A LANDSCAPE EVALUATION OF BISON MOVEMENTS AND DISTRIBUTION IN NORTHERN CANADA



Prepared for: The Canadian Bison Association, Parks Canada, and The Department of Resources, Wildlife and Economic Development: GNWT





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DEPARTMENT OF RESOURCES, WILDLIFE AND ECONOMIC DEVELOPMENT (Government of the Northwest Territories)

A LANDSCAPE EVALUATION OF BISON MOVEMENTS AND DISTRIBUTION IN NORTHERN CANADA

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EXECUTIVE SUMMARY

Wood Buffalo National Park (WBNP) and the surrounding area support the largest metapopulation of wood bison in existence. However, these herds became infected during the 1920's with the two cattle diseases bovine tuberculosis (Mycobacterium bovis) and bovine brucellosis (Brucella abortus). The diseases continue to persist and have been the underlying cause of the dramatic decline of infected wild populations of bison in WBNP and the surrounding area. The issue of disease management was the subject of a controversial proposal to eradicate infected bison in the region in 1990. Although the recommendation to depopulate the infected population was not acted on, motivation to address the issue has increased since 1990 for two reasons: 1) the increasing risk to the conservation of recovering disease-free free-ranging bison; and 2) the risk to a rapidly expanding commercial bison industry in the region. The primary focus in recent years has been to conduct additional research to increase understanding of the issue prior to determining a final course of action. Part of the research program was to assess the risk to susceptible populations posed by the diseases. The Canadian Food Inspection Agency's Animal, Plant and Food Health Risk Assessment Network (APFRAN) conducted a risk assessment in 1998. Our research was designed to compliment and build upon the work done by APFRAN by compiling local knowledge on bison movements and distribution and modeling movement corridors. Host-borne contagious pathogens like *M. bovis* and *B. abortus* are dependent for transmission opportunities upon movement of the host and its interactions with other susceptible individuals. Therefore, understanding and predicting bison movement patterns is an important aspect of epidemiology and disease risk management.

Our research focused on the following objectives:

- to compile local knowledge on bison movement and distribution around WBNP;
- to define the relative influences of specific biophysical and management factors from local knowledge sources;
- to develop a habitat model for bison in WBNP;
- to integrate quantitative and local qualitative data on biophysical factors into a bison movement model;
- to represent model results in mapping products that will inform the development of risk management guidelines; and
- to provide results to APHRAN for refinement of the disease risk assessment should agencies desire additional risk analysis.

Thirty-five people from communities surrounding WBNP participated in providing local knowledge for the project. Knowledge was provided on the locations of bison ranches, the distribution of free-ranging bison and the influence of biophysical and management factors on bison movement and distribution. In 2000, information was collected on 116 bison ranches in the Peace Country of northern Alberta and British Columbia (note that there are now probably more than 116 ranches in this region). Seventeen bison ranches are located within 170 km of an infected bison population, the maximum observed

distance of a bison sighting that could have originated from an infected population. Eighty-eight percent of bison groups observed >10 km outside known herd ranges were male. These adult male dispersers represent a more likely risk of transmission of tuberculosis than do female bison.

From local knowledge we mapped three additional wild bison populations outside defined herd ranges in northern Alberta; the Firebag River herd, the Talbot Lake herd, and a herd located southwest of the Buffalo Head Hills. Movement patterns and trail networks described by local participants in this study were consistent with patterns described for bison populations in other areas. Bison rapidly establish trails along the most direct and practical route between favored habitat patches. These movement corridors may include water crossings that according to local information are usually associated with river bends, gradual approaches and shallow fords.

Local knowledge was also compiled on the habitat affinities of bison. Bison prefer grassy meadows and have an affinity for burned areas. They typically avoid muskeg, dense forest and steep terrain. This set of affinities is consistent with the patterns of habitat selection reported in the literature for bison throughout their range. Maps of centers of bison activity, major movement corridors, and water crossings were generated from local ecological knowledge for the Slave River Lowlands and northern Alberta.

We analyzed habitat selection by bison in WBNP using the locations of radio equipped bison and classified satellite data (MSS, vegetation classification) provided by WBNP. Bison in WBNP clearly preferred sedge meadows and willow/aspen vegetation cover classes (MSS classified image) in both the summer and winter. While bison preferred sedge meadows, aspen/willow complexes were used in proportion to their availability. Coniferous and mixed forest vegetation (except for wet black spruce) and complexes of willows and birch were avoided.

Because different systems are used for classification of vegetation and terrain in Alberta and WBNP, we used 'greenness' to create a continuous classification system for inside and outside the park. Greenness is correlated with phytomass. Our results suggest that greenness is a sufficiently robust substitute for a methodologically homogenous and spatially continuous vegetation/terrain classification for the risk assessment area.

A summer habitat selection model was constructed with the variables 'greenness' and 'distance to water' based on radio collared bison relocation data and satellite reflectance data for one area in WBNP. The probability of summer bison habitat use increases with an increase in the greenness score and decreases with distance to water. The bison summer habitat model was consistent with an independent sample of radio-locations and with local knowledge of areas of good habitat and areas used by bison.

The bison movement model used the principle of "least cost/least resistance" which considers that movement is most likely to follow a path of least resistance along a vector defined by the juxtaposition of relative high quality habitat patches weighted by distance. The habitat component of the model was based upon the bison summer habitat model generated as a spatial dataset. Local knowledge and literature sources were used to define the influence of biophysical factors on bison movement, with the primary spatial factor being steep slopes derived from digital elevation models. A total of 875 movement routes were generated between 7 entry points in WBNP and 25 exit points in the northern Alberta study area resulting in a pathway density map representing most



probable bison movement corridors. The highest density corridors paralleled the Peace River in the vicinity of Fort Vermilion and another cluster ran from WBNP southwest across the south end of the Buffalo Head Hills (Figure E-1). The broadest network of corridors was defined between High Level and WBNP, aligned with the Peace River. The movement corridors calculated in our study represent the most likely routes of travel for bison dispersing from populations in and near WBNP and corresponded reasonably with the distribution of bison sightings west of WBNP.

The closest captive bison herd to an infected population was the bison research project in Fort Vermilion. It was 64 km from the Wabasca herd on a least distance pathway. The Ft. Vermilion bison research project was also the closest captive herd to the Wentzel herd (117 km). While the free ranging Wabasca herd is infected with tuberculosis and brucellosis, the disease status of the Wentzel herd is unknown. Bison ranches in the Deadwood agricultural area were the furthest destinations from potentially infected wild bison herds along least cost pathways (range 259 to 383 km). For comparison, we calculated the straight-line distance of each of the susceptible herd locations to the nearest wild bison sighting. Distances to captive herds ranged from 11 to 53 km, substantially shorter than any of the distances generated with the movement model. Wild bison had been seen on the proposed project site at the Paddle Prairie Metis Settlement; therefore the distance was zero. Likewise, the distance to the Hay-Zama herd was zero. The Hay-Zama herd may have already experienced contact with emigrants from other wild herds.

We offer the following risk management recommendations for susceptible wild bison populations:

- Immediate implementation of a tuberculosis and brucellosis monitoring program for the Hay-Zama population.
- Disease monitoring should be implemented for the Nordquist, Pink Mountain and Etthithun populations in British Columbia, and the Nahanni population in the NWT.
- The Bison Control Program in the NWT should be continued for managing the risk of infection of the Mackenzie and Nahanni populations

We offer the following risk mitigation recommendations for commercial bison ranches:

- Designate a high-risk zone (region) for bison production (and other livestock).
- A risk management zone (region) should be defined collaboratively between governments and industry associations.
- Develop region specific interventions, including surveillance for wild bison, special market surveillance, livestock transport regulations and record keeping, special fencing standards, appropriate location of ranches, and periodic testing protocols.

- The Captive Ungulate Policy as it initially applied to domestic bison should be maintained and enforced in the high-risk region (testing and transport regulations).
- Bison ranches should not be developed within 170 km of infected herds, particularly within the movement corridors identified in this study.
- Bison ranchers need to be made aware of high-risk locations for bison ranching and of the consequences of disease transmission to the livestock industry and to other disease free, free-ranging bison populations.
- Ensure that animals coming onto a farm are from a disease free source by ensuring the source herd has no risk of exposure to wild or otherwise untested bison and that the source herd has maintained disease free status through testing.
- Diligence by industry associations and individual producers is required to prevent entry of untested animals into the commercial industry.
- Prevent contact with free-ranging bison and other potential host species by maintaining appropriate barriers; by locating ranches in reduced risk areas such as in the center of agricultural developments rather than in peripheral uncultivated or natural areas;
- The abundance and seasonal aggregation patterns of wild cervids (deer family) should be monitored and managed in the agricultural area near WBNP.
- Commercial cervid farming may not be wise in the agricultural area near WBNP under current circumstances.
- Provisions are needed under both the Alberta Wildlife Act and the Public Lands Act to reduce the risk of escapes and for preventing stray domestic bison from establishing free-ranging wild populations and negatively affecting existing or future conservation herds.
- Commercial operators should be informed of the consequences of disease transmission and should be made aware of the distribution of known populations and history of sightings in the area of interest.

The mapping products generated during this study provide a spatially explicit view of risk, provide the foundation for further discussion, and allowed the authors to develop some management recommendations. Local knowledge recorded and mapped in this study has contributed to a higher level of understanding of bison ecology and distribution in the areas of concern and provided information that can be used to formulate an intervention plan. The least cost pathway distances generated from our study may be used to adjust the invasion probability equation in the APHRAN model. However, we suggest that recalculating the risk of infection is of secondary importance to the immediate need for risk mitigation and development of a long-term plan.

There is a strong interest by communities surrounding Wood Buffalo National Park in bison recovery outside the park. The persistence of tuberculosis and brucellosis infected

populations at low density inside the park limits the opportunity for recovery of viable, ecologically meaningful populations that could contribute to the resource-based economies of surrounding communities. Since the presence of the diseases affects a region and communities much larger than WBNP, it would be unreasonable to expect that a single agency or government could develop an action plan that would be acceptable to the broad range of interests involved. Therefore, we recommend that a collaborative planning process be developed in which the interests of communities, the livestock industry, conservation groups, and government agencies are fairly represented.

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CHAPTER 1

INTRODUCTION

Wood Buffalo National Park (WBNP) and the surrounding area, located in the northeast corner of the province of Alberta and the southern Northwest Territories, supports the largest metapopulation of wood bison in existence. Unfortunately, populations in this area are infected with two cattle diseases introduced during the 1920's, resulting from a massive release of infected plains bison imported from east central Alberta. Mycobacterium bovis and Brucella abortus are the causative agents of the two reportable diseases, bovine tuberculosis and bovine brucellosis. The role of the diseases in the population ecology of free-ranging bison is the subject of current research programs in Wood Buffalo National Park (BRCP 1996) and Yellowstone National Park (NPS 1998). The pathobiology of each disease is considered similar in bison and cattle (Tessaro 1988, 1989, Rhyan et al. 2001). The main clinical features of brucellosis are a high incidence of abortion during the first pregnancy following infection (Davis et al 1990, 1991), and a low incidence of bursitis leading to arthritis and reduced joint mobility (Tessaro 1988, 1989). Tuberculosis in bison and cattle is primarily a pulmonary disease, although any organ system may be affected. Advanced tuberculosis is generally fatal (Tessaro 1988). Owing to the importance of brucellosis and tuberculosis as zoonoses and reportable diseases, they have been the subject of intensive, long-term eradication programs in livestock populations in Canada and the United States. The Canadian livestock population was declared free of brucellosis in 1985. Tuberculosis continues to occur sporadically in livestock herds throughout Canada, but the incidence of the disease is extremely low. The last outbreak occurred in a cattle herd in Manitoba in 1997 (D. Scott, Canadian Food Inspection Agency pers. comm.). Bison in the Greater Wood Buffalo National Park area represent the last known reservoir of the diseases in Canada.

The issue of disease management was the subject of a controversial proposal to eradicate infected bison in the region (FEARO 1990). Although the Government of Canada rejected the proposed action, concern about the persistence of the diseases has not diminished. Indeed, the reasons for concern have increased since 1990 in two main areas including the risk to the conservation of recovering disease-free, free-ranging bison and the risk to a rapidly expanding commercial bison industry in the region.

Since the termination of intensive bison management in WBNP and the adjacent Slave River Lowlands around 1970 (Carbyn et al. 1989), the Greater WBNP Ecoregion (GWBNPE) bison population has declined by over 80%, from16, 000 in 1971 to 2,151 in 1999 (Joly 2001). This stock represents a mix of original wood bison and introduced plains bison (van Zyll de Jong et al. 1995, Wilson and Strobeck 1999) and was the source of three salvage projects undertaken to establish brucellosis and tuberculosisfree herds representing as close as possible the wood bison phenotype and genotype (Gates et al. 2001). There have been no management initiatives undertaken to promote growth or recovery of infected herds since the 1960's. During the past three decades, six wild populations of non-infected bison have been reestablished in northern Canada, which now number approximately 4,700 bison in aggregate. They include one plains bison and five wood bison populations. Should any of these herds become infected, management support for their conservation would likely diminish as it has in the past for existing infected populations. Managing the risk of infection of the nearest herds to WBNP is the focus of initiatives in the Northwest Territories and Alberta and is a concern for three herds in British Columbia (Harper and Gates 1999). The Yukon population is sufficiently remote that diseases would only be of concern if nearby herds became infected.

Other considerations in the management of diseased bison include the status of wood bison under COSEWIC (listed as 'threatened'), and the designation of WBNP by the United Nations Educational Scientific and Cultural Organization (UNESCO) as a World Heritage Site predominantly because of wildlife populations that inhabit the park (UNESCO 1982). A national program for conservation of wood bison has existed in various forms since the early 1970's. Currently, the Recovery of Nationally Endangered Wildlife program (RENEW) provides direction for a National Recovery Team which provides advice to jurisdictions and coordinates recovery actions in Canada. The Team has published a National recovery plan that identifies four primary goals to guide recovery efforts (Gates et al. 2001):

- Reestablish viable, healthy, free-roaming wood bison populations in original range, thereby contributing to the maintenance of ecological processes and biological diversity;
- 2. Ensure the genetic integrity of wood bison is maintained without further loss as a consequence of human intervention;
- Restore healthy wood bison herds for long term sustained use, thereby contributing to the aesthetic, cultural, economic, and social well being of rural communities and society in general; and
- 4. Encourage the establishment of long term cooperative management programs for wood bison, in which rural communities, aboriginal people, and public agencies play an integral role.

In addition, a Research Advisory Committee (RAC) was established in 1995 by the WBNP administration to provide advice for the Bison Research and Containment Program (BRCP 1996). The long-term goal of the BRCP is to support research efforts that contribute to a better understanding of bison ecology within the Greater Wood Buffalo National Park Ecoregion.

In response to these concerns, the Canadian Bison Association (CBA) formed a Disease Risk Management Committee (DRMC), which requested the CFIA/Animal, Plant and Food Health Risk Assessment Network (APFRAN) to conduct a risk assessment. Similarly, Wood Buffalo National Park's (WBNP) Research Advisory Committee (RAC), which serves its Bison Research and Containment Program (BRCP 1996), identified the need for a disease risk assessment. APFRAN completed an assessment in September 1998. The DRMC and Parks Canada recognized that the assessment, though valuable, was limited in detail and management application. In particular, biophysical factors affecting bison movement and distribution were not taken into consideration. Neither was local ecological knowledge incorporated into the epidemiological model. APFRAN (1998) acknowledged this limitation in its report to the CBA, explaining that limited time and resources prevented consideration of this type of information. The purpose of the project is to develop a model that combines relevant biophysical data from conventional and rural knowledge sources into a landscape model of bison movements in defined risk areas around Wood Buffalo National Park. The project adds to the value of the analysis completed by APFRAN. It satisfied some of the outstanding research topics outlined by the BRCP-RAC provided to us by Parks Canada. Specifically, the project provided analyses and information that contributed to the following BRCP research sub-topics:

- Estimate the risk of brucellosis and tuberculosis transmission from bison to humans, livestock, non-diseased bison and other wildlife in the southwestern portion of the GWBNPE under the current management regime as well as under the full range of management options.
- Produce a GIS cover-type map for WBNP, identifying suitable habitat for bison.
- Develop and assess alternatives for effective brucellosis and tuberculosis containment, management and elimination, including ecological impacts, operations and administrative requirements, and costs.
- Develop risk assessments for the possibility of brucellosis and tuberculosis transmission from infected bison to humans, livestock, non-diseased bison and other wildlife in the remainder of the GWBNPE.

OBJECTIVES

The following objectives were developed for the project.

1) To compile local knowledge on bison movement and distribution around WBNP.

2) To define the relative influences of specific biophysical and management factors from local knowledge sources.

3) To develop a habitat model for bison in WBNP.

4) To integrate quantitative and local qualitative data on biophysical factors into a bison movement model.

5) To represent model results in mapping products that will inform the development of risk management guidelines.

6) To provide results to APHRAN for refinement of the disease risk assessment should agencies desire additional risk analysis.



STUDY AREA

This study took place in Northern Canada, specifically in northern Alberta and British Columbia, and southern Northwest Territories. Three focal study areas were identified around WBNP. At the time of writing, geographic data were only available for the Alberta and WBNP study area and had not yet been provided for the NWT study areas by the Government of the Northwest Territories (GNWT). Although local ecological knowledge was compiled for each area, the analysis of bison movements was completed only for the Alberta/WBNP study area. We are committed to completing the movement models for the NWT areas if the digital data are provided by the GNWT.

APPROACH

A review of the literature on bison movements and dispersal was carried out to define the extent and content of published knowledge on factors affecting these aspects of bison behaviour. Areas for which information was available included the Mackenzie Bison Range in the NWT (Gates and Larter 1990, Larter et al. 2000), Wood Buffalo National Park (Joly and Messier 2001a, Westworth and Associates 2000), Yellowstone National Park (Meagher 1989a,b, Bjornlie and Garrot. 1999), and Konza Prairie, Kansas (Nellis and Briggs 1997).

Current and historic local ecological knowledge was also an important component of the assessment. Local knowledge of bison movements and factors that influence movements were obtained through a process referred to as participatory appraisal, which was developed and applied first in Africa (McCorkle and Mathias-Mundy 1992, Mariner 1999). The main method used in our work was semi-structured interviews using checklists of questions related to bison ecology and map overlays to build a spatial and historical picture of bison distribution and abundance in the study areas. Contacts included resource specialists with Aboriginal groups, forestry and wildlife agencies, and local community residents who had special knowledge about bison and the ecosystem.

The affinity of bison for specific habitat features was quantitatively defined from data for an area in Wood Buffalo National Park for which Parks Canada provided Landsat 7 data. A data set on the locations of radio collared bison obtained during a recent study of bison movements in WBNP (Joly and Messier 2001a) were provided by the University of Saskatchewan. A model was constructed relating the probability of occurrence of bison to Landsat scene "greenness" and distance to water and the effect of slope on the ease of movement. We based the bison movement corridor model on the "least cost" principle which states that wildlife movement is most likely to follow a path of least resistance along a vector defined by the juxtaposition of relative high quality habitat patches weighted by distance. The geographic analysis and image processing software IDRISI32 (Clark Labs 2001) provides an example of a program that calculates the route of least cost distance between one or more points. This model was applied across the Alberta study area and can be applied to the other two areas once the digital satellite data are made available.

Finally, the implications of the findings of this study to disease risk management are discussed. The DRMC subcommittee on disease mitigation guidelines provided valuable

insights that were used in formulating management recommendations. The overarching implication of the study is that the persistence of tuberculosis and brucellosis infected populations at low density inside WBNP limits the opportunity for recovery of viable, ecologically meaningful bison populations that could contribute to the resource-based economies of surrounding communities. It is evident that a collaborative process is required to develop an action plan in which the interests of communities, the livestock industry, conservation groups, and government agencies are fairly represented.

CHAPTER 2

LOCAL KNOWLEDGE OF BISON MOVEMENTS AND DISTRIBUTION IN NORTHERN CANADA: A STUDY IN PARTICIPATORY RURAL EPIDEMIOLOGY

Applied ecology and veterinary epidemiology require attention to complex relationships focusing on the acquisition of detailed knowledge. In these sciences, it is commonly necessary to describe reality using methods based on positivism in which qualities are transformed into quantities before relationships can be analyzed and understood (Catley 1999). Although guantitative data processing and analysis have become more formal and sophisticated, these developments do not necessarily result in improved conservation, risk management or human welfare. Meek (1993) recognized the limitations of scientific positivism, noting that although scientific methods are preferred in the physical and life sciences, "This may not be in society's best interest, because the choice of method ought to be made on the basis of its appropriateness to the phenomenon being studied'. Leyland (1996) acknowledged the need to base research on the needs of local people rather than solely on the preconceptions of researchers. He indicated that research projects should provide the platform for all groups to participate in decision making. Catley (1999) suggested that amalgamation of qualitative and quantitative methods with increased participation of local community members improves the relevancy of veterinary epidemiology to society.

In addition to conventional methods of epidemiological investigation, primarily involving application of the scientific method, participatory approaches to research have been used as an effective technique to collect and apply local epidemiological information (McCorkle and Mathias-Mundy 1992, Mariner 1996, Leyland 1996 and Catley 1997, 1999). Participatory methods acknowledge the importance of local insights and context and are used for identifying and priorizing information relevant to animal health problems. A veterinary application, termed Participatory Rural Appraisal (PRA), evolved from Rapid Rural Appraisal (RRA), further shifting the paradigm from the researcher as an extractor of information, to a facilitator of community participation in problem solving (IIED 1994). This technique was pioneered in the international sustainable development forum as an efficient method for integrating locally available information with scientific data to produce a semi-quantitative product for analysis (Mariner 1999).

The importance of complex knowledge held by rural and local people has been recognized in social anthropology and agricultural development fields for many years (Howes 1979, Swift 1979, Brokensha et al. 1980, Farrington and Martin 1988, Atte 1993 and Agrawal 1995). Local information was used historically in epidemiology and ecology, however its value became overshadowed by strictly scientific approaches (Mariner 1999 and Wentzel 1999). Although local knowledge was recognized for cognitive contributions to scientific validation (Horton 1967, Brokensha et al 1980, Johannes 1981, Pinkerton 1989 and Wynne 1989), its incorporation into modern ecological and epidemiological research and decision making has become more common in recent years with the theoretical and conceptual development of participatory research (Chambers 1983, Kloppenburg 1991, Ruddle 1994, Calheiros et al. 2000 and Usher 2000). It has been suggested that to fully understand current landscapes and resource bases, local



knowledge must be incorporated into the assessment process (Stromquist et al 1999). The inclusion of local knowledge in the management of bovine tuberculosis (*Mycobacterium bovis*) and bovine brucellosis (*Brucella abortus*) in the wood bison of northern Canada is essential to provide useful information, interpretation and validation of analyses and for enhancing local capacity to develop interventions.

Wood Buffalo National Park (WBNP) and the surrounding area, located in northern Alberta and the southern Northwest Territories, supports the largest metapopulation of wood bison in existence. Unfortunately, bison in these subpopulations are infected with two cattle diseases (bovine tuberculosis and bovine brucellosis) introduced during the 1920s with a massive release of infected plains bison imported from east central Alberta. Owing to the importance of brucellosis and tuberculosis as zoonoses (diseases of animals that can be transmitted to humans), they have been the subject of intensive, long-term eradication programs in livestock populations in Canada and the United States. The Canadian livestock population was declared free of brucellosis in 1985. Tuberculosis continues to occur sporadically in livestock herds throughout Canada, but the incidence of the disease is extremely low. The last outbreak occurred in a cattle herd in Manitoba in 1997 (D. Scott, CFIA, pers. comm.). Bison in the Greater Wood Buffalo National Park area represent the last known reservoir of the diseases in Canada. The issue of disease management was the subject of a controversial proposal to eradicate infected bison in the region (FEARO 1990). Although the Government of Canada rejected the proposed action, concern about the persistence of the diseases has not diminished. Indeed, the reasons for concern have increased since 1990 in two main areas including the risk to the conservation of recovering disease-free, free-ranging bison, and the risk to a rapidly expanding commercial bison industry in the region.

In response to these concerns, the Canadian Bison Association (CBA) