (i.e., NPV with Perpetuity). The method used to extend the NPV calculation is discussed in Koeckhoven (2008). NPVs for the crop and beef enterprises are also presented. It should be noted that these NPVs do not sum to the twenty year farm NPV, for reasons outlined in the previous section regarding input costs. Forage sales and purchases represent the annual average values, calculated over all years and iterations. Since there are some years in which forages are sold (i.e., excess production) and other years when forage is purchased by the farm (i.e., excess demand for the beef herd), both purchases and sales have positive averages. Finally, summary information regarding the length of grazing season and weaning weights are included.

#### 4.6.2. Farmer maintains habitat rather than converting to cropland

In this scenario, the impact of bulldozing or draining wildlife habitat is modelled. As noted above, the results for this scenario are used to assess the financial impact of maintaining habitat. The difference between the results for these scenarios, and the base scenario, represent the direct economic effect of habitat maintenance. Four separate scenarios, representing situations frequently faced by farm managers in the region, are evaluated:

a) riparian habitat on land is converted to cropland
b) riparian habitat on land is converted to tame grass
c) forested habitat on land is converted to cropland
d) forested habitat on land is converted to tame grass.

In all four of these scenarios, model parameters are unchanged from the base farm scenario, with the exception of the amount of habitat acreage being protected. In the base case, 10% of the land in fields used for crop production is attributed to riparian or forested habitat and is therefore not utilized for agricultural production. For one quarter section this would represent 16 acres. As well, any fields dedicated to pasture in the base case are assumed to include 20% riparian or forested habitat.

In the scenarios involving conversion of habitat to cropland or tame grass, results for three sub-scenarios are modeled and reported. These represent different “degrees” of conversion, In particular, conversion of 1/3 and 2/3 of the current habitat area, along with complete (i.e., 100%) conversion, is modeled. Given the initial assumption that 10% of a cropland field is habitat area, these three sub-scenarios result in 6.67%, 3.33% and 0% of habitat per cropland quarter remaining after conversion, respectively. Any land converted from either forested habitat or riparian habitat to cropland or tame grass is assumed to have equal productive capabilities as the surrounding area.

#### 4.6.2.1. Scenario 1: Farm converts riparian habitat to cropland

In this scenario, the amount of land seeded to cropland per quarter section is increased from 144 acres to 160 acres (i.e., riparian areas are decreased from 10% to 0% of total area). The resulting change in MNFC is then calculated and incorporated into NPV calculations. The initial assumptions are that conversion of riparian areas to cropland only affects farming activities by changing the amount of acreage utilized. It should be recognized, however, that there may be other considerations related to this conversion that result in additional impacts on costs or returns. For example, the “removal” of riparian (or forested) areas may allow the producer to seed in straight rows and thus avoid nuisance costs (e.g., Cortus, 2005)[7].

The various NPV results associated with conversion to cropland (for the three sub-scenarios), excluding conversion costs and other costs, are provided in Table 7-24. It should be noted that land used to grow tame grass for hay production is included as cropland in this scenario due to similarities to cropland in terms of management (i.e., harvesting, spraying, etc.). The resulting positive impact on the beef enterprise from this change (i.e., increased hay production) explains the increase in the beef enterprise NPV presented in Table 7-24.

[7] As Cortus (2005) notes, nuisance costs can be a significant factor in producer decisions whether to drain wetlands. However, they are seldom explicitly incorporated into empirical analysis because the magnitude of nuisance costs is very dependent on field configuration as well as the size and shape of the wetland. Cortus was able to incorporate estimates of nuisance costs in his wetland drainage study by using GIS mapping of individual fields and measuring sizes and shapes of wetlands. It is likely that the impact of nuisance costs would be similar in decisions relating to habitat conversion in the current study. However, explicit consideration of these costs is beyond the scope of the current modeling analysis.

The cost of draining/converting riparian areas on cropland was calculated post-simulation[8] and then used to adjust the values in Table 7-24. All riparian habitat conversion was assumed to be carried out through surface drainage. The cost of draining lands was derived from Saskatchewan Agriculture (2008-b) figures and from the Cortus (2005) analysis. The rental rates for a scraper and heavy disk were set at $131.10/hr and $9.46/acre, respectively. Cortus determined that an average quarter section in the Emerald region of Saskatchewan required a minimum of 200m of scraping, and that a 6.5 yard scraper would require 0.26 hr/m to complete this task. Since 10% of the acreage on a quarter section of the representative farm in the current study is assumed to be riparian habitat, the conversion to cropland will cost $6,968.56 per quarter section or $435.45 per acre converted. The Saskatchewan Wetland Conservation Corporation (1993) estimated a range for the cost of surface draining lands which, when adjusted for inflation to 2008 dollars, converts to a range of $180 to $1,190/hectare ($72 - $482/acre), depending on the specific conditions (e.g., size of riparian area). The value calculated for this study falls within the range of estimated values but is towards the upper end.

Adjusting the NPV values from Table 7-24 (i.e., incorporating the $435.45/acre conversion cost) to include the cost of converting riparian habitat to cropland results in the values provided in Table 7-25, for the three conversion sub-scenarios. The cost of converting habitat to cropland is attributed as an extra cost to the crop enterprise for the purposes of NPV calculations. After conversion costs are factored into the analysis, there remains a positive benefit to the farm from converting riparian area to cropland.

#### 4.6.2.2. Scenario 2: Farmer converts riparian habitat to tame grass.

The second scenario considered, with respect to riparian areas, was conversion to tame grass for pasture. The management of the cow herd is assumed to remain unchanged. The riparian area is drained/broken and then seeded to grass. It should be noted that the base scenario already incorporates unlimited grazing within riparian or forested habitat. In the case of conversion to tame pasture, cows are now assumed to graze on newly converted tame grass. However, the stocking rate attributed to this area now changes to be consistent with the rest of the tame grass

[8] The basic simulation model was not directly designed to evaluate “drainage” or conversion of riparian areas to cropland. Hence the model was simply run with increased crop acres. The costs of conversion were assumed to be deterministic (i.e., non-stochastic) and were calculated ex-post and subtracted from the simulation NPVs. This process provides an approximation of the net benefits associated with conversion.

pasture on the farm. Riparian stocking rates were established based on information from the Saskatchewan Agriculture website (2008-f) and are set in the model at 1.2 AUM/acre. Thus, the base scenario is simulated with the cow herd grazing on tame pasture where 20% of this pasture is dedicated to riparian habitat, with the appropriate stocking rates. The conversion modeled here is assumed to be done for riparian areas that lie within the area initially devoted to tame pasture. Riparian areas within native pasture areas on the farm are not converted.

As noted earlier, this scenario does not involve any changes being made to production practices for the beef herd. As well, the same costs of draining riparian habitat from the previous scenario are used in this scenario; that is, $435.45/acre converted to tame pasture. However, there is an extra cost of $50.12/acre (Soulodre, 2008), incorporated to account for seeding the converted area to perennial forage. This results in a total cost of draining equal to $485.66/acre, which was deducted from the NPV simulation results. This cost was also incorporated into the beef enterprise NPV calculation, as it is assumed to be “attributed” to that enterprise. A summary of the results for this scenario are provided in Table 7-26, again for three sub-scenarios involving differing degrees of conversion. In general the effect of this scenario on NPV is negative; that is, if conversion costs are included in the analysis, the impact of converting habitat to tame pasture is to reduce the mean farm NPV.

In terms of an interpretation of the results for this scenario, it would appear that there are no positive economic incentives for producers to convert riparian habitat, if the conversion is to tame pasture. The benefits from increased pasture productivity do not outweigh the cost of converting riparian habitat to tame grass. However, as noted earlier this analysis assumes no change in production practices for the beef enterprise. It may be that case that there are potential direct benefits from this conversion that have not been included in this analysis (e.g., increasing the size of the beef enterprise to exploit increased pasture productivity) that, if incorporated, would have an influence on the results.

#### 4.6.2.3. Scenario 3: Farm converts forested habitat to cropland.

This scenario is similar to the first scenario (i.e., converting riparian habitat to cropland). In this case, however, forested habitat is converted to cropland. The costs of converting forested land differ from the conversion costs of riparian habitat. For the purposes of the current analysis it was assumed that a D6 Bulldozer and Heavy Breaking disk were required to convert (i.e., clear and break) forested habitat to cropland. The custom rate per acre used for the heavy breaking disk was $20.14/acre (Saskatchewan Agriculture 2008-b). The estimated cost for clearing forested area using a bulldozer was $175/hr and it was assumed that 3 hours per acre converted[9] would be required. A flat fee of $360 was charged for transporting the D6 to the farm site. Given the assumption that 10% of a quarter section is forested habitat, it would cost $9082.24 per quarter section, or $567.64 per acre converted to completely change the forested habitat over to usable cropland. The NPV results after incorporating the breaking and clearing costs are reported in Table 7-27. The results suggest that the farm can generate positive direct benefits (i.e., increased NPV) from conversion of forest habitat to cropland.

#### 4.6.2.4. Scenario 4: Farm converts forested habitat to tame grass.

This scenario and the associated assumptions are similar to the second scenario (i.e., conversion of riparian habitat to tame grass). However, different stocking rates apply for pasture in forested areas relative to riparian areas. The base case scenario assumes that the cow herd grazes on tame and native pasture, and that 20% of this pasture constitutes forested habitat. Thus, stocking rates were required for grazing within forested lands. These stocking rates were established using information from the Saskatchewan Agriculture website (2008-i). The stocking rate value used for forested area was 0.15 AUM/acre, for forested areas located within both tame and native pasture. All land is subject to the upland stocking rate. For the purposes of this scenario the base case was re-simulated, assuming grazing in forested area instead of riparian area with associated adjustments in stocking rates. Since the stocking rate value for forested area is significantly smaller than that for riparian area, the base scenario used for comparison has a lower NPV than that for riparian habitat.

Management of the beef herd is again assumed to remain unchanged. The cost of clearing forested habitat for conversion to tame grass is assumed to be the same as clearing forested habitat to cropland (i.e., similar to the previous, third scenario), with exception that there is an additional cost for seeding tame grass. As with the earlier scenario of converting riparian area to tame grass, an additional cost of $50.12 was added to the cost of clearing forested habitat. Thus, an investment cost of $617.76/acre is required to convert forested habitat to tame grass.

[9] Personal communication with Central Peace Contracting, a heavy equipment contracting company in Berwyn, Alberta (October 31, 2008).

The results for this scenario are summarized in Table 7-28. The results indicate a similar pattern as was the case for converting forest habitat to cropland. There is a direct positive increase in NPVs, despite the costs of conversion. This differs from the results determined for converting riparian area to tame pasture. The reason for this is the difference in degree of improvement in pasture "productivity" arising from the two "conversion to pasture" scenarios. In the case of converting forested area, the degree of improvement is such that the benefits from improved pasture productivity outweigh the costs of conversion.

#### 4.6.3. Farmer converts cropland to tame grass

One means by which wildlife habitat can be increased and protected is by converting usable lands from cropland to tame grass. The conversion can be considered in this way because a greater number of wildlife species can utilize habitat provided by tame grass production than would be the case with cropland. As a result, this type of conversion is considered as a scenario within the simulation analysis. The results from this analysis can provide an indication of whether incentives may be required to convert existing cropland to land dedicated to tame grass, which is then utilized for either hay or pasture purposes, or whether the conversion provides direct economic benefits to the producer.

In this scenario, the farmer converts a quarter section of cropland to forage production (i.e. tame pasture or hay) and cow-calf activities. In order to do this, the parameters of the farm model are changed from the original base scenario, in terms of the allocation of land to alternative activities. The original allocation provided in Table 7-2 is changed to the acreage allocation as presented in Table 7-29. Specifically, one quarter of cropland is "moved" to tame pasture. The six year annual crop rotation remains unchanged (Table 7-3). Two versions of this scenario are modeled; the first involves the converted area being used for pasture while in the second version it is used for hay production.

With increased pasture area, the producer could choose to increase the size of the beef herd. This would represent one way to capture any economic benefits associated with this scenario. However, the decision was made to maintain the initial size of the beef herd. The impact of increased pasture acres is captured in the model by allowing for an extended grazing season, which is an alternative way to model the financial benefits associated with this scenario. With an extended grazing season, weaning weights will potentially increase, wintering costs may decrease and/or there may be increased forage sales. The simulation results for this scenario are summarized in Table 7-30.

