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Slave River Lowland Bison Ranch Feasibility Study - Module B
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September 30, 1987

Mr. K. Hudson
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FORT S-Northwest Territories
XOE OPO

Dear Mr. Hudson,

RE: Slave River Lowland Bison Ranch - Feasibility Study (Module B)

We are pleased to enclose our final **findings** relating to the supply aspects of establishing a bison ranch in the **Slave River** Lowlands. This study incorporates updated fence costs as well as conclusions drawn from site **observations** made during the summer of 1987. In particular, allowances were made for range improvement through incorporating additional ditching costs to drain some of the ranch area. Although substantial detail is provided in the attached **report,** a number of key conclusions are highlighted as follows:

- an optimal location for the ranch was selected based on a **review** of four **sites** and the application of **technical, biological** and **economic** criteria. The site identified consists of 6750 ha on the east side of the Slave River **north** of Fort Smith
- the optimal scale of the ranch is approximately 1350 head with a long-term **annual** harvest of 400 animals. This results in **delivered** costs of production of about $7.04/kg. This is marginally adequate for N.W.T. markets, in which prices **avera**ge just over $7.00/kg, **although** rhe financial security of the ranch depends upon the availability and access to existing Alberta markets at $18.00/kg.
- total debt financing for the project is approximately $2.3 million. Cash flow modelling indicated **that,** if the project construction commenced in 1988, then total **debt would** be essentially **eliminated by** 1999.
- the largest **risk** factors facing the ranch are: Alberta market availability, productivity **growth, fencing** costs, and road access. Specific measures are available to mitigate all of these risks. It is again stressed that **the** optimal long-term configuration of the **ranch** would involve plain **bison or hybrid bison unless regulations change in** southern markets. **A number** of herd and-range management programs are **discussed** in the text to ensure high levels of productivity. Fence cost uncertainties **are addressed** through a **recommended phased in development.** Road access costs can **be mitigated by** conducting more **detailed** site work and ground truthing.

Based on the above, it is noted that the logistical and financial feasibility of the ranch has been established The final results **reflected** in this report are consistent with the revised operational plan outlined in the final assessment report which will follow shortly under separate cover.

Yours sincerely,

H.J. Ruitenbeek

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CHAPTER 1 INTRODUCTION

1.1 STUDY BACKGROUND

In prefeasibility studies prepared by the Fort Smith Hunters and Trappers Association (HTA) and the GNWT Department of Renewable Resources, the potential for the commercial development of a bison ranch was identified in the Slave River Lowlands (SRL). The potential scale of the operation includes a 6400 hectare free range with harvesting for either meat or trophy production. Markets for both local consumption and extra-ten-itorial export have been noted.

The Economic Development Agreement (EDA) between the Governments of Canada and the NWT provides for the promotion and development of viable northern enterprises which will enhance the local economy. Under the EDA, the development of indigenous resources is recognized as an important potential contribution to export trade and to promoting economic self-sufficiency of Canada's North. I*

Although the biological potential for a bison ranch has been identified, such a project is still in the preliminary planning stages. The purpose of this study is to provide a rigourous multi-disciplinary analysis of the logistics of bringing a bison ranch into commercial operation at an optimal scale.

The overall study is organized in eight distinct stages as follows:

- I Market Definitions
- II Legal and Regulatory Analysis
- III Production Parameters
- IV Base Case Financial Feasibility
- V Social Cost-Benefit Analysis
- VI Integrated Risk Analysis
- VII Logistical Plan
- VIII Implementation Strategy

The purpose of this report is to summarize the findings of Phases III to VI through an analysis of factors affecting the supply and cost of bison products. These four phases were integrated into one module to reflect the fact that they all have an important bearing on determining the optimal supply and scale of a bison ranching operation.

The previous module, which dealt with the markets and regulatory aspects of bison ranching, concluded that no onerous regulatory and marketing constraints existed to developing a bison ranch. This module more closely investigates the specific design, logistics, costs, and risks associated with bison ranching. Coupled with the market analysis, the results indicate an optimal scale and configuration for an operation in the SRL.

Based on the analyses in this module, it will be determined whether the economics of a commercial scale ranch are sufficiently attractive to proceed with arranging financing and, ultimately, developing such a facility.

1.2 PURPOSE OF SUPPLY ANALYSIS

Given a realistic degree of market penetration, this module concentrates on the technical supply factors and the costs associated with them. An optimal scale is established for which a detailed financial feasibility analysis is conducted. In addition, recognizing the important biological component to this study, a rigourous risk and sensitivity analysis integrating production parameters and economic concerns isundertaken. The purpose of the risk analysis is both to present an assessment of the *prima facie* risks inherent in the project, as well as determining those parameters which are critical to the commercial success of the project.

The results of the assessment of the production parameters represent the required input for conducting a more detailed design of the commercial facility. This design basis is used as a base case for selecting an optimal scale based on market potential and highest long-run average profit. A feasibility analysis is then undertaken to show casMow profiles during both a "developmental" phase as well as a "commercial" phase of production. An integrated economic risk analysis of the optimal case is developed in assessing the production parameters. Finally, the study highlights any direct and indirect social costs and benefits which, although unquantifiable, will arise in the region.

It should be realized that the analysis undertaken herein is based on a long-term *planning* approach. It attempts to provide a configuration for the bison ranch which will accommodate reasonable expectations regarding market penetration, while also providing long-term profit potential in an environment which mitigates risks to the maximum extent feasible. In this regard, the study provides a basis for long-term capital budgetting as well as describing major operational concerns. Actual short-run management decisions may, however, deviate from those postulated in this study as market and supply conditions are noxmally expected to vary from one year to the next.

Given the above, therefore, the scope of this module is essentially to provide the following:

- technical description of an optimal scale bison ranch operation;
- capital and operating cost analysis of this operation;
- estimated degree of technical and economic risks in the operation;
- estimated secondary impacts arising from the operation;
- recommendation regarding the optimal project configuration.

Based on these analyses, the study will provide a recommendation as to whether sufficient economic merit exists to proceed to the final phases of the study.

1.3 METHODOLOGY

The number of alternative configurations for the bison ranching operation are many fold. Therefore, in undertaking the optimization studies, essentially a two-step procedure is adopted:

i) selection of a "Base Case" configuration;
ii) determination of an "Optimal Case" through sensitivity and risk analyses.

The base case scenario represents a plausible technical configuration of the ranch based on preliminary site overviews and considerations of production parameters such as herd growth, carrying capacity, and range management options. The Base Case relies upon informed judgement regarding the production parameters, and is subsequently used as a preliminary design basis for the commercial facility.

A Base Case cost estimate is prepared for the Base Case technical scenario, including estimates of all of the capital and operating costs for the particular configuration. optimization studies respecting the sensitivity of scale then use this Base Case as a starting point. Curve estimates are developed for the various critical cost centres. Sensitivity studies with respect to project scale determine the optimal long-term scale, given the markets available, which maximizes the expected profitability form the ranch. In addition, a development path is defined which shows herd growth and harvest in any given year building up to the long-term steady state conditions.

Finally, the Optimal Case is used as the basis for final facility design and costing, and serves as the target configuration for range management practices. Also, the profitability, risk, and social cost-benefit analyses are based on this Optimal Case configuration.

CHAPTER 2 SITE SELECTION

The Slave River Lowlands have supported free-ranging bison throughout historic times. However, biophysical conditions are highly variable within the Lowlands and only a portion of this region is considered to be good bison range. Consequently, biophysical considerations played an important role in the selection of potential ranch sites. This section of the report briefly describes the biophysical characteristics of the Lowlands and the criteria used in selecting and evaluating potential ranch sites.

2.1 BIOPHYSICAL SETTING

2.1.1 Climate, Soils and Vegetation

The Slave River Lowlands fall within the Great Slave Plains physiographic subregion of the Northwest Territories, as described by Day (1972). The area is characterized by low-lying (maximum elevation of 183 m) flat land, with numerous lakes and abandoned river meander scars scattered throughout. The climate of the region has been described as continental, with irregular extremes in temperature and precipitation (Harris and Carder 1975).

The bedrock of the Lowlands is dominated by Middle Devonian material, and is generally buried deeply below glacial tills and/or lacustrine and alluvial deposits (Rowe 1972). Because of high water table levels and resulting wet conditions, Hurnic Gleysols and Gleysols have developed over the majority (50%) of the area, with weakly developed Regosols (33% of the area) and Brunisols (6% of the area) occurring on better drained sites.

Falling within the Upper Mackenzie section of the Boreal Forest biophysical region, as described by Rowe (1972), the Lowlands are a mosaic of meadows, shrublands and forests. Meadows, dominated by sedges (*Carex* spp.) and reed grasses (*Calamagrostis* spp.), occupy the depressional areas between major river levees and other elevated glacial deposits. Pockets of black spruce (*Picea mariana*) and tamarack (*Larix laricina*) occur sporadically within the meadow communities. Relatively pure or mixed stands of aspen (*Populus tremuloides*), white spruce (*Picea glauca*) and, to a lesser extent, poplar (*Populus balsamifera*) and jack pine (*Pinus banksiana*) develop on better drained sites on the alluvial floodplains and levees bordering the river. Willow-dominated shrublands (*Salix* spp.) generally represent the ectone between meadow and forest cornrnunities.

2.1.2 Status of Bison in the Lowlands

Of the large mammals Occurnng in the Lowlands (i.e., bison, moose, wolf, black bear, and occasionally caribou and white-tailed deer), bison are the most abundant. First noted in the Lowlands in the 1700's (Hearne 1795), bison were apparently extirpated from the region during the 1800's (Hewitt 1921). However, during the 1940's following a series of major fires in adjacent bison ranges, a group of bison moved out of Wood Buffalo National Park and reinvaded the Lowlands, reaching 200 in number by 1949 (Fuller 1950) and up to 2,500 animals by 1962 (Choquette et *af.* 1972). Following a series of anthrax outbreaks in 1962 and 1964 and a major slaughter of bison in a vain attempt to prevent the spread of this disease, the population dropped substantially, but recovered and numbered 2,000 by the early 1970's (Rippin 1971). At that time, a rnajordecline commenced and the population has dropped to its current level of approximately 400 animals (data files, Department of Renewable Resources, Fort Smith).

Bison range in the Lowlands is primarily associated with extensive meadow communities. Animals are currently distributed over much of the region between the Little Buffalo and Talston-Tethul river systems, from the Salt River area on the south to McConnel Island on the north (see Figure 1). All sites evaluated for this study fell within the boundaries of this range.

2.2 CRITERIA FOR THE SELECTION OF POTENTIAL RANCH SITES

Three basic criteria were used in the selection of a site for the proposed Slave River Lowlands (SRL) bison ranch. They were:

1. habitat suitability;
2. logistical considerations; and
3. political considerations.

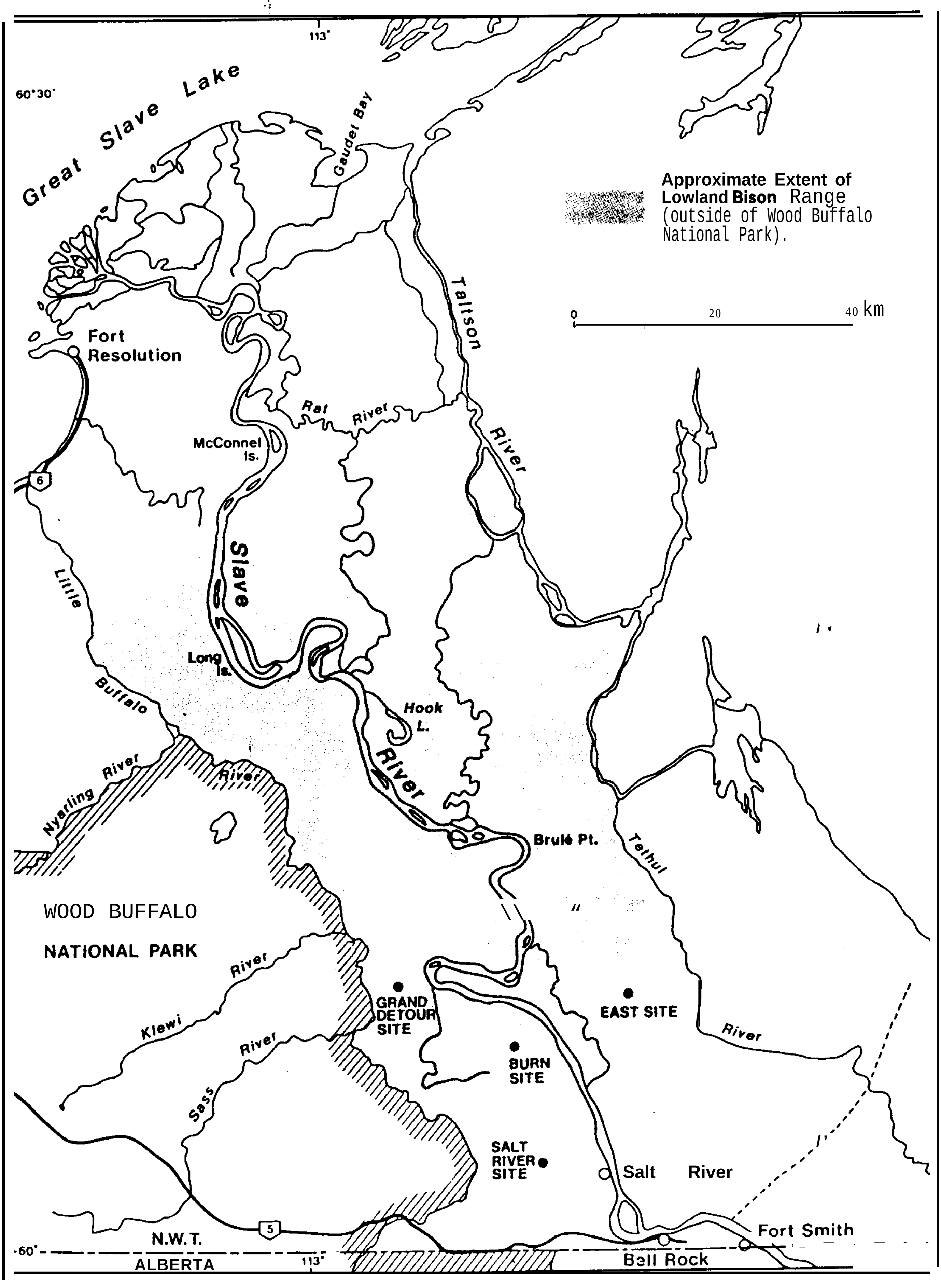


Figure 1. Approximate Location of Bison Range and Potential Ranch Sites in the Slave River Lowlands.

2.2.1 Habitat Suitability

- **Food Requirements**

Within the boreal forest biomes of northern Alberta and southwestern Northwest Territories, bison are highly dependent on meadow and shrub meadow communities associated with deltas, hydric lowlands, and floodplains as a food source, exploiting the herbaceous layer of shrublands and forest communities only to a minor degree. Slough sedge (*Carex atherodes*) and, to a lesser extent, reed grasses are the two major dietary items of bison within the Slave River Lowlands. Reynolds et al. (1978) found that these food items comprised 92% of the bison's spring diet, 70% of the summer diet, 79% of the fall diet, and 77% of the winter diet. Other noticeable dietary items included beaked sedge (*Carex rostrata;* up to 17% of diet,), willows (*Salix* spp.; up to 8% of diet), water sedge (*Carex aquatilis*; up to 3% of diet), avens (*Geum alleppicum;* up to 4% of diet), and baltic rush (*Juncus balticus;* up to 490 of diet).

Within the Lowlands, bison prefer wet meadow communities dominated by sedges over reed grass-dominated dry meadow communities as a year-round food source, although meadows with excessive standing water are likely avoided in spring and summer. This preference maybe in response to the early growth of sedges in spring and their relatively high overwintering nutritional value, relative to grasses (Reynolds *et af.* 1978). To optimize bison production in the Lowlands, it has been recommended that management be ".. orientated toward wet meadows because of bison feeding preferences and higher vegetative productiveness of wet habitat" (Reynolds et *al.* 1978).

- **Cover Requirements**

The cover requirements of bison vary on a seasonal basis. For most of the snow free months, bison in the Lowlands occupy relatively expansive meadow communities with little available cover. During this period, it would appear that bison are seldom thermally stressed, seeking shade on only the hottest of days, and that they rely on their large size, mobility and gregarious nature, rather than cover, to minimize attack from potential predators. In addition, insect harassment is frequently low on these meadows, where winds are most persistent. In winter, the cover requirements of bison appear to become more pronounced. Reynolds *et al.* (1978) reported that bison wintering in the Lowlands feed in small meadow habitats, and rest and ruminate in forests. They tend to follow creek bottoms, gullies and small meadows during their feeding activity throughout the winter months. A similar pattern of habitat selection seems to be followed in the Peace-Athabasca Delta, although to a lesser degree. The majority of the Delta herd summers on the expansive Sweetgrass meadows, dispersing south and east to the Hilda and Mamawi Lake areas during the winter where shrub thickets and fringes tend to be more interspersed among the meadow communities. Within such areas, the bison feed primarily along the edges of meadows, using willows or other forest trees as cover (Lamoureux et *al.* 1982; Eccles et *al.* 1986).

Foraging and bedding in the proximity of cover offers obvious thermal advantages to bison. Although extreme cold seems to have little effect on bison, the combined effects of cold and wind presents a discomfort to these animals, and shelter is generally sought. However, more importantly, the wind breaking characteristics of shrub or forest communities eliminates or greatly reduces the degree of wind packing on the snow cover. Reynolds et al. (1978) found that snow in large, open meadows "would support the weight of a man but snow in forest and sheltered meadows would not. Therefore, snow density and hardness would present less of a problem to foraging bison on smaller sheltered meadows". Fuller (1962) also suggested that snow compaction "is rapid on wind-blown plains, lakes and rivers, but is entirely lacking in the shelter of the forests".

- <u>Reproductive Cover</u>

Much of the bison research conducted within northern Alberta and southern Northwest Territories suggests that bison cover requirements during the calving period are minimal. On the Peace-Athabasca Delta, calves are regularly dropped in expansive meadows among large numbers of foraging animals (McCourt 1970), although it is possible that cows briefly separate from such herds during actual parturition (Egerton 1962; Meagher, in Schmidt and Gilbert (eds.) 1978). Similarly, the majority of calving immediately north of the Delta occurs in large meadow complexes between the Hay Camp and Darough Creek meadows and the Raup Lake meadows. Data summaries by Collingwood (1977) suggest the occasional use of reproductive cover by bison. For example, aerial surveys conducted during the latter half of May (i.e., calving period) in 1976 and 1977 observed O. 1% and 39.4%, respectively, of the total number of sighted animals in "shrubby" habitats, indicating high yearly variation in use of potential calving cover. Egerton (1962), in her bison study at Waterton Lakes National Park, reported that 57% of observed calving females dropped calves in the shelter of a clump of trees or in thick willow brush, while the remaining 43$%0 calved in the open.

These studies suggest that specific calving cover is not required by bison, but that shrub or forest cover will be used if convenient. Although not discussed specifically in the literature, it would also seem probable that dry ground is a prerequisite for successful calving to prevent postpartum chilling of calves and potential respiratory disorders.

- <u>Summary</u>

Based on the above information, sites selected as potential game ranches had to meet the following habitat criteria:

1. meadows or shrub meadow communities, particularly those dominated by sedges, had to be the major vegetative cover type;
2. forest or shrub cover had to be available on-site, preferably interspersed among the meadow communities to reduce wind packing of snow during winter months;
3. dry areas had to be available on-site during the spring months (mid-April to mid-June) for calving purposes, preferably interspersed among the meadow communities to offer foraging and reproductive habitat in close proximity.

2.2.2 Logistical Considerations

Logistical issues considered during the selection of potential ranch sites included:

- land tenure:

- accessibility; and
- geotechnical suitability.

- Land Tenure

As previously discussed by Ruitenbeek *et al.* (1985), theproposed bison ranch ' would, in all probability, have to be located on crown land leased by the H.T.A. or by the corporation formed for ranch management. This particular land tenure arrangement posed no serious problem to the selection of potential ranch sites since the Lowlands fall entirely under crown land jurisdiction. However, because of the agricultural potential of this area, the currently imposed federal land freeze on crown land capabk of agricultural development would have to be modified to permit the ranch's development.

- Accessibility

The logistical costs of operating a ranch accessible only by aircraft for muchof the year would be prohibitively high. Consequently, potential ranch sites were located moderately close to exiting trails, roads and/or the Slave River to ensure that costs associated with access development could be minimized. A trail/road which is navigable throughout the winter and during the drier summer months, given adequate maintenance, currently extends from Salt River north to the Grand Detour, paralleling the west bank of the river. This road could serve as a major access corridor to ranch sites on the west side of the river, or to a staging area for sites located east of the Slave River. During the open water months, the river offers an alternative travel corridor, being deep enough to permit the passage of barge traffic.

From another perspective, existing, well developed access to the site also increases the potential for trespassing, vandalism and even poaching. Consequently, ranch locations and configurations which would permit the perimeter fence to be several km removed from well travelled public road systems were preferred. With such a layout, a single, gated road could be used to limit uncontrolled access to the site.

- <u>Geotechnical Suitability</u>

Both the floodplain and adjacent lowlands of the Slave River system demonstrate minimal topographic relief. While this flat topography minimizes many of the construction problems associated with facility developments in more undulating terrain, it must be recognized that the Lowlands fall within the region of discontinuous permafrost and, in the absence of relief, excessive moisture and ice retention in the soil is a common feature of much of the area. This particular characteristic poses engineering problems for facility development.

In general, vegetation cover types are good site-specific indicators of the moisture and ice content of soils, and active layer depths (i.e., zone of seasonal freeze/thaw cycles). In the Lowlands, the following indicators can be applied.

- Sedge meadows are generally associated with hydric soil conditions, segregated ice (i.e., ice lenses) within the soil, and a thin active layer (i.e., approximately 0.5 m).

- White spruce or aspen forests develop on moderate to well drained soils, frequently on river or stream levees. Such soils have a low ice/moisture content and a relatively deep active layer (i.e., approximately 1.0 to 1.5 m).

- Dense willow shrublands represent soil, moisture and ice conditions which fall between the extremes of meadow vs forest communities.

From an engineering perspective, soils with a thin active layer, high moisture content, and segregated ice present serious construction problems for roads, fences or buildings. Soil bearing capacity is inadequate to support conventional footings and differential frost heaving and thaw settlement can cause the rapid deterioration of road beds and fence lines. Conversely, freeze-thaw processes and soil instability are greatly reduced in well-drained soils, and the deeper active layer provides improved structural conditions for footings, fence-post holes, and road beds.

During the selection of potential ranch sites, the geotechnical suitability of soil conditions, as indicated by vegetative cover, was used as an evaluation criteria. In general, the interspersion or juxtaposition of meadow communities and shrub/forest cover was considered essential to ensure that suitable construction scenarios for the ranch could be developed which avoided poor soil conditions.

2.2.3 Political Considerations

Although the ranch is to be located on crown land, it is very probable that certain individuals, particularly hunters and trappers will voice strong opposition to the project if areas of traditional use are alienated by its development. While the majority of this potential opposition cannot be identified at this time, it is recognized that the northern portion of the Lowlands (i.e., from Hook Lake to the Slave River Delta) is considered to fall under the trapping jurisdiction of the Ft. Resolution H.T.A. Consequently, ranch sites were only seleeted south of Hook Lake, within the trapping jurisdiction of the Fort Smith H.T.A.

2.2.4 Potential Sites

Based on the criteria discussed above, four potential ranch sites were initially identified on 1:50,000 scale air photos of the Lowlands (see Figure 1). These are referred to as:

- Salt River site;
- Bum site;
- Grand Detour site;
- East site.

A reconnaissance flight over all four areas was undertaken in April 1985 to permit further evaluations. In May 1985, unusually high flood water levels occurred in the Lowlands and a second flight was undertaken to record the extent of the flooding at the sites, particularly the Grand Detour and East sites. A brief summary of the findings of these flights is presented below.

- Salt River Site

This site is situated approximately 10 km west of the settlement of Salt River, located at the junction of a large meadow community and an extensive burn which stretehes east to the Slave River (see Photos 1 and 2). From a habitat perspective, the site does not have an ideal interspersion of food and cover

Photo 1 Salt River Site, looking north from existing road and fence network.

Photo 2 Salt River Site, east of Photo 1. An extensive burn, with remnant stands of white spruce and aspen dominate this region.

resources. The meadow, although likely supporting productive sedge communities in places, does contain large saline areas which may produce less palatable forage species. In addition, because of its expansive nature, much of this meadow may develop dense, wind-packed snow during mid to late winter, resulting in difficult foraging conditions. The adjacent burn area, with its remnant spruce and aspen stands, offers good thermal cover and relatively dry ground for calving purposes. However, foraging areas are limited to the few stream channels and meanders scrolls scattered throughout this bum, some of which are saline.

Access to the site is currently well developed, with roads leading to the area from both the Ft. Smith-Hay River highway and the settlement of Salt River. Situated less than 30 km from Ft. Smith, the potential for unwanted visitors and even poaching would be relatively high.

From a geotechnical perspective, the site would appear to be suitable for development, particularly in light of the successful road and fence construction which has been undertaken in past (see Photo 1). However, there are therrnokarst features (i.e. sink holes) immediately south of the site, suggesting that localized pockets of permafrost and hydric soils maybe encountered along any fenceline configuration developed for this ranch.

- Burn Site

The Bum site is located immediately west of the Slave River, approximately 10 km downstream from the settlement of Salt River. Occurnng on moderately well drained floodplain deposits, this site, as the name implies, is a large bum which, prior to the fire, supported a white spruce-aspen mixed forest stand interspersed with sedge-dominated meadows and abandoned river meander scrolls. Although some remnant spruce stands are still present, regenerating willows and aspen now dominate most of the previously forested areas and appear to be encroaching into many of the meadows (see Photo 3). While cover and food resources are adequately interspersed, productive foraging areas are unquestionably limiting, and range improvement (i.e. burning, clearing) would be required to produce a more favorable ratio of foraging to cover areas.

Photo 3 Bum Site, looking west from Slave River.

From a logistical perspective, this site is suitable for development. A single access road now leads to the site from Salt River and, with only minor alterations, could be upgraded to an all weather road (See Photo 4). This road could be easily monitored to control poaching and vandalism. Geotechnically, soils are moderately well drained and would pose few problems for road, fence or building development

- Grand Detour Site

The Grand Detour site is situated west of the Slave River, approximately 45 km northwest of the settlement of Salt River. Similar to the Salt River site, this site would encompass an expansive meadow community bordered on the east by a large bum area (see Photo 5). Based on limited ground reconnaissance and sampling, the meadow supports a productive sedge community, with reed grasses occurring to a lesser degree, and would bean excellent forage source for bison. However, because shrub/tree cover is almost entirely lacking for most of the meadow, wind-packing of snow during mid to late winter may present foraging problems for the animals. The bum area bordering the meadow on the east supports regenerating willows and aspen, with remnant stands of white spruce, and offers some thermal cover. However, the forage resources within the bum are extremely limiting, and much of this area would be unattractive to bison.

Of greater concern from a habitat perspective is the vulnerability of this site to spring flooding. In particularly high water years (eg. May 1985), flood waters from the Little Buffalo River can inundate the large meadow community and adjacent bum area to be used by this site, leaving few dry areas for the resting and calving activities of the bison (see Photos 6 and 7). Such extremely wet conditions during May could result in serious calving losses.

Logistically, the Grand Detour site is only moderately well suited to development. Accessed by the same winter road as the Bum site, it is more than four times the distance from an existing all weather road, a factor which would greatly increase road maintenance costs. Although moderately well-drained, floodplain deposits dominate much of the bum area, they are prone to occasional flooding, as are the poorly drained organic soils of the adjacent

Photo4 Looking south from Burn Site, along existing access road.

Photo 5 Grand Detour Site, looking southeast towards the Slave River.

Photo 6 Flooding of the Grand Detour Site, May 1985.

Photo 7 Bison utilizing "island" of dry ground on the Grand Detour Site, May 1985.

meadow communities, raising problems for fenceline, road or facility developments.

- **East Site**

As the name implies, this site is situated east of the river, approximately 30 km north of the settlement of Salt River. From a habitat perspective, this site offers a mosaic of sedgedominated meadow and shrub meadow communities, willow shrublands, and wetlands (see Photo 8), with spruce-aspen mixed forest occurring sporadically. Consequently, food and cover resources are well interspersed, and wind-packing of snow should not present serious foraging problems for most of the site. During the high water levels of May 1985, flooding of some of the meadow communities did occur, similar to the Grand Detour site. However, the availability of dry meadow and shrub meadow areas was much more extensive than in the Grand Detour site (see Photos 9 and 10, taken just west of the proposed ranch site), and calving problems in high water years should not be serious.

Logistically, this site is moderately well suited for ranch development. The winter road which accesses the Bum and Grand Detour sites would also function as the travel route to a staging area for this site on the west side of the river. While its east shore location will discourage unwanted visitors to the ranch, it will also make legitimate travel to the site more difficult. An ice bridge would be needed for winter travel, with a small-scale barging operation being a possible means of cross-river travel during the open water months. The development of approximately 10 km of new road from the east shore of the river to the ranch would also be required. Geotechnically, the on-site conditions are favorable for construction. Both the access road and buildings could be located on moderately well drained floodplain deposits currently supporting mixed forests or shrublands. Because of the interspersion of shrub thickets with meadows, the fenceline could be routed to intercept more favorable soil conditions, avoiding large open stretches of wet, sedge meadow areas wherever possible.

Photo 8 Potential ranch site east of the She River.

Photo 9 Flooded meadow communities just west of potential ranch site, May 1985.

Photo 10. Dry areas just west of potential ranch site, May 1985.

2.2.5 Preferred Site Selection

Based on the site conditions discussed above, each site was evaluated on its suitability for ranch development. Table 2.1 lists those criteria used in the evaluation in addition to the scores assigned to each site (i.e., l=poor; 2=fair; 3=good). It should be noted that land tenure and political issues were not included in the evaluation, since all sites were considered comparable in these respects.

The East site scored highest in the evaluation, merging high habitat suitability with acceptable logistics. Consequently, detailed economic, biological and geotechnical assessments proceeded for this site only.

Table 2.1. Evaluation of Potential Ranch Sites*

		Salt River Site	Bum Site	Grand Detour Site	East Site
HABITAT FACTORS	Availability of Food	2**	1	3	3
	Availability of Cover	2***	2***	2***	3
	Food/cover Interspersion	1	2	1	3
	Vulnerability to Flooding	3	3	1	2
LOGISTICAL FACTORS	Current Access	3	2	2	1
	Potential for Controlling Access	1	2	2	3
	Geotechnical Suitability	2	3	1	2
	Total Score	14	15	12	17

* Scoring System: I=Poor; 2=fair; 3=good
** Possible salinity problems
*** Bum areas are considered to be less than optimal cover.

CHAPTER 3 PRODUCTION PARAMETERS

3.1 STOCK SELECTION

Because wood bison attain adult weights which are 15-20% higher than those of plains bison, this larger subspecies is the preferred ranch stock foranorthem ranching ‘ operation. However, its endangered status may resultin marketing problems outside of the Northwest Territories and plains bison or hybrids may have to be utilized to avoid such problems. Plains bison are available from any one of a large number of commercial bison operations currently present in western Canada.

Given the probable cash flow limitations of the ranch early in its development, it has been assumed that only 100 animals would be purchased as starter stock, and this figure has been used for the purposes of projecting herd growth. The’composition of this starter stock has been arbitrarily set at 85 females (ranging in ages from one to three) and 15 young but sexually mature bulls (ages three to four). Costs associated with the purchase and transport of this stock are presented in later sections.

3.2 CARRYING CAPACITY ESTIMATES

Based on a preliminary lay-out design, the proposed ranch site would cover 6750 ha (see Figure 2), slightly larger than the 6400 ha operation proposed in pre-feasibility studies by the Fort Smith H.T.A. and the GNWT Department of Renewable Resources. To permit forage yield and associated stocking rates to be estimated for the proposed ranch site, an assessment of vegetative cover and forage productivity was undertaken. Since detailed botanical measurements were not within the’scope of this study, a simple cover typing system for the ranch was developed based on a brief field reconnaissance in July 1985, air photo interpretation and a review of previous botanical work done in the area (Reynolds et *al.* 1978; Jalkotzy and Van Camp 1980; Eccles et *al.* 1986). Five broad cover types were recognized for the study area and delineated on a 1:50 000 scale air photo mosaic (see Figure 3). Their areas were determined using a computerized digitizing pad adjusted to the scale of the mosaic. The cover types included:

- Willow-Graminoid Mosaic (W-G);
- Willow Shrubland (W);
- Grarninoid Meadow (G);

- Wetland (WT): and
- Mixed Forest (NE).

In July 1985, a series of 1 m^2 plots were clipped of vegetation in a representative Graminoid Meadow and Willow-Graminoid Mosaic to permit yield calculations and nutritional analyses of potential forage species to be undertaken. ·

3.2.1 Willow-Graminoid Mosaic (W-G)

This mosaic covers 56.4% of the ranch site, or 3807 ha. Comparable to the Low ShrubberyWet Meadow Mosaic described by Jalkotzy and Van Camp (1980), this cover type is comprised of islands of shrubland interspersed among small meadow communities (see Photo 11). Based on a series of near-vertical 35 mm photos taken from an above--ground altitude of 150 m, the average ratio of meadow cover to shrub cover was calculated at 2: 1, although this value was quite variable from site to site.

Botanically, the shrubland component of the mosaic is dominated by willows ***(Salix*** spp.) less than 5 m in height, and supports a herbaceous understory of reed grasses ***(Calamagrostis*** spp.) and sedges ***(Carex*** spp.) to a lesser extent. Baltic rush ***(Juncus balticus)*** and horsetails ***(Equisetum*** spp.) are also abundant locally. Based on measurements from clipped sample plots, forage yield within the shrubdom.inated areas averaged 586 kg/ha (S.D. = 259) in1985.

The meadow component of the mosaic is more variable in botanical composition, being influenced by moisture conditions. Wetter areas (i.e. standing water depths of >5 cm) are dominated by dense stands of slough sedge ***(Carex atherodes,*** see Photo 12), with reed grass being of secondary importance, while drier sites demonstrate a reversal in this pattern. Because of the range of botanical dominance occurring in the area, no attempt was made to strain the meadows into wet vs. dry communities, and a mean yield value of 2844 kg/ha (S.D. = 1083) was calculated for the meadows as a whole. Based on the ratio of meadow to shrubland cover and their respective forage yields, forage production for this mosaic was estimated at 2099 kg/ha.

Willow-Graminoid Mosaic within ranch site.

Dense sedge stands within the Willow-Graminoid Mosaic.

3.2.2 Willow Shrubland (W)

Comprising 22% of the ranch site or 1478 ha, this cover type is comparable to the Low Shrubbery described by Jalkotzy and Van Camp (1980). The shrub strata is dominated by willows, with scattered occurrences of alder *(Alnus* spp.), aspen *(Popufus tremuloides)* and regenerating white spruce *(Picea glauca)*, while the understory is dominated by sedges, reed grass and, to a lesser extent, rushes and horsetail. Scattered within the shrubland cover are small meadows of comparable botanical composition to the meadow communities of the mosaic discussed above. However, the average ratio of meadow to shrubland cover drops to 1:6, a value which was again derived from 35 mm aerial shots of the cover type. By applying the same forage yield estimates determined for the mosaic above to this ratio, the overall productivity of this cover type was calculated to be 902 kg/ha.

3.2.3 Graminoid Meadow (G)

Comprising 18.2% of the ranch site or 1229 ha, this community is likely a mosaic of the Wet Meadow and Dry Prairie types described by Jalkotzy and Van Camp (1980). However, because these two meadow types are not easily discernible from air photos available for the area, they have been combined as a single entity. Willow-dominated shrubland pockets are a third component of this cover type, representing, on average, 13% of the ground cover (see Photo 13).

The Graminoid Meadow sampled during the July field reconnaissance was relatively dry, and supported a reed grass-dominated community in all but one of the 12 sampling plots. Slough sedge (*Carex dun-odes)* and beaked sedge (C. *rostrata)* were the next most dominant graminoids. Reynolds *et af.* (1978) found comparable botanical conditions in Dry Meadows of the Hook Lake area, where reed grass comprised 64% of the available forage by weight, and rushes and sedges were of lesser importance (13% and 5%, respectively). Conversely, Wet Meadows, which have water tables at or near the surface throughout the growing season, are dominated by slough sedge (49% by weight), reed grass (18% by weight), and beaked sedge (17% by weight) (Reynolds et *af.* 1978).

Based on measurements from clipped sample plots, forage yield averaged 2305 kg/ha in 1985, a value not unlike that of Reynolds *et al.* (1978) (2680 and 1880 kg/ha in 1974 and 1975, respectively) for Dry Meadow communities. Utilizing the

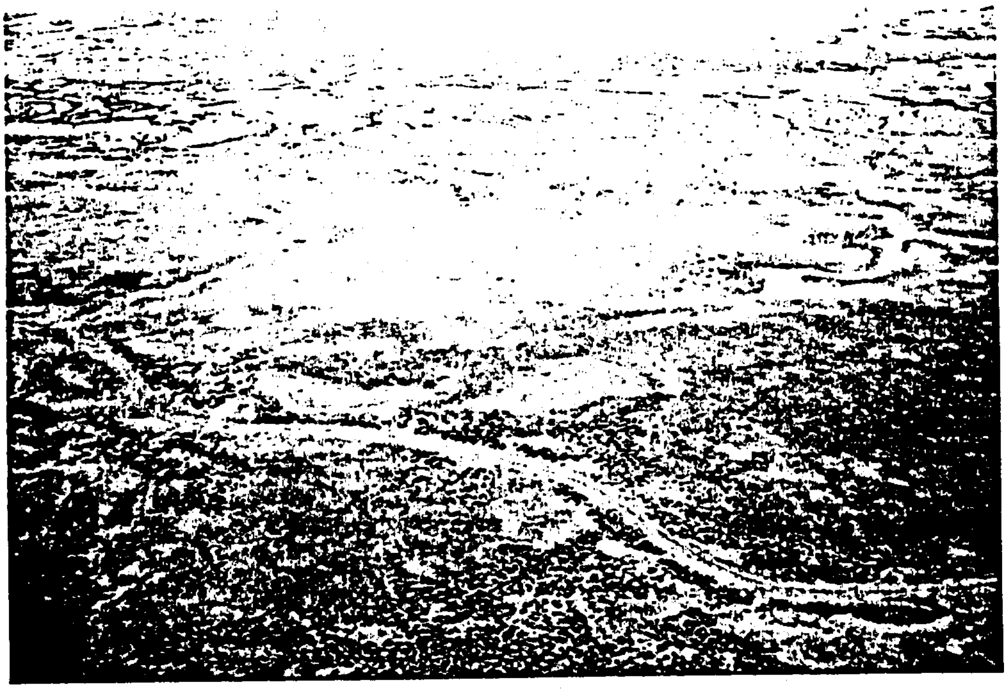


Photo 13 Graminoid Meadow community, with Willow-Graminoid Mosaic in the background.

ratio of meadow to shrubland cover and the forage yield values of both, the overall productivity of the cover type was calculated to be 2082 kg/ha. However, this should be treated as a conservative value for two major reasons:

- Wet meadow communities almost certainly occur within this cover type, although they were not sampled;
- Wet meadow communities are almost twice as productive as dry meadows (4480 and 4320 kg/ha in 1974 and 1975, respectively [Reynolds *et al.* 1978])

3.2.4 Wetlands (WT)

Wetlands comprise 1.9% of the ranch site, or 128 ha. Although not sampled directly, these wetlands are likely characterized by highly variable water levels, both on a seasonal and yearly basis, with sedges dominating much of their perimeters. The more persistent wetlands may support such emergents as *Glyceria* spp., link (*Scholochloa festucacea),* andeven cattail (*Typha latifolia*) and bulrush (*Scirpus* spp.). Forthe purposes of estimating forage production, it was assumed that half of these wetlands supportedopen water with little foraging potential. The remaining emergent and seasonally drier portions of the wetlands were considered to have comparable forage yields to the meadow communities of the Willow-Graminoid Mosaic cover type discussed above. Consequently, per ha yields were estimated at 1422 kg/ha.

3.2.5 Mixed Forest (MF)

Comprising 1.6% of the ranch site or 108 ha, this cover type occurs primarily in the southeast comer of the ranch. Its overstory is dominated by aspen, with white spruce being of secondary importance (see Photo 14). The shrub strata generally supports a moderately open stand of dogwood (*Cornus stolonifera),* lowbush cranberry *(Viburnum edule*), *rose (Rosa acicularis*) and regenerating white spruce, while the ground strata is dominated by herbs and moss. Because of limited gra@noid production in this cover type (i.e. cl% ground cover IEccles et al. 1986]), forage yield has been considered negligible.

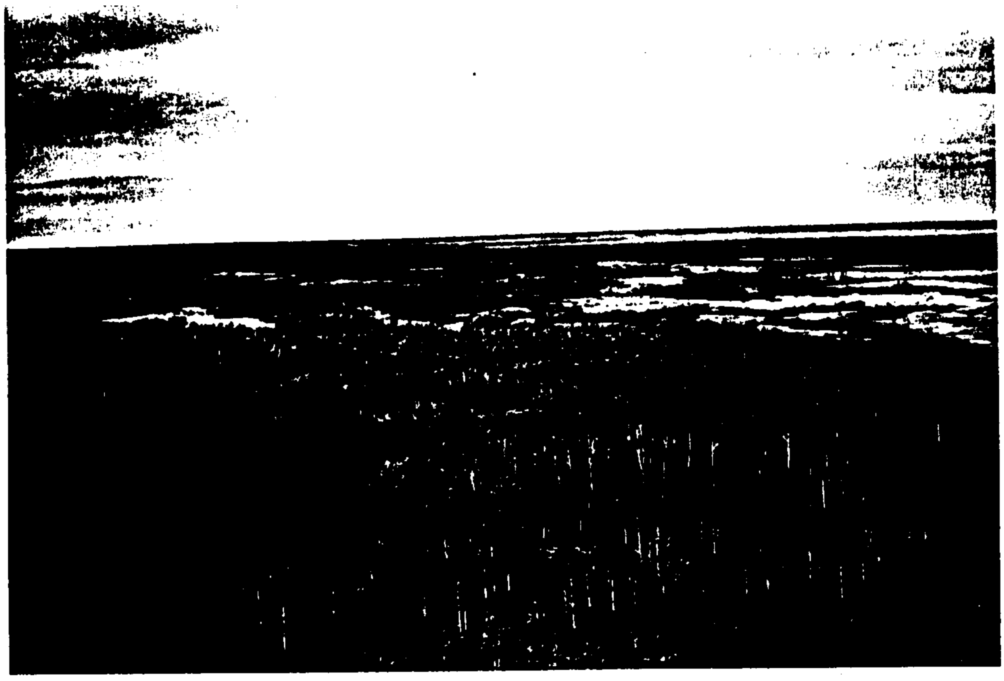


Photo 14 Mixed Forest Community, with Willow Shrubland, Willow-Graminoid Mosaic and Wetlands in the background.

3.2.6 Total Forage Yield/Carrying Capacity Estimates for the Ranch

Table 3.1 summarizes the aerial extent and estimated productivity of each of the cover types. Using these figures, the total forage yield for the ranch in 1985 was estimated to be 12,064,843 kg (dry weight). This is considered to be a conservative estimate for two major reasons:

- highly productive wet meadows were not encountered during the sampling program but were, in all probability, present on site (see discussion in Section 2.3.2.3); and

- yield estimates were based on a single clipping completed in mid-summer. Since clipped plants were capable of growth for at least an additional month, more forage would have been available by the end of the growing season.

In any managed grazing system, the total forage produced on a given range is not considered to be entirely available to the grazing animal. Consumption of the majority of above-ground growth by the animal can prevent seed production and, late in the growing season, will prevent nutrient replenishment in the plant's root reserves, thus retarding plant growth in the following spring. Consequently, to ensure that grazing pressures do not impair range vigour and quality, guidelines have been established for safe levels of forage utilization. Generally, 40 to 50% of total forage yield is considered to be available to grazing animals. Reynolds et *al.* (1978) stated that " ...50 percent utilization of dry meadow herbage could take place without serious darnage to forage plants", but suggested that only 33% of wet meadow forage was available for grazing. Because the ranch site is comprised of a composite of dry and relatively wet meadow communities, a utilization value of 40% has been selected for this study. Consequently, the available forage yield for the ranch was estimated to be 4,825,937 kg in 1985.

Little detailed information is currently available on the nutritional requirements of bison, since these animals have only recently been raised for commercial meat production. However, bioenergetically, they are similar to domestic cattle, and the well-researched food and energy requirements of cattle can be applied to bison with some degree of confidence. One mature range cow (454 kg, with or without a weaned calf at her side) requires 11.8 kg of dry matter per day, or 4307 kg per year (Smoliak et *al.* 1976). Dividing this requirement into the estimated available forage yield of the ranch produces a stocking rate

Table 3.1. Summary of Forage Yield Estimates for the Proposed Bison Ranch

Cover Types	Area	Forage Yield (kg/ha)	Total Annual Yield (kg)
Willow-Graminoid Mosaic (W-G)	3807	2099	7,990,893
Willow Shrubland (W)	1478	902	1,333,156
Graminoid Meadow (G)	1229	2082	2,558,778
Wetland (WT)	128	1422	182,016
Mixed Forest (MF)	108	0	0
TOTAL	6750	.-	12,064,843

of 1120 adult bison. Assuming that approximately 500 calves would be produced annually by such a herd and that they would be maintained primarily by the forage resources of the ranch up to the time of their slaughter (i.e., 18 months of age), the core adult herd (animals 3+ years old) would have to be reduced to less than 700 animals to prevent excessive stocking rates from developing.

3.3 ESTIMATES OF HERD PRODUCTIVITY AND GROWTH

It is anticipated that 100 bison would be purchased as starting stock, consisting of 85 females and 15 males. The productivity of such a herd is difficult to predict, since reproductive success will be dependent on range and weather conditions and the effectiveness of disease and parasitic control. To establish a productivityvalue from which to make herd growth projections for this study, population information was collected from several northern commercial and non-commercial bison herds (see Table 3.2). Values for the Wood Buffalo National Park and Lowlands herds have not been included in the table because of the severe disease problems plaguing these animals, and their unusually low productivity levels (i.e., <31 calves/100 cows).

Elk Island National Park has the most extensive data set on herd productivity of the non-commercial herds reviewed. From 1975-82, average production of the Park's wood bison herd exceeded 75 calves/100 cows (3+ years of age), dropping to 47 and 56 calves/100 cows in 1985 and 1986, respectively. In the plains bison herd, production averaged 60 or more calves/100 cows (3+ years of age) from 1965-75, but chopped below 50 calves/100 cows in the early 1980's. Following a reduction of cows in the herd, productivity exceeded 85 calves/100 cows in each of the last three years. Reasons for the recent drops in productivity in both herds are not known, although an age structure problem (i.e., excessive numbers of older [20+ years of age] cows) and competition with other ungulates for forage resources have been cited as possible factors (Wes Olson [Elk IslandNational Park Warden]; pers. comm.). It would also appear that productivity in the Park is density-dependent, since the lowest calving rates appear to occur when cow numbers are highest. The Mackenzie Bison Sanctuary herd has demonstrated moderately high productivity in recent years, with calving rates in excess of 60 calves/100 cows (2+ years of age). Considering that a sizeable proportion of the cows (10-15%) tallied during surveys were non-productive 2 year-olds, the productivity of sexually mature cows (3 years and older) would likely approach 70 calves/100 cows. It is also probable that some calves succumbed to pre@ion or physiological complications at or shortly after birth, prior

Table 3.2 Productivity Levels of Several Northern Bison Herds

Bison Herd	Subspecies	Year	No. of cows	Caking Success (Calves/100 cows)	Calf Survival (to 1 year)	Major Cause of Mortality	Cow to Bull RMio	Data Source
1) **Non-Commercial**								
Elk Island National Park	wood	1984 1985	80 82	54[2] 41[2]	N/A N/A	Abandonment snd Coyote predation	N/A 2.3:1	Wes Olson, Elk Island National Park
Elk Island National Park	Plains	Data not available at this time						
Mackenzie Bison Ranch	wood	1985 1986	400450 400-4s0	61[1] 61[1]	so% 50%	Predation Predation	50:50 50:50	Cmm Gates, Regional Biologist for G.N.W.T., Ft. Smith
Assumption	wood	1984 1985	14 16	50[1] 61	-70% 100%	unknown	47:53 47:53	Bob McFetridge (Habitat Biologist) and Gerry Thompson (Director): Fish and Wildlife Division, Peace River
2) **Commercial**								
Bezanson (Adams Ranch) Herd 1	Plains	1985 1986	200 200	40[2] 80[2]	>98% >98%	---	N/A .7:1	Dan Patton, Marketing Manager, Adsms Rsnch
Herd 2	Plains	1985 1986	135 175	75[2] ~90[2]	>98% >98%	---	10:1 10:1	
Held 3	Plains	1985 1986	104-150 140-140	-s0 - W	>98% >98%	---	10:1 10:1	
Kikano Rsncb	Plains	Nw. 1984 Jan. 1986	45 45	33[1] 29[1]	N/A N/A		51:49 N/A	Dabbs Environmental services and LGL Ltd. (1984) Gary Lyncyh, Biologist, Fish and Wildlife Division

[1] calving success for cows 2 yeas snd older
[2] calving success for cows 3 yeua and older

to the calving surveys, and that actual productivity would be even higher. In the Assumption area where calving success has been 10W, there is some concern that poor forage resources are limiting productivity, and a winter supplemental feeding program is currently being employed. In addition, it has been suggested that flooding of the range in the spring of 1984 resulted in high early calf mortality and the subsequent low calf crop (Bob McFetridge, Alberta Fish and Wildlife Division, pers. comm.).

Known calf survival (i.e., proportion of calves surviving from post-calving surveys [summer] to late winter surveys) is variable for the free-ranging herds, remaining at or near the **50%** level for the Mackenzie Bison Sanctuary where wolf predation is **prevalent,** and increasing to **70+%** in the Assumption herd. Data on calf survivai in Elk Island National Park was not available at the time of this report's preparation.

In the commercial herds, productivity is variable in spite of more intensive management practices. At Kikano, productivity has remained below 50% while the South Calling Ranch (not listed on Table 3.2) has achieved slightly higher levels (50%; L. Renecker **[University** of Alberta], pers. comm.). The Adams ranch, one of the **larger** and **more** progressive *operations,* has recently increased the productivity of its sexually mat&e cows (3+ years of age) to more than 90% in two of their three herds. Calf survival in commercial herds is high (>98%) because of predator controls and the availability of veterinary care.

For the purposes of projecting herd growth rates and sustained yield for this study, the SRL bison ranch is considered to represent ranching conditions between the more intensively managed commercial operations and the unmanaged or lightly managed non-commercial herds. Consequently, calving success of sexually mature cows (3+ years of age) has been projected at 80%. Given the recommended management scheme proposed for the calves in Chapter 5, (i.e., segregation from adults at 5 months of age and supplemental **feeding** during winter), calf survival is expected to be high and has been set at **90%.**

As previously discussed, the starter stock of 100 animals would be comprised of 85 cows and 15 bulls, resulting in a cow to **bull** ratio of 5.7:1. This ratio would be maintained in the herd for production purposes. Although this represents a higher proportion of bulls than that utilized in some Alberta commercial operations (cow to bull ratio of 7:1 to 10:1; Dan Patton [Adams Ranch]; pers. comm.), it is viewed as a necessary precautionary measure to ensure adequate female servicing in **the free ranging** system of **the** SRL ranch, where cows may be dispersed in small segregated **groups. Increasing** bull numbers further may lead to higher levels of male dominance disputes during the rutting period and reduced levels of female servicing.

The longevity of productive animals has also been considered for herd growth ‘ projections. Bulls in commercial operations are known to be capable of breeding at the age of two, but are often rejected by adult cows (Jennings and Hebbring 1983). They become dependable breeders at three and remain productive into their 20’s, although many ranchers prefer to retire bulls in their prime (Jennings and Hebbring 1983). Cows generally commence breeding at two and, hence, produce calves in their third year. Although they continue to produce into their 20’s, they are frequently removed from production in commercial operations after the age of 12 (e.g., Adams Ranch **[Dan** Patton, **pers. comm.]).**

In Table 3.3, population projections have been provided for the herd during its gmvthphase. Assumptions adopted for these projections have been **summarized** below:

- projections are based on **maximizing** meat production
- projections **are** based on October counts, prior to harvesting
- the starter stock would consist of 15 males (3 to 4 years of age), 29 three year-old females, 28 two year-old females, and 28 yearling females
- the starter stock would be transported to the ranch in March, prior to the calving season
- the starter stock would produce 26 calves during the initial calving season
- calving success of mature females (3+ years of age) in subsequent years would be ***80%0***
- ***53%*** of calves would be males (Fuller 1962)
- **calf survival** to yearling age **class** would be 90%
- survival **of all remaining** age classes would be 98%
- all females would be harvested at 13 **years** of age
- a female to male ratio of 5.7:1 would be maintained (This ratio pertains only to **mature *[3+*** years of age] animals.)
- the desired adult stocking rate for the ranch would be 600 females and 105 males
- the maximurn ovenvintering herd size (including immature animals) would not exceed 1400 animals

Table 3.3. Herd Growth

	Main Herd									Surplus Herd					
Year	Mature Females (3+ years)	2 year old Females	Yearling Females	Female Calves	Male Calves	Yearling Males	2 year old Males	Mature Males (3+ years)	Total Herd Size	Surplus Yearling Males	Surplus Males (2-12 years)	Surplus Males (12+ years)	Surplus Yearling Females	Surplus Females (12+ years)	Total* Surplus Herd
1	29	28	28	12	14	–	–	15	126	–	–	–	–	–	–
2	56	28	11	21	24	2	–	15	157	11			–	–	11
3	82	11	10	31	35	3	2	15	109	19	11	–	–	–	30
4	90	19	28	34	38	4	3	16	232	27	29	–	–	–	56
5	106	28	31	40	45	6	4	19	279	28	55	–	–	–	83
6	131	31	36	49	56	7	6	23	339	33	82	–	–	–	115
7	158	36	44	59	67	10	7	28	409	40	112	–	–	–	152
8	190	43	53	71	81	12	10	33	493	48	147	–	–	–	195
9	228	52	64	86	96	14	12	40	592	59	192	2	–	–	253*
10	274	63	77	103	116	13	14	48	708	73	–	3	–	–	76
11	331	75	93	125	140	15	13	58	850	99	73	4	–	–	176
12	397	91	113	149	169	19	15	70	1023	107	172	2	–	–	281*
13	478	111	103	180	202	7	19	84	1184	145	–	–	31	–	176
14	577	101	36	207	245	3	7	101	1287	179	142	–	126	00	447*
15	600	35	38	226	254	6	3	106	1267	214	–	1	157	64	436*
16	600	37	43	226	254	7	6	105	1278	222	–	1	160	22	405*
17	600	42	50	226	254	10	7	105	1294	219	–	4	153	24	400*
18	600	49	58	226	254	12	10	105	1314	217	–	5	145	29	396*
19	600	57	69	226	254	14	12	105	1337	215	–	8	134	36	393*
20	600	68	79	226	254	13	14	105	1359	216	–	10	124	44	394*

* Harvesting occurs only when 200 or more surplus . nimal are

- animals would be harvested first from the yearling **cohort,** then sequentially from the 12+ to 2 year old classes **until** the desired number of surplus animals was removed
- because of the high costs of establishing a mobile abattoir, slaughtering **operations** would not be undertaken unless 200 or more surplus animals were available.

Based on projections from Table 3.3, the desired stocking rate would not be achieved until the 15th year of operation, although sufficient surplus animals would be available for harvesting in the 12th year, 14th year and all subsequent years. At equilibrium, a sustained harvest of approximately 400 animals could occur, of which 330 to 350 would be yearling animals.

For this initial feasibility study, density dependent influences on **herd** productivity have not been incorporated into herd growth projections (largely because of our limited knowledge of the nature and severity of such influences), and it has been assumed that calving success rates will be constant throughout the herd's development. However, this assumption may not be valid. At Elk Island National Park, wood bison **productivity** peaked (25% increase in herd size per year) when stocking densities were at 0.02 animals/ha, and dropped to 20% when the stocking density doubled to 0.04 animals/ha (Chuck Blyth, pers. comm.). Consequently, it is possible that the Lowlands herd may have to be maintained at slightly lower levels to maximize recruitment and harvesting levels. This can only be determined by carefully monitoring the herd's reproductive success during its developing years and the **first** several years at proposed maximum levels.

CHAPTER 4 HERD MANAGEMENT PRACTICES

Although the SRL bison ranch will not be as intensively managed as most commercial bison operations, certain regular management practices will have to be undertaken to maximize herd productivity and minimize animal losses. These have been categorized as:

- Disease/parasite control;
- Age-sex class segregation
- Supplemental feeding; and
- Redatorcontrol

4.1 DISEASE/PARASITE CONTROL

Anthrax, brucellosis and tuberculosis are three significant diseases enzootic to bison in the Lowlands. Not only can they significantly impair bison productivity and survival rates but they can also be dangerous to humans involved with the handling of diseased animals. Consequently, such diseases must be controlled where practical to ensure the viability of a ranching operation in the area.

In the sections below, the nature of these diseases is discussed, together with recommended controls.

4.1.1 Anthrax

Anthrax is a highly contagious bacterial disease caused by *Bacillus anthracis* and is generally fatal to bison once the bacteria vegetate (reproduce) within the host animal. Death is generally rapid, with few preliminary symptoms being evident, although listlessness and staggering can be observed (West (cd.), 1975). In bison, infection nearly always results from the ingestion of food or water contaminated with living bacillus or spores. The spores of anthrax are extremely difficult to destroy and can remain viable in moist soils for more than 10 years, if not exposed to direct sunlight. Consequently, pastures which have been infected in past (i.e., from disseminated body fluids of past animal mortalities) are difficult if not impossible to render totally safe to stock on future occasions, particularly in wet marshy areas. It is of note that the proposed ranch site contains no know burial mounds from previous anthrax eradication programs, thus reducing the potential for high concentrations of anthrax spores on-site.

Humans can contract this disease through the inhalation and absorption (through the skin) of anthrax bacteria, and death is frequently the outcome. Although the cooking of infected meat will readily kill the bacteria in its vegetative state, spores are not readily destroyed. Consequently, the ingestion of infected meat can also be a means ofconlracting the disease.

Effective control of anthrax is achieved through vaccination, although immunity to the disease lasts for only 6 to 8 months following the treatment. Consequently, the vaccination, when employed, is generally administered each spring, prior to the *major* outbreak season (i.e., summer).

4.1.2 Brucellosis

Brucellosis in bison results from infection with ***Brucella abortus*.** Although not generally fatal to infected animals, it causes abortion in pregnant cows and can have'a devastating effect on herd productivity. In bulls, symptoms are usually slight or absent, even in infectious carriers, although advanced cases can result in reduced sperm production. Contraction of the disease is generally via the mouth (i.e., ingestion of forage contaminated by abortion fluid) or through the vagina during servicing by a carrier bull. Unlike the anthrax organism, brucellosis bacteria can remain viable in the soil for only several months, and the risk of re-infections from the soil can be eliminated by having an infected range unstocked for at least a year (S. Tessario [Agriculture Canada], pers. comm.). However, canids in the Lowlands are known carriers of the disease (4 of 13 wolves and 1 of 36 foxes tested were positive; S. Tessario, pers. cornm.) and there is the remote possibility of a bison being infected by a canid-inflicted wound or by contacting contaminated canid scats during grazing.

From a human perspective, brucellosis is seldom fatal but can result in persistent, flu-like symptoms. The bacteria can be absorbed through cuts in the skin, inhaled or ingested from infected meat. It is readily killed by high temperatures and, consequently, poses no threat in well-cooked meat.

The control of brucellosis is generally achieved through the eradication of infected animals. Although a vaccine (S19) has proven to be effective at reducing abortion in cattle (70% effective), there are major problems with its use. When used in adult animals, it creates serum characteristics which cannot be distinguished from a natural infection (this is not always the case in adults vaccinated as calves, where it is generally easy to determine natural infections from the effects of the vaccination) (West (cd.), 1975). Secondly, while reducing abortion, it does not eliminate the disease, and carrier animals can continue to spread virulent bacteria (west (cd.) 1975). Thirdly, the vaccine has not been widely tested in bison (S. Tessario, pers. comm.).

4.1.3 Tuberculosis

Tuberculosis is a chronic contagious disease of most domesticated animals caused by. *Myobacterium tuberculosis.* While the disease can be fatal, its adverse effects on body condition (i.e., weight loss, loss of appetite) are generally of greater concern. It is characterized by the development of nodules or tubercules in almost any organ in the body, although it is most commonly associated with the lungs. Infected animals generaUy spread the disease by coughing and disseminating tubercule bacilli into the air. These bacilli a&, in turn, inhaled by adjacent animals. The sputum, urine and feces of infected animals can also contaminate forage and be ingested by grazing animals. Like brucellosis, the tubercle bacilli can survive in the soil for only several months. Although canids can be carriers of the disease, this problem does not appear to be prevalent in the Lowlands, where only 1 of 13 wolves and O of 36 foxes tested positive in a recent pathological study (S. Tessario, pers. comm.).

Infected animals can pose some danger to humans, particularly to individuals involved in slaughtering operations, since bacteria can be absorbed through cuts in the skin. However, the disease is seldom contracted from the ingestion of meat since the bacteria are readily killed by high temperatures and, consequently, are not virulent in well-cooked meat.

There is no known effective vaccine for tuberculosis in bison and the control of this disease would be through the periodic testing of the herd, and the eradication of infected animals.

4.1.4 Other Potential Health Problems

In addition to anthrax, brucellosis **and** tuberculosis, there are a **variety** of other ailments which can impair bison productivity, both bacterial and parasitic. Some of the more common ones are discussed here.

Gastro-intesti.nal parasites (eg., tapeworms **[*Cestoda*],** round worms **[*Nematoda*])** are of considerable concern from a productivity perspective, since heavy loads in a host animal can cause a rapid deterioration of body condition. The majority of such parasites are ingested as eggs or larvae by grazing animals, and then develop into egg-laying adults within their **host.** Eggs are, in turn, excreted onto pasture forage in **feces** where they are re-ingested by animals to complete the cycle (West (cd.), 1975). Also of potential concern to ranchers are a variety of non-biting muscid flies which lay their eggs on living tissue, **such as natural orifices, cuts or sores, and then become parasitic in their larval stages.** Parasitic problems generally increase in severity with increasing animal densities, where levels of forage contamination and the numbers of potential host animals are high. Effective treatments for the control of such parasites are available, and generally involve the periodic application of a variety of **sulphur-based** drugs (S. Tess*o, **pers. comm.).** ! '

Lungworrns, as the name implies, infect lung tissue, frequently causing tuberculosis-like symptoms, and their presence has been noted in bison in Wood Buffalo National Park (S. Tessario, pers. comm.). Eggs are laid and hatched in the lung, and the larvae, climbing up the **trachea,** are swallowed and excreted in feces. After moulting twice, these larvae reach a resistant infective stage and can survive on pasture throughout the winter (West (cd.), 1975). By clinging to forage, they are re-ingested by grazing animals, permitting them to repeat their cycle. Similar to gastro-intestinal parasites, **lungworms** can be controlled with the periodic application of drugs.

Several additional diseases may present problems to a northern ranching operation, including foot rot (necrotic lesions of the foot, lameness), Leptospirosis (bacterial disease of the kidneys) and **clostridial** diseases such as black leg, malignant edema, etc. All of these have effective vaccines or treatments and can be readily controlled upon early identification (S. Tessario pers. comm.). The presence of such diseases in a northern ranching operation can **almost** certainly be **avoided,** if animals purchased as starter stock **are** free of such disorders.

4.1.5 Recommended Disease/Parasite Control Measures for the SRL Ranch

Because bison herds in the Lowlands and Wood Buffalo National Park represent the only known bovid populations in North America still harboring brucellosis and tuberculosis, a bison ranch operated in this area will fall under intense scrutiny from regulatory agencies to ensure that the spread of these diseases is controlled. In November 1986, officials from Parks Canada, Agricultural Canada and other interested government agencies held meetings on the possible eradication of all bison currently occupying these ranges and the subsequent reintroduction of "disease free" stock (Dr. W. Bulmer [Agricultural Canada]; pers. comrn.). Should wild herds be completely eradicated prior to stocking the game ranch, disease-related concerns will be greatly reduced. However, in the event that the proposed program does not proceed, other protective measures will have to be undertaken to maintain herd health and marketability.

Based on discussions with personnel of the Animal Health Care Division of Agriculture Canada, it would not appear that a regular vaccine program for the proposed Lowlands ranch would be recommended or required by this government agency. As discussed previously, there is no effective vaccine against tuberculosis, and the brucellosis vaccine, although 70% effective, frequently makes blood testing for the disease difficult to interpret. Although a highly effective anthrax vaccine is available, outbreaks of this disease occur only sporadically under specialized ambient conditions. Therefore, it is more cost effective to administer the vaccine only when signs of the disease are present than to implement a regular vaccination program.

Control of these diseases can best be achieved by:

- theeradieation ofexisting disea.sed animals in the vicinity of the ranch;
- theintroduction of''clean" stock into the ranch site; and
- thedeveloprnentof suitable facilities for handling and processing animals, in the event of disease outbreak.

The proposed ranch site is located in the southeastern comer of the Lowlands bison range, and this area currently supports bison throughout the year. For example, during an early spring reconnaissance flight on April 19, 1985, nine animals (7 adults, 1 yearling, 1 calf) were sighted on the proposed ranch site, and 60-80 animals were tallied during surveys in the following winter (C. Gates, pm. COrnm.). **Consequently,** there is a high probability that infectious camiers are currently on site. **Their exclusion** from the vicinity of the ranch must occur at least one year prior to stock introductions to ensure that viable spores of brucellosis and tuberculosis are not present in the soil. Once the ranch is in operation, free-ranging bison must also be kept well-removed from the ranch's fence-line to ensure continued isolation from the diseases. This exclusion of indigenous animals can s be achieved in a two step process. After the construction of the ranch's perimeter fence, an intensive survey of the site must be undertaken to locate and destroy all bison inadvertently trapped within the fenceline. All animals destroyed during this survey should be disposed of outside of the perimeter fence and preferably away from watercourses which intersect the ranch site. Prior to introducing stinter stock onto the range, a second buffer fence should then be constructed around the perimeter fence to prevent ranch animals from coming into contact with **diseased,** free roaming bison or contaminated **forage/surface** water along the **fenceline.** This buffer fence should be of comparable quality to the perimeter fence and a minimum of 50 m from it. It may also be necessary to divert the two small streams which currently intersect the northwest comer of the ranch site away from the **perimeter fence to** ensure that viable spores do not enter occupied range **land.**

The health of starter stock is also of paramount importance to the success of the ranch. Purchased stock must be rigorously tested for brucellosis, anthrax and tuberculosis, in addition to the less severe disorders such as **Leptospirosis,** clostridial diseases, and parasitic loads. During the growth phase of the herd, it is recommended that a yearly fall round-up and blood testing program involving all herd members be undertaken, and that such a similar but less intensive sampling program be continued in conjunction with the harvesting of animals in later years. Such a program will permit the detection of many potential problems and the development of suitable treatments to control them. For the specific control of gastrointestinal parasites, it is also recommended that fresh fecal samples be collected from the field on a bimonthly basis for the **first** several yearn of operation and analyzed for parasitic eggs and larvae to determine the types and relative abundance of parasites infecting the range. At a lab cost of approximately $10 per sample, such fecal **profiles** will permit the most effective drugs to be selected for administration

Recently, several commercial bison ranches have found that an intensive de-worming program implemented during the six to eight week period prior to the rut **significantly** increases pregnancy rates in their herds (Chuck **Blyth,** pers. cornm.). In the case of the Lowlands ranch, the adoption of such a program would entail a second yearly round-up of the herd in early June. Given the expansiveness of the ranch and the free-ranging nature of the bison, such an operation would be very costly and could present a hazard to recently born calves and to cows nearing their pregnancy term. Consequently, a spring de-worming program should only be implemented if spring parasitic loads are sufficiently high to warrant such a program, and if effective, year-round protection cannot be provided by slow-release drugs administered in the fall. Other less intensive management options are also available for the control of parasitic loads, including the use of a rotational grazing system. By subdividing the ranch into distinct seasonal ranges and redistributing the animals on a seasonal basis, high levels of fecal accumulations and resulting forage contamination can be avoided. This, in turn, will greatly reduce the number of parasitic eggs and larvae which are re-ingested by the animals during foraging.

In spite of these precautionary measures taken during site preparation, stock purchase and herd development, there remains the potential for unforeseen disease outbreaks (e.g., anthrax) which will require immediate action. Consequently, quipment which facilitates the rapid round-up and handling of more than 1000 animals is a per-quisite for a successful ranching operation. Helicopter support will likely be employed during round-ups to at least initiate herd movements in desired directions. However, several drift fences extending one or two km from handling facilities would be required for the final funnelling of animals into holding corrals and handling shutes.

4.1.6 **Anticipated Veterinary Requirements**

Veterinary assistance will unquestionably be required by the ranch for the detection and control of diseases. However, it would appear that some of the costs associated with blood testing for major diseases will not be the responsibility of the ranch. Under the auspices of the Animal Disease Protection Act, Agricultural Canada is proposing to implement a brucellosis and tuberculosis testing program for all wild game ranches in Canada (Dr. W. Bulmer [Agricultural Canada]; pers. comm.). Under such a program, ranchers would be responsible for providing the facilities and labour necessary to round-up and process the animals, but all veterinary and lab costs associated with blood testing would be covered by Agricultural Canada. Since such a program could be conducted in conjunction with normal yearly round-up and slaughtering operations, the program would not constitute a significant additional work load for ranch staff.

Agricultural Canada would continue testing animals and destroying positive **reactors** on a yearly basis at any given ranch until the herd **was** considered disease free. After that time, meat and carcass inspection (by government inspectors) at the time of slaughtering would constitute the only on-going testing requirements for **brucellosis** and tuberculosis. In the case of the SRL ranch where a mobile abattoir will be **utilitized,** the ranch will have to approach the Meat Hygiene Division of Agricultural Canada to arrange for a meat inspector to be on-site during slaughtering operations. Such a **service** will also be provided at no cost to the ranch.

It is of note that the SRL ranch, if marketing its products only in the Northwest Territories, is not required under the Federal Meat Inspection Act to have its meat inspected However, since inspection represents an inexpensive means of monitoring herd health, the ranch should adopt meat inspection as a standard operating practice, regardless of the location of its markets.

In addition to the participation of Agriculture Canada veterinarians in the ranch's early development it is recommended that the ranch retain an independent **veterinarian** for long term herd health management. Such a **person** would be responsible for monitoring herd production parameters (e.g., calf crops, slaughtering weights, carcass characteristics, mortality rates), detecting herd-related health problems (e.g., high parasite loads, poor nutrition) and recommending specific programs (e.g., de-worming, feed supplements, range improvements) to correct these problems. Such services on a long term basis can be obtained for $175-$200 per day (plus expenses, lab costs and drug costs) (Dr. Bruce Rodgers [Bragg Creek Animal Hospital Ltd.]; pm. comm.).

4.2 AGE-SEX CLASS SEGREGATION

4.2.1 **Bull Segregation**

A variety of management practices involving the segregation of particular age and sex classes of animals have been employed by ranchers, depending on the size and nature of their operation. On smaller, intensively managed spreads where animals are maintained at higher densities, bulls are frequently separated from the remaining age/sex classes (except during the breeding season) to minimize herd tension and aggressive encounters with smaller animals (Jennings and Hebbring 1983). On larger free-ranging operations, this practice is not required unless highly synchronous calving is the desired result.

4.2.2 Calf Segregation

The separation of calves from remaining age classes is also a practice generally used on more intensively managed systems, with calves being segregated in October or November. In the absence of adult animals, calves are faced with less competition for forage during the winter and can frequently maintain better body conditions. However, ‘ this system is only effective where the calves are to be supplementally fed or have access to relatively snow-free pasture. In areas of high snow accumulations, energy expenditures related to foraging are greatly elevated, causing a negative energy balance and subsequent weight loss. Costs of foraging are particularly high when snow depths reach an animal’s chest height (65-75 cm for adult bison [Van Camp 1975] and substantially less for calves). If supplemental feed is not to be used in deep snow areas, then the calves should be left in the maternal herd, where they can forage and travel with less impedance in the foraging craters and trails of adult animals.

4.2.3 Recommended Segregation Practices for the SRL Ranch

The separation of bulls from remaining herd members is considered to be an umecessary practice for the SRL ranch. At a maximum proposed stocking rate of less than 20 anirnals/km^2 (approximately 5 ha/animal), there is little concern for aggressive animal interactions and injuries. There is also little chance of a high degree of asynchronous calving. Free ranging herds in the area currently drop the great majority of their calves from mid-April to early June (C. Gates, pers. comrn.) and even southern stock introduced to the area would vaxy little from this schedule (Hebbring and Jennings 1983).

Calf separation and supplemental feeding for the winter period would produce definite production advantages for the SRL ranch. Snow depths in the area's meadow communities can frequently reach 70 cm, with variable degrees of crusting and wind packing (Eccles et *al.* 1986). In the existing wild herds, calves are faced with difficult foraging conditions, even in the trails and feeding craters of adult animals, and weight loss almost certainly occurs over the winter months. By splitting calves from the adult herd in October or early November, holding them in a relatively confined, sheltered area and providing bales of moderate quality sedge or grass hay during the winter months, body condition would be maintained and weight gain may even occur, producing a larger yearling animal for slaughter in the following fall.

4.3 SUPPLEMENTAL FEEDING

Feed costs can represent a major expenditure to any ranching operation. Since the economic concept behind game ranching is to minimize feed costs by rearing animals on native forages, the nutritional properties of such forage must be investigated for any given ranch to identify deficiencies and supplement requirements.

Two &ta sets are available on important nutritional parameters of SRL forage. During a seven year study (1968-74) on the agricultural potential of the Lowlands by Agriculture Canada, hay samples from several plant associations near the Grand Detour site were collected for several consecutive summers and analyzed for macro-nutrients and minerals. For this feasibility study, comparable samples were collected from the Grand Detour and East sites in April 1985 and from the East site in August 1985 to assess late w@er and summer forage quality, respectively. Table 4.1 summarizes the results of these analyses.

Little information is currently available on nutrient requirements and mineral tolerances of bison. Consequently, in evaluating the suitability of Lowlands vegetation as forage, the nutrient and mineral requirements of domestic cattle have been used (National Research Council 1980; Alberta Agriculture Feed Test Report form).

4.3.1 Crude Protein and Total Digestible Nutrients

Crude protein (CP) levels typically peaked in the hay samples during the high photo period of June, ranging from 10% in grass species to over 15% in sedge stands. By late August CP levels generally fell in the 7 to 9% range, dropping below 6% in the majority of samples by late winter (April). A CP level of 7% is generally recognized as the minimum requirement in cattle to maintain body conditioning (L. Renecker (University of Alberta); pers. comm.), suggesting that available forage may be protein deficient for up to eight months of the year. However, from a bison ranching perspective, such deficiencies will actually persist for a shorter period of time for two reasons:

1) Estimates of protein content were based on an analysis ofal.1 vegetative material above ground level. Recognizing that protein levels are generally highest in the upper leafy portion of grarninoids and that bison demonstrate a grazing preference for the top 1/2 to 1/3 of such plants (Reynolds *et al.* 1978), it is

Table 4.1. Results of Chemical Analysis[1] of Native Hay Samples From The Slave River Lowlands, N.W.T.

Sampling Date	Site Description	Dominant Graminoids	crude Protein (%)	TDN (%)	Mg (%)	K (%)	Ca (%)	P (%)	Ca/P	Zn (ppm)	Cu (ppm)	Mo (ppm)	se (ppb)
SUMMER													
June 1%8-70	2 Seed-wetmeadm	Clrex ● krodee-	15.3	N/A	0.13	2.8	0.32	0.30	1.1	57.0	9.7	148	N/A
July 1968-70	(Grand Detour -	Calamagrostis inexpansa	12.5	N/A	0.13	2.2	0.44	0.16	2.7	S3.O	7.2	107	N/A
Aug. 1%8-70	Site 1)		10.8	N/A	0.13	1.8	0.61	0.1s	4.1	66.0	4.7	144	N/A
June 1%8-70	Seed-wetmadow	Carex aquatilis	14.2	N/A	0.13	2.4	0.36	0.22	1.6	33,0	10.7	234	N/A
July 1968-70	(Grand Detour -		11.4	N/A	0.12	1.9	0.48	0.17	2.8	33.0	7.9	252	N/A
Aug. 1968-70	Site 1)		10.0	N/A	0.12	1.5	0.65	0.14	4.6	32.0	2.9	351	N/A
June]%8-70	Dry meadow	Calamagrostis canadensis-	10.0	N/A	0.13	1.2	0.31	0.21	].5	29.0	2.5	101	N/A
July 1968-70	(Grand Detour -	Agropyron trachycaulum	8.7	N/A	0.13	1.0	0.36	0.20	1.8	24.0	2.0	127	N/A
Aug. 1%8-70	Site2)		6.5	N/A	0.12	0.6	0.41	0.14	3.0	22.0	1.9	113	N/A
June 1%8-70	Semi-wet meadow	Calamagrostis inexpansa-	12.2	N/A	0.14	1.7	0.31	0.21	1.5	29.0	2.5	156	N/A
July 1%8-70	(Grand Detour -	Carex atherodes	9.4	N/A	0.14	1.2	0.38	0.16	2.3	25.0	1.9	160	N/A
Aug. 1%8-70	Site2)		7.7	N/A	0.15	0.8	0.52	0.11	4.7	30.0	1.7	184	N/A
June 1%8-70	Wet meadow	Scolochloa festucacea-	11.6	N/A	0.11	1.9	0.44	0.16	2.8	41.0	6.4	241	N/A
July 1%8-70	(Grand Detour -	Carex atherodes	10.0	N/A	0.11	1.6	0.52	0.12	4.3	39.0	4.1	207	N/A
Aug. 1968-70	Site 4)		8.6	N/A	0.11	1.0	0.65	0.10	6.5	38.0	2.1	250	N/A
Aug. 1985	wet meadow component of a shrub-meadow mosaic (East Site)	Carex Spp. - Calamagrostis canadensis	7.4	59.7	1.91	N/A	0.37	0.13	2.8	3.6	1.1	262	N/A
Aug. 1985	Semi-wet shrub component of a shrub-meadow mosaic (East Site)	Calamagrostis canadensis -Carex Xpp. -Juncus spp.	8.7	59.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Aug. 1985	Large semi-wet meadow (East Site)	Calamagrostis canadensis -Carex spp.	6.6	58.6	3.58	N/A	0.21	0.10	2.1	0.6	,6	49	N/A
LATE WINTER													
April 1985	Semi-wet meadow component of shrub-meadow mosaic (Grand Detour)	Carex atherodes - Calamagrostis canadensis	4.2	57.2	0.07	N/A	0.S3	0.11	4.8	27.5	.9	426	84.6
April 1985	Dry shrub component of shrub meadow mosaic (Grand Detour)	Calamagrostis canadensis	3.8	56.1	0.11	N/A	0.50	0.11	4.5	20.4	.2	173	N/A
ApriJ 1985	Wet meadow (Grand Detour)	Calamagrostis canadensis Carex aquatilis	4.1	57.1	0.09	N/A	0.66	0.09	7.3	24.0	2.7	272	NIA
April 1985	Dry to semi-wet meadow (East Site)	Calamagrostis canadensis -Carex atherodes	7.2	58.3	0.17	NIA	0.34	0.12	2.8	16.3	3.0	48	148.0
April 1985	Wet meadow component of a shrub-meadow mosaic (East Site)	Carex atherodes Carex aquatilis	5.3	57.4	0.20	NIA	0.43	0.09	4.8	8.8	1.6	253	90.3
Minimum Requirements (in cattle)[4]			7.0		.15	.8	.40	.26	1.0	50.0	10.0	40	100
Maximum Tolerable Levels (in cattle)[5]					.50	3.0	2.00	1.00	7.0	500.0	100.0	1000	2000

1. Values presented on a dry matter basis.
2. 1968-70 values from Pringle (draft) in Reynolds and Hawley (eds.).
3. N/A = not analyzed.
4. From L. Renecker (University of Alberta), pers. comm. and Alberta Agriculture Feed Test Report Forms.
5. National Research Council 1980.

probable that actual ingested CP levels would be higher than that indicated from the analysis; and

2) Bison are extremely efficient at utilizing poor quality forage (Hawley et al. 1981), possibly because of an ability to enhance nitrogen recycling to the rumen (Peden *et al.* 1974). Consequently, minimum CPrequirements are likely less in ' bison than in cattle.

Total digestible nutrient (TDN) levels were only determined for August and April forage samples. August values ranged from 58.6% to 59.8% for the reed grass-dominated samples. In April, values were only slightly lower for sedge and grass samples, ranging from 56.1% to 58.3%. Although TDN levels were not determined for samples collected during the peak growing season (i.e., June, July), they undoubtedly exceeded 60%, given the high levels of CP and low levels of crude fibre in the forage at this time.

NRC nutritional guidelines for beef cattle recommend TDN levels of at least 50% for overwintering weanling calves to maintain some weight gain, 50% for overwintering pregnant cows, 60% for nursing cows, and 55 to 58% for normal growth and maintenance in bulls. TDN levels of 65% are generally considered optimal for finishing yearling cattIe prior to slaughter. Assuming that these guidelines can also be applied to bison, it would appear that Lowlands forage offers acceptable TDN levels for most of the year, being slightly deficient only in late summer and early fall for the purposes of maximizing weight gain in yearlings.

4.3.2 Other Macronutrients

Of the four macronutrients assessed in the forage analyses (magnesium, potassium, calcium and phosphorous), both potassium and phosphorous reached their highest levels during the peak growing period (i.e,. June), with substantially lower levels being present in late summer and winter. Calcium followed a reversed pattern while magnesium showed no significant seasonal trend.

From a deficiency perspective, the majority of forage samples were slightly deficient in magnesium, although two summer 1985 samples from the East Site actually exceeded maximum tolerable levels. Potassium levels were adequate in the majority of summer samples, although the relatively low August levels suggest that minor deficiencies may occur during winter months. Calcium was at an adequate level in the majority of forages sampled, while phosphorous was deficient in most. The Ca:P ratio was generally higher than the recommended level of 1:1 to 2:1, but exceeded the maximum tolerable ratio of 7:1 in only one sample (7.3:1).

4.3.3 Minerals

Of the minerals analyzed, only copper showed any clear seasonal trend in concentration, reaching its highest level in June, and decreasing with the advance of season. Manganese levels demonstrated a stronger relationship with soil moisture”than with season, being higher on average in sedge-dominated samples from wet areas than in grass dominated samples collected from drier sites.

Although manganese occurred in acceptable levels in the forage samples, selenium, copper and zinc were at deficient levels in the majority of samples.

4.3.4 Recommended Supplemental Feeding Practices for the SRL Ranch

4.3.4.1 Forage Supplements

Most cattle ranching operations. in Canada supplementally feed animals during the *winter* months to maintain body conditioning and improve overall reproductive performance and/or growth. However, such a practice does not appear to be as necessary for bison because of their efficiency at utilizing poor quality forage. -Consequently, in several ranching operations, the provision of adequate forage quantity rather than quality has become the management emphasis in winter. Forage quality is now being considered of greater significance to the reproductive performance of bison in the six week period between calving and breeding, and management strategies are being developed to best address this issue (Dan Patton [Adams Ranch]; pers. comm.; Judd Bunnage [Alberta Agriculture]; pers. comm.).

Based on the above information, supplemental feeding of.adult animals (i.e., 18 months+) has not been recommended as a standard practice for the SRL ranch. Instead, a rotational grazing system should be implemented which ensures that a major portion of the ranch is reserved for winter grazing. Preferably, the northern half of the ranch should be designated as winter range, since it is dominated by a Willow-Graminoid Mosaic community and, hence, offers improved shelter from wind chill and wind packing. Adult bison should be placed on the range in November, following the round-up, testing and slaughtering operations, and should remain there until early April prior to the peak calving period. At that time, the animals can be herded into the large meadow communities dominating the ranch's southern half, where exposure to warm winds and sun will have removed much of the snow cover and where high quality new growth will soon be available for pre-rut conditioning. While overwintering adults may experience some loss of body weight and conditioning during the winter months under this scenario, this is not critical from a meat production perspective for two major reasons.

1) Adult animals do not represent a significant component of harvested meat on the ranch; hence, overwinter weight loss will not significantly influence meat harvest levels; and

2) Provided that abundant high quality forage is available to the animals during the six week period prior to the rut, the herd's reproductive performance will not be significantly influenced by some overwintering loss of body conditioning.

In the Lowlands, there is the potential for occasional thaws in mid to late winter, followed by exteme cold. Such weather conditions can lead to heavy crusting of the snow, even in sheltered meadows, and difficult foraging conditions even for adult bison. If such crusting persists for long periods of time, animals can experience a rapid decline in body conditioning and increased mortality rates. Consequently, hay reserves should be stored on site as a precautionary measure to permit supplemental feeding during periods of extremely difficult foraging conditions. Hay should be of a low to moderate quality to prevent digestive upsets in the bison and should be distributed in several or more locations within the winter range to prevent localized overcrowding and aggression. It should be noted that hay reserves required to supplementally feed calves during the winter (see discussion immediately below) can serve as a short term emergency food supply for adult animals as well.

The overwintering care and management of the ranch's calf component must be viewed from an entirely different perspective. Because of difficult foraging conditions (i.e., deep snow) and competition from adult animals, calves wintering on native range will experience more substantial losses in body weight and conditioning, in addition to high mortality rates in particularly severe winters. Domestic cattle studies have shown that animals subjected to restricted energy intake at an early age may eventually reach the same size as animals well fed from birth, but will demonstrate retarded growth rates and prolonged growth periods (Maynard and Loosli 1969). Consequently, bison calves entering their second summer of life (i.e., yearlings) in poor physiological condition will reach significantly lower slaughtering weights than healthier counterparts. Since yearlings (18 months of age) will represent the major slaughtering component of the SRL ranching operation, maximizing their growth rates until slaughtering will yield obvious production benefits. Therefore, as previously discussed, all calves should be segregated from adult herd members in November, confined to a relatively small paddock (i.e., 500 ha) close to ranch headquarters and supplementally fed, both during herd growth and at peak stocking rates. In addition to increasing the weight of calves designated for slaughter, such a practice will also advance the maturing process in female calves needed for herd maintenance and increase the incidence of two and three year old cows bearing young.

Calves will not require particularly high quality supplements to maintain overwintering condition, and summer-harvested grass or sedge hay is recommended as a forage. Assuming that overwintering bison calves will have feed requirements comparable to similarly aged beef cattle, one can anticipate forage intake rates of approximately 7 kg per animal per day (based on air dried feed containing 90% dry matter; Maynard and Loosli 1969). At peak stocking rates (i.e., maximum of 500 overwintering calves) and a maximum feeding period of 200 days, a total of 700,000 kg of air dried hay would be required each year.

Hay supplements should be provided on elevated feed bunks to minimize wastage and contamination from feces. Feed bunks should be well distributed throughout the holding paddock to prevent overcrowding and aggressive animal interactions, and should be firmly anchored to the ground. In intensive feed lot operations, two feet of feedbunk are commonly provided per head of homed animal (Jennings and Hebbring 1983). However, in the more free-ranging situation of the SRL ranch, this requirement could be reduced by 50 or 60%.

4.3.4.2 Mineral Supplements

Of the mineral deficiencies discussed above for Lowlands vegetation (i.e., magnesium, phosphorous, copper, zinc and selenium), only the particularly low levels of phosphorous, copper, zinc and selenium represent potential problems to a ranching operation if not rectified. Phosphorous is necessary for normal reproductive function in cows (McLean 1979) and, along with calcium, is particularly important for normal skeletal development. A suitable ratio of the two elements is essential for the assimilation of both (Maynard and Loosli 1969). Copper deficiencies will lower iron metabolism and cause anemia, while inadequate zinc levels will inhibit normal enzyme activity and growth rates (Maynard and Loosli 1969). Selenium deficiencies can, in turn, retard growth and reproduction and cause white muscle disease (Maynard and Loosli 1969; McLean 1979). Fortunately, most deficiencies can be easily rectified through the use of commercially produced mineral blocks containing such compounds as sodium phosphate, zinc carbonate and copper sulphate. Grain or oil meals provided in small amounts are generally used to supplement selenium levels in diets. Inoculations are also available and could be administered during the fall round-up in the case of the SRL ranch. Elevated, easily visible bunks for dispensing mineral supplements should be located throughout both summer and winter ranges, distributed in such a fashion to encourage animal dispersion and homogeneous utilization of the ranges.

It must be recognized that a complete analysis of nutrient levels in SRL forage was not within the scope of this study, and a more thorough program conducted every two-to three years should be implemented by the ranch to document nutrient levels throughout the calender year. Data generated from such a program could prove invaluable in identifying nutritionally-related problems in herd performance.

4.4 PREDATOR CONTROLS

In 1976, the Canadian Wildlife Service initiated a study in the Lowlands to assess the degree of wolf predation on bison. A total of 13 wolves were successfully fitted with radio-collars and released for monitoring purposes. Aircraft surveys were subsequently used to relocate animals and document bison kill rates and characteristics (Van Camp [draft], in Reynolds and Hawley [eds.]).

Based on more than 250 radio relocations, it was estimated that 40 to 47 wolves comprising four different packs resided in the Lowlands east of the Slave River. The largest of these packs (Hanging Ice Pack - 14 to 17 animals) occupied a territory which completely encompassed the site of the proposed ranch. Scat analyses indicated that bison formed the major dietary component of wolves on a year round basis, and in some areas, bison kill rates were relatively high. For example, from 3 March to 15 April, 1977 the

Hanging Ice Pack killed and consumed at least three female bison (Van Camp [draft], in Reynolds and Hawley [eds.]).

During the winter of 1977-78, a wolf control program removed 44 animals from the Lowlands, reducing the packs to pairs and small groups. The status of wolves in the Lowlands is now unknown, although recent aerial surveys for bison and moose in the area have sighted extremely low numbers of wolves (data files, Department of Renewable Resources, Fort Smith; Eccles *et al.* 1986).

At present, it would not appear that wolves would present serious predation problems to the ranch. However, the introduction of moderately high densities of bison onto the ranch could eventually attract wolves from adjacent areas. Consequently, it is recommended that an aggressive trapping/poisoning program along the ranch's perimeter fence be adopted as a standard operating practice by ranch staff. Weekly fence patrols should also be undertaken to document signs of digging under the fence by canids and potential fence failures resulting from bison activity or soil instability. These practices will greatly reduce the potential for wolf-related bison kills and the possible introduction of brucellosis to bison from canid-inflicted wounds.

CHAPTER 5 RANGE MANAGEMENT PRACTICES

During the development of the ranch plan for the Lowkmds, it has been inherently assumed that mature Lowlands forage can withstand moderate grazing pressure each year for an indefinite period of time. It is recognized that the major graminoid species in these meadows reproduce vegetatively (i.e., via rhizomes or stolons), and, hence, are better ' adapted to withstand grazing than seed-dependent bunchgrass species. However, work by Agriculture Canada (Pringle [draft], in Reynolds and Hawley [eds.]) on experimental plots in the Grand Detour area from 1968-74 found the following:

1) Those plots clipped of vegetation most frequently during the growing season (i.e., 3 times) developed greater forb cover, less sedge cover, and greater grass cover than plots clipped less frequently, suggesting that meadow communities may be invaded by less desirable species if overgrazed.

2) Annual clipping of drier meadow plots over a four year trial period resulted in substantial reductions in annual herbage yield by the fourth year of the trial. Little regrowth occurred on these plots following cutting to permit the replenishment of root reserves, a factor which likely contributed to the decline in productivity. Comparable clipping pressure on wet meadow plots resulted in negligible reductions in annual yield, suggesting that wet meadows would be more resilient to grazing pressures.

Other potential problems resulting from heavy grazing pressure include soil compaction and degradation. Soils in the meadow communities are fine-grained lacustrine materials rich in organics and, hence, are prone to compaction from grazing animals. Compaction can reduce a soil's aeration, infiltration rate (i.e., rate at which water enters the soil), moisture holding capacity and rooting qualities which, in turn, can result in reduced plant growth, cover and floristic composition (Duffey *et al.* 1974; Clifford et *al.* 1977).

Because of the potential concerns raised by the above information, it is imperative that range management play an integral role in ranch operations. Recommended practices for maintaining and monitoring range condition are presented below.

5.1 USE OF SEASONAL RANGES

An important range management tool which could be employed by the ranch is the establishment of two distinct seasonal ranges. The northern portion of the ranch should be designated as winter range and grazed from early November to early April. The remaining southern portion of the ranch will provide summer range and should be occupied from mid- , April to round-up in late October. This scenario has considered the following aspects of range phenology and animal requirements in its development:

1) The designated winter range is dominated by a Willow-Graminoid Mosaic, offering superior cover from wind chill and wind packing than the more expansive meadow communities in the south.

2) Based on a brief field reconnaissance and limited forage sampling, it would appear that the meadow communities in the northern portion of the ranch are wetter than in more southern locales and, consequently, are dominated by sedges (eg., *Carex atherodes, C. aquatilis*) rather than grasses (eg., *Calamagrostis canadensis, C. inexpansa).* Sedges cure at a slightly higher nutritive level than grasses (Reynolds *et al.* 1978) and, hence, are more suitable as overwintering forage.

3) The drier meadows comprising much of the summer range support forages of comparable quality in June to those growing in wet meadow communities (Reynolds and Hawley [draft], in Reynolds and Hawley [eds.]), and are better able to withstand trampling because of their drier, more stable soils. Consequently, they are highly suited as a pre-rut conditioning range for the bison.

4) Southern portions of the ranch are better suited to calving activities, since they support pockets of mixed forest and shrubland habitat on moderately drained sites, and relatively dry meadow communities. The forests and shrublands will also provide adequate shading for animals during the summer months.

5) The stocking rate recommended for the ranch is designed to leave a 50-60% carryover of above ground forage material on the summer range at the end of the growing season. Such a carryover will ensure that adequate root reserves of

nutrients are developed by the end of the growing season to support the initial growth phase of the plants in the following spring.

6) This grazing system minimizes the number of forced herd movements required during the year, and the stress placed on the animals from such moves. However, it must be recognized that an early April move occurs when an abundance of cows in late stages of pregnancy will be present in the herd. Consequently, the fence line separating the winter and summer ranges must be equipped with a large number of gates and associated drift fences to facilitate the passive herding of the *animals* between ranges.

Regardless of the seasonal grazing system used, bison tend to develop traditional behavioral patterns on large ranges, frequently over-utilizing preferred areas and under-utilizing other comparable areas for no apparent reason. Fence lines are commonly over-utilized areas, where the feeding movements of animals are blocked and the animals congregated for extended periods of time.

A variety of techniques are used by cattle ranchers to evenly distribute range cattle, including water sources, riding or herding, supplemental mineral and feed blocks, and even spot applications of fertilizer, and some will be applicable to the proposed bison ranch. On the SRL ranch, water is not a limiting factor on the range and, hence, cannot be used as a means of distributing bison. In many areas of the ranch, herding by all-terrain vehicle or horseback will be extremely difficult because of terrain conditions. However, supplemental mineral blocks, if strategically distributed over the range, will influence animal grazing patterns. In addition, spot applications of nitrogen fertilizer could be used to enhance forage palatability on under-utilized sites, thus attracting greater animal use.

5.2 MONITORING RANGE CONDITION

Most mature ranges respond to excessive grazing pressure by demonstrating reductions in annual herbage yield, changes in botanical composition, or both. By excluding portions of a range from grazing, composition and yield comparisons between grazed and ungrazed areas can be used to detect unfavorable trends in range condition. Given our limited knowledge of the responses of northern meadows to sustained use by bison, there is little question that a series of range enclosures should be established on the SRL ranch to monitor range condition. These enclosures will be particularly important on the summer range, where forage plants will be subjected to grazing pressure during their more vulnerable growth phase, rather than during overwintering dormancy. For any given meadow community selected for sampling, botanical measurements should be undertaken along permanent transects located within and adjacent to the enclosures to permit meaningful grazed vs ungrazed comparisons to be made.

Although a variety of botanical measurements can be used to assess and monitor range conditions (eg., relative foliage composition of decreaser, increaser and invader species, vigour and density of forage species, percent ground cover of forage species, forage quality, annual yield), those which measure the relative percent composition and/or total biomass contribution of individual forage species provide the most essential information for range management (Pitt 1984). Depending on the level of precision and accuracy required, a number of different mensuration techniques can be employed to quantify such parameters. Although it is not within the scope of this study to select and/or design an appropriate sampling program for the ranch, it would appear that "frequency of occurrence" techniques for range assessment best combine the "simplicity, objectivity, statistical reliability and cost characteristics required of an extensive monitoring program" (Eckert in: Society of Range Management 1982). Assessments should be undertaken every two or three years preferably in late July when seed heads are available to aid in species identification and standing biomass is nearing its peak yearly value.

5.3 RANGE IMPROVEMENT TECHNIQUES

Should the range monitoring program detect unfavorable trends in range condition at or near recommended stocking levels, a variety of range improvement techniques could be employed to increase the extent of meadow communities and the availability of forage species. These techniques are considered to be contingency measures to be employed only in the event of range-related deficiencies and have not been included in the initial operational plan of the ranch.

5.3.1 Burning/Clearing

A major proportion of the ranch's total area is dominated by shrub cover and, in many areas, new shrub growth is beginning to invade meadow communities. Clearing shrub-dominated areas and re-seeding to palatable forage represents an effective means of increasing the forage base. Both chemical and mechanical techniques are commonly used for shrub control although, given the logistical problems of ground-based travel on the SRL ranch, the aerial application of foliar herbicides is likely the most cost effective technique for large scale range improvements. Herbicides such as 2,4-d, 2,4,5-g Silvex or Tordon applied at the full leaf stage (i.e., July) at a rate of 56 to 1121 per ha (5 to 10 gal. per acre) are extremely effective control agents (McLean 1979). Aerial spraying would be particularly well suited to the ranch's winter range, since application would occur when the animals were well removed from the area. Localized shrub clumps can be effectively uprooted and cleared with the raised angled blade of a bulldozer. This work should be undertaken on frozen ground to minimize soil disturbance, preferably in the late fall or early spring. A variety of palatable native and agronomic seed mixes are available for seeding cleared land, with late fall generally being the preferred time for seeding.

Burning is a commonly referenced technique for shrub control. However, if improperly applied or controlled, it can eliminate both target and non-target plant species and cause soil degradation. In the Lowlands, the presence of excessive surface moisture during the preferred burning period (i.e., spring) will likely limit the use of this technique. However, burning could be used to dispose of shrub piles in cleared areas.

5.3.2 Fertilizing

Results of fertilization trials by Agriculture Canada in the Grand Detour area suggest that low nitrogen levels in the regional soil maybe limiting the quality and quantity of Lowlands forage (Pringle [draft], in Reynolds and Hawley [eds.]). Moderate to high application rates of nitrogen fertilizer (i.e., 150 to 300 kg/ha) in June substantially increased both forage yield and crude protein levels, particularly in *Carex* dominated communities, up to three years following the application. Fall applications of nitrogen fertilizer (50 kg/ha) significantly increased forage yield and crude protein levels the following year. The addition of phosphorous, potash and sulphur-based fertilizers resulted in no signiilcant effects on forage yield, although phosphorous uptake by forage increased by 30% on plots where that element was supplied.

Based on these trials, it would appear that the application of nitrogen fertilizer could be used to enhance range productivity, should the need arise. Fertilization could be effectively used on winter range to increase crude protein levels and, hence, the overwintering quality of the native forage.

5.3.3 Drainage Techniques

During years of high snow loads andfor rapid spring run-off, the proposed ranch site experiences flooding, or at least saturated soil conditions, over a portion of its area. Although the extent of this flooding has not been documented, excessive surface water could reduee the amount of available spring forage and limit the number of suitable calving , areas in particularly wet years. The construction of drainage ditches radiating out from major drainage channels which currently flow through or adjacent to the ranch represents a potential means of drying out some portions of the ranch's spring/summer range, should the need arise. Tributaries of both the Tethul River (paralleling the eastern fence line of the ranch) and the Slave River (flowing through the northwest comer of the ranch) offer potential "catch" channels for a ditching program. Ditches would simply be constructed along low elevation contours, joining the catch channels with the adjacent, low-lying wetlands of concern. Ditches with particularly low gradients would require control structures at their mouths (i.e., at the confluence of the ditch and stream channel) to prevent the back flow of water during high flood years.

The construction of ditches through fens is a relatively inexpensive operation. Approximately 41,300 m^3 of ditch (1.2 m x 2.4 m) were recently developed by Ducks Unlimited in the lower Saskatchewan River delta at an average cost of $1.80 per linear m of ditch, excluding survey costs (Chris Smith [Ducks Unlimited]; pers. comm.). Construction was completed during the summer months by a Caterpillar 225 backhoe (approximately $60/h) with a 1 m^3 bucket. Similar ditching in Saskatchewan was developed at an average cost of $1.37 per linear m (Dick Iverson [Ducks Unlimited]; pers. comrn.). It should be recognized that winter construction of ditches would result in a doubling of the cost, since a tractor mounted ripper would likely be required to loosen the frozen soil prior to backhoe operations.

Beeause damage to the ditches from bison (i.e., trampling) and beaver activity (i.e., dam building) can be anticipated, post development maintenance of the ditches will likely be required each year. Therefore, it is recommended that a tracked backhoe and a D-6 wide-pad Caterpillar (or comparable machine) with a power take-off and volumetric pump attachment be purchased for the ranch. This equipment could 'be used for both the construction and maintenance of the ditches.

CHAPTER 6 BASE CASE COMMERCIAL FACILITY DESIGN

6.1 GENERAL DESIGN BASIS

The general purpose of this chapter is to develop and present a base case commercial facility design and the costs associated with such a facility. This representsa ' preliminary design basis to the extent that costs are presented for particular units which can be scaled up or down depending upon the final scale of the ranch. It is clear that a number of the costs will allow for economies of scale, such as fencing which generally increases in cost proportional to the square root of the total land, whereas others are linearly realted to the scale of the operation. Any such relationship will be identified and specified in the costing. The reason that costs are presented in this manner is to allow subsequent analysis of the ranch production costs at various scales without going through a detailed costing exercise.

6.2 CONSTRUCTION PHASE - FIXED FACILITIES

6.2.1 Site Layout

The basic site layout for the base case design was shown previously in Figure 2. The ranch consists of a total area of 6,750 ha on the east side of the Slave River. A compound containing the ranch buildings and the handling facilities is situated in the southwest comer of the ranch. As was noted in previous sections, it is assumed that construction of the ranch facilities will allow for a one year time period between completion of the barrier fences and the introduction of bison stock to the ranch. The following sections outline the capital construction costs associated with starting the ranch, disaggregate by major cost centres.

6.2.2 Fencing and Corrals

The costs associated with the fences and the corrals represent the largest overall cost centre in the project. As these expenditures also occur well before commercial production begins, optimization of these costs is critical to the financial feasibility of the ranch.

Fencing requirements can basically be divided into the following categories: (i) buffer fences to isolate wiId bison from the ranch; (ii) perimeter fencing around the ranch; **and,** (iii) cross-fencing within the ranch perimeter to facilitate range management practises. Buffer and perimeter fencing requirements **are** estimated to be 32 km each, and total cross-fencing not associated with the handling facilities is 16 km.

A number of fence designs are available and, as a part of this study, a review was undertaken of vaxious fencing materials and costs. It is important to note that the long-term costs and maintenance requirements of these fenecs are subject to some uncertainty and, to mitigate risks, recommendations will be made in subsequent chapters regarding the actual materials to be used. In Alberta the boundary fence to enclose big game **must** be at least 2.1 m high and be composed of 9 gauge paige wire with less than a 15 x 15 cm mesh. Jennings and Hebbring (1983) note that 1.8 m fences, supported by strong posts, are adequate for bison. The cost of construction of a steel fence of the type recommended would be about $7000/km. Current alternatives to such a system involve either post and rail construction, or electric fencing.

Electric fencing would cost about $2200/km for a 2.1 m high, 14 strand high **tensile** wire fence. Cross fencing can be constructed of ten strands of high tensile wire on 2.1 m high wooden posts set 30 metres apart with fiberglass stays every 7 m. The average cost of the cross fencing would be of the order of $2000/km.

Post and rail construction tends to be the most expensive alternative available, although it has the added advantage that it can be constructed from local materials. A typical construction would involve a 2 m high fence and would require posts at 4 m intervals, specially treated to prevent deterioration. Posts will be installed by pushing them into soft ground or, where dry ground exists, augering the holes and tamping in dry ground The estimated costs for post and rail construction are $8000/km if local materials are available.

It should be noted that geotechnical conditions within the ranch site may cause construction and maintenance problems for all of the above fencing scenarios. Saturated soils, ice lenses and shallow active Iayers characterize a significant proportion of the ranch site, and any one of these conditions will reduce the integrity and durability of standard post-supported fences. In the Hook Lake area where an extensive network of fences was constructed to facilitate the anthrax control program in the 1960's, a surface support system was utilized to stabilize much of the fenceline (see Photo 15) and similar structures will likely be required for the ranch in many areas. Such structures can increase fencing costs considerably.

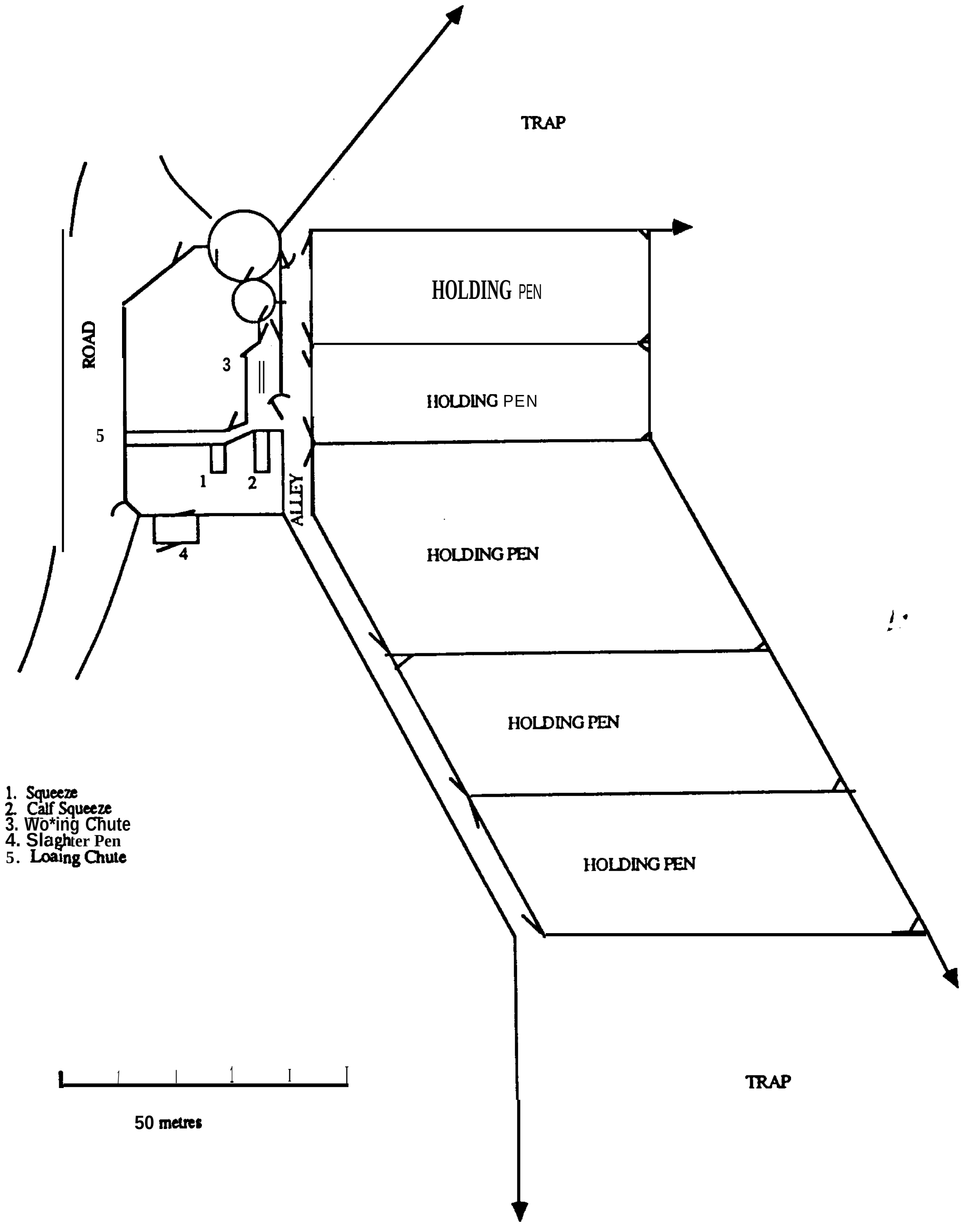
From the above discussion it is clear that a wide range of costs can be used for cost-estimating the fencing. In the base case, a conservative approach is adopted and an average cost of $8000/km for all fencing is allowed. A pilot stage is later described in which it is recommended that, for the first three years of operation, both post and rail and paige wire fencing be used in parts of the ranch. Upon full expansion the construction technique with the best cost efficiency will be utilized. Electric fencing is currently discounted because of the uncertain and potentially high maintenance costs associated with this alternative. It should be noted that all fence design is based on single fences.

Ranch layout and handling facility design have an important bearing on the ease of herd and range management. Housing for personnel would be located close to the facility. A well designed facility would permit animals to be held, sorted, handled for close inspection, treated, and weighed without injury and little stress. Bison handling facilities usually consist of drive alleys from the pasture to the corral, with fences arranged to allow herding of the animals into the enclosures, several holding pens 0.1 ha to 0.3 ha in area, a working alley 4 m wide that can be segmented into shorter units by gates, a circular or half circular crowding pen with a dual exit and a sweep gate that follows the curved' wall, a loading chute, and squeeze chutes. Such facilities are made of planks to limit the vision and reduce disturbance to the corraled animals, and have no comers to prevent animal bunching. A sample layout of such a facility for the basis of costing is shown in Figure 6.1. Actual facilities on the site may differ somewhat depending upon the site specific geotechnical suitability of the available area. Detailed ground work was beyond the scope of this analysis.

The total costs for the corrals and handling facilities are estimated to be $128,000. This is disaggregated as $50,000 for the corrals, chutes, holding pens, runways and working shed, $30,000 for handling equipment (squeeze and scale), and $48,000 for 6 krnoffencing to "trap" and facilitate herding of the animals.

Photo 15 Surface support system used for I Iook Lake fenceline.

Figure 6.1. **Handling** Facility - Sample Layout



6.2.3 Permanent Structures and Equipment

A minimal number of buildings are required for the facility, consisting primarily of residences for permanent and temporary staff. A total building cost of $63,000 is allowed, disaggregated as follows: $25,000 for a permanent residence; $20,000 for a shed/workshop/garage; $8,000 for a supplementary bunkhouse; and a $10,000 allowance for transportation of materials to the site and site preparation work. The exact locations of these facilities are not precisely specified and will rely on geotechnical ground work.

Total equipment cost is estimated to be $170,000, as follows:

Snowmobile	$5,000
ArgoA'railer	12,000
Boat &Motor	10,000
Wide-pad D6	45,000
Tracked backhoe	35,000
Pumps, control gates, etc.	30,000
Tools	10,000
Tarps for Hay	5,000
Miscellaneous	8,000
Transportation to site	10.OOQ
TOTAL	$170,000

6.2.4 Access Facilities

A discussion of the access facilties is presented in Appendix A. The total cost indicated for road construction involved an initial capital cost of approximately $75,000.

6.2.5 Utility Provision

The provision of utilities will be through on-site electrical generation and a pumped water well. The water system includes a hot water system with sufficient capacity to allow hot water production for any cleaning operations during animal slaughter. Total costs for utility provision are estimated to be $30,000: $7,000 for the electrical system, $20,000 for the water system, and $3,000 for fuel storage.

6.2.6 Stock Procurement

As noted **previously,** initial stocking will consist of 85 cows and 15 bulls. Prices of these animals delivered to the NWT would average approximately $1000 if purchased commercially and transported by trailer to Fort Smith. As noted by Ruitenbeek ***et. al.*** (1985), marketing will be greatly assisted by using plains bison, or hybrid bison in the ranch as regulations currently would not allow export of wood bison products to the rest of Canada. Initial stocking will, however, be with wood bison and the introduction of a hybrid strain will only occur if regulations do not change sufficiently over the next 5 to 10 years.

6.2.7 Summary of Fixed Facility Cost Estimate

The total capital cost of the ranch also allows for a 10% contingency and is thus estimated to be $1,327,000. A disaggregation of these costs is provided in Table 6.1.

Table 6.1. Base Case Commercial Facility Capital Cost Summary

Cost Centre	cost (1987$)
Fencing	640,000
corrals	128,000
Permanent Structures	63,000
Equipment	170,000
Road and Access	75,000
Utility Provision	30,000
Stock Procurement	100,000
Contingency	121,000
TOTAL	1,327,000

6.3 OPERATING PHASE

6.3.1 Operating Practices

The ranch operating practices are generally as described in Chapters 2 to 5. The population growth is estimated to provide for a peak population of about 1400 animals after about 17 years. The following sections describe specific operating costs, on a per unit basis, of the base case ranch.

6.3.2 Land Leasing

At this time no definite resolution as to land leasing exists. The alternatives were fully described in Module A of this study (Ruitenbeek *et.al.*, 1985). It is clear, however, that some allowance must be made for land leasing, and hence an annual fee of $1/ha has been assumed. At the full scale of operation, this fee thus results in a total annual cost of $6,750.

6.3.3 Slaughtering and Inspection

Slaughtering could be conducted using a mobile abattoir or a fixed abattoir. As described in Module A of this study, a fixed abattoir would normally be required to meet southern Canadian standards, although Agriculture Canada has accepted mobile slaughtering operations elsewhere in the N.W.T. Primary concerns are that the operation is insect free and that hot water is available. As the slaughtering will normally occur in late fall, the insect problem does not exist, and hot water containers can be outfitted on the trailer.

The cost of the mobile abattoir is already included within the equipment costs specified in the previous section. A fixed abattoir would cost approximately $1.5 million and would be economic only if more than 200 animals were slaughtered annually in it. Even so, the incremental cost of bison meat production would exceed $3.00/kg.

The actual slaughtering and inspection process will involve some specific operating costs. These were estimated to be $6,000/year for a helicopter supported roundup in the fall, plus approximately a $10/animal charge for each bison slaughtered. Manpower costs are estimated separately. At the commercial production rate, total slaughtering and roundup costs are estimated to be $9,900 annually.

6.3.4 Veterinary Care

Although veterinary care will bean important part of the annual inspection process, costs associated with it are minimal because most of them will be covered by Agriculture Canada. Nonetheless, a $3/animal annual allowance is provided.

6.3.5 Supplemental Feed

Supplemental feed requirements are among the most expensive annual operating costs for the ranch. Prelimary economic feasibility tests indicated that it would be uneconomic to supplementally feed the entire herd during the winter, and that some productivity loss could be tolerated for the cost savings. This same argument did not hold true, however, for the calf component, as the productivity losses would be unacceptably high without supplemental feeding. It was thus recommended that all animals less than 18 months old be segregated and supplementally fed during the winter. Supplementary feed requi.mments are estimated to be 1.4 tonnes/animal annually. Feed costs to bring hay from Alberta to the ranch site via truck and barge are estimated to be $65/tonne. Some of this hay may be sourced locally (and maybe available at lower prices) once ranch operation is established For cost planning, however, the use of Alberta hay will insure a secure supply of hay.

In addition, modest mineral supplements were required for the entire herd. These could be achieved through shots, or through distribution of mineral blocks. For the pourpose of this analysis, the use of mineral blocks was assumed as they also provide!an opportunity for range management. The mineral block requirement is based on one block for every ten animals, at a cost of $15 per block. In summary, the total costs of supplementary feed at full scale operation would be $43,700 annually for the hay and $2,000 annually for the mineral blocks.

6.3.6 Operating Manpower

Operating manpower requirements were based on an average cost of $36,000 per person-year. In addition to one full-time resident employee, part-time help will be required annually, particularly during the roundup and slaughtering period. This part-time requirement was estimated to be 12 person-weeks for every 100 animals harvested. Total manpower requirements during full operation are therefore 2.44 person-years annually resulting in a total cost of $87,800.

6.3.7 Operating Maintenance

Maintenance costs are disaggregated between the regular facility maintenance costs and the fence and corral system maintenance costs. Maintenance costs for structures and equipment typically ranges from 3% to 5% annually of the initial cost. For this study, an estimate of 4% was used, applied to the buildings, equipment, and utility systems. Fence material maintenance requirements are subject to some uncertainty, but are conservatively estimated to be 3% annually of the initial installed cost. This provides a maintenance budget of almost $23,000 annually for the fence and corral systems. While this may appear excessive given that the labour charges are included elsewhere, it is believed that such a level is necessary because of the uncertainties involved with the fence materials under the conditions to which they will be subjected.

6.3.8 Other Operating Costs

Fuel costs for pumping, heating and electricity are estimated to be $400/month on average, or $4,800 annually. Road access will be re-established yearly and will require an additional cost of 60% of the first year cost of the road, or $45,000/year. Last, a provision for monitoring and herd management has been allowed involving an allowance of $3/animal and $1/ha. While this translates to only some $12,000 per year, it is adequate to cover regular lab tests of range forage (nutritional analyses) and feces (parasitic loads) and thus allows the early detection of potential problems. Additional research may be warranted for general research purposes but such costs are not directly attributed to the ranching operation.

6.3.9 Summary of Operating Costs

The total operating cost of the ranch also allows for a 5% contingency and is thus estimated to be $263,400 at full commercial scale. A disaggregation of these costs is provided in Table 6.2. It is important to note that, because a number of the costs are production linked, the total cost will be lower in the initial years. Actual operating costs on an annual basis are provided in Appendix B.

Table 6.2. Base Case Commercial Facility Annual Operating Cost Summary

Cost Centre	Annual Cost (1987$)
Slaughter and Round-up	9,900
Veterinary	5,300
Utilities	4,800
Building and Equipment Maintenance	10,500
Fence Maintenance	23,000
Operating Manpower	87,800
Supplementary Feeding & Minerals	45,700
Land Lease	6,800
Access	45,000
Monitoring	12,000
Contingency	12,500
TOTAL	263,400*

* **May** not add due to rounding.

CHAPTER 7 ECONOMIC ANALYSIS AND DESIGN OPTIMIZATION

7.1 BASE CASE EVALUATION

7.1.1 Modelling Methodology and Assumptions

The purpose of this section is to determine and recommend an economically optimal scale of production which reflects production costs and market conditions. The analysis depends critically upon the market analysis undertaken in Module A and on the production parameters and costs discussed previously.

It is recognized that a number of project scales are physically viable for the game ranch. Although other proposals have suggested a long term equilibrium level of 1000 animals, the optimal level may differ depending upon a number of technical and economic factors. Important considerations in establishing optimal size include the potential economies of scaIe and the size and value of the markets.

The generaI approach used here is to prepare a number of critical economic indicators as a function of project scale. These indicators are:

i) Average Production Costs (APC) - signifying the average cost of delivering the ranch products to the ranch gate for external sale;
ii) Average Ranch Gate Price - signifies the average price for the product which is received at the ranch gate for the product; and,
iii) Average Ranch Gate Profit (ARGP) - being the difference between the above average costs and prices.

It should be noted that all of the optimization work is conducted on a before-tax basis, although taxes are included in the final cash flow analysis.

The APC is comprised of a number of cost types, each dependent upon ultimate ranch scale. Chapter 6 discussed a number of the relationships between costs and scale. To compute the average cost, an averaging technique known as "cost levelization" is utilized (Bradley, 1979). The levelized cost indicates the price which must be received for each and every unit of output for a project to just break-even. It is, in a sense, a cost of service for producing any particular good. The advantage of this method is that it allows a cost calculation to be done independent of knowing what the ultimate market strategy or allocation will be. Also, through the levelizing technique, up-front capital costs are distributed over all production periods by allowing some rate of return on capital which reflects a fair market rate of return. This analysis uses a 10% real rate of return, which is that suggested for financial analyses by the Canadian Treasury Board.

The average ranch gate price will also be computed on the basis of project scale, but this will be dependent upon the specific market allocations. From the market analysis undertaken in Module A, a ranch gate price is presented for a number of market areas. These prices represent the prices in the end markets less any transportation and distribution costs to get the products into those markets. At this stage a linear programming technique is employed to select the optimal market allocation given any level of, output. The linear programrning process essentially sells output into that combination of markets which will maximize some objective function. In this case the objective function is specified as that which maximizes ranch gate revenue.

Through this process a relationship between project scale and average ranch gate price will be derived. It should be noted that it is expected that this will be a declining curve, as the optimization procedure will always select those markets with the highest value first. By the same token, however, the APC curve will be declining with increased scale because of the effects of economies of scale. Differential analysis of the two curves through the above procedures will provide the relationship between average ranch gate profit (ARGP) and the long-term equilibrium size of the ranch. The point at which ARGP is at a maximum is selected as the optimal profit maximizing scale for the actual feasibility study.

At this stage it is relevant to note that preliminary cost data were available to the consultants which allowed a number of preliminary optimization studies to be undertaken prior to selecting a ranch layout and population forecast. The design studies indicated that the optimal size would be somewhere around 1500 animals, and hence the base case described in chapters 2 to 6 was based on that, consistent with biological constraints. It is hence expected that the base case described earlier is close to the optimal scale. The purpose of this analysis is therefore also one of confirming that this is indeed the optimal scale.

A special long-term planning model was developed to facilitate the analysis. The model combines components of the levelization procedure, the linear-programming procedure, and the after-tax financial analysis. The model uses all the available cost information to develop cash flow profiles for the ranch at any scale, over a period of 35 years of production. In addition, for any given scale, the model selects an optimal market allocation of products for every year *of production* to each of the markets using the linear programming approach. **Finally,** the financial analysis allows specification of various debt.kquity arrangements and tax parameters to prepare pro-forma after-tax cash flow summaries. This long-term planning model also accommodates changes in herd growth performance, supplemental feeding requirements, and other technical production parameters. On the operations planning side, it also estimates labour requirements for every year.

The model, while used here for the initial planning, has further applications in the ongoing optimization of ranch configuration during the implementation, development, and operating phases.

7.1.2 Market **Specification** - Average Ranch Gate Price

A complete survey and discussion of markets is presented in the Module A results of this study (Ruitenbeek et.al., 1985). Table 7.1 summarizes the market study results. -"It indicates that premium markets exist in Alberta for about 100,000 kg of bison product annually at a price of about $18.00/kg. Lower prices would apply if a higher degree of market penetration were achieved.

The linear programming model was run with two cases:

Case A. Selling products to Alberta and the N.W.T. at current N.W.T. prices which would average just over $7.00/kg.

Case B. Selling Products on an unconstrained basis to the highest value market first.

In the latter case **it** was further assumed that no more than 100,000 kg/year would enter Alberta at a price of $18.00/kg.

The results for the base case scale were that the average ranch gate prices over the life of the project would be as follows:

Case A.	$ 7.08/kg
Case B.	$17.13/kg

It is **clear that,** in Case B, any market expansion would lower the average price. This price sensitivity is illustrated in Section 7.2 below.

Table 7.1. Baseline Market Penetration and Netback Prices at Fort Smith - Bison Products

Market Area/Segment	Price(1) Fort Smith ($ W	Annual Volume (kg)	Target Market Growth (%/yr)	
Fort Smith (Town)				
Retail	*7.00*	770	1.8	
Institutional	*7.00*	390	1.8	
Hospitality	*9.67*	220	1.8	
Lower Mackenzie(2)				
Retail	6.81	4,900	1.7	
Institutional	6.81	2,480	1.7	
Hospitality	9.48	1,390	1.7	
Upper Mackenzie(2)				
Retail	6.57	12,330	1.6	
. Institutional	6.57	6,230	1.6	
Hospitality	9.24	3,490	1.6	
Alberta	17.92-18.41(3)	100,000(4)	o%	
General				
Breeding Stock	$1700/head	de	n/e	!”
Total		132,200	--	

1) The “Netback Price” refers to the market price less freight changes into the central market point. It is assumed that pricing to outlying communities will be based on f.o.b. prices at the market centre plus freight.

2) Lower Mackenzie communities include: Hay River (market centre); Deta.h; Fort Liard; Fort Providence; Fort Resolution and Pine Point.

Upper Mackenzie communities include: Yellowknife (market centre); Rae Edzo; Inuvik and Norman Wells

3) Price depends on product marketed. A price of $18.41/kg is achieved if finished products are shipped to Edmonton. A slightly lower price is received if live animals are shipped for slaughter in Edmonton.

4) This corresponds to current market penetration at current prices. The market is very price sensitive and could, at the extreme, expand to 3,000,000 kg/year if prices fell to beef equivalent values.

7.1.3 Supply Costs -Average Production Costs

The average production cost, or supply cost, for the base case commercial ranch is $7.04/kg. This implies that if a price of $7.04/kg were received for every kilogram of output from the bison ranch, then the ranch would be capable of generating exactly a 10% real return on the initial capital invested. This 10% real rate of return corresponds approximately to a 15% nominal rate of return if one takes inflation into account. This is considered to be a marginally acceptable rate of return for this type of an investment The $7.04/kg is also to be considered as a break-even price which must be received for the output from the ranch. The average production cost is the same for both cases described above.

The model allows disaggregation of the cost share components of the average production cost. These components are summarized in Table 7.2 for the capital and operating costs separately. This analysis again underlines the fact that fencing is the most expensive capital component of the ranch. The capital and maintenance costs alone contribute $1.80/kg to the final delivered cost of the bison, which represents 26% of the final delivered cost. Labour costs represent $1.39/kg, or 20% of the delivered cost. The next major component is the initial road construction and annual re-establishrnent of access. This component accounts for $1.15/kg of the final delivered cost, or 16%.

The cost share analysis is also useful for determining the influence of cost over-runs on the overall ranch break-even price. For example, doubling the equipment cost would add an additional $0.38/kg to the cost of the output. By the same token, halving the hay costs would decrease the cost by about $0.20/kg.

7.1.4 Analytical Results - Project Profitability

Taking the difference between the average ranch gate price and the average production costs gives the project margin or profitability. Results areas follows:

Case A.	$ o.04/kg
Case B.	$10.09/kg

It is clear that a strong preference exists for accessing Alberta markets and this should be a major component of the marketing plan of the ranch.

Table 7.2. Base Case Commercial Facility Average Production CoSts (1987$)

Cost Centre	cost ($/kg)
Fencing	1.33
corrals	0.29
Permanent Structures	0.14
Equipment	0.38
Road and Access	0.17
Utility Provision	0.07
Stock Procurement	0.19
Contingency	0.26
SUB-TOTAL CAPITAL	2.82
Slaughter and Round-up	0.15
Veterinary	0.05
Utilities	0.09
Building and Equipment Maintenance	0.23
Fence Maintenance	0.47
Operating Manpower	1.39
Supplementary Feeding & Minerals	0.41
Land Lease	0.11
Access	0.98
Monitoring	0.16
Contingency	0.20
SUB-TOTAL OPERATING	4.22
TOTAL	7.04

*** Numbers may not add due to rounding.**

7.2 SCALE OPTIMIZATION

7.2.1 Assumptions

The base case commercial scale of the ranch involved the annual sustained harvest of 394 animals once the commercial scale had been achieved. Sensitivity analyses to scale ' were conducted which assumed that the entire operation would change such that both the final commercial scale as well as the initial stocking level changed proportionately. This implied that the time frame for development was not affected, but that total land requirements would increase or decrease in proportion because carrying capacity would remain fixed. Economy of scale relationships would hence exist in all fixed capital components, especially the fencing requirements which would vary directly to the square root of any increases in costs.

Scale sensitivities were also conducted to the markets. As markets expand, lower price markets must be accessed and hence the average ranch gate price is expected to decline with substantial expansions. This implies that, although costs might be declining from economies of scale, the profit margin will eventually fall because the average ranch gate price will fall faster than the average production cost. These phenomena are shown in the form of cost curves in the following sections.

7.2.2 Analytical Results

Figures 7.1 to 7.3 summarize the results of the scaling, with the numerical results shown in Appendix Table Cl. Sensitivities were run from a minimum of 20% of the base case scale to a maximum of 550% of the base case scale. The results illustrate clearly that the *minimum* viable scale is 40% of the base case if markets in Alberta are accessed. If only N.W.T. markets are relied on, then the minimum commercial scale is essentially the base case design. Both scenarios could expand considerably without suffering any loss in commercial viability.

7.3 SELECTION OF OPTIMAL CASE

Figure 7.3 also illustrates that a plateau is reached which represents the maximum profit margin available. This occurs with access to Alberta markets at a scale of approximately 110% that of the base case. The profit margin is maximized at this point

Figure 7.1. Average Production Costs

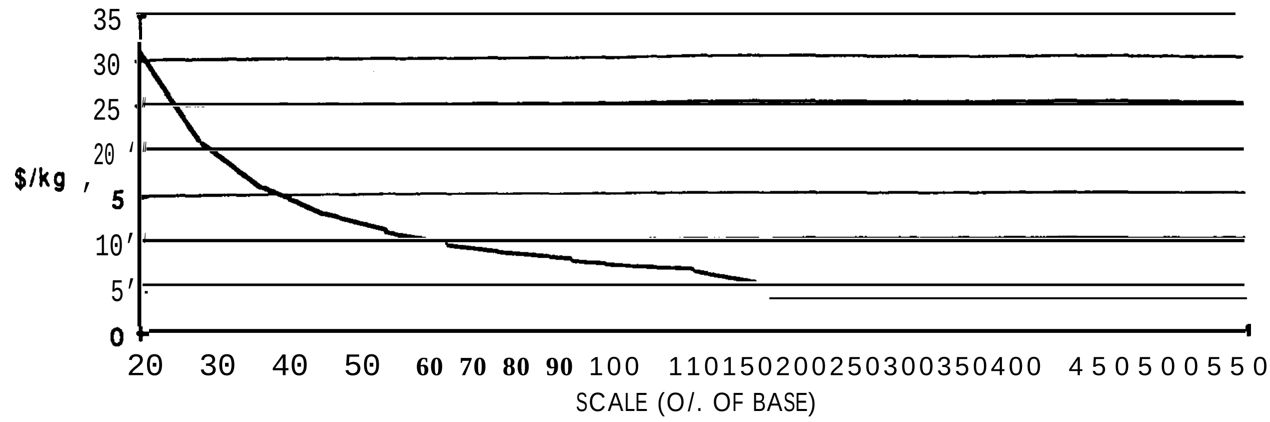


Figure 7.2. Average Prices

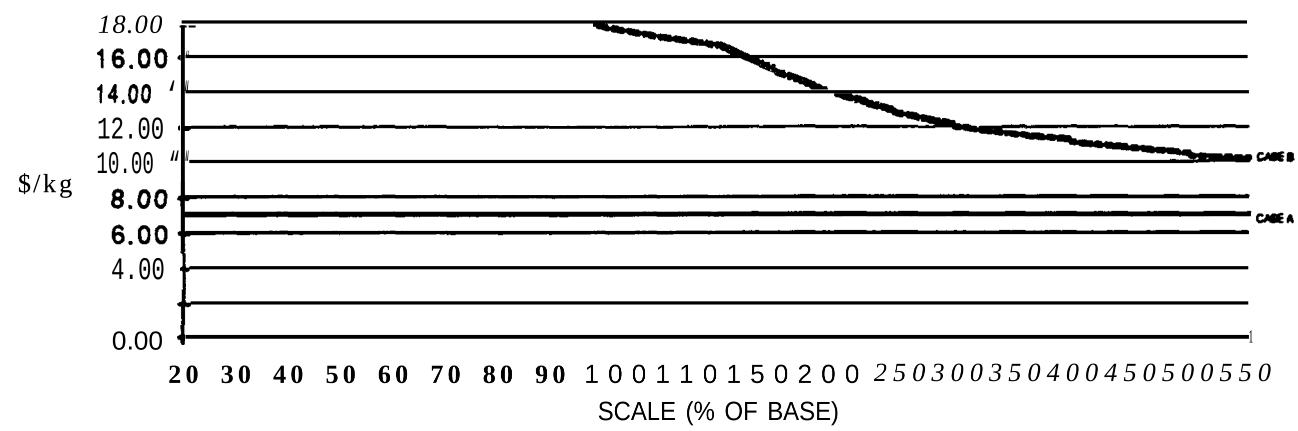
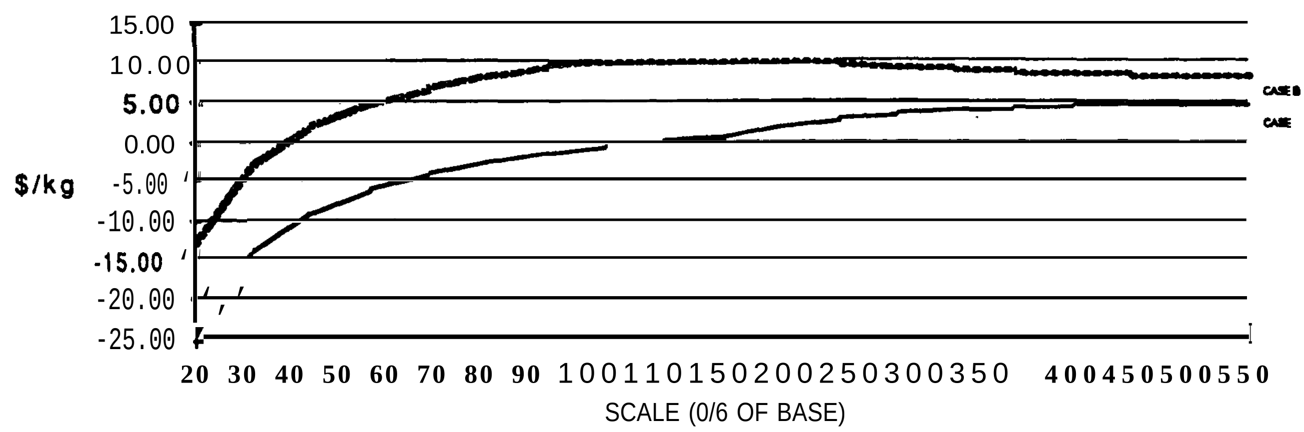


Figure 7.3. Average Ranch Gate Profit



which, over the long-term, will provide maximum operating flexibility and minimum risk for the project. As the optimal scale of the ranch is so close to the design basis, the base case project is used as the basis for subsequent financial and investment analyses.

CHAPTER 8 PROFITABILITY ANALYSIS - OPTIMAL CASE

8.1 CASHFLOW ANALYSIS

8.1.1 Project Cashflows

Costs developed in the previous sections for the base case also apply to the optimal scale design basis. Detailed results of the cash flow modelling are presented in Appendix B. The purpose of the following sections is to summarize a number of the key results for the project cash flows and the major economic profitability indicators.

Table 8.1 shows the annual cash flow projections for the optimal case, disaggregated by operating costs, capital costs, and various revenue centres. These cash flows are before the application of any income taxes or interest charges on debt servicing. All estimates are provided in 1987$, with inflationary effects removed. It was assumed for the cash flow projections that construction of initial fencing would not commence until 1988. Any acceleration or delay in this start-up schedule would create similar schedule shifts for the rest of the project, but they would not materially affect the results presented for the various profitability analyses.

It is clear that the project long-term revenue is of the order of $1.9 million per year, with annual operating costs of approximately $263,000. This indicates that, although the long lead times for ranch development cause a long initial payout period, the substantial net income generated by the project is sufficient to pay back the initial invested capital.

8.1.2 Profitability Indicators

The cash flow results allow the calculation of a number of conventional profitability indicators. These indicators are, again, before taxes. Two sets of profitability indicators were calculated: (i) for the entire full scale project over a 35 year productive life; and, (ii) for the development phase which was defined to include 15 years from 1988 to 2002, inclusive. The year 2003 represents the year in which the long-run level of production is first achieved.

Table 8.1. Project Cash Flows (thousands of 1987$)

Year	Capital Costs	Operating Costs	Total costs	Alberta Revenues	N.W.T. Revenues	Total Revenues	Net Cash Flow
1987	0	0		0	0	0	
1988	794	0	79!	0	0	0	-79!
1989	282	71	352	0	0	0	-352
1990	251	142	393	0	0	0	-393
1991	0	171	171	56	0	56	-115
1992	0	174	174	154	0	154	-20
1993	0	184	184	287	0	287	103
1994	0	186	186	426	0	426	240
1995	0	191	191	590	0	590	399
1996	0	197	197	780	0	780	583
1997	0	205	205	1000	0	1000	796
1998	0	214	214	1298	0	1298	1084
1999	0	202	202	390	0	390	188
2000	0	216	216	903	0	903	687
2001	0	234	234	1441	0	1441	1208
2002	o	230	230	903	o	903	673
2003	0	266	266	1800	194	1994	1728
2004	0	267	267	1800	172	1972	1705
2005	0	264	264	1800	109	1909	1645
2006	0	264	264	1800	99	1899	1636
2007	0	263-	263	1800	91	1891	1628
2008	0	263	263	1800	85	1885	1622
2009-24	0	263	263	1800	87	1887	1624

The following represents the before tax profitability of the enterprise:

Indicator	Total Project	Development **Phase**
Net Present Value	$3.72 million	$0.58 million
Benefit-Cost Ratio	2.43	1.28
Real Rate of Return	21.03%	14.69%
Rojeet Payout	1997	1997

The net present value and benefit cost ratios were calculated using a 10% real discount rate. The results clearly indicate that the project pays out in about 8 years, well within the development phase if surplus animals are sold on the hoof or slaughtered. The real rate of **return** indicates the rate of return on the investments excluding any **inflationary** effects. This would translate to a rate of return well in excess of 25%/year for the projeet as a whole if the inflationary component were included.

8.2 INVESTMENT ANALYSIS

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8.2.1 Debt Analysis

A total investment analysis of the project was undertaken assuming that the ranch would be partially debt financed, to derive the optimal level of debt for the ranch from the investment perspective. To calculate this, specific assumptions are required regarding the debt/equity structure, the tax structure, and the debt servicing approach. The following describes the **specific** assumptions inherent in the analysis.

Debt leverage was calculated in 5% increments from O% to 100%. In all cases this was applied only to the capital outlays, and it was assumed that all working capital requirements would be provided by debt. **This** implies that even in the 0% debt case, some debt will still be required to bridge the gap from the initial years, in which negative operating cash flow is projected, to the years in which net operating income is generated.

The after tax analysis assumed an inflation rate for **all** operating costs, capital costs, and revenues of **4.5%** annually. All eligible capital was depreciated at a rate of 10%, which is the average capital cost allowance (CCA) for the **project.** Fences and **corrals,** which are directly defined in the income tax act, have a CCA of 10%, roads are 8%, and other equipment is 10% to 20%. An average CCA of 10% is therefore believed to be a reasonable estimate, particularly given that the major cost share is for fences and corrals. Livestock purchase is carried at book cost and is not depreciated, nor is any appreciation attributed to the herd value. Interest expenses, assumed to be at a borrowing rate of 11%/year of the principal amount, is fully deductible, as are any of the operating costs associated with the ranch. Tax losses are assumed to be carried forward, given that no other income exists against which to write them off, and the average effective tax rate is assumed tobe2190.

Debt servicing is assumed to involve 100% dedication of available net cash flow to the principal amount. This implies that in the early years of the project, the total debt load grows substantially as all interest expense must be capitalized. A detailed debt retirements schedule is provided in the following section.

Table 8.2 shows the net present value of the project, as well as the real rate of return, for all of the debt leverage scenarios. It is clear that the project is sufficiently profitable to generate a non-convergent series which will allow the servicing of any level of debt. This is not unusual given that the average production cost, even including taxes, is just over one-half of the revenue. For analytical purposes, however, it is believed that 100% debt leverage is normally impractical to obtain, and hence a 75% level was selected as optimal. This results in a maximum debt requirement of about $2.4 million for the entire ranch, and total equity injections of **$372,000.**

8.2.2 Financial Position of the Ranch

Given the high debt load in the ranch, it is important to specify precisely the financial position of the ranch. A pro-forma financial statement was hence prepared indicating the primary financial indicators for each year of the ranch life, shown in Table 8.3. It is notable that the total debt is paid off before the ranch achieves its long-term production level.

Table 8.2. Debt Leverage Sensitivity Results

Equity (%)	Net Present Value (thousands of dollars)	Real Rate of Return (%)
100	2785	19.75
95	2795	19.99
90	2806	20.25
85	2818	20.54
80	2831	20.87,
75	2844	21.22
70	2857	21.60
65	2869	22.01
60	2882	22.46
55	2897	23.00
50	2912	23.60
45	2927	24.28
40	2942	25.05
35	2956	25.95
30	2971	27.01
25	2987	28.33'
20	3004	30.05
15	3021	32.36
10	3037	35.82
5	3054	42.28
0	3070	

Figure 8 Financial Position of Ranch (thousands of dollars)

Year	Income	Costs	Interest	Depreciation	Before Tax Income	Taxes	After Tax Income	Retained Earnings (De	Long-term Debt	Assets at Book	Livestock at Book	Net Assets
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	72	80	(152)	0	(152)	(152)	651	802	0	151
1989	0	81	115	102	(298)	0	(298)	(450)	1,044	1,019	0	(26)
1990	0	169	171	119	(459)	0	(459)	(909)	1,553	1,194	119	(240)
1991	70	214	205	107	(456)	0	(456)	(1,365)	1,867	1,074	119	(673)
1992	200	227	231	97	(354)	0	(354)	(1,719)	2,098	967	119	(1,012)
1993	391	251	256	87	(203)	0	(203)	(1,921)	2,329	870	119	(1,340)
1994	606	265	269	78	(7)	0	(7)	(1,928)	2,445	783	119	(1,542)
1995	877	283	261	70	262	0	262	(1,666)	2,373	705	119	(1,549)
1996	1,211	306	224	63	617	0	617	(1,049)	2,040	634	119	(1,287)
1997	1,623	332	150	57	1,085	8	1,077	29	1,360	571	119	(670)
1998	2,201	363	24	51	1,762	370	1,392	1,421	218	514	119	415
1999	691	359	3	46	283	60	224	1,645	24	462	119	558
2000	1,672	400	0	42	1,230	258	972	2,616	3	416	119	533
2001	2,790	452	0	37	2,300	483	1,817	4,434	0	375	119	493
2002	1,826	465	0	34	1,327	279	1,048	5,482	0	337	119	456
2003	4,214	561	0	30	3,622	761	2,861	8,344	0	303	119	423
2004	4,354	590	0	27	3,737	785	2,953	11,296	0	273	119	392
2005	4,406	609	0	25	3,772	792	2,980	14,276	0	246	119	365
2006	4,580	635	0	22	3,922	824	3,099	17,375	0	221	119	340
2007	4,766	663	0	20	4,082	857	3,225	20,600	0	199	119	318
2008	4,964	693	0	18	4,253	893	3,360	23,960	0	179	119	298
2009	5,193	725	0	16	4,452	935	3,517	27,478	0	161	119	280
2010	5,427	758	0	15	4,655	978	3,677	31,155	0	145	119	264
2011	5,671	792	0	13	4,867	1,022	3,845	35,000	0	131	119	250
2012	5,926	827	0	12	5,087	1,068	4,019	39,019	0	118	119	237
2013	6,193	864	0	11	5,318	1,117	4,201	43,220	0	106	119	225
2014	6,472	903	0	10	5,559	1,167	4,392	47,611	0	95	119	214
2015	6,763	944	0	9	5,810	1,220	4,590	52,202	0	86	119	205
2016	7,067	986	0	8	6,073	1,275	4,798	56,999	0	77	119	196
2017	7,385	1,031	0	7	6,348	1,333	5,015	62,014	0	69	119	189
2018	7,718	1,077	0	6	6,634	1,393	5,241	67,255	0	62	119	182
2019	8,065	1,126	0	6	6,934	1,456	5,478	72,732	0	56	119	175
2020	8,428	1,176	0	5	7,246	1,522	5,725	78,457	0	51	119	170
2021	8,807	1,229	0	5	7,573	1,590	5,983	84,440	0	46	119	165
2022	9,203	1,285	0	4	7,915	1,662	6,253	90,693	0	41	119	160
2023	9,618	1,342	0	4	8,271	1,737	6,534	97,227	0	37	119	156
2024	10,050	1,403	0	3	8,644	1,815	6,829	104,056	0	33	119	152

CHAPTER 9 INTEGRATED RISK ANALYSIS

9.1 MARKET RISK

In designing a final implementation strategy for the project, it will be critical to know which factors will have the greatest irnpacton financial viability. The purpose of the ‘ risk analysis is to undertake a number of sensitivity studies on selected parameters to determine those areas which merit attention. Specific sensitivity tests are presented for those factors for which risk exposure is not obvious. In addition to these tests, the cost share analysis presented in Table 7.2 will serve to provide additional detail regarding risk exposure. As noted in Chapter 7, risk can be directly correlated to the size of the cost share for any particular category.

One area which is not inherent in the cost share analysis is the risk exposure from the markets. As noted previously, a wide range of prices persists, in particular between Alberta and the N.W.T., and access to the Alberta market premium prices was identified previously as an important factor in establishing the commercial viability of the ranch. Nonetheless, because of the uncertainties involved with marketing, it is paramount to evaluate the ranch profitability under the assumption of limited markets. This was defined earlier as Case A, having access only to N.W.T. markets. Under these conditions the following before tax profitability indicators were computed:

Indicator	Total Project	Development Phase
Average Ranch Gate Profit	$ 0.04/kg	
Net Present Value	$0.013 million	- $lo04 million
Benefit-Cost Ratio	1.01	0.s0
Real Rate of Return	10,06%	<o
Project Payout	2004	2004

It is clear that, although the project is still commercially viable in the long-term, it is only marginal and a slight drop in production or increase in costs would render the project uneconomic. It is therefore critical that access to Alberta markets be established.

9.2 TRANSPORTATION COSTS

Considerable concern is often expressed regarding the transportation costs of products in and out of the N.W.T., in particular from remote sites. It is noted that, in extreme cases, products may have to be flown out to reach markets. In the case of slaughtered bison, this would involve a fairly significant cost. Preliminary cost estimates indicated that such a scenario would cost up to 40¢/kg, and that cost savings in other areas (in particular road maintenance and construction) might be realized. Sensitivity studies were therefore taken over this range, corresponding to extremes in transportation requirements. The results are shown as follows:

Incremental costs ($@)	Average Ranch Gate Profit ($/kg)	Net Cash Flow Rate of Return (%)	After Tax Rate of Return (%)
0.00	10.09	21.03	28.33
0.20	9.89	20.87	28.11
0.40	9.69	20.71	27.89

It indicates that shifts in transportation costs will have little material affect on the overall financial viability of the ranch.

9.3 ANIMAL PROCUREMENT COSTS

Another area of concern involves animal procurement costs. In the base case an allowance of$1000/animal was made for the initial 100 animal herd. Some animals maybe available at little or no cost from the Mackenzie Bison Sanctuary, whereas animals obtained from southern markets could cost up to $2000 each. Appropriately, a sensitivity test was undertaken with respect to this range of costs for bison purchase. The results are as follows:

Bison cost ($/animal)	Average Ranch Gate Profit ($/kg)	Net Cash Flow Rate of Return (%)	After Tax Rate of Return (%)
0	10.29	21.50	29.22
1000	10.09	21.03	28.33
2000	9.88	20.53	27.53

Again, although the investment in initial stock is substantial, the project could afford to pay considerably more for the bison than current market values without jeopardizing the financial viability of the ranch.

9.4 FACILITY COSTS

The impacts of changes in fixed facilitiy costs such as buildings and equipment can be obtained from Table 7.2. It is useful, however, to specifically illustrate the impacts which changes in fence costs will have on the overall operation. Although in the base case it was assumed that fencing would cost $8000/km, any cost savings or increases would have dramatic impacts on project economics because of the significant cost share of this component. The following summarizes the results of sensitivity analyses on fencing costs:

Fence cost ($/km)	Average Ranch Gate Profit ($/kg)	Net Cash Flow Rate of Return (%)	After Tax Rate of Return (%)
5,000	10.85	23.23	31.79
6,000	10.59	22.43	30.53
7,000	10.34	21.70	29.37
8,000	10.09	21.03	28.33
9,000	9.84	20.41	27.40
10,000	9.58	19.83	26.53
11,000	9.33	19.29	25.71
12,000	9.08	18.79	24.94
13,000	8.82	18.32	24.21
14,000	8.57	17.88	23.52

It shows that, while fencing does affect the project economics, even a 50% increase in fence costs would not render the project uneconomic. Indeed, it can be shown that the project would be viable as long as fencing costs were under $50,000/km!

9.5 PRODUCTION PARAMETERS

The impacts which various production parameters have on project economics, other than simple efficiencies from increased scale, can be substantial. To illustrate the impacts on a general basis, sensitivities are summarized through the presentation of changes in productivity from the base case. These changes in productivity could occur because of higher mortality, poaching, lower carrying capacity, and so on. A number of management techniques to control these were previously described in Chapters 4 and 5. The results of the sensitivity tests follow:

Productivity (% of Base)	Average Ranch Gate Profit ($/kg)	Net Cash Flow Rate of Return (%)	After Tax Rate of Return (%)
50	4.24	13.04	17.30
60	6.48	15.12	20.41
70	8.08	16.94	22.58
80	9.27	18.56	24.71
90	9.97	19.92	26.70
100	10.09	21.03	28.33
150	10.29	25.96	35.71

It is clear that any substantial declines in productivity might seriously threaten the viability of the ranch. Management and monitoring programs previously described are hence considered to be appropriate.

9.6 RANKING OF RISK

Based on the above analyses and the cost share studies undertaken in Chapter 7, a subjective ranking of high to low risk items carl be developed. These will be important in establishing the implementation strategies in subsequent modules to this study.

High Risk	Market Access to Alberta Fencing Costs Road Access and Maintenance Costs Herd Productivity
Intermediate Risk	Manpower Costs Supplementary Feed Costs
Low Risk	Land Lease Costs Structure and Equipment Costs Transportation Costs Stock Procurement Costs

This suggests that any implementation and development strategy concentrate on controlling the high risk items indicated above. Appropriately, specific recommendations regarding these items will be made in Chapter 11.

CHAPTER 10 SOCIAL COST-BENEFIT ANALYSIS

10.1 INTRODUCTION

The preceding chapters have been concerned strictly with quantifiable economic and , financial analyses affecting the ranch. There me, however, a number of other issues which may not have a direct bearing on the project owners and operators, yet will be of significant interest to Governments and Government institutions. This section therefore concentrates on undertaking an analysis of a number of the social costs and benefits through evaluating any indirect or unquantifiable impacts not included in the financial analyses. The issues addressed include the indirect and induced impacts from inter-industry purchases, impacts on government transfer payments, intercommunity trade and any unquantifiable benefits.

10.2 INDIRECT AND INDUCED IMPACTS

Although food products are a staple requirement for all economies, the ability to be self-sufficient in agricultural production is not usually inherent in northern economies. The development of a bison ranch will therefore have numerous diversification impacts from establishing what will essentially be a new industry. The generation of any new industry will have second-round and subsequent impacts through the multiplier effect. Although such effects are often discounted in highly developed economies with high capital mobility, real impacts can be demonstrated in less developed regions such as the N.W.T. An assessment of the indirect and induced impacts can be made through standard agricultural industry multipliers available through the Statistics Canada industrial input-output model. The model defines all of the linkages in the economic system and estimates the number of jobs and income generated by industry. Application of these multipliers yields the following results:

	Construction Phase	Operating Phase
Direct Expenditures	$1,327,000	$263,400/year
Total Income Generated	$2,310,000	$685,000/year
Total Employment Generated	15 man-years	20/year

The multipliers for the operating phase tend to be much higher because of the higher labour intensity of annual operations.

10.3 DIRECT IMPACTS ON TRANSFER PAYMENTS

A number of costs associated with the project are of direct concern to project sponsors, yet are quite irrelevant from a social perspective to the extent that they do not represent any displacement of society's resources. Whereas, for example, fuel costs are a direct cost, transfer payments such as income taxes do not represent a real burden from a social point of view since they are a transfer directly to government. Similarly, a certain portion of all direct or imbedded wages is costless to society if the person hired is otherwise unemployed. This section provide estimates of any such impacts on government coffers through either increases in tax receipts or decreases in transfer payments. The analysis is based on cash flow estimates presented earlier, and average unemployment rates and transfer payments incomes (UIC and welfare) presented in Lutra (1985).

The results areas follows:

	Construction Phase	Operating Phase
Land Lease Receipts	o	$ 6,750/year
Tax Receipts	o	$340,800/year!
Decreased UIC/Welfare	$5,400	$ 7,250/year
TOTAL	$5,400	$354,800tyear

10.4 IMPACTS ON IMPORT DISPLACEMENT

Although the ranch will rely heavily on its ability to sell products outside of the N.W.T., the long-term development plan of the ranch also calls for considerable levels of saies to occur within the N.W.T. This decreases the required levels of imports from the south, enhances inter-community trade, and has associated savings in the area of transportation costs for the imported goods. An analysis was undertaken based on product values and transportation margins as reported by Lutra (1985). The results indicate that, in the long-term, the total value of bison meat sold into the N.W.T. will be approximately $100,000 annually. Assuming that this displaces beef, this represents a displacement of approximately 14,000 kg of beef annually. The transportation cost savings, which represent a direct non-productive leakage, are estimated to be almost $3,000 annually to northern residents.

10.5 OTHER IMPACTS

A number of benefits will arise which are not directly quantifiable in dollar terms, yet will contribute significant enhancements to the northern environment and to residents. In addition to introducing a new industry, the establishment of a local ranching operation may induce, over time, other major industries associated with bison product marketing. In particular, it would even be conceivable that a large abatoir be locally established south of Slave Lake. Such a facility, at an appropriate scale, could serve much of the lower Mackenzie by importing live cattle from Alberta.

The biological impacts of establishing a bison ranch are also significant. Introduction of disease control programs and the establishment of a “clean” herd in the Slave River Lowlands will have substantial positive impacts in the entire ecosystem. Surplus ranch animals could also be used for bison reintroduction programs in suitable but currently uninhabitated areas or for enlarging existing wild herds.

Finally, the ranch is consistent with enhancing the local lifestyle and providing alternative business opportunities for local residents. While creating obvious direct employment, it also provides a forum for additional potential downstream ventures in packaging and small manufacturing.

CHAPTER 11 CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to undertake a detailed analysis of the financial feasibility ofabison ranch in the Slave River Lowlands. The study involved site selection, herd productivity assessment and the design and costing ofan optimal scale ranch. Subsequenttothedesign and costing, detailed financial and risk analyses were undertaken ' to determine the overall commerciality oftheranch.

Offoursites which were originally identified, asite with an area of6,750 hawas selected as the preferred site on the east side of the Slave River to the north of Fort Smith. Although it has a relatively remote location, a combination of biological, geotechnical, and economic factors favoured' this site over the others. Carrying capacities of the site were estimated based on laboratory analyses of nutrient levels in the local vegetation, and an optimal scale was developed consistent with this carrying capacity and the available markets.

Based on a linear-programming and cost-minimizing approach, an optimal ranch scale involved a steady state herd size of 1350 animals which allows an annual harvest of approximately 400 bison. Original stocking would involve 100 animals, 85 of which are female. A supply cost analysis of the ranch indicated that the given scale would result in delivered costs of production of about $7.04/kg. This is marginally adequate for N.W.T. markets, in which prices average just over $7.00/kg, although the financial security of the ranch depends upon the availability and access to existing Alberta markets at $ 18.00i_kg.

Cash flow summaries for the project were prepared. Total capital requirements are $1.33 million (1987$), with average long-term operating costs of $263,400 per year. Average long term revenue for the ranch was estimated to be $1.9 million annually. Debt/equity analyses indicated that an optimal level of debt would involve 25% equity financing. Assuming that all working capital was also financed through debt in the early years of the project, total debt financing for the project is approximately $2.3 million. Cash flow modelling indicated that, if the project construction commenced in 1988, then total debt would be essentially retired by 1999.

In general, the project is considered to show favorable potential for commercial success. Risk and sensitivity analyses identified a number of key factors, however, which should be addressed in designing any long-term implementation strategy. Specific recommendations are associated with each of these factors to mitigate potential risks.

The most important element to guaranteeing the commercial viability of the ranch is access to markets outside of the N.W.T. Previous study results indicated that severe marketing constraints existed for wood bison, and that access to southern markets could only be established through the use of plains bison or a hybrid species. Technically, however, wood bison are preferred because of their hardier nature and higher yield. To maintain maximum flexibility, therefore, it is recommended that the initial planning be based on wood bison, but that the ranch introduce some pIains bison or a hybrid species if no improvements develop in the regulatory framework.

The second most vital element is to maintain herd productivity. This is established through a number of herd and range management programs, described in detail in the text. One element of this program would involve segregation of the calves from the rest of the herd during their first winter, and supplementally feeding them. In addition, cross-fencing is recommended within the ranch perimeter to more readily allow herd management..

A third major concern for the ranch is selecting a cost-efficient fence design, although a number of alternatives were reviewed, a great deal of uncertainty surrounds this aspect because many of the materials investigated have not yet been ngourously tested as bison enclosures under the terrain conditions which occur in the Slare River Lowlands. Because the total fence capital and maintenance costs together contributed about 26% to the final delivered cost of the production, a strategy is necessary to mitigate the potential for cost increases. Specifically, it is recommended that the implementation strategy should allow for a phasing in of the overall ranch scale. Initial fence construction would involve two types of design: post and rail, and paige wire. After a few years of operating experience with both designs, the most cost effective design will be selected for expansion to the full scale. Because the herd is growing from an initial level of only 100 animals, such a procedure would not over-tax the carrying capacity of the site.

Finally, the last high risk item which was identified involved road access to the site. Although original access would cost only about $75,000, re-establishing the access on an annual basis would involve annual expenditures of about $45,000. On a discounted cost basis, this element represents about 16% of the final delivered cost. A geotechnical study was undertaken based on airphoto interpretation to select potential routes. Mitigation of the risk associated with this access can be achieved through initiating some detailed ground truthing of the proposed routes prior to construction.

In summary, while there are *some* logistical challenges which must be overcome, a commercial scale ranch in the Slave River Lowlands is an economically viable enterprise. Although its financial success will depend to a degree on access to southern markets, it will also nonetheless contribute significantly to the well-being of northern businesses and residents.

This unit has been further subdivided into:
-well drained terrain (la)
-moderately drained terrain (lb)

2) Organic terrain, comprised of organic silt and peat overlying mineral soil. According to the thickness and type of organic and vegetation cover, this unit is further subdivided as follows:

-shallow organic cover, meadow vegetation (2a)
-moderate organic cover, woody vegetation (2b)
deep organics, thermokarst features (2c)

Terrain conditions encountered along the selected road alignments are summarized in the following table:

Road Alternative	Total Length (km)	Lacustrine Plain Type la (km)	Type lb (km)	Organic Temain Type 2a (km)	Type 2b (km)	Type 2c (km)
Al	9.0	3.3	3.3	1.3	0.4	0.7
A2	10.2	3.4	3.1	2.9	0.8	--
B1	9.0	1.5	2.2	2.6	1.5	1.2
B2	9.8	0.3	2.2	2.5	3.4	1.4

From a geotechnical perspective, routes Al and A2 are prefexred to routes BI and B2. Al is, in turn, shorter than A2 but it traverses a section of deeper muskeg. This should not impose major difficulties for winter access. However, should an extended access season be desired, the use of geosynthetics (grids) and/or the introduction of structural fill across this area may be required.

In conclusion, it is recommended that either route Al or A2 be selected for more detailed on-site evaluation.

Road Construction Cost Estimate

The construction costs for a winter access along either route Al or A2 will not differ **significantly.** The basic work elements for both alternatives remain the same (i.e., mobilization, demobilization, clearing and cutting trees and clearing snow to allow for frost penetration).

Estimated first year construction costs (excluding upgrading of the existing road west of the river) are as follows:

-Equipment mobilization and demobilization, incl. camp	$10,OOO
-Clearing, grading, construction of an ice bridge (15 days)	30,000
-Clean-up, slashing	5,000
-Contingency	5,000
TOTAL	$50,000

The cost of re-opening the winter road during subsequent years would likely be in the order of 60 to 75% of the **first** year **cost.**

It should be noted that the inital construction methods used for access development will influence future road stability and costs associated with maintenance**and/or** yearly re-opening. Although the use of corduroy, geosythetic grids or other geotechnical aids across problematic *terrain* segments will increase the intial cost of the road, such materials will reduce operational costs during subsequent years and will extend the access season.

Although no detailed terrain analysis was undertaken in the vicinity of the existing winter road west of the Slave River, it is estimated that this road could be upgraded to adequate standards for ranch use for approximately $25,000. Operational costs after this upgrading would also be **60-75%** of **first** year costs.

APPENDIX B BISON MODEL RESULTS

This section contains the output from the bison ranch modelling, on an annual basis. All revenue and cost figures on an annual basis are shown in thousands of 1987$, unless otherwise indicated.

BISONMODEL

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1																						
2	YEAR	HERD	HERD	CALVES	SURPLUS	SURPLUS	HERD	HARVESTED	HARVEST	STOCK	FENCING	STOCK	FENCING	CORRALS	STRUCTURES	EQUIPMENT	ACCESS	UTILITY	CONTINGENCY	TOTAL	ANIMALS	HAY
3		MIN	MIN		HERD	HERD	MAX	HERD	('000 KG)	PURCHASE	(KM)	PURCHASE						FIXED	10.0	CAPITAL	<18 MONTH	(TONNES)
4		BASE	ACTUAL	BASE	BASE	ACTUAL	ACTUAL			#		('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	1.000	
5			1.000			1.000																
6																						
7																						
8	1987	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
9	1988	0	0	0	0	0	0	0	0	0	32	0.0	256.0	128.0	63.0	170.0	75.0	30.0	72.2	794.2	0	0
10	1989	0	0	0	0	0	0	0	0	0	32	0.0	256.0	0.0	0.0	0.0	0.0	0.0	25.6	281.6	0	0
11	1990	126	126	26	0	0	126	0	0	100	16	100.0	128.0	0.0	0.0	0.0	0.0	0.0	22.8	250.8	26	36
12	1991	157	157	45	11	11	168	11	3.135	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45	63
13	1992	198	198	66	30	30	228	30	8.55	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66	92
14	1993	232	232	72	56	56	288	56	15.96	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72	101
15	1994	279	279	85	83	83	362	83	23.655	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	85	119
16	1995	339	339	105	115	115	454	115	32.775	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	105	147
17	1996	409	409	126	152	152	561	152	43.32	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	126	176
18	1997	493	493	152	195	195	688	195	55.575	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	152	213
19	1998	592	592	182	253	253	845	253	72.105	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	182	255
20	1999	708	708	219	76	76	784	76	21.66	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	219	307
21	2000	850	850	265	176	176	1026	176	50.16	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	265	371
22	2001	1023	1023	318	281	281	1304	281	80.085	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	318	445
23	2002	1184	1184	382	176	176	1360	176	50.16	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	382	535
24	2003	1287	1287	452	447	447	1734	447	127.395	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	452	633
25	2004	1267	1267	480	436	436	1703	436	124.26	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
26	2005	1278	1278	480	405	405	1683	405	115.425	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
27	2006	1294	1294	480	400	400	1694	400	114	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
28	2007	1314	1314	480	396	396	1710	396	112.86	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
29	2008	1337	1337	480	393	393	1730	393	112.005	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
30	2009	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
31	2010	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
32	2011	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
33	2012	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
34	2013	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
35	2014	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
36	2015	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
37	2016	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
38	2017	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
39	2018	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
40	2019	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
41	2020	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
42	2021	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
43	2022	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
44	2023	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
45	2024	1359	1359	480	394	394	1753	394	112.29	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480	672
46																						
47	SUM								2959.7	100.0	80.0	100.0	640.0	128.0	63.0	170.0	75.0	30.0	120.6	1326.6		
48	N.P.V. 5%								945.6			82.3	558.6	116.1	57.1	154.2	68.0	27.2	108.4	1170.0		
49	N.P.V. 10%								368.9			68.3	491.3	105.8	52.1	140.5	62.0	24.8	94.5	1039.2		
50	N.P.V. 15%								169.3			57.2	435.1	96.8	47.6	128.5	56.7	22.7	84.5	929.1		
51																						
52	S.P. 5%	$/KG				IRR1	10.06	%				0.09	0.59	0.12	0.06	0.16	0.07	0.03	0.11	1.24		
53	S.P. 10%	$/KG				IRR2	21.03	%				0.19	1.33	0.29	0.14	0.38	0.17	0.07	0.28	2.82		
54	S.P. 15%	$/KG				IRR3	28.33	%: SELECT-	2			0.34	2.57	0.57	0.28	0.76	0.34	0.13	0.50	5.49		
55						BREAKEVEN	7.04	$/KG				STOCK	FENCING	CORRALS	STRUCTURES	EQUIPMENT	ACCESS	UTILITY	CONTINGENCY	TOTAL		
56	CUTOFF	0	ANIMALS			P1	7.08	$/KG												CAPITAL		
57	WEIGHT	285	KG/ANIMAL			P2	17.13	$/KG														
58	STOCK	1000	$/ANIMAL			B/C1 all	1.01															
59	FENCE	8000	$/KM	8000		B/C2 all	2.43															
60						B/C1 devt	0.50															
61	PRICE	7.08	$/KG			B/C2 devt	1.28															
62	PRICENWT	7.08	$/KG																			
63	LANDPRICE	1	$/HA	1																		
64	WAGE	36000	$/YR/MAN																			
65	FEEDCOST	65	$/TONNE																			
66	VETFEE	3	$/HEAD																			
67	KILLFEE	10	$/HEAD																			
68	HAYEACH	1.4	TONNE/HEAD																			
69	MONPERHEAD	3	$/HEAD		MONITORING																	
70	MONPERHA	1	$/HA	1	& MANAGEMENT																	
71	UTIL	4800	$/YEAR																			
72	PROUNDUP	6000	$/YEAR																			
73	MINERAL	15	$/BLOCK																			

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO
1																			
2	RANCH	PEOPLE	SLAUGHTER	ROUND UP	VET	UTILITIES	MAINT.	FENCE MAIN.	MANPOWER	SUPP. FEED	LAND LEASE	ACCESS	MON & MGT	MINERALS	OP. CONT.	TOTAL	TOTAL	TOTAL	NET
3	AREA						4	3				60			5	OPERATING	COSTS	REV.SIMPLE	CASH FLOW
4	(HA)		('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)	('000 $)
5																			
6																			
7																			
8	0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	200	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.4	794.6	0.0	-794.6
10	200	0.00	0.0	0.0	0.0	0.0	10.5	11.5	0.0	0.0	0.2	45.0	0.2	0.0	3.4	70.8	352.4	0.0	-352.4
11	2,500	1.31	0.0	0.0	0.4	4.8	10.5	19.2	47.2	2.4	2.5	45.0	2.9	0.2	6.7	141.7	392.5	0.0	-392.5
12	2,500	1.76	0.1	6.0	0.5	4.8	10.5	23.0	63.4	4.1	2.5	45.0	3.0	0.2	8.2	171.4	171.4	22.2	-149.2
13	2,500	1.76	0.3	6.0	0.7	4.8	10.5	23.0	63.4	6.0	2.5	45.0	3.2	0.3	8.3	174.0	174.0	60.5	-113.5
14	6,750	1.76	0.6	6.0	0.9	4.8	10.5	23.0	63.4	6.6	6.8	45.0	7.8	0.3	8.8	184.2	184.2	112.9	-71.3
15	6,750	1.76	0.8	6.0	1.1	4.8	10.5	23.0	63.4	7.7	6.8	45.0	7.8	0.4	8.9	186.3	186.3	167.4	-18.9
16	6,750	1.80	1.2	6.0	1.4	4.8	10.5	23.0	64.6	9.6	6.8	45.0	8.1	0.5	9.1	190.5	190.5	231.9	41.4
17	6,750	1.88	1.5	6.0	1.7	4.8	10.5	23.0	67.7	11.5	6.8	45.0	8.4	0.6	9.4	196.9	196.9	306.6	109.7
18	6,750	1.98	2.0	6.0	2.1	4.8	10.5	23.0	71.3	13.8	6.8	45.0	8.8	0.7	9.7	204.5	204.5	393.3	188.8
19	6,750	2.11	2.5	6.0	2.5	4.8	10.5	23.0	76.1	16.6	6.8	45.0	9.3	0.9	10.2	214.2	214.2	510.3	296.1
20	6,750	1.76	0.8	6.0	2.4	4.8	10.5	23.0	63.4	19.9	6.8	45.0	9.1	1.1	9.6	202.3	202.3	153.3	-49.1
21	6,750	1.94	1.8	6.0	3.1	4.8	10.5	23.0	69.7	24.1	6.8	45.0	9.8	1.3	10.3	216.2	216.2	355.0	138.8
22	6,750	2.18	2.8	6.0	3.9	4.8	10.5	23.0	78.4	28.9	6.8	45.0	10.7	1.5	11.1	233.5	233.5	566.7	333.2
23	6,750	1.94	1.8	6.0	4.1	4.8	10.5	23.0	69.7	34.8	6.8	45.0	10.8	1.8	11.0	230.0	230.0	355.0	125.0
24	6,750	2.56	4.5	6.0	5.2	4.8	10.5	23.0	92.2	41.1	6.8	45.0	12.0	1.9	12.7	265.7	265.7	901.5	635.9
25	6,750	2.54	4.4	6.0	5.1	4.8	10.5	23.0	91.3	43.7	6.8	45.0	11.9	1.9	12.7	267.0	267.0	879.3	612.3
26	6,750	2.46	4.1	6.0	5.0	4.8	10.5	23.0	88.7	43.7	6.8	45.0	11.8	1.9	12.6	263.9	263.9	816.8	552.9
27	6,750	2.45	4.0	6.0	5.1	4.8	10.5	23.0	88.3	43.7	6.8	45.0	11.8	1.9	12.5	263.5	263.5	806.7	543.2
28	6,750	2.44	4.0	6.0	5.1	4.8	10.5	23.0	88.0	43.7	6.8	45.0	11.9	2.0	12.5	263.2	263.2	798.7	535.4
29	6,750	2.44	3.9	6.0	5.2	4.8	10.5	23.0	87.7	43.7	6.8	45.0	11.9	2.0	12.5	263.1	263.1	792.6	529.5
30	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
31	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
32	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
33	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
34	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
35	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
36	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
37	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
38	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
39	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
40	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
41	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
42	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
43	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
44	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
45	6,750	2.44	3.9	6.0	5.3	4.8	10.5	23.0	87.8	43.7	6.8	45.0	12.0	2.0	12.5	263.4	263.4	794.6	531.2
46																			
47		77.9	103.9	204.0	139.5	168.0	378.7	814.1	2802.9	1144.3	223.9	1620.0	363.4	54.2	400.8	8417.7	9744.3	20945.0	11200.8
48			33.2	79.9	45.1	67.9	157.9	332.7	1062.9	364.9	85.8	875.4	130.9	17.5	152.7	3206.8	4376.8	6691.4	2314.6
49			12.9	39.4	17.9	34.8	84.1	173.0	512.2	142.6	41.3	359.9	59.2	7.0	74.2	1550.5	2597.7	2610.8	13.1
50			5.9	22.7	8.4	20.9	52.7	105.6	292.8	66.0	23.3	225.4	31.7	3.3	42.9	901.5	1830.6	1197.8	-632.8
51																			
52			0.04	0.08	0.05	0.07	0.17	0.35	1.12	0.39	0.09	0.71	0.14	0.02	0.16	3.39	4.63	7.08	2.45
53			0.04	0.11	0.05	0.08	0.23	0.47	1.38	0.39	0.11	0.98	0.16	0.02	0.20	4.22	7.04	7.08	0.04
54			0.04	0.13	0.05	0.12	0.31	0.62	1.73	0.39	0.14	1.33	0.19	0.02	0.25	5.33	10.82	7.08	-3.74
55																			
56			SLAUGHTER	ROUND UP	VET	UTILITIES	MAINT.	FENCE MAIN.	MANPOWER	SUPP. FEED	LAND LEASE	ACCESS	MON & MGT	MINERALS	OP. CONT.	TOTAL	TOTAL	INTERNAL	
57																OPERATING	COSTS	RATE OF	
58																		RETURN (%)	10.06
59																		IRRdev	#NUM!
60																			
61																npvdev0	3943.5	3235.0	-708.5
62																npvdev5	2785.9	1803.7	-982.2
63																npvdev10	2093.8	1051.8	-1042.0
64																npvdev15	1651.1	638.6	-1012.5
65																			
66																			
67																			
68																			
69																			
70																			
71																			
72																			
73																			

BISON.MODEL

	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF
1	MARKETS	SMITH	SMITH	L-MACK	L-MACK	U-MACK	U-MACK	ALTA1	ALTA2	TOTAL	TOTAL	TOTAL	RESIDUAL	AVERAGE	TOTAL	NET	CUMM
2	YEAR	R/I	HOSP	R/I	HOSP	R/I	HOSP			HARVEST	ALTA	ALTA		PRICE	REVENUE	CASHFLOW	CASHFLOW
3		('000kg)	('000kg)	('000kg)	('000kg)	('000kg)	('000kg)	('000kg)	('000kg)	($'000)	SALES ('000kg)	REVENUE ($'000)	('000kg)	($/KG)	($'000)	($'000)	($'000)
4																	
5		PR1	PR2	PR3	PR4	PR5	PR6	PR7	PR8								
7		1.160	0.220	7.380	1.390	18.560	3.490	100.000	0.000	0.000	0.000	0.0	0.000	0.00	0.0	0.0	0.0
8	1987	1.181	0.224	7.505	1.414	18.857	3.546	100.000	0.000	0.000	0.000	0.0	0.000	0.00	0.0	-794.6	-794.6
9	1988	1.202	0.228	7.633	1.438	19.159	3.603	100.000	0.000	0.000	0.000	0.0	0.000	0.00	0.0	-352.4	-1147.0
10	1989	1.224	0.232	7.763	1.462	19.465	3.660	100.000	0.000	0.000	0.000	0.0	0.000	0.00	0.0	-392.5	-1539.6
11	1990	1.246	0.236	7.895	1.487	19.777	3.719	100.000	0.000	3.135	3.135	56.4	0.000	18.00	56.4	-114.9	-1654.5
12	1991	1.268	0.241	8.029	1.512	20.093	3.778	100.000	0.000	8.550	8.550	153.9	0.000	18.00	153.9	-20.1	-1674.6
13	1992	1.291	0.245	8.165	1.538	20.415	3.839	100.000	0.000	15.960	15.960	287.3	0.000	18.00	287.3	103.1	-1571.5
14	1993	1.314	0.249	8.304	1.564	20.741	3.900	100.000	0.000	23.655	23.655	425.8	0.000	18.00	425.8	239.5	-1332.0
15	1994	1.338	0.254	8.445	1.591	21.073	3.963	100.000	0.000	32.775	32.775	590.0	0.000	18.00	590.0	399.4	-932.6
16	1995	1.362	0.258	8.589	1.618	21.410	4.026	100.000	0.000	43.320	43.320	779.8	0.000	18.00	779.8	582.9	-349.7
17	1996	1.387	0.263	8.735	1.645	21.753	4.090	100.000	0.000	55.575	55.575	1000.4	0.000	18.00	1000.4	795.8	446.1
18	1997	1.412	0.268	8.884	1.673	22.101	4.156	100.000	0.000	72.105	72.105	1297.9	0.000	18.00	1297.9	1083.7	1529.8
19	1998	1.437	0.273	9.035	1.702	22.454	4.222	100.000	0.000	21.660	21.660	389.9	0.000	18.00	389.9	187.5	1717.3
20	1999	1.463	0.277	9.188	1.731	22.814	4.290	100.000	0.000	50.160	50.160	902.9	0.000	18.00	902.9	686.7	2404.0
21	2000	1.489	0.282	9.344	1.760	23.179	4.359	100.000	0.000	80.085	80.085	1441.5	0.000	18.00	1441.5	1208.0	3612.1
22	2001	1.516	0.288	9.503	1.790	23.550	4.428	100.000	0.000	50.160	50.160	902.9	0.000	18.00	902.9	672.9	4285.0
23	2002	1.543	0.293	9.665	1.820	23.926	4.499	100.000	0.000	127.395	100.000	1800.0	27.395	18.00	1993.9	1728.2	6013.2
24	2003	1.571	0.298	9.829	1.851	24.309	4.571	100.000	0.000	124.260	100.000	1800.0	24.260	18.00	1971.7	1704.6	7717.8
25	2004	1.599	0.303	9.996	1.883	24.698	4.644	100.000	0.000	115.425	100.000	1800.0	15.425	18.00	1909.2	1645.3	9363.1
26	2005	1.628	0.309	10.166	1.915	25.093	4.719	100.000	0.000	114.000	100.000	1800.0	14.000	18.00	1899.1	1635.6	10998.7
27	2006	1.657	0.314	10.339	1.947	25.495	4.794	100.000	0.000	112.860	100.000	1800.0	12.860	18.00	1891.0	1627.8	12626.4
28	2007	1.687	0.320	10.515	1.980	25.903	4.871	100.000	0.000	112.005	100.000	1800.0	12.005	18.00	1885.0	1621.8	14248.3
29	2008	1.718	0.326	10.693	2.014	26.317	4.949	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	15871.8
30	2009	1.748	0.332	10.875	2.048	26.738	5.028	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	17495.4
31	2010	1.780	0.338	11.060	2.083	27.166	5.108	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	19119.0
32	2011	1.812	0.344	11.248	2.119	27.601	5.190	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	20742.6
33	2012	1.845	0.350	11.439	2.155	28.042	5.273	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	22366.2
34	2013	1.878	0.356	11.634	2.191	28.491	5.357	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	23989.7
35	2014	1.912	0.363	11.832	2.228	28.947	5.443	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	25613.3
36	2015	1.946	0.369	12.033	2.266	29.410	5.530	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	27236.9
37	2016	1.981	0.376	12.237	2.305	29.881	5.619	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	28860.5
38	2017	2.017	0.382	12.445	2.344	30.359	5.709	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	30484.1
39	2018	2.053	0.389	12.657	2.384	30.844	5.800	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	32107.6
40	2019	2.090	0.396	12.872	2.424	31.338	5.893	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	33731.2
41	2020	2.128	0.404	13.091	2.466	31.839	5.987	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	35354.8
42	2021	2.166	0.411	13.313	2.508	32.349	6.083	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	36978.4
43	2022	2.205	0.418	13.540	2.550	32.866	6.180	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	38602.0
44	2023	2.245	0.426	13.770	2.594	33.392	6.279	100.000	0.000	112.290	100.000	1800.0	12.290	18.00	1887.0	1623.6	40225.6
45	2024	2.285	0.433	14.004	2.638	33.926	6.379	100.000	0.000								
46													302.6		49969.8	40225.6	
47															16062.4	11685.6	
48															6319.5	3721.7	
49															2925.9	1095.3	
50																	
51															16.99	12.36	
52															17.13	10.08	
53															17.29	6.47	
54																	
55															INTERNAL		
56															RATE OF		
57															RETURN (%)	21.03	
58															IRRdev	14.69	
60															8228.5	4285.0	
61															4587.8	1801.9	
62															2675.2	581.5	
63															1624.4	-26.7	
64																	
65																	
66																	
67																	
68																	
69																	
70																	
71																	
72																	
73																	

	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV
1	PROFORMA			INFLATION	4.50	%										
2		SELECT(1-2):	2												BTAX	BTAX
3															MONEY	NCF
4	YEAR	INFLATOR	REAL	REAL	REAL	NOMINAL	NOMINAL	NOMINAL	NOMINAL	EQUITY	DEBT	PRINCIPAL	PAYMENT	INTEREST	OUT	
5			REVENUES	CAPITAL	OPERATING	REVENUES	CAPITAL	OPERATING	NCF							
6			($'000)	($'000)	($'000)	($'000)	($'000)	($'000)	($'000)							
7																
8	1987	1.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	1988	1.09	0.0	794.2	0.4	0.0	867.3	0.5	-867.7	216.8	650.9	650.9	0.0	71.6	217.3	-216.8
10	1989	1.14	0.0	281.6	70.8	0.0	321.4	80.8	-402.2	80.3	321.8	1044.3	0.0	114.9	161.1	-80.3
11	1990	1.19	0.0	250.8	141.7	0.0	299.1	169.0	-468.1	74.8	393.3	1552.6	0.0	170.8	243.8	-74.8
12	1991	1.25	56.4	0.0	171.4	70.3	0.0	213.5	-143.2	0.0	143.2	1866.6	0.0	205.3	213.5	0.0
13	1992	1.30	153.9	0.0	174.0	200.4	0.0	226.6	-26.2	0.0	26.2	2098.1	0.0	230.8	226.6	0.0
14	1993	1.36	287.3	0.0	184.2	390.9	0.0	250.7	140.3	0.0	0.0	2328.9	140.3	256.2	390.9	0.0
15	1994	1.42	425.8	0.0	186.3	605.5	0.0	264.9	340.6	0.0	0.0	2444.8	340.6	268.9	605.5	0.0
16	1995	1.49	590.0	0.0	190.5	876.7	0.0	283.1	593.6	0.0	0.0	2373.1	593.6	261.0	876.7	0.0
17	1996	1.55	779.8	0.0	196.9	1210.9	0.0	305.8	905.1	0.0	0.0	2040.5	905.1	224.5	1210.9	0.0
18	1997	1.62	1000.4	0.0	204.5	1623.4	0.0	331.9	1291.5	0.0	0.0	1359.8	1291.5	149.6	1623.4	0.0
19	1998	1.70	1297.9	0.0	214.2	2201.1	0.0	363.3	1837.8	0.0	0.0	217.9	217.9	24.0	581.2	1619.9
20	1999	1.77	389.9	0.0	202.3	690.9	0.0	358.6	332.4	0.0	0.0	24.0	24.0	2.6	382.5	308.4
21	2000	1.85	902.9	0.0	216.2	1672.1	0.0	400.3	1271.8	0.0	0.0	2.6	2.6	0.3	403.0	1269.1
22	2001	1.94	1441.5	0.0	233.5	2789.8	0.0	451.9	2337.9	0.0	0.0	0.3	0.3	0.0	452.2	2337.6
23	2002	2.02	902.9	0.0	230.0	1828.0	0.0	465.1	1360.9	0.0	0.0	0.0	0.0	0.0	465.1	1360.8
24	2003	2.11	1993.9	0.0	265.7	4213.8	0.0	561.4	3652.3	0.0	0.0	0.0	0.0	0.0	561.4	3652.3
25	2004	2.21	1971.7	0.0	267.0	4354.4	0.0	589.7	3764.7	0.0	0.0	0.0	0.0	0.0	589.7	3764.7
26	2005	2.31	1909.2	0.0	263.9	4406.1	0.0	609.0	3797.0	0.0	0.0	0.0	0.0	0.0	609.0	3797.0
27	2006	2.41	1899.1	0.0	263.5	4580.0	0.0	635.5	3944.5	0.0	0.0	0.0	0.0	0.0	635.5	3944.5
28	2007	2.52	1891.0	0.0	263.2	4765.8	0.0	663.4	4102.4	0.0	0.0	0.0	0.0	0.0	663.4	4102.4
29	2008	2.63	1885.0	0.0	263.1	4964.3	0.0	693.0	4271.4	0.0	0.0	0.0	0.0	0.0	693.0	4271.4
30	2009	2.75	1887.0	0.0	263.4	5193.3	0.0	724.9	4468.4	0.0	0.0	0.0	0.0	0.0	724.9	4468.4
31	2010	2.88	1887.0	0.0	263.4	5427.0	0.0	757.5	4669.4	0.0	0.0	0.0	0.0	0.0	757.5	4669.4
32	2011	3.01	1887.0	0.0	263.4	5671.2	0.0	791.6	4879.6	0.0	0.0	0.0	0.0	0.0	791.6	4879.6
33	2012	3.14	1887.0	0.0	263.4	5926.4	0.0	827.2	5099.1	0.0	0.0	0.0	0.0	0.0	827.2	5099.1
34	2013	3.28	1887.0	0.0	263.4	6193.1	0.0	864.5	5328.6	0.0	0.0	0.0	0.0	0.0	864.5	5328.6
35	2014	3.43	1887.0	0.0	263.4	6471.7	0.0	903.4	5568.4	0.0	0.0	0.0	0.0	0.0	903.4	5568.4
36	2015	3.58	1887.0	0.0	263.4	6763.0	0.0	944.0	5819.0	0.0	0.0	0.0	0.0	0.0	944.0	5819.0
37	2016	3.75	1887.0	0.0	263.4	7067.3	0.0	986.5	6080.8	0.0	0.0	0.0	0.0	0.0	986.5	6080.8
38	2017	3.91	1887.0	0.0	263.4	7385.3	0.0	1030.9	6354.5	0.0	0.0	0.0	0.0	0.0	1030.9	6354.5
39	2018	4.09	1887.0	0.0	263.4	7717.7	0.0	1077.3	6640.4	0.0	0.0	0.0	0.0	0.0	1077.3	6640.4
40	2019	4.27	1887.0	0.0	263.4	8065.0	0.0	1125.7	6939.2	0.0	0.0	0.0	0.0	0.0	1125.7	6939.2
41	2020	4.47	1887.0	0.0	263.4	8427.9	0.0	1176.4	7251.5	0.0	0.0	0.0	0.0	0.0	1176.4	7251.5
42	2021	4.67	1887.0	0.0	263.4	8807.2	0.0	1229.3	7577.8	0.0	0.0	0.0	0.0	0.0	1229.3	7577.8
43	2022	4.88	1887.0	0.0	263.4	9203.5	0.0	1284.7	7918.8	0.0	0.0	0.0	0.0	0.0	1284.7	7918.8
44	2023	5.10	1887.0	0.0	263.4	9617.6	0.0	1342.5	8275.2	0.0	0.0	0.0	0.0	0.0	1342.5	8275.2
45	2024	5.33	1887.0	0.0	263.4	10050.4	0.0	1402.9	8647.5	0.0	0.0	0.0	0.0	0.0	1402.9	8647.5
46																
47			49969.8	1326.6	8417.7											
48			16062.4	1170.0	3206.8											
49			6319.5	1039.2	1558.5											
50			2925.9	929.1	901.5											
51																
52			16.99	1.24	3.39											
53			17.13	2.82	4.22											
54			17.29	5.49	5.33											
55																
56	EQUITY	25	%					INTERNAL							INTERNAL	
57	LOANRATE	11	%					RATE OF							RATE OF	
58								RETURN (%)	26.47						RETURN (%)	36.38
59	TAXRATE	21	%					IRRdev	19.85						IRRdev	29.19
60	CCA	10	%													
61																6523.9
62	ELIGIBLE	92.46	%	(EXCL. HERD)												3126.8
63																1504.8
64																705.4
65																
66																
67																
68																
69																
70																
71																
72																
73																

BISON MODEL

	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI
1	TAXES							NOMINAL		NOMINAL	REAL		REAL
2	GROSS	DEDUCTIONS	CAPITAL	INC1	INC1	CUMM	ACTUAL	TAXES		ATAX	TAXES		ATAX
3	INCOME	OPERATING	POOL	CCA	TAXABLE	LOSSES	TAXABLE	PAID		NCF	PAID		NCF
4		& INTEREST			INCOME		INCOME						
7			0										
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0
9	0.0	72.1	801.9	80.2	-152.3	-152.3	0.0	0.0		-216.8	0.0		-198.6
10	0.0	195.7	1018.8	101.9	-297.6	-449.8	0.0	0.0		-80.3	0.0		-70.4
11	0.0	339.8	1193.5	119.4	-459.2	-909.0	0.0	0.0		-74.8	0.0		-62.7
12	70.3	418.9	1074.2	107.4	-458.0	-1364.9	0.0	0.0		0.0	0.0		0.0
13	200.4	457.4	966.7	96.7	-353.6	-1718.6	0.0	0.0		0.0	0.0		0.0
14	390.9	506.9	870.1	87.0	-202.9	-1921.5	0.0	0.0		0.0	0.0		0.0
15	605.5	533.8	783.1	78.3	-6.6	-1928.1	0.0	0.0		0.0	0.0		0.0
16	876.7	544.1	704.8	70.5	282.1	-1646.0	0.0	0.0		0.0	0.0		0.0
17	1210.9	530.2	634.3	63.4	617.3	-1048.7	0.0	0.0		0.0	0.0		0.0
18	1623.4	481.5	570.8	57.1	1084.8	38.1	38.1	7.6		-7.8	4.7		-4.7
19	2201.1	387.2	513.8	51.4	1762.5	1762.5	1762.5	370.1		1249.8	218.2		737.0
20	690.9	361.2	462.4	46.2	283.5	283.5	283.5	59.5		248.9	33.6		140.4
21	1672.1	400.6	416.1	41.6	1229.9	1229.9	1229.9	258.3		1010.9	139.5		545.8
22	2789.8	451.9	374.5	37.5	2300.4	2300.4	2300.4	483.1		1854.5	249.6		958.3
23	1826.0	465.1	337.1	33.7	1327.2	1327.2	1327.2	278.7		1082.1	137.8		535.1
24	4213.8	561.4	303.4	30.3	3622.0	3622.0	3622.0	760.6		2891.7	359.9		1368.3
25	4354.4	589.7	273.0	27.3	3737.4	3737.4	3737.4	784.8		2979.8	355.4		1349.3
26	4406.1	609.0	245.7	24.6	3772.5	3772.5	3772.5	792.2		3004.8	343.3		1302.0
27	4580.0	635.5	221.2	22.1	3922.4	3922.4	3922.4	823.7		3120.8	341.5		1294.0
28	4765.8	663.4	199.0	19.9	4082.4	4082.4	4082.4	857.3		3245.0	340.2		1287.6
29	4964.3	693.0	179.1	17.9	4253.5	4253.5	4253.5	893.2		3378.1	339.2		1282.7
30	5193.3	724.9	161.2	16.1	4452.2	4452.2	4452.2	935.0		3533.4	339.7		1283.9
31	5427.0	757.5	145.1	14.5	4654.9	4654.9	4654.9	977.5		3691.9	339.9		1283.7
32	5671.2	791.6	130.6	13.1	4866.5	4866.5	4866.5	1022.0		3857.6	340.0		1283.5
33	5926.4	827.2	117.5	11.8	5087.4	5087.4	5087.4	1068.4		4030.8	340.2		1283.4
34	6193.1	864.5	105.8	10.6	5318.0	5318.0	5318.0	1116.8		4211.8	340.3		1283.3
35	6471.7	903.4	95.2	9.5	5558.9	5558.9	5558.9	1167.4		4401.0	340.4		1283.2
36	6763.0	944.0	85.7	8.6	5810.4	5810.4	5810.4	1220.2		4598.8	340.5		1283.1
37	7067.3	986.5	77.1	7.7	6073.1	6073.1	6073.1	1275.4		4805.5	340.5		1283.1
38	7385.3	1030.9	69.4	6.9	6347.5	6347.5	6347.5	1333.0		5021.5	340.6		1283.0
39	7717.7	1077.3	62.5	6.2	6634.2	6634.2	6634.2	1393.2		5247.2	340.6		1282.9
40	8065.0	1125.7	56.2	5.6	6933.6	6933.6	6933.6	1456.1		5483.2	340.7		1282.9
41	8427.9	1176.4	50.6	5.1	7246.4	7246.4	7246.4	1521.8		5729.7	340.7		1282.9
42	8807.2	1229.3	45.5	4.6	7573.3	7573.3	7573.3	1590.4		5987.4	340.7		1282.8
43	9203.5	1284.7	41.0	4.1	7914.7	7914.7	7914.7	1662.1		6256.7	340.8		1282.8
44	9617.6	1342.5	36.9	3.7	8271.5	8271.5	8271.5	1737.0		6538.2	340.8		1282.8
45	10050.4	1402.9	33.2	3.3	8644.2	8644.2	8644.2	1815.3		6832.3	340.8		1282.8
48								2322.8		8455.8	864.1		2987.2
49								856.1		2957.3	340.9		1004.8
50													
51								7.76		28.91	2.61		9.50
56									FINAL RATE OF			FINAL RATE OF	
57									RETURN (%)	34.10		RETURN (%)	28.33
58									IRRdev	26.42		IRRdev	20.90
59													
60											783.4		2580.2
61											395.7		1171.4
62											207.4		503.6
63											112.4		179.4

	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV
1						BTAX		ATAX	RETAINED	DEBT	ASSETS	LIVESTOCK	NET
2	YEAR	INCOME	COSTS	INTEREST	DEPR	INCOME	TAXES	INCOME	EARNINGS (DEFICIT)		AT BOOK	AT BOOK	FIXED ASSETS
3													
4													
5													
6													
7													
8	1987	0	0	0	0	0	0	0	0	0	0	0	0
9	1988	0	0	72	80	(152)	0	(152)	(152)	651	802	0	151
10	1989	0	81	115	102	(298)	0	(298)	(450)	1,044	1,019	0	(26)
11	1990	0	169	171	119	(459)	0	(459)	(909)	1,553	1,194	119	(240)
12	1991	70	214	205	107	(456)	0	(456)	(1,365)	1,867	1,074	119	(673)
13	1992	200	227	231	97	(354)	0	(354)	(1,719)	2,098	967	119	(1,012)
14	1993	391	251	256	87	(203)	0	(203)	(1,921)	2,329	870	119	(1,340)
15	1994	606	265	269	78	(7)	0	(7)	(1,928)	2,445	783	119	(1,542)
16	1995	877	283	261	70	262	0	262	(1,666)	2,373	705	119	(1,549)
17	1996	1,211	306	224	63	617	0	617	(1,049)	2,040	634	119	(1,287)
18	1997	1,623	332	150	57	1,085	8	1,077	29	1,360	571	119	(670)
19	1998	2,201	363	24	51	1,762	370	1,392	1,421	218	514	119	415
20	1999	691	359	3	46	283	60	224	1,645	24	462	119	558
21	2000	1,672	400	0	42	1,230	258	972	2,616	3	416	119	533
22	2001	2,790	452	0	37	2,300	483	1,817	4,434	0	375	119	493
23	2002	1,826	465	0	34	1,327	279	1,048	5,482	0	337	119	456
24	2003	4,214	561	0	30	3,622	761	2,861	8,344	0	303	119	423
25	2004	4,354	590	0	27	3,737	785	2,953	11,296	0	273	119	392
26	2005	4,406	609	0	25	3,772	792	2,980	14,276	0	246	119	365
27	2006	4,580	635	0	22	3,922	824	3,099	17,375	0	221	119	340
28	2007	4,766	663	0	20	4,082	857	3,225	20,600	0	199	119	318
29	2008	4,964	693	0	18	4,253	893	3,360	23,960	0	179	119	298
30	2009	5,193	725	0	16	4,452	935	3,517	27,478	0	161	119	280
31	2010	5,427	758	0	15	4,655	978	3,677	31,155	0	145	119	264
32	2011	5,671	792	0	13	4,867	1,022	3,845	35,000	0	131	119	250
33	2012	5,926	827	0	12	5,087	1,068	4,019	39,019	0	118	119	237
34	2013	6,193	864	0	11	5,318	1,117	4,201	43,220	0	106	119	225
35	2014	6,472	903	0	10	5,559	1,167	4,392	47,611	0	95	119	214
36	2015	6,763	944	0	9	5,810	1,220	4,590	52,202	0	86	119	205
37	2016	7,067	986	0	8	6,073	1,275	4,798	56,999	0	77	119	196
38	2017	7,385	1,031	0	7	6,348	1,333	5,015	62,014	0	69	119	189
39	2018	7,718	1,077	0	6	6,634	1,393	5,241	67,255	0	62	119	182
40	2019	8,065	1,126	0	6	6,934	1,456	5,478	72,732	0	56	119	175
41	2020	8,428	1,176	0	5	7,246	1,522	5,725	78,457	0	51	119	170
42	2021	8,807	1,229	0	5	7,573	1,590	5,983	84,440	0	46	119	165
43	2022	9,203	1,285	0	4	7,915	1,662	6,253	90,693	0	41	119	160
44	2023	9,618	1,342	0	4	8,271	1,737	6,534	97,227	0	37	119	156
45	2024	10,050	1,403	0	3	8,644	1,815	6,829	104,056	0	33	119	152
46													
47		159,430	24,387	1,980	1,346	131,717	27,660	104,056					
48													
49	NPV10												
50													
51													
52													
53	ep10												
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APPENDIX C BISON MODEL SCALE SENSITIVITIES

This section contains the output from the bison ranch rnodelling of scale sensitivities (see Table C. 1). Detailed discussion of the approach to these sensitivities is presented in Chapter 7.

Table C.1. Sensitivity Analyses to Project Scale

SCALE (% of Base)	HERD	HARVEST	CASE A APC $/kg	CASE A PRICE $/kg	CASE A ARGP $/kg	CASE A IRR %	CASE B APC $/kg	CASE B PRICE $/kg	CASE B ARGP $/kg	CASE B IRR %
20	[illegible]	79	31.10	7.08	(24.02)	<0	31.10	18.00	(13.10)	[illegible]
[illegible]	408	118	21.03	7.08	(13.95)	<0	21.03	18.00	[illegible]	[illegible]
40	544	158	[illegible]	7.08	(8.94)	<0	16.02	18.00	1.98	11.23
[illegible]	[illegible]	197	13.02	[illegible]	(5.94)	3.23	13.02	18.00	[illegible]	13.52
[illegible]	815	[illegible]	11.02	7.08	(3.94)	5.09	11.02	[illegible]	[illegible]	15.47
70	951	[illegible]	9.60	7.08	(2.52)	6.60	9.60	18.00	8.40	17.18
90	1087	[illegible]	8.53	7.08	(1.45)	7.89	8.53	17.99	[illegible]	18.71
90	1223	[illegible]	7.70	7.08	(%)	[illegible]	7.70	17.76	10.06	19.99
100	1359	394	7.04	7.08		10.06	7.04	17.13	10.09	21.03
110	1495	433	[illegible]	7.08	0.58	10.99	[illegible]	16.62	10.12	22.04
150	[illegible]	591	[illegible]	[illegible]	[illegible]	14.13	5.06	15.10	10.04	25.65
200	2718	788	4.07	7.08	3.01	17.22	4.07	13.82	9.75	29.29
[illegible]	[illegible]	985	3.47	7.08	3.61	19.78	3.47	[illegible]	9.34	32.14
[illegible]	4077	1182	3.08	[illegible]	[illegible]	21.99	3.08	12.08	[illegible]	[illegible]
[illegible]	4757	[illegible]	[illegible]	7.08	4.28	23.95	[illegible]	11.51	8.71	[illegible]
400	5436	1576	2.58	[illegible]	[illegible]	[illegible]	2.58	11.07	8.49	38.72
[illegible]	6116	[illegible]	[illegible]	[illegible]	4.66	27.35	[illegible]	10.72	8.30	40.46
500	6795	1970	2.29	7.08	[illegible]	29.96	2.29	10.40	8.11	41.99
550	7475	2167	2.18	7.08	[illegible]	30.26	2.18	10.14	[illegible]	43.46

	APC		CASE A'	CASE B		CASE A	CASE B
[illegible]	31.1	20	7.08	18.00	20	-24.02	-13.10
[illegible]	21.03	30	7.08	18.00	[illegible]	-13.95	-3.03
40	16.02	[illegible]	7.08	18.00	40	-8.94	1.99
[illegible]	13.02	[illegible]	7.08	18.00	50	-5.94	4.98
[illegible]	11.02	[illegible]	[illegible]	18.00	60	-3.94	6.99
70	9.6	70	[illegible]	18.00	[illegible]	-2.52	8.40
90	8.53	90	[illegible]	17.99	80	-1.45	9.46
90	7.7	90	7.08	17.76	90	-0.62	10.06
100	7.04	100	[illegible]	17.13		[illegible]	10.09
110	6.5	110	7.08	16.62	110	0.58	10.12
150	5.06	150	[illegible]	15.10	150	2.02	10.04
[illegible]	[illegible]	200	[illegible]	13.82	200	[illegible]	9.75
250	3.47	250	[illegible]	12.81	[illegible]	[illegible]	[illegible]
[illegible]	3.08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	350	4.28	8.71
[illegible]	2.59	400	[illegible]	[illegible]	400	[illegible]	8.49
[illegible]	2.42	450	[illegible]	[illegible]	[illegible]	4.66	[illegible]
[illegible]	2.29	[illegible]	[illegible]	10.40	500	4.79	[illegible]
[illegible]	2.18	550	7.08	10.14	[illegible]	[illegible]	[illegible]

NOTE: APC= Average Production Cost
ARGP= Average Ranch Gate Profit
IRR= Real Internal Rate of Return

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