The alternative version of this scenario is to convert annual cropland to tame grass which is used for hay production. Again the crop rotation is assumed to remain the same and the beef herd remains unchanged. The producer can take advantage of the extra quarter section dedicated to hay by decreasing the grazing season, increasing weaning weights, or increasing his forage sales. The simulation results of converting one quarter section to tame hay are summarized in Table 7-31.

The impact of this scenario varies depending on the use made of the converted area. The overall effect of converting cropland to pasture is positive; the mean farm NPV increases from $971,313 to $983,547. This is primarily driven by an increase in the beef enterprise NPV, which is due to the benefits noted earlier (i.e., longer grazing season, heavier weaning weights, reduced winter costs). Conversely, there is a negative effect on the cropping enterprises (i.e., reduced crop enterprise NPV). This is not surprising, given that the scenario results in a reduction in cropped area. The overall impact on farm NPV is positive, however.

Conversely, the overall direct economic effect of converting cropland to hay production is negative; the mean farm NPV decreases to $910,724. In this case, the impact on the beef enterprise is negligible. However, there is a significant decline in the crop enterprise NPV; the NPV decreases from $506,064 for the base scenario to $441,139. The reason for this decline is that sales of grain/oilseed production is replaced by hay sales and as modeled in the analysis the expected profitability for hay production (in terms of direct sales) is lower. The impact of the conversion scenario involving hay production, as modeled in this analysis, will be heavily dependent on the relative profitability of field crops versus hay.

#### 4.6.4. Farmer uses alternative grazing strategies to increase habitat quality

Another option for producers that would potentially enhance wildlife habitat is to limit cattle access to riparian areas through fencing and/or off-stream watering. For example, a producer could change the pasture stocking rate or implement rotational grazing to preserve the biological diversity on native pasture. Within this general type of practice to increase habitat quality, two alternative scenarios are modeled; changing the stocking rate and changing pasture management practices. These are described in the following sub-sections.

#### 4.6.4.1. Scenario 1: Changing stocking rate

This scenario examines the impact of a producer changing stocking rates for pasture that has been overgrazed (i.e., poor pasture condition). Rather than in the representative farm, the assumption is made that all land dedicated to pasture is in a degraded state. In response, the farm operator could potentially decrease stocking rate in order to allow improvement in the pasture condition. The trade-off is that the farmer would then need to either decrease herd size or provide supplementary feed during the grazing season. However, the long term benefit is that if the pasture condition improves, the farmer operator may be able to increase stocking rate after only a short period and thus increase profit in the long run.

A key assumption underlying this scenario is that all lands dedicated to native pasture start in a reduced forage productivity state; that is, at the beginning of the simulation time horizon. Hence there is less forage available for grazing in the base scenario, relative to the originally assumed situation for the representative farm (Section 4.1). Within the simulation model, this reduced forage availability for grazing is captured through a decrease in the forage utilization factor. The original forage utilization factor for the representative farm is 0.5. Decreasing this utilization factor in turn decreases the amount of forage available to cows from pasture. Grazing parameters such as starting stocking rate and herd size are unchanged, but there is simply less forage available for the cattle. This has the effect of reducing the days on pasture.

Table 7-32 provides a summary of the simulation results (i.e., NPVs) resulting from decreasing pasture conditions while maintaining the representative farm stocking rate (i.e., at 0.65 AUM/acre for native, and 1.30 AUM/acre for tame). Three sub-scenarios are simulated, varying the forage utilization factor from 0.466 to 0.40. The combination of degraded pasture condition and constant stocking rates results in a greater degree of overgrazing in terms of a starting condition. A decrease in the utilization factor from 0.5 to 0.4 represents a 20% decrease in the amount of forage from tame and native pasture. Table 7-33 provides an indication of how much the total forage available decreases with a decreased utilization factor (given in AUM/acre and lbs/year). Not surprisingly, there is a steady decline in the mean farm NPV associated with reduced forage availability.

This overgrazed condition represents the revised “base” scenario from which to compare alternative grazing practices. After assuming that the pasture is starting from an overgrazed condition (less forage available for cows), the next step is to model the impact of a new grazing practice being introduced. This revised practice involves lowering the stocking rate in order to increase long run range health. If pasture is overgrazed, there may be economic (farm wealth) or intrinsic (wildlife habitat) reasons why the farm operator may want to lower the stocking rate. A second assumption is made that if the farmer lowers stocking rate, that the health of the pasture improves, and cows can utilize more forage from the pasture.

A number of model assumptions were made regarding the rate at which the pasture condition improves as a result of the lower stocking rate:

a) herd size (i.e., number of calves, bulls, and cows), forage yields, and grazing parameters all remain unchanged; economic changes are captured through changes in grazing season length and weaning weights;
b) the degree of annual improvement in pasture condition increases with a lower stocking rate;
c) as stocking rate decreases, the length of time over which pasture conditions are improved itself increases;
d) the stocking rate changes occur on both native and tame pasture and they occur concurrently (e.g., a 1% reduction in stocking rate for tame pasture would be done in conjunction with a 1% reduction in the stocking rate for native pasture).

To model the improvement in pasture condition, an incremental increase in the utilization factor over time was used for each change in stocking rate. Values for the incremental increase in the utilization factor and the number of years over which this increase occurs were assigned for a set of specific stocking rates. These are provided in Table 7-34.

The starting level of forage production on pasture is 0.65 AUM/acre for native pasture, and 1.3 AUM/acre for tame pasture. For each lowered stocking rate scenario, stocking rates are decreased by 0.05 AUMs on native pasture, and 0.10 AUMs on tame pasture. The overgrazed pasture condition base case scenario assumes a 20% decrease in forage utilization rate (i.e., 20% below the “good pasture condition” represented by a utilization factor of 0.4, or the right-hand column in Table 7-32). After the adjustment in management, the condition of the native range improves, allowing increased utilization.

A summary of the results for this scenario are reported in Table 7-35. NPVs first increase than decrease after the stocking rate is decreased by more than 8% (0.05 AUM/acre for native).

This suggests that decreasing stocking rates by a small amount, with a short improvement in pasture condition, can improve farm wealth on current overgrazed pasture. However, decreasing the stocking rates by more than 8% can lead to losses; that is, the "cost" of lost pasture use outweighs the longer term benefits from improved pasture condition. Furthermore, the results show that if stocking rates are reduced by more than 23% (0.15 AUM/acre for native), NPVs would once again improve relative to the base scenario. This suggests that dramatically decreasing stocking rates that lead to significant improvements in forage availability can increase farm profitability.

It is important to note that the degree to which pasture would improve from a decrease in stocking rate is unknown. Since one cannot be sure how the pasture actually improves with a lower stocking rate, the "cost" of lost pasture use may be more or less than what is calculated in the NPV results presented here. For this reason, Table 7-36 provides a summary of the amount of forage generated per year for each of the lower stocking rate scenarios. Grazing season days was used as a proxy for the increase in forage available per year with a lower stocking rate. With more forage available for cows through improved pasture condition cows can remain on pasture longer. The results in Table 7-36 show that when stocking rates are lowered, forage availability in year one is directly decreased (given in AUM/acre and lbs/year). However, if the pasture can show sufficient improvement over the first few years, the decrease in the stocking rate can be offset, and the long-run forage available from the land can be increased in subsequent years. The number of grazing season days for the year in which the increase in utilization stops (i.e., the last year for each lowered stocking rate scenario) follows for every year thereafter for the 20 year farm horizon.

#### 4.6.4.2. Scenario 2: Changing management of pasture

The second pasture management scenario involves changing management of existing pasture to improve habitat. Specifically, in this scenario the farm operator incorporates additional fencing in order to implement rotational grazing. The assumption is made that the producer has two quarter sections of tame pasture that are adjacent to each another (i.e., there is a single perimeter fence around the 320 acres), and two quarter sections of native pasture, also adjacent to each another, with a similar assumption being made about perimeter fencing. In the base case scenario, cows can graze within each of the two half-section pasture areas without limitation.

In the adjusted management scenario, the farm operator splits each 320 acre pasture area into two quarter sections by adding a 2640 foot fence "down the middle". The cattle are now allowed to graze using a rotation system (i.e., they are periodically moved from one quarter section pasture area to another). Given existing literature on pasture management, the productivity of these tame and native pasture areas should improve under this management strategy. As with the previous pasture management scenario, assumptions were made regarding the rotational grazing management, and the change in pasture conditions generated by the adjustment in management:

a) there exists only one natural watering source in each of the two 320 acre parcels; for this reason, an off-stream watering source is constructed for one of the fenced quarter sections, in each of the tame and native pasture areas;
b) the construction of new watering sources and additional fencing is initiated and completed over a two year period, with 50% being completed within the first year of the simulation and the other 50% of construction occurring in the second year of the simulation; the producer initiates rotational grazing in year 2 of the simulation on one 320 acre parcel, and in year 3 of the simulation on the other 320 acre parcel;
c) pasture conditions for all four quarter section areas improve with implementation of rotational grazing; this improvement is represented in the model by an incremental annual increase in the utilization factor.

The investment cost for off-stream watering is calculated to be $47.41 per cow per off-stream watering site; this value is multiplied by two as two sites are constructed (as noted above). The total cost of implementing off-stream watering is $11,000. In addition, there is a fencing cost of $0.71/foot, for a total fencing cost of $3,764. Yearly maintenance costs are assumed to be 2% of the initial cost of investment.[10]

There is a lack of consensus in the literature regarding how much pasture improves per year with rotational grazing and the longevity of the improvement. Thus, sensitivity analysis around the forage utilization factor was performed to evaluate the impact of improved forage production under rotational grazing. Table 7-37 provides a summary of the simulation results, varying the annual improvement in utilization factor (i.e., rate of pasture improvement). In each case, the length of time over which improvement occurs is held constant at four years.

[10] These investment costs are adapted from similar calculations in Koeckhoven (2008).

The base case scenario assumes that grazing occurs on all 4 quarter sections without rotational grazing. In the base scenario there is no construction of fence or off-stream watering, and there is no pasture improvement. For the other three scenarios presented in Table 7-37, the costs of constructing the additional fence and off-stream watering sources are included, rotational grazing is implemented, and the pasture improvement is modeled. The results indicate that if the pasture improves, and the utilization factor increases by 0.5% or 1.0% (meaning an increase of 0.0025 or 0.005 from 0.5) per year, then the full costs of construction are not recouped; that is, the impact on mean farm NPV is negative.

However, with sufficient improvement in pasture condition, such that the utilization factor increases by more than 1.0% per year for four consecutive years, then farm wealth is increased; that is, mean farm NPV increases relative to the base scenario. The crop enterprise and beef enterprise NPVs are increasing throughout these results, regardless of the impact on farm NPV, because the cost of implementation is not attributed to either enterprise. Both enterprise NPVs (i.e., crop and beef) increase slightly with this scenario, but the impact is minimal.

A summary of the degree to which pasture improves per year for each of the sensitivity scenarios is provided in Table 7-38. Once again, increases in forage availability per year are reflected in greater grazing season days (i.e., used as a proxy). In the scenario where the utilization factor increases annually by 1.5% for four years, grazing season days in the fourth year (266.18) are sufficiently larger than the base case scenario (259.10) to offset the cost of implementing rotational grazing.

The second sensitivity analysis conducted is with respect to the longevity of pasture improvement. Specifically, the number of years over which the pasture improves is varied while keeping the rate at which pasture improves constant; the utilization factor increase per year is held constant at 1.0%. Table 7-39 reports a summary of the simulation results for periods of improvement ranging from 3 to 6 years. Table 7-40 reports the results in terms of the amount of forage available for each year over the time period of pasture improvement, similar to Table 7-38, for each of these scenarios. Results suggest that if pasture improvement occurs for no more than four years, with an annual 1.0% increase in utilization factor, the costs of implementing rotational grazing are not recouped; the mean farm NPV decreases relative to the base. For longer periods of improvement, however, mean farm NPV is improved. As with the previous analysis, the costs of implementation are attributed to the farm, but not to the individual enterprises. As a result, the impact on enterprise NPV is minimal. Both mean NPVs increase over the time period range, but only slightly.

#### 4.6.5. High Input Cost Environment

As noted earlier in the discussion regarding model data, input costs were included that matched up, time-wise, with the historical commodity price data used to estimate pricing equations. However, more recently input costs have been significantly higher than the historical values used to generate the simulation results presented in this report. As a result, a decision was made to "run" some of the scenarios with higher input costs to reflect the current high cost environment. This was done to investigate whether these higher costs have a significant effect on the incentives (positive or negative) for implementing practices that promote production of EF&S.

For the original base case representative farm scenario, 2005 crop input costs were used, based on Saskatchewan producer crop budgets for direct seeding in the Black/Grey soil zone (see section 4.3.2 for reference). In this "higher input cost" scenario costs were adjusted to reflect an average of 2007 and 2008 Saskatchewan producer crop budgets for direct seeding in the Black/Grey soil zone. These new crop input costs are provided in Table 7-41. An average of 2007 and 2008 crop budgets was used due to the fact that the costs of inputs were not significantly greater than the original historical (i.e., 2005) values until mid-2007. As well, these are budgets are often constructed prior to the actual crop year, and are based on past information. For this reason, 2008 crop budgets might be more representative of actual 2007 costs than would be 2007 crop budgets.

Only crop input costs were assumed to increase in this high cost environment, as the cost increase was more profound in cropping than in the beef sector. For this reason, only the scenarios that directly affected the crop enterprise were re-run for the high cost environment. The scenarios examined under a higher crop cost environment were:

1. conversion of riparian habitat to cropland
2. conversion of forested habitat to cropland
3. conversion of a quarter of cropland to tame pasture
4. conversion of a quarter of cropland to tame hay.

For each scenario, nothing is changed from the previous discussion except for the increase in crop input costs.[11] The cost of conversion for forested and riparian habitat is calculated and used to adjust NPVs in the same manner. The results for the new base scenario are significantly lower (i.e., reduced NPV) due to the fact that it now costs more, every year, to plant a crop (see the first column of results in Table 7-42)

Results for the first scenario, where riparian habitat is converted to cropland, are summarized in Table 7-42. In this high cost environment, it would cost almost $112 per year per acre converted to preserve riparian habitat, assuming 1/3 of the habitat is converted. This is significantly greater than the results reported using 2005 input costs (i.e., that was $79.55, as reported in Table 7-25).

Results for the second scenario, where the farmer converts forested habitat to cropland, are given in Table 7-43. Here, it costs between $31 and $33/converted acre/year (depending on the extent of conversion) to preserve forested habitat, which is less than the results reported using 2005 input costs (Table 7-27). Higher crop input costs make it more profitable to convert riparian habitat to cropland and less profitable to convert forested habitat to cropland.

Finally, results associated with conversion of a cropland quarter section to tame grass for pasture and hay purposes are provided in Tables 7-44 and 7-45. The results here are similar to the previous low input cost scenario due to the fact that converting cropland to tame pasture leads to a net NPV increase, while converting cropland to tame hay leads to a net NPV decrease. However, it is now more profitable to convert cropland to tame grass for either pasture or hay purposes with higher input costs.

Given the nature of the change made in the model parameters, these results are not surprising. The basic effect of higher crop input costs is simply to reinforce the patterns already noted in terms of financial incentives or disincentives for adoption of practices.

#### 4.6.6. Inclusion of Lease Payments in Cash Flow (i.e. Rented Land)

The last scenario that was modeled assumes that the farm operator leases all land required for production rather than owning this land. This scenario was added at the request of the Lower Souris Watershed Committee and readers are requested to review the cautionary discussion at the end of this sub-section. This approach essentially added a rental cost or direct return to land and

[11] See the discussion earlier in this section 4 for an explanation of the specifics for each of these scenarios.

other capital ownership to the cash flow. The cost of lease payments can be a significant operating expense for those farms where all land is rented. For this reason, including this cost was analyzed to determine if there were significant changes in incentives for wildlife habitat conversion. The alternative way to view the land lease payment and paid capital interest is that this is a direct cash payment to the farm for ownership of capital such as land and it is a proxy for the cost of owing this capital.

Because the farm operator is showing an annual payment for renting land, the cost structure of both the crop and beef enterprise had to be adjusted. This cost structure was altered through inclusion of two additional input costs, one for cash/share rent and land lease, and the other for paid capital interest. These costs were based on the type of crop planted on the land (whether crop or forage) and on the amount of acres per year planted, and are provided in Table 7-46. The cash/share rent and land lease input cost was determined through consultation with Etienne Soulodre and the Lower Souris River Watershed Committee (2009). The paid capital interest input costs are from Alberta Agriculture and Rural Development (Kaliel, 2007). The additional lease payment costs increase the overall costs of production for all crops, as well as forages for both pasture and hay.

After incorporating the new input costs, selected simulation scenarios were re-run. All other parameters were left unchanged from the original base scenario and alternative production practice scenarios. The results from these simulations can be found in Tables 7-47 to 7-55.

Results indicate that the increase in NPV when converting habitat (whether riparian or forested) to cropland is significantly lower than if lease payments were excluded (Tables 7-47 and 7-49). This is not surprising, as crop production is now more costly with the inclusion of the cash flows noted above. Converting cropland to tame grass for pasture purposes has a much higher increase in NPV with the lease payments, while when converting cropland to tame grass for hay purposes the NPV stays roughly the same (Tables 7-51 and 7-52). This result could be attributed to the difference between the rental rates for pasture versus those for cropland since land used for tame hay is treated as cropland in model. The conversion of forested habitat to tame grass shows a greater increase in NPV/acre with inclusion of lease payments (Table 7-50).

Furthermore, when lowering stocking rates leads to increased NPV (the extremes of a small decrease and a large decrease in stocking rate), this increase is significantly larger than when lease payments are not included (Table 7-53). Finally, including lease payments has the effect of allowing the costs of implementing rotational grazing to be recouped earlier (Tables 7-54 and 7-55). Forage yield availability output was not provided because the amount of grazing season days generated for each scenario was identical to that of the base case scenario.

A cautionary warning must be placed on the results coming from this analysis. By incorporating the cost of lease payments, the model is including expenditures that are not directly tied to the capital flow of a farm in operation. For this reason, when discounting the revenues generated by the farm over the twenty year period, the cost of lease payment can be said to be 'double-counted'. Recall section 3.1 which states that net present value accounts for any initial capital outlays that are associated with acquisition of assets that will generate the future cash flows (Ross et al., 2003). The rental cost is incorporated as a direct input cost in addition to the static capital cost being discounted with calculation of NPV. Readers are advised to use the results from Tables 7-47 to 7-55 with caution.

# 5. Conclusions

A cost/benefit simulation analysis was performed to examine the direct economic impacts of implementing alternative agricultural production management scenarios. These scenarios were all related to production of Ecological Goods and Services for a representative mixed crop-beef operation in the Lower Souris watershed in south-eastern Saskatchewan. The study was undertaken in order to gain an appreciation for the magnitude of direct costs and benefits for agricultural producers who are interested in maintaining or improving riparian areas and wildlife habitat on their operations.

Data were collected from several sources to model relevant economic and biophysical relationships for the representative farm. Crop yields, as well as crop and beef prices were modeled as stochastic parameters. There were incorporated into a dynamic stochastic Monte Carlo simulation analysis. An initial base scenario was simulated and compared to a set of alternative scenarios, each of which represented a significant change in production practices for the representative farm. Comparisons were made using Net Present Value calculated over a twenty year period.

The scenarios considered in this study were:

a) conversion of riparian area to cropland or tame grass
b) conversion of forested area to cropland or tame grass
c) conversion of cropland to tame grass for hay or pasture
d) reducing stocking rate on native pasture to allow for recover of productivity
e) implementation of rotational grazing on tame and native pasture to improve pasture productivity

In general, the results from these scenarios suggest that implementation of production practices to enhance production of Ecological Goods and Services is costly to the producer, in terms of the impact on farm wealth. This was consistent through most of the analysis. The magnitude of impact varied by the type of scenario.

There were some exceptions to these results. For example, conversion of riparian areas into agricultural production (i.e., reduction of Ecological Goods and Services production) of tame grass (i.e., increased pasture production) did not have a positive economic impact. This suggests that if this type of conversion is considered by producers, there may not be direct economic incentives to reduce wildlife habitat. Similarly, implementation of alternative pasture management practices, either through reduced stocking rates to allow recovery of degraded pasture, or through rotational grazing, had positive economic impacts in some cases. For these practices, as suggested by the results for sensitivity analysis, the direct economic impacts are very much dependent on the degree of pasture productivity improvement that occurs as a result of the change.

Undoubtedly, the magnitude of the direct economic benefits and costs associated with these practices will vary by farm. In particular, they may vary by size of operation and by the type(s) of enterprise(s) found on the farms. However, the research results reported in this paper provide a starting point for quantifying the impact of potential practices that improve Ecological Goods and Services for agricultural producers in the Lower Souris watershed.

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# 7. Appendix: Tables

## Table 7-1 Average Farm Characteristics in Lower Souris

| | Agricultural Region 1B | Agricultural Region 1A | Moosomin (#121) | Redvers (#61) |
|---|---|---|---|---|
| **Farm Size (Acres)** | 1327 | 1474 | 1108 | 1277 |
| **Land in Crops (Acres)** | 834 | 998 | 812 | 931 |
| **Land in Summerfallow (Acres)** | 202 | 287 | 195 | 187 |
| **Land in Tame Pasture (Acres)** | 342 | 357 | 277 | 213 |
| **Land in Native Pasture (Acres)** | 344 | 529 | 306 | 205 |
| **Spring Wheat acreage** | 416 | 481 | - | 445 |
| **Oats acreage** | 207 | 176 | 211 | 158 |
| **Barley acreage** | 246 | 256 | 269 | 258 |
| **Canola acreage** | 373 | 448 | 438 | 389 |
| **Flax acreage** | 249 | 291 | 361 | 305 |
| **Alfalfa acreage** | 209 | 221 | 184 | 161 |
| **Tame hay acreage** | 146 | 198 | 172 | 137 |
| **Number of Cattle and calves** | 189 | 162 | 199 | 141 |
| **Number of Beef cows** | 86 | - | 84 | 70 |
| **Number of Bulls** | 4 | 5 | - | 4 |
| **Total farm capital ($)** | 720,999 | 779,525 | 706,382 | 761,351 |
| **Value of farm machinery ($)** | 183,034 | 210,122 | 173,306 | 206,731 |
| **Total gross farm receipts ($)** | 155,759 | 130,504 | 157,831 | 140,312 |
| **Total operating expenses ($)** | 137,964 | 119,309 | 139,394 | 127,929 |

### Table 7-2 Representative Farm Acreage

| **Crop** | **Acreage** | **Forage** | **Acreage** | **Pasture** | **Acreage (AUM)** |
|---|---|---|---|---|---|
| Spring Wheat | 320 | Alfalfa-Grass Mix | 320 | Native Pasture | 320 (0.65) |
| Barley | 160 | Tame Grass | - | Tame Pasture | 320 (1.3) |
| Canola | 320 | | | AfterMath Grazing | 800 (0.3) |
| Flax | 160 | | | | |
| Oats | - | | | | |
| Total | **960** | | **320** | | **640** |
| Farm Total | **1920** | | | | |

### Table 7-3 Crop Rotations

**Crop Rotation**

| **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **Year 6** |
|---|---|---|---|---|---|
| Wheat | Canola | Wheat | Canola | Barley | Flax |

### Table 7-4 Forage Stand Progression

| **year** | **Forage** |
|---|---|
| 1 | Greenfeed (Barley Cover Crop) |
| 2 | Alfalfa-Grass Mix |
| 3 | Alfalfa-Grass Mix |
| 4 | Alfalfa-Grass Mix |
| 5 | Alfalfa-Grass Mix |
| 6 | Alfalfa-Grass Mix |
| 7 | Alfalfa-Grass Mix |
| 8 | Alfalfa-Grass Mix |

**Table 7-5 Alfalfa-Grass Yield Variation Over Time**

| year | % yield Differential Relative to 5 year mean |
|---|---|
| 1 | 10.00% |
| 2 | 34.20% |
| 3 | 20.38% |
| 4 | -14.98% |
| 5 | -53.88% |

**Table 7-6: Initial stocking rates for upland, riparian, and forested areas (AUM/acre)**

| | Upland | Riparian | Forested |
|---|---|---|---|
| **Tame pasture** | 1.3 | 1.2 | 0.15 |
| **Native pasture** | 0.65 | 1.2 | 0.15 |
| **Aftermath** | 0.3 | 1.2 | 0.15 |

**Table 7-7: Beef Herd Production Parameters**

| | |
|---|---|
| **Basic Herd** | 116 |
| **Bulls** | 4 |
| **Mean cow weight (lbs)** | 1,350 |
| **Conception Rate (%)** | 89 |
| **Calving Rate (%)** | 98 |
| **Weaning Rate (%)** | 97 |
| **Cow Death Loss (%)** | 1 |
| **Calf Weight Gain (lbs/day)** | 1.9 |
| **Desired Market Weight (lbs)** | 550 |

### Table 7-8 Winter Feed Diet (lbs of dry matter/animal/day) by Type of Animal

| Feed/type | Cows | Bulls | Replacement Heifers | Market Calves* |
|---|---|---|---|---|
| Hay/Greenfeed | 35.00 | 45.50 | 35.00 | 7.60 |
| Barley Grain | - | - | - | 11.50 |
| Minerals | 0.08 | 0.10 | 0.08 | - |

* Market calves are those that do not meet the desired market weight of 550lbs at the end of the grazing season and are fed in the drylot until this weight is reached.

### Table 7-9 Machinery Complement

| Power Equipment | Size | Drawn Equipment | Size |
|---|---|---|---|
| Tractor | (150 - 200 hp) | Seeder (with tank) | 25 foot |
| Combine | (150 - 250 hp) | Cultivator | 25 foot |
| Grain Truck | single axle, one ton | Bale Mover | 7-8 bales |
| Swather (pull-type) | 25 foot | Round Baler | |
| | | Cattle trailer (bumper) | |

### Table 7-10 Weather Distributions

| Variable | Chi-Square statistic | Anderson-Darling | Kolmogorov-Smirnov Test |
|---|---|---|---|
| **GDD** | **Logistic (2.1111)**<br>Normal (5.6111)<br>Triangle (6.7778) | **Logistic (0.4847)**<br>Normal (0.8041)<br>Triangle (1.6905) | **Logistic (0.1094)**<br>Normal (0.1244)<br>Triangle (0.1803) |
| **GS** | **LogLogistic (0.5556)**<br>LogNorm (1.7222)<br>Logistic (2.8889) | **LogLogistic (0.1086)**<br>Log Norm (0.2702)<br>Logistic (0.3327) | **LogLogistic (0.0581)**<br>Logistic (0.0725)<br>logNorm (0.0833) |

## Table 7-11 AIC and BIC Criterion Statistics for Crop Price Lags

| | | Canola | Flax | Wheat | Barley |
|---|---|---|---|---|---|
| Five Lag | Bayesian (BIC) | 8011.2 | 10597 | 2175.8 | 1937.4 |
| | Akaike's (AIC) | 6037.3 | 7986.2 | 1639.7 | 1460 |
| Four Lag | Bayesian (BIC) | 7326.6 | 11596 | 1987.6 | 1956.4 |
| | Akaike's (AIC) | 5800.7 | 9180 | 1573.6 | 1548.9 |
| Three Lag | Bayesian (BIC) | 8093.3 | 14264 | 2322.3 | 3057.3 |
| | Akaike's (AIC) | 6726.1 | 11854 | 1930 | 2540.9 |
| Two Lag | Bayesian (BIC) | 9907.2 | 15162 | 2375.4 | 2810.6 |
| | Akaike's (AIC) | 8635.3 | 13215 | 2070.5 | 2449.7 |
| One Lag | Bayesian (BIC) | 13108 | 16036 | 6994.5 | 5786.9 |
| | Akaike's (AIC) | 11972 | 14646 | 6388 | 5285.1 |

## Table 7-12 Estimated Crop Price Equations

| | **Estimated Coefficients** | | | |
|---|---|---|---|---|
| **Variable** | **Canola** | **HRS** | **Flax** | **Barley** |
| Lag 1 | 0.74936*** | 1.0796*** | 0.59308*** | 1.1019*** |
| | *0.1403* | *0.1394* | *0.1132* | *0.1102* |
| Lag 2 | -0.23514 | - 0.57802*** | -0.090975 | -0.82623*** |
| | *0.1562* | *0.208* | *0.1282* | *0.155* |
| Lag 3 | 0.059573 | 0.12182 | -0.16591 | 0.51693*** |
| | *0.1185* | *0.1574* | *0.1139* | *0.1413* |
| Lag 4 | 0.19297** | 0.22467*** | 0.22969*** | -0.055817 |
| | *0.09852* | *0.08236* | *0.08332* | *0.1207* |
| Lag 5 | | | 0.13280*** | 0.11735* |
| | | | *0.03916* | *0.0652* |
| Constant | 78.111** | 23.447 | 91.780*** | 18.162 |
| Std. Error | 64.584 | 33.822 | 72.054 | 31.537 |
| $R^2$ | 0.8614 | 0.8755 | 0.8469 | 0.8833 |

### Table 7-13 Comparison of 10 Year Historical Data Versus Simulation in Year 20 ($/tonne)

| | **Canola** | **Wheat** | **Flax** | **Barley** |
|---|---|---|---|---|
| **Historical Mean** | 357.24 | 178.55 | 341.73 | 167.86 |
| **Pre-Adjusted @Risk Simulation Mean** | 335.34 | 155.78 | 305.33 | 128.49 |
| **Post-Adjusted @Risk Simulation Mean** | 357.24 | 178.55 | 341.73 | 167.86 |
| **Adjusted constant** | 1.0667 | 1.1569 | 1.1219 | 1.3481 |

### Table 7-14 AIC and BIC values for Beef Price Equations

| | **Feeder Heifers** | | **Feeder Steers** | | **Cull Cows** | |
|---|---|---|---|---|---|---|
| **lag** | **AIC** | **BIC** | **AIC** | **BIC** | **AIC** | **BIC** |
| 1 | 5.38 | 5.47 | 5.42 | 5.51 | 5.18 | 5.27 |
| 2 | 5.32 | 5.46 | 5.34 | 5.48 | 4.88 | 5.02 |
| 3 | 5.36 | 5.55 | 5.4 | 5.59 | 4.66 | 4.85 |
| 4 | 5.46 | 5.7 | 5.5 | 5.73 | 4.76 | 5 |
| 5 | 5.57 | 5.86 | 5.61 | 5.89 | 4.85 | 5.14 |
| 6 | 5.64 | 5.98 | 5.71 | 6.05 | 4.93 | 5.26 |

### Table 7-15 Estimated Beef Price Coefficients

**Estimated Coefficients**

| **Variable** | **Feeder Heifers** | **Feeder Steers** | **Cull Cows** |
|---|---|---|---|
| Lag 1 | 0.87123***<br>*0.1295* | 0.84592***<br>*0.1279* | 0.41603***<br>*0.1414* |
| Lag 2 | -0.10531<br>*0.1356* | -0.08469<br>*0.1337* | 0.66559***<br>*0.1217* |
| Lag 3 | | | -0.31938**<br>*0.1398* |
| Constant | 28.694** | 32.21** | 11.339** |
| Std Error | 13.769 | 13.503 | 9.1963 |
| R^2 | 0.7031 | 0.694 | 0.74727 |

## Table 7-16 Price Equations for Alternative Steer and Heifer Weight Classes

| | Steer Price Estimation | | | Heifer Price Estimation | | |
|---|---|---|---|---|---|---|
| **Variable** | **4-5 cwt** | **6-7 cwt** | **7-8 cwt** | **4-5 cwt** | **6-7 cwt** | **7-8 cwt** |
| 5-6 cwt price | 1.0951*** | 0.8682*** | 0.77122*** | 1.0870*** | 0.87307*** | 0.76244*** |
| | 0.04608 | 0.01782 | 0.02398 | 0.02351 | 0.01856 | 0.02864 |
| constant | -5.475 | 9.2065*** | 14.278*** | -5.3007* | 8.8228*** | 16.877*** |
| Std. Error | 6.1607 | 2.3821 | 3.2065 | 3.2543 | 2.5689 | 3.9639 |
| R^2 | 0.9528 | 0.9884 | 0.9736 | 0.9871 | 0.9875 | 0.962 |

## Table 7-17 Estimated Crop Yield Equations

| | Estimation Coefficients | | | |
|---|---|---|---|---|
| **Variable** | **Flax** | **Wheat** | **Barley** | **Canola** |
| (GS/GDD) | 0.97766 | 2.4357** | 3.1134 | 0.46954 |
| | *1.095* | *1.082* | *1.913* | *1.078* |
| $(GS/GDD)^2$ | -0.9454 | -3.572* | -3.9619 | -0.07103 |
| | *1.958* | *1.934* | *3.422* | *1.928* |
| Constant | 0.27293** | 0.38407*** | 0.46308* | 0.35223*** |
| Std. Error | 0.13248 | 0.1309 | 0.23156 | 0.13048 |
| $R^2$ | 0.083 | 0.1623 | 0.1347 | 0.0693 |

## Table 7-18 Comparison of 10 Year Historical Versus Survey Yield Estimates (tonnes/acre)

| | **Flax** | **Wheat** | **Barley** | **Canola** |
|---|---|---|---|---|
| **Historical Mean (Sask. Ag. – RM#123)** | 0.47 | 0.75 | 0.98 | 0.48 |
| **Pre-adjusted @Risk Simulation Mean** | 0.44 | 0.74 | 0.94 | 0.45 |
| **Yield Estimate Overall Mean (LSEG&S)** | 0.49 | 1.00 | 1.29 | 0.62 |
| **Post-Adjusted @Risk Simulation Mean** | 0.49 | 1.00 | 1.29 | 0.62 |
| **Adjusted constant** | 1.1877 | 1.6752 | 1.7584 | 1.4742 |

## Table 7-19 Crop, Forage and Pasture Yield Correlation Matrix

| | **Tame Pasture** | **Mix Ptr** | **Greenfeed** | **Alf/Grs Hay** |
|---|---|---|---|---|
| **Native Pasture** | 0.6 | 0.6 | | |
| **Barley** | | | 0.6 | 0.3 |

## Table 7-20 Simulation Results - Forage Yield for Tame and Native Pasture

| | **Native Pasture (0.65 AUM/acre)** | | **Tame Pasture (1.3 AUM/acre)** | |
|---|---|---|---|---|
| | Index | AUM/acre | kg/acre | AUM/acre |
| Starting value | 100.00 | 0.65 | 2687.00 | 1.30 |
| Year -3 | 77.10 | 0.51 | 2166.97 | 1.15 |
| Year -2 | 159.62 | 0.82 | 3558.60 | 1.55 |
| Year -1 | 77.20 | 0.51 | 2456.09 | 1.23 |
| Year 0 | 82.84 | 0.53 | 2563.71 | 1.27 |
| Year 1 | 75.09 | 0.50 | 2419.84 | 1.22 |
| Year 2 | 82.44 | 0.53 | 2562.03 | 1.26 |
| Year 3 | 91.25 | 0.57 | 2726.30 | 1.31 |
| Year 4 | 93.79 | 0.57 | 2771.73 | 1.32 |
| Year 5 | 74.07 | 0.50 | 2422.14 | 1.23 |
| Year 6 | 123.63 | 0.69 | 3394.50 | 1.50 |
| Year 7 | 91.48 | 0.57 | 2864.80 | 1.35 |
| Year 8 | 127.13 | 0.70 | 3534.58 | 1.54 |
| Year 9 | 96.76 | 0.59 | 3028.00 | 1.40 |
| Year 10 | 87.85 | 0.55 | 2860.66 | 1.35 |
| Year 11 | 150.84 | 0.79 | 4091.45 | 1.70 |
| Year 12 | 88.65 | 0.56 | 3079.39 | 1.41 |
| Year 13 | 101.97 | 0.61 | 3356.99 | 1.49 |
| Year 14 | 106.65 | 0.62 | 3449.29 | 1.51 |
| Year 15 | 111.01 | 0.64 | 3533.99 | 1.54 |
| Year 16 | 151.25 | 0.79 | 4302.62 | 1.76 |
| Year 17 | 80.91 | 0.53 | 3102.05 | 1.42 |
| Year 18 | 98.59 | 0.59 | 3508.62 | 1.53 |
| Year 19 | 127.51 | 0.70 | 4126.18 | 1.71 |
| Year 20 | 74.85 | 0.50 | 3103.83 | 1.42 |
| | | | | |
| **Mean** | 101.30 | 0.61 | 3106.85 | 1.42 |
| **Variance** | 639.90 | 0.01 | 326288.53 | 0.03 |
| **Standard Deviation** | 25.30 | 0.10 | 571.22 | 0.16 |
| **Conf. Interval (5%)** | 10.12 | 0.04 | 228.53 | 0.06 |

### Table 7-21 Crop Input Costs ($/acre/year)

| | Wheat | Flax | Canola | Barley | Greenfeed | Alf/Grs | Tame | Native |
|---|---|---|---|---|---|---|---|---|
| Seed | 7.58 | 8.75 | 27.36 | 6.37 | 5.25 | 3 | 0 | 0 |
| Fertilizer | 30.58 | 26.7 | 33.2 | 30.6 | 18 | 6.75 | 0 | 0 |
| Chemical | 24.38 | 27.43 | 29.79 | 22.37 | 0 | 0 | 0 | 0 |
| Crop Insurance Premium | 4.59 | 6.6 | 7.16 | 4.48 | 1.69 | 0.55 | 1.98 | 0.29 |
| Fuel, Oil & Lube | 8.26 | 9.44 | 8.85 | 8.26 | 7 | 12.44 | 0.07 | 0.14 |
| Machinery Repairs | 9.5 | 11.4 | 9.5 | 9.5 | 7 | 10.63 | 0.15 | 0.08 |
| Building Repairs | 1.6 | 1.6 | 1.6 | 1.6 | 0.78 | 0.33 | 0.19 | 0.17 |
| Utilities & Misc. | 4.93 | 4.93 | 4.93 | 4.93 | 3.86 | 3.08 | 0.13 | 0.12 |
| **Custom Work** | | | | | | | | |
| Spraying | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 | 3.46 | 0 | 0 |
| Grain Handling | 4.18 | 2.70 | 3.15 | 6.77 | - | - | - | - |
| **Capital Costs** | | | | | | | | |
| Taxes, Water Rates, lic. & Ins. | 5 | 5 | 5 | 5 | 5 | 5 | 1 | 0.2 |

### Table 7-22 Beef Input Costs

| **Direct Expenses** | **Cow/Calf ($/cow)** | **Drylot ($/cow/day)** |
|---|---|---|
| Vet. & Medicine | 19.06 | 0.13 |
| Fuel | 17.82 | 0.05 |
| Machinery Repairs | 12.71 | 0.07 |
| Corral & Building Repairs | 5.14 | 0.08 |
| Utilities & Misc. | 16 | 0.13 |
| Custom Work | 15.62 | 0.05 |
| **Capital costs** | | |
| Taxes, Water Rates, lic. & Ins. | 5.03 | |
| **Beef Enterprise costs** | | |
| Winter Feeding & Bedding | 156.59 | 0.96 |
| Pasture | 146.35 | |

**Table 7-23 Summary Statistics from Simulation for Representative Farm***

| Variable | Mean | SD |
|---|---|---|
| Twenty Year NPV | $ 971,313 | $ 233,967 |
| NPV with Perpetuity | $1,109,688 | $ 267,832 |
| Crop Enterprise NPV | $ 506,064 | $ 214,621 |
| Beef Enterprise NPV | $ 384,499 | $ 61,853 |
| Forage Sales | $ 2,952 | $ 1,479 |
| Forage Purchases | $ 991 | $ 607 |
| Grazing Season Days (w/ Aftermath) | 259.1 | 26.18 |
| Weaning Weight (lbs) | 572.29 | 49.75 |

*** Discount rate used is 10%.**

**Table 7-24 Simulation Results, Conversion of Riparian Habitat to Cropland Excluding Conversion Costs***

| | Acres of Riparian Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 10.66 (6.67%) | 5.33 (3.33%) | 0 (0%) |
| Farm NPV Mean* | $ 971,313 | $ 1,006,901 | $ 1,040,093 | $ 1,074,252 |
| St. Dev. | $ 233,967 | $ 241,835 | $ 247,470 | $ 254,258 |
| Total NPV Increase | | $ 35,588 | $ 68,780 | $ 102,939 |
| NPV Increase ($/ac Converted) | | $ 1,113 | $ 1,075 | $ 1,072 |
| Annualized Increase ($/ac Converted) | | **$ 130.71** | **$ 126.31** | **$ 125.95** |
| Annual Forage Sales Mean | $ 2,952 | $ 3,269 | $ 3,586 | $ 3,900 |
| St. Dev. | $ 1,479 | $ 1,467 | $ 1,488 | $ 1,493 |
| Crop Enterprise NPV Mean* | $ 506,064 | $ 537,623 | $ 568,388 | $ 599,330 |
| St. Dev. | $ 214,621 | $ 221,563 | $ 228,939 | $ 236,073 |
| Beef Enterprise NPV Mean | $ 384,499 | $ 385,877 | $ 385,610 | $ 386,109 |
| St. Dev. | $ 61,853 | $ 60,317 | $ 61,608 | $ 61,511 |
| Grazing Season Days | 259.1 | 259.11 | 259.1 | 259.1 |
| Weaning Weight (lbs) | 572.29 | 572.31 | 572.29 | 572.29 |

*Runs from simulation model and excludes all conversion costs.

### Table 7-25 Simulation Results, Conversion of Riparian Habitat to Cropland with Conversion Costs*

| | Acres of Riparian Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 10.66 (6.67%) | 5.33 (3.33%) | 0 (0%) |
| Farm NPV Mean | $ 971,313 | $ 992,964 | $ 1,012,218 | $ 1,032,440 |
| St. Dev. | $ 233,967 | $ 249,591 | $ 252,294 | $ 262,606 |
| Total NPV Increase | | $ 21,651 | $ 40,905 | $ 61,127 |
| NPV Increase ($/ac Converted) | | $ 677 | $ 640 | $ 637 |
| Annualized Increase ($/ac Converted) | | **$ 79.55** | **$ 75.15** | **$ 74.79** |
| Annual Forage Sales Mean | $ 2,952 | $ 2,361 | $ 2,564 | $ 3,107 |
| St. Dev. | $ 1,479 | $ 1,659 | $ 1,726 | $ 1,770 |
| Crop Enterprise NPV Mean | $ 506,064 | $ 523,686 | $ 540,513 | $ 557,519 |
| St. Dev. | $ 214,621 | $ 221,563 | $ 228,939 | $ 236,073 |
| Beef Enterprise NPV Mean | $ 384,499 | $ 385,877 | $ 385,610 | $ 386,109 |
| St. Dev. | $ 61,853 | $ 60,317 | $ 61,608 | $ 61,511 |
| Grazing Season Days | 259.1 | 259.11 | 259.1 | 259.1 |
| Weaning Weight (lbs) | 572.29 | 572.31 | 572.29 | 572.29 |

*Reduced nuisance costs are not included in these estimates.

### Table 7-26 Simulation Results, Conversion of Riparian Habitat to Tame Grass Including Conversion Costs

| | Acres of Riparian Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 21.33 (13.33%) | 10.67 (6.67%) | 0 (0%) |
| Farm NPV Mean | $ 971,313 | $ 962,832 | $ 954,396 | $ 945,913 |
| St. Dev. | $ 233,967 | $ 233,951 | $ 233,832 | $ 233,769 |
| Total NPV Increase | | -$ 8,481 | -$ 16,917 | -$ 25,400 |
| NPV Increase ($/ac Converted) | | -$ 398 | -$ 397 | -$ 397 |
| Annualized Reduction ($/ac Converted) | | **-$ 46.70** | **-$ 46.58** | **-$ 46.62** |
| Annual Forage Sales Mean | $ 2,952 | $ 2,983 | $ 3,015 | $ 3,046 |
| St. Dev. | $ 1,479 | $ 1,480 | $ 1,481 | $ 1,483 |
| Crop Enterprise NPV Mean | $ 506,064 | $ 507,121 | $ 508,156 | $ 509,186 |
| St. Dev. | $ 214,621 | $ 214,544 | $ 214,474 | $ 214,404 |
| Beef Enterprise NPV Mean | $ 384,499 | $ 374,988 | $ 365,540 | $ 356,054 |
| St. Dev. | $ 61,853 | $ 61,854 | $ 61,829 | $ 61,848 |
| Grazing Season Days | 259.1 | 259.67 | 260.25 | 260.82 |
| Weaning Weight (lbs) | 572.29 | 573.38 | 574.47 | 575.56 |

### Table 7-27 Simulation Results, Converting Forested Habitat to Cropland Including Conversion Costs

| | Acres of Forested Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 10.66 (6.67%) | 5.33 (3.33%) | 0 (0%) |
| Farm NPV Mean | $ 766,189 | $ 778,791 | $ 791,852 | $ 805,443 |
| St. Dev. | $ 223,617 | $ 231,463 | $ 239,456 | $ 247,501 |
| Total NPV Increase | | $ 12,602 | $ 25,663 | $ 39,254 |
| NPV Increase ($/ac Converted) | | $ 394 | $ 401 | $ 409 |
| Annualized Increase ($/ac Converted) | | **$ 46.26** | **$ 47.10** | **$ 48.03** |
| Annual Forage Sales Mean | $ 345 | $ 464 | $ 611 | $ 786 |
| St. Dev. | $ 730 | $ 822 | $ 916 | $ 1,011 |
| Crop Enterprise NPV Mean | $ 378,711 | $ 386,339 | $ 394,681 | $ 403,845 |
| St. Dev. | $ 205,138 | $ 213,546 | $ 222,056 | $ 230,585 |
| Beef Enterprise NPV Mean | $ 303,346 | $ 305,650 | $ 307,685 | $ 309,475 |
| St. Dev. | $ 51,821 | $ 51,302 | $ 50,839 | $ 50,431 |
| Grazing Season Days | 200.48 | 200.48 | 200.48 | 200.48 |
| Weaning Weight (lbs) | 460.92 | 460.92 | 460.92 | 460.92 |

### Table 7-28 Simulation Results, Converting Forested Habitat to Tame Grass Including Conversion Costs

| | Acres of Forested Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 21.33 (13.33%) | 10.67 (6.67%) | 0 (0%) |
| Farm NPV Mean | $ 766,189 | $ 773,857 | $ 782,742 | $ 792,114 |
| St. Dev. | $ 223,617 | $ 225,653 | $ 228,721 | $ 231,520 |
| Total NPV Increase | | $ 7,668 | $ 16,552 | $ 25,925 |
| NPV Increase ($/ac Converted) | | $ 359 | $ 388 | $ 405 |
| Annualized Increase ($/ac Converted) | | **$ 42.22** | **$ 45.58** | **$ 47.58** |
| Annual Forage Sales Mean | $ 345 | $ 500 | $ 699 | $ 942 |
| St. Dev. | $ 730 | $ 863 | $ 999 | $ 1,131 |
| Crop Enterprise NPV Mean | $ 378,711 | $ 390,879 | $ 404,097 | $ 418,298 |
| St. Dev. | $ 205,138 | $ 207,789 | $ 210,472 | $ 212,928 |
| Beef Enterprise NPV Mean | $ 303,346 | $ 299,108 | $ 295,048 | $ 290,596 |
| St. Dev. | $ 51,821 | $ 51,813 | $ 52,156 | $ 53,633 |
| Grazing Season Days | 200.48 | 207.1 | 213.71 | 220.33 |
| Weaning Weight (lbs) | 460.92 | 473.48 | 486.05 | 498.62 |

### Table 7-29 Representative Farm Acreage (After Conversion)

Table 3.6. Representative Farm Acreage (After Conversion)

| Crop | Acreage | Forage | Acreage | Pasture | Acreage (AUM) |
|---|---|---|---|---|---|
| Spring Wheat | 320 | Alfalfa-Grass Mix | 320 | Native Pasture | 320 (0.65) |
| Barley | 160 | Tame Grass | - | Tame Pasture | 480 (1.3) |
| Canola | 160 | | | AfterMath Grazing | 800 (0.3) |
| Flax | 160 | | | | |
| Oats | - | | | | |
| Total | **800** | | **320** | | **800** |
| Farm Total | **1920** | | | | |

### Table 7-30 Simulation Results, One Cropland Quarter Converted to Tame Pasture

| | Base | Quarter Converted to Pasture |
|---|---|---|
| Farm NPV Mean | $ 971,313 | $ 983,547 |
| St. Dev. | $ 233,967 | $ 199,059 |
| Total NPV Increase | | $ 12,234 |
| NPV Increase ($/ac Converted) | | $ 85 |
| Annualized Increase ($/ac Converted) | | **$ 9.98** |
| Annual Forage Sales Mean | $ 2,952 | $ 5,766 |
| St. Dev. | $ 1,479 | $ 1,696 |
| Crop Enterprise NPV Mean | $ 506,064 | $ 464,054 |
| St. Dev. | $ 214,621 | $ 182,286 |
| Beef Enterprise NPV Mean | $ 384,499 | $ 451,811 |
| St. Dev. | $ 61,853 | $ 93,364 |
| Grazing Season Days | 259.1 | 314.31 |
| Weaning Weight (lbs) | 572.29 | 677.2 |

### Table 7-31 Simulation Results, Conversion of Annual Cropland to Tame Hay

| | Base | Quarter Converted to Hay |
|---|---|---|
| Farm NPV Mean | $ 971,313 | 910,724 |
| St. Dev. | $ 233,967 | 200,623 |
| Total NPV Increase | | - 60,588 |
| NPV Increase ($/ac Converted) | | -$ 421 |
| Annualized Increase ($/ac Converted) | | **-$ 49.42** |
| Annual Forage Sales Mean | $ 2,952 | $ 7,151 |
| St. Dev. | $ 1,479 | $ 1,578 |
| Crop Enterprise NPV Mean | $ 506,064 | $ 441,139 |
| St. Dev. | $ 214,621 | $ 182,141 |
| Beef Enterprise NPV Mean | $ 384,499 | $ 396,264 |
| St. Dev. | $ 61,853 | $ 59,841 |
| Grazing Season Days | 259.1 | 259.1 |
| Weaning Weight (lbs) | 572.29 | 572.29 |

### Table 7-32 Simulation Results, Decreasing Pasture Conditions (Utilization)

| | Utilization Factor | | | |
|---|---|---|---|---|
| | Base | 0.466 | 0.433 | 0.4 |
| Farm NPV Mean | $ 971,313 | $ 952,692 | $ 931,593 | $ 906,252 |
| St. Dev. | $ 233,967 | $ 235,345 | $ 236,817 | $ 237,623 |
| Total NPV Increase | | -$ 18,621 | -$ 39,720 | -$ 65,060 |
| Annualized Increase | | -$ 2,187 | -$ 4,665 | -$ 7,642 |
| | | | | |
| Annual Forage Sales Mean | $ 2,952 | $ 2,653 | $ 2,322 | $ 1,947 |
| St. Dev. | $ 1,479 | $ 1,489 | $ 1,488 | $ 1,464 |
| Crop Enterprise NPV Mean | $ 506,064 | $ 495,371 | $ 482,523 | $ 466,690 |
| St. Dev. | $ 214,621 | $ 215,771 | $ 216,897 | $ 217,722 |
| Beef Enterprise NPV Mean | $ 384,499 | $ 376,083 | $ 367,205 | $ 357,035 |
| St. Dev. | $ 61,853 | $ 61,540 | $ 60,066 | $ 57,623 |
| Grazing Season Days | 259.1 | 253.66 | 247.56 | 240.46 |
| Weaning Weight (lbs) | 572.29 | 561.95 | 550.36 | 536.87 |

### Table 7-33 Starting Forage Availability with Lowered Utilization Factor

| | | AUM/acre | | Utilizable forage per year (lbs) | |
|---|---|---|---|---|---|
| Utilization rate | % decrease | Native | Tame | Native | Tame |
| 0.5 | | 0.67 | 1.33 | 253340 | 500039 |
| 0.466 | 6.67% | 0.65 | 1.3 | 243014 | 487553 |
| 0.433 | 13.33% | 0.62 | 1.26 | 231441.758 | 473558 |
| 0.4 | 20.00% | 0.58 | 1.22 | 217959.355 | 457255 |

### Table 7-34 Utilization Rate Changes Versus Stocking Rates

| Stocking rates (Upland) | Increase in Utilization factor per year | Number of years |
|---|---|---|
| Tame (1.2), Native (0.6) | 1.0% | 4 |
| Tame (1.1), Native (0.55) | 1.5% | 5 |
| Tame (1.0), Native (0.5) | 2.0% | 6 |
| Tame (0.9), Native (0.45) | 2.5% | 7 |

### Table 7-35 Simulation Results, Pasture Improvement with Lower Stocking rates Based on Table 7.34

| | Decreasing stocking rate with increasing pasture conditions (AUM) | | | | |
|---|---|---|---|---|---|
| | Base (0.4) | Tame (1.2), Native (0.6) | Tame (1.1), Native (0.55) | Tame (1.0), Native (0.5) | Tame (0.9), Native(0.45) |
| Farm NPV Mean | $ 906,252 | $ 907,700 | $ 904,346 | $ 904,627 | $ 907,523 |
| St. Dev. | $ 237,623 | $ 241,858 | $ 241,113 | $ 243,008 | $ 245,069 |
| Total NPV Increase | | $ 1,448 | -$ 1,906 | -$ 1,626 | $ 1,271 |
| Annualized Increase | | $ 170.06 | -$ 223.90 | -$ 190.96 | $ 149.28 |
| | | | | | |
| Annual Forage Sales Mean | $ 1,947 | $ 1,977 | $ 1,991 | $ 2,045 | $ 2,157 |
| St. Dev. | $ 1,464 | $ 1,528 | $ 1,597 | $ 1,670 | $ 1,758 |
| Crop Enterprise NPV Mean | $ 466,690 | $ 466,261 | $ 464,855 | $ 464,562 | $ 466,270 |
| St. Dev. | $ 217,722 | $ 218,825 | $ 219,760 | $ 220,679 | $ 221,743 |
| Beef Enterprise NPV Mean | $ 357,035 | $ 360,063 | $ 359,069 | $ 360,760 | $ 363,268 |
| St. Dev. | $ 57,623 | $ 58,558 | $ 61,567 | $ 63,478 | $ 64,585 |
| Grazing Season Days | 240.46 | 238.58 | 236.33 | 234.45 | 233.07 |
| Weaning Weight (lbs) | 536.87 | 533.3 | 529.03 | 525.46 | 522.82 |

### Table 7-36 Simulation Results, Forage Availability for Lowered Stocking Rates per Year

| | | | AUM/acre | | Utilizable forage per year (lbs) | |
|---|---|---|---|---|---|---|
| | Year | Grazing season days | Native | Tame | Native | Tame |
| Tame 1.2, Native 0.6 | year 0 | 236.38 | 0.56 | 1.11 | 212,453 | 419,337 |
| | year 1 | 237.54 | 0.57 | 1.12 | 214,634 | 423,642 |
| | year 2 | 238.70 | 0.58 | 1.14 | 216,816 | 427,948. |
| | year 3 | 239.86 | 0.58 | 1.15 | 218,997 | 432,254 |
| | year 4 | 241.02 | 0.59 | 1.16 | 221,179 | 436,560 |
| Tame 1.1, Native 0.55 | | | | | | |
| | year 0 | 233.61 | 0.55 | 1.09 | 207,236 | 409,040 |
| | year 1 | 235.28 | 0.56 | 1.10 | 210,375 | 415,235 |
| | year 2 | 236.95 | 0.57 | 1.12 | 213,514. | 421,431 |
| | year 3 | 238.61 | 0.57 | 1.13 | 216,653 | 427,626. |
| | year 4 | 240.28 | 0.58 | 1.15 | 219,79 | 433,822 |
| | year 5 | 241.95 | 0.59 | 1.17 | 222,931 | 440,017 |
| Tame 1.0, Native 0.5 | | | | | | |
| | year 0 | 231.24 | 0.54 | 1.06 | 202,767 | 400,219 |
| | year 1 | 233.37 | 0.55 | 1.08 | 206,774 | 408,129 |
| | year 2 | 235.50 | 0.56 | 1.10 | 210,782 | 416,039 |
| | year 3 | 237.62 | 0.57 | 1.13 | 214,789 | 423,948 |
| | year 4 | 239.75 | 0.58 | 1.15 | 218,797 | 431,858 |
| | year 5 | 241.88 | 0.59 | 1.17 | 222,804 | 439,768 |
| | year 6 | 244.01 | 0.60 | 1.19 | 226,812 | 447,678 |
| Tame 0.9, Native 0.45 | | | | | | |
| | year 0 | 229.39 | 0.53 | 1.04 | 199,295 | 393,367 |
| | year 1 | 231.94 | 0.54 | 1.07 | 204,083 | 402,816 |
| | year 2 | 234.48 | 0.55 | 1.09 | 208,870 | 412,266 |
| | year 3 | 237.02 | 0.57 | 1.12 | 213,658 | 421,715 |
| | year 4 | 239.57 | 0.58 | 1.14 | 218,446 | 431,165 |
| | year 5 | 242.11 | 0.59 | 1.17 | 223,233 | 440,614 |
| | year 6 | 244.65 | 0.61 | 1.19 | 228,021 | 450,064 |
| | year 7 | 247.19 | 0.62 | 1.22 | 232,808 | 459,513 |

Table 7-37 Simulation Results, Pasture Improvement (improvement ends after 4 years)

| | | Increase in Utilization Factor | | |
|---|---|---|---|---|
| | Base | 0.5% | 1.0% | 1.5% |
| Farm NPV Mean | $ 971,313 | $ 963,915 | $ 969,693 | $ 976,340 |
| St. Dev. | $ 233,967 | $ 234,862 | $ 234,203 | $ 233,846 |
| Total NPV Increase | | -$ 7,398 | -$ 1,620 | $ 5,027 |
| Annualized Increase | | -$ 868.96 | -$ 190.26 | $ 590.46 |
| | | | | |
| Annual Forage Sales Mean | $ 2,952 | $ 3,081 | $ 3,215 | $ 3,346 |
| St. Dev. | $ 1,479 | $ 1,481 | $ 1,514 | $ 1,531 |
| Crop Enterprise NPV Mean | $ 506,064 | $ 510,160 | $ 513,614 | $ 517,248 |
| St. Dev. | $ 214,621 | $ 214,368 | $ 214,540 | $ 214,516 |
| Beef Enterprise NPV Mean | $ 384,499 | $ 388,804 | $ 391,808 | $ 395,448 |
| St. Dev. | $ 61,853 | $ 60,593 | $ 63,052 | $ 63,241 |
| | | | | |
| Grazing Season Days | 259.1 | 259.79 | 260.45 | 261.13 |
| Weaning Weight (lbs) | 572.29 | 573.6 | 574.86 | 576.14 |

**Table 7-38 Simulation Results, Forage Availability for Increasing Utilization Factor (improvement ends 4 years)**

| | | | AUM/acre | | Utilizable forage per year (lbs) | |
|---|---|---|---|---|---|---|
| | Year | Grazing season days | Native | Tame | Native | Tame |
| 0.50% | Year 0 | 258.10 | 0.67 | 1.33 | 251,126 | 502,253 |
| | Year 1 | 258.77 | 0.67 | 1.34 | 252,382 | 504,764 |
| | Year 2 | 259.45 | 0.67 | 1.35 | 253,637 | 507,275 |
| | Year 3 | 260.12 | 0.68 | 1.35 | 254,893 | 509,787. |
| | Year 4 | 260.79 | 0.68 | 1.36 | 256,149 | 512,298. |
| | | | | | | |
| 1.00% | Year 0 | 258.10 | 0.67 | 1.33 | 251,126 | 502,253 |
| | Year 1 | 259.45 | 0.67 | 1.35 | 253,637 | 507,275 |
| | Year 2 | 260.79 | 0.68 | 1.36 | 256,149 | 512,298 |
| | Year 3 | 262.14 | 0.69 | 1.37 | 258,660 | 517,320 |
| | Year 4 | 263.48 | 0.69 | 1.39 | 261,171 | 522,343 |
| | | | | | | |
| 1.50% | Year 0 | 258.10 | 0.67 | 1.33 | 251,126 | 502,253 |
| | Year 1 | 260.12 | 0.68 | 1.35 | 254,893 | 509,787 |
| | Year 2 | 262.14 | 0.69 | 1.37 | 258,660 | 517,320 |
| | Year 3 | 264.16 | 0.70 | 1.39 | 262,427 | 524,854 |
| | Year 4 | 266.18 | 0.71 | 1.41 | 266,194 | 532,388 |

**Table 7-39 Simulation Results, Pasture Improvement with Varying Years of Improvement (holding utilization – improvement in forage availability- increase constant at 1%/year)**

| | Number of Years the Pasture Improves Before Improvement Stops | | | | |
|---|---|---|---|---|---|
| | Base | 3 | 4 | 5 | 6 |
| Farm NPV Mean | $ 971,313 | $ 966,915 | $ 969,693 | $ 972,270 | $ 974,713 |
| St. Dev. | $ 233,967 | $ 234,189 | $ 234,203 | $ 233,813 | $ 233,909 |
| Total NPV Increase | | -$ 4,398 | -$ 1,620 | $ 957 | $ 3,400 |
| Annualized Increase | | -$ 516.63 | -$ 190.26 | $ 112.42 | $ 399.41 |
| | | | | | |
| Annual Forage Sales Mean | $ 2,952 | $ 3,154 | $ 3,215 | $ 3,273 | $ 3,328 |
| St. Dev. | $ 1,479 | $ 1,506 | $ 1,514 | $ 1,522 | $ 1,529 |
| Crop Enterprise NPV Mean | $ 506,064 | $ 512,045 | $ 513,614 | $ 514,981 | $ 516,189 |
| St. Dev. | $ 214,621 | $ 214,547 | $ 214,540 | $ 214,542 | $ 214,548 |
| Beef Enterprise NPV Mean | $ 384,499 | $ 390,319 | $ 391,808 | $ 393,263 | $ 394,758 |
| St. Dev. | $ 61,853 | $ 62,150 | $ 63,052 | $ 62,816 | $ 62,924 |
| Grazing Season Days | 259.1 | 260.45 | 260.45 | 260.45 | 260.45 |
| Weaning Weight (lbs) | 572.29 | 574.86 | 574.86 | 574.86 | 574.86 |

**Table 7-40 Simulation Results, Forage Availability for Years Utilization Increases (holding utilization – improvement in forage availability- increase constant at 1%/year; see Table 7-39)**

| | | | AUM/acre | | Utilizable forage per year (lbs) | |
|---|---|---|---|---|---|---|
| | Year | Grazing Season days | Native | Tame | Native | Tame |
| 3.00 | Year 0 | 258.10 | 0.67 | 1.33 | 251,126 | 502,253 |
| | Year 1 | 259.45 | 0.67 | 1.35 | 253,637 | 507,275 |
| | Year 2 | 260.79 | 0.68 | 1.36 | 256,149 | 512,298 |
| | Year 3 | 262.14 | 0.69 | 1.37 | 258,660 | 517,320 |
| | | | | | | |
| 4.00 | Year 4 | 263.48 | 0.69 | 1.39 | 261,171 | 522,343 |
| | | | | | | |
| 5.00 | Year 5 | 264.83 | 0.70 | 1.40 | 263,682 | 527,365.99 |
| | | | | | | |
| 6.00 | Year 6 | 266.18 | 0.71 | 1.41 | 266,194 | 532,388 |

**Table 7-41 Average of 2007-2008 Crop Inputs Costs ($/acre/year)**

| | Wheat | Flax | Canola | Barley | Greenfeed | Alf/Grs | Tame | Native |
|---|---|---|---|---|---|---|---|---|
| Seed | 11.365 | 7.875 | 26.475 | 8.92 | 5.25 | 3 | 0 | 0 |
| Fertilizer | 39 | 33.9 | 40.2 | 39 | 18 | 6.75 | 0 | 0 |
| Chemical | 24.52 | 27.13 | 28.015 | 21.835 | 0 | 0 | 0 | 0 |
| Crop Insurance Premium | 4.98 | 6.965 | 7.045 | 4.605 | 1.69 | 0.55 | 1.98 | 0.29 |
| Fuel, Oil & Lube | 10.99 | 12.56 | 11.775 | 10.99 | 7 | 12.44 | 0.07 | 0.14 |
| Machinery Repairs | 5.94 | 7.92 | 5.94 | 5.94 | 7 | 10.63 | 0.15 | 0.08 |
| Building Repairs | 1.6 | 1.6 | 1.6 | 1.6 | 0.78 | 0.33 | 0.19 | 0.17 |
| Utilities & Misc. | 5.355 | 5.355 | 5.355 | 5.355 | 3.86 | 3.08 | 0.13 | 0.12 |
| **Custom Work** | | | | | | | | |
| Spraying | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 | 3.46 | 0 | 0 |
| Grain Handling | 4.18 | 2.7 | 3.15 | 6.77 | - | - | - | - |
| **Capital Costs** | | | | | | | | |
| Taxes, Water Rates, lic. & Ins. | 5 | 5 | 5 | 5 | 5 | 5 | 1 | 0.2 |

**Table 7-42 Simulation Results, Conversion of Riparian Habitat to Cropland Including Conversion Costs (high crop costs)**

| | Acres of Riparian Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 10.66 (6.67%) | 5.33 (3.33%) | 0 (0%) |
| Farm NPV Mean | $ 860,862 | $ 877,419 | $ 893,776 | $ 910,006 |
| St. Dev. | $ 234,861 | $ 241,604 | $ 248,362 | $ 255,150 |
| Total NPV Increase | | $ 16,557 | $ 32,914 | $ 49,144 |
| NPV Increase ($/ac Converted) | | $ 517 | $ 514 | $ 512 |
| Annualized Increase ($/ac Converted) | | **$ 60.70** | **$ 60.39** | **$ 60.13** |
| Annual Forage Sales Mean | $ 2,952 | $ 3,270 | $ 3,586 | $ 3,900 |
| St. Dev. | $ 1,479 | $ 1,484 | $ 1,488 | $ 1,493 |
| Crop Enterprise NPV Mean | $ 397,886 | $ 411,209 | $ 424,319 | $ 437,321 |
| St. Dev. | $ 214,621 | $ 221,785 | $ 228,939 | $ 236,073 |
| Beef Enterprise NPV Mean | $ 381,520 | $ 382,097 | $ 382,631 | $ 383,131 |
| St. Dev. | $ 62,348 | $ 62,213 | $ 62,098 | $ 61,999 |
| Grazing Season Days | 259.1 | 259.11 | 259.1 | 259.1 |
| Weaning Weight (lbs) | 572.29 | 572.31 | 572.29 | 572.29 |

### Table 7-43 Simulation Results, Conversion of Forested Habitat to Cropland Including Conversion Costs (high crop costs)

| | Acres of Forested Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 10.66 (6.67%) | 5.33 (3.33%) | 0 (0%) |
| Farm NPV Mean | $ 652,159 | $ 660,785 | $ 669,871 | $ 679,491 |
| St. Dev. | $ 225,668 | $ 233,509 | $ 241,500 | $ 249,541 |
| Total NPV Increase | | $ 8,625 | $ 17,712 | $ 27,332 |
| NPV Increase ($/ac Converted) | | $ 270 | $ 277 | $ 285 |
| Annualized Increase ($/ac Converted) | | **$ 31.66** | **$ 32.51** | **$ 33.44** |
| Annual Forage Sales Mean | $ 345 | $ 464 | $ 611 | $ 786 |
| St. Dev. | $ 730 | $ 822 | $ 916 | $ 1,011 |
| Crop Enterprise NPV Mean | $ 270,533 | $ 274,149 | $ 278,487 | $ 283,647 |
| St. Dev. | $ 205,138 | $ 213,546 | $ 222,056 | $ 230,585 |
| Beef Enterprise NPV Mean | $ 297,580 | $ 299,884 | $ 301,919 | $ 303,709 |
| St. Dev. | $ 52,633 | $ 52,100 | $ 51,624 | $ 51,203 |
| Grazing Season Days | 200.48 | 200.48 | 200.48 | 200.48 |
| Weaning Weight (lbs) | 460.92 | 460.92 | 460.92 | 460.92 |

### Table 7-44 Simulation Results, One Cropland Quarter converted to Tame Pasture (high crop costs)

| | Base | Quarter Converted to Pasture |
|---|---|---|
| Farm NPV Mean | $ 860,862 | $ 891,365 |
| St. Dev. | $ 234,861 | $ 199,370 |
| Total NPV Increase | | $ 30,503 |
| NPV Increase ($/ac Converted) | | $ 212 |
| Annualized Increase ($/ac Converted) | | **$ 24.88** |
| Annual Forage Sales Mean | $ 2,952 | $ 7,151 |
| St. Dev. | $ 1,479 | $ 1,578 |
| Crop Enterprise NPV Mean | $ 397,886 | $ 372,519 |
| St. Dev. | $ 214,621 | $ 182,286 |
| Beef Enterprise NPV Mean | $ 381,520 | $ 450,554 |
| St. Dev. | $ 62,348 | $ 93,262 |
| Grazing Season Days | 259.1 | 259.1 |
| Weaning Weight (lbs) | 572.29 | 572.29 |

### Table 7-45 Simulation Results, Cropland Quarter Converted to Tame Hay (high crop costs)

| | Base | Quarter Converted to Hay |
|---|---|---|
| Farm NPV Mean | $ 860,862 | $ 817,237 |
| St. Dev. | $ 234,861 | $ 201,267 |
| Total NPV Increase | | -$ 43,625 |
| NPV Increase ($/ac Converted) | | -$ 303 |
| Annualized Increase ($/ac Converted) | | **-$ 35.58** |
| Annual Forage Sales Mean | $ 2,952 | $ 7,151 |
| St. Dev. | $ 1,479 | $ 1,578 |
| Crop Enterprise NPV Mean | $ 397,886 | $ 349,659 |
| St. Dev. | $ 214,621 | $ 182,141 |
| Beef Enterprise NPV Mean | $ 381,520 | $ 393,956 |
| St. Dev. | $ 62,348 | $ 60,183 |
| Grazing Season Days | 259.1 | 259.1 |
| Weaning Weight (lbs) | 572.29 | 572.29 |

**Cautionary Note: Tables 7-46 to 7.55 include cash flow with land lease payments. Due to the double counting of capital costs, these results should be used with caution. Please see section 4.6.6 for additional details.**

**Table 7-46 Capital Input Costs (with land rent and capital interest)**

| | Wheat | Flax | Canola | Barley | Greenfeed | Alf/Grs | Tame | Native |
|---|---|---|---|---|---|---|---|---|
| Cash/Share Rent & Land Lease | 25 | 25 | 25 | 25 | 25 | 25 | 15 | 15 |
| Taxes, Water Rates, lic. & Ins. | 5 | 5 | 5 | 5 | 5 | 5 | 1 | 0.2 |
| Paid Capital Interest | 1.83 | 1.83 | 1.83 | 1.83 | 0.34 | 1.83 | 5.5 | 0.2 |

### Table 7-47 Simulation Results, Converting Riparian Habitat to Cropland (with lease payments)

| | Acres of Riparian Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 10.66 (6.67%) | 5.33 (3.33%) | 0 (0%) |
| Farm NPV Mean | $ 670,616 | $ 681,441 | $ 692,086 | $ 702,602 |
| St. Dev. | $ 238,705 | $ 245,450 | $ 252,202 | $ 258,981 |
| | | $ 10,825 | $ 21,470 | $ 31,986 |
| NPV Increase ($/ac Converted) | | $ 338 | $ 335 | $ 333 |
| Annualized Increase ($/ac Converted) | | **$ 39.74** | **$ 39.40** | **$ 39.14** |
| Annual Forage Sales Mean | $ 2,952 | $ 3,270 | $ 3,586 | $ 3,900 |
| St. Dev. | $ 1,479 | $ 1,484 | $ 1,488 | $ 1,493 |
| Crop Enterprise NPV Mean | $ 243,583 | $ 251,183 | $ 258,582 | $ 265,872 |
| St. Dev. | $ 214,621 | $ 221,785 | $ 228,939 | $ 236,073 |
| Beef Enterprise NPV Mean | $ 267,525 | $ 268,102 | $ 268,637 | $ 269,136 |
| St. Dev. | $ 64,606 | $ 64,457 | $ 64,330 | $ 64,221 |
| Grazing Season Days | 259.1 | 259.11 | 259.1 | 259.1 |
| Weaning Weight (lbs) | 572.29 | 572.31 | 572.29 | 572.29 |

### Table 7-48 Simulation Results, Converting Riparian Habitat to Tame Grass (with lease payments)

| | Acres of Riparian Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 10.66 (6.67%) | 5.33 (3.33%) | 0 (0%) |
| Farm NPV Mean | $ 670,616 | $ 666,799 | $ 663,025 | $ 659,210 |
| St. Dev. | $ 238,705 | $ 238,657 | $ 238,507 | $ 238,413 |
| Total NPV Increase | | -$ 3,818 | -$ 7,591 | -$ 11,406 |
| NPV Increase ($/ac Converted) | | -$ 318 | -$ 316 | -$ 317 |
| Annualized Reduction ($/ac Converted) | | **-$ 37.37** | **-$ 37.15** | **-$ 37.22** |
| Annual Forage Sales Mean | $ 2,952 | $ 2,983 | $ 3,015 | $ 3,046 |
| St. Dev. | $ 1,479 | $ 1,480 | $ 1,481 | $ 1,483 |
| Crop Enterprise NPV Mean | $ 243,583 | $ 244,640 | $ 245,674 | $ 214,404 |
| St. Dev. | $ 214,621 | $ 214,545 | $ 214,474 | $ 214,404 |
| Beef Enterprise NPV Mean | $ 267,525 | $ 262,667 | $ 257,868 | $ 253,039 |
| St. Dev. | $ 64,606 | 64607.37 | 64584.16 | 64604.29 |
| Grazing Season Days | 259.1 | 259.67 | 260.25 | 260.82 |
| Weaning Weight (lbs) | 572.29 | 573.38 | 574.47 | 575.56 |

**Table 7-49 Simulation Results, Converting Forested Habitat to Cropland (with lease payments)**

| | Acres of Forested Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 10.66 (6.67%) | 5.33 (3.33%) | 0 (0%) |
| Farm NPV Mean | $ 447,362 | $ 450,309 | $ 453,729 | $ 457,689 |
| St. Dev. | $ 232,905 | 240756.57 | 248764.41 | 256824.39 |
| Total NPV Increase | | $ 2,947 | $ 6,367 | $ 10,327 |
| NPV Increase ($/ac Converted) | | $ 92 | $ 99 | $ 108 |
| Annualized Increase ($/ac Converted) | | **$ 10.82** | **$ 11.68** | **$ 12.64** |
| Annual Forage Sales Mean | $ 345 | $ 464 | $ 611 | $ 786 |
| St. Dev. | $ 730 | $ 822 | $ 916 | $ 1,011 |
| Crop Enterprise NPV Mean | $ 116,229 | $ 114,123 | $ 112,750 | $ 112,198 |
| St. Dev. | $ 205,138 | 213545.55 | 218797.08 | 230585.24 |
| Beef Enterprise NPV Mean | $ 171,858 | 174162.25 | 222056.09 | 177987.88 |
| St. Dev. | $ 55,682 | 55099.69 | 54576.06 | 54111.94 |
| Grazing Season Days | 200.48 | 200.48 | 200.48 | 200.48 |
| Weaning Weight (lbs) | 460.92 | 460.92 | 460.92 | 460.92 |

**Table 7-50 Simulation Results, Converting Forested Habitat to Tame Grass (with lease payments)**

| | Acres of Forested Habitat per Quarter (% of Qtr) | | | |
|---|---|---|---|---|
| | Base | 21.33 (13.33%) | 10.67 (6.67%) | 0 (0%) |
| Farm NPV Mean | $ 447,362 | $ 457,467 | $ 468,674 | $ 480,304 |
| St. Dev. | $ 232,905 | $ 234,395 | $ 236,957 | $ 239,225 |
| Total NPV Increase | | $ 10,105 | $ 21,312 | $ 32,942 |
| NPV Increase ($/ac Converted) | | $ 474 | $ 500 | $ 515 |
| Annualized Increase ($/ac Converted) | | **$ 55.65** | **$ 58.68** | **$ 60.46** |
| Annual Forage Sales Mean | $ 345 | $ 500 | $ 699 | $ 942 |
| St. Dev. | $ 730 | $ 863 | $ 999 | $ 1,131 |
| Crop Enterprise NPV Mean | $ 116,229 | $ 128,402 | $ 141,613 | $ 155,816 |
| St. Dev. | $ 205,138 | $ 207,790 | $ 210,471 | $ 212,928 |
| Beef Enterprise NPV Mean | $ 171,858 | $ 169,384 | $ 167,065 | $ 164,342 |
| St. Dev. | $ 55,682 | $ 55,514 | $ 55,926 | $ 57,280 |
| Grazing Season Days | 200.48 | 207.1 | 213.71 | 220.33 |
| Weaning Weight (lbs) | 460.92 | 473.48 | 486.05 | 498.62 |

### Table 7-51 Simulation Results, Converting Cropland Quarter to Tame Pasture (with lease payments)

| | Base | Quarter Converted to Pasture |
|---|---|---|
| Farm NPV Mean | $ 670,616 | $ 726,527 |
| St. Dev. | $ 238,705 | $ 201,363 |
| Total NPV Increase | | $ 55,911 |
| NPV Increase ($/ac Converted) | | $ 388 |
| Annualized Increase ($/ac Converted) | | **$ 45.61** |
| Annual Forage Sales Mean | $ 2,952 | $ 7,151 |
| St. Dev. | $ 1,479 | $ 1,578 |
| Crop Enterprise NPV Mean | $ 243,583 | $ 234,464 |
| St. Dev. | $ 214,621 | $ 182,286 |
| Beef Enterprise NPV Mean | $ 267,525 | $ 317,676 |
| St. Dev. | $ 64,606 | $ 92,578 |
| Grazing Season Days | 259.1 | 259.1 |
| Weaning Weight (lbs) | 572.29 | 572.29 |

### Table 7-52 Simulation Results, Converting Cropland Quarter to Tame Hay (with lease payments)

| | Base | Quarter Converted to Hay |
|---|---|---|
| Farm NPV Mean | $ 670,616 | $ 612,349 |
| St. Dev. | $ 238,705 | $ 204,649 |
| Total NPV Increase | | -$ 58,267 |
| NPV Increase ($/ac Converted) | | -$ 405 |
| Annualized Increase ($/ac Converted) | | **-$ 47.53** |
| Annual Forage Sales Mean | $ 2,952 | $ 7,151 |
| St. Dev. | $ 1,479 | $ 1,578 |
| Crop Enterprise NPV Mean | $ 243,583 | $ 178,986 |
| St. Dev. | $ 214,621 | $ 182,141 |
| Beef Enterprise NPV Mean | $ 267,525 | $ 281,090 |
| St. Dev. | $ 64,606 | $ 62,002 |
| Grazing Season Days | 259.1 | 259.1 |
| Weaning Weight (lbs) | 572.29 | 572.29 |

### Table 7-53 Simulation Results, Pasture Improvement with Lower Stocking Rates (with lease payments)

| | Base (factor of 0.4) | Tame (1.2), Native (0.6) | Tame (1.1), Native (0.55) | Tame (1.0), Native (0.5) | Tame (0.9), Native (0.45) |
|---|---|---|---|---|---|
| Farm NPV Mean | $ 600,592 | $ 605,610 | $ 598,892 | $ 599,382 | $ 602,670 |
| St. Dev. | $ 244,075 | $ 247,901 | $ 247,937 | $ 250,045 | $ 252,317 |
| Total NPV Increase | | $ 5,018 | -$ 1,700 | -$ 1,210 | $ 2,078 |
| Annualized Increase | | $ 589.41 | -$ 199.72 | -$ 142.08 | $ 244.09 |
| Annual Forage Sales Mean | $ 1,947 | $ 1,977 | $ 1,991 | $ 2,045 | $ 2,157 |
| St. Dev. | $ 1,464 | $ 1,528 | $ 1,597 | $ 1,670 | $ 1,758 |
| Crop Enterprise NPV Mean | $ 204,208 | $ 209,312 | $ 202,374 | $ 202,080 | $ 203,789 |
| St. Dev. | $ 217,722 | $ 219,198 | $ 219,760 | $ 220,679 | $ 221,743 |
| Beef Enterprise NPV Mean | $ 235,802 | $ 237,588 | $ 238,132 | $ 240,069 | $ 242,979 |
| St. Dev. | $ 61,264 | $ 65,963 | $ 65,310 | $ 67,391 | $ 68,755 |
| Grazing Season Days | 240.46 | 238.58 | 236.33 | 234.45 | 233.07 |
| Weaning Weight (lbs) | 536.87 | 533.3 | 529.03 | 525.46 | 522.82 |

### Table 7-54 Simulation Results, Pasture Improvement - Holding Number of Years Constant (with lease payments)

| | Increase in Utilization Factor | | | |
|---|---|---|---|---|
| | Base | 0.5% | 1.0% | 1.5% |
| Farm NPV Mean | $ 670,616 | $ 662,832 | $ 670,077 | $ 677,246 |
| St. Dev. | $ 238,705 | $ 238,644 | $ 238,695 | $ 238,221 |
| Total NPV Increase | | -$ 7,784 | -$ 539 | $ 6,630 |
| Annualized Increase | | -$ 914.29 | -$ 63.31 | $ 778.72 |
| | | | | |
| Annual Forage Sales Mean | $ 2,952 | $ 3,081 | $ 3,215 | $ 3,346 |
| St. Dev. | $ 1,479 | $ 1,481 | $ 1,514 | $ 1,531 |
| Crop Enterprise NPV Mean | $ 243,583 | $ 247,411 | $ 251,133 | $ 254,767 |
| St. Dev. | $ 214,621 | $ 214,579 | $ 214,540 | $ 214,516 |
| Beef Enterprise NPV Mean | $ 267,525 | $ 271,733 | $ 275,853 | $ 279,991 |
| St. Dev. | $ 64,606 | $ 64,681 | $ 65,735 | $ 65,831 |
| Grazing Season Days | 259.1 | 259.79 | 260.45 | 261.13 |
| Weaning Weight (lbs) | 572.29 | 573.6 | 574.86 | 576.14 |

### Table 7-55 Simulation Results, Pasture Improvement - Holding Utilization increase per Year Constant (with lease payments)

| | Number of Years the Pasture Improves | | | | |
|---|---|---|---|---|---|
| | Base | 3 | 4 | 5 | 6 |
| Farm NPV Mean | $ 670,616 | $ 667,052 | $ 670,077 | $ 672,885 | $ 675,541 |
| St. Dev. | $ 238,705 | $ 238,747 | $ 238,695 | $ 238,251 | $ 238,309 |
| Total NPV Increase | | -$ 3,564 | -$ 539 | $ 2,269 | $ 4,925 |
| Annualized Increase | | -$ 418.63 | -$ 63.31 | $ 266.53 | $ 578.50 |
| | | | | | |
| Annual Forage Sales Mean | $ 2,952 | $ 3,154 | $ 3,215 | $ 3,273 | $ 3,328 |
| St. Dev. | $ 1,479 | $ 1,506 | $ 1,514 | $ 1,522 | $ 1,529 |
| Crop Enterprise NPV Mean | $ 243,583 | $ 249,563 | $ 251,133 | $ 252,499 | $ 253,708 |
| St. Dev. | $ 214,621 | $ 214,547 | $ 214,540 | $ 214,542 | $ 214,548 |
| Beef Enterprise NPV Mean | $ 267,525 | $ 274,130 | $ 275,853 | $ 277,528 | $ 279,226 |
| St. Dev. | $ 64,606 | $ 64,923 | $ 65,735 | $ 65,440 | $ 65,552 |
| Grazing Season Days | 259.1 | 260.45 | 260.45 | 260.45 | 260.45 |
| Weaning Weight (lbs) | 572.29 | 574.86 | 574.86 | 574.86 | 574.86 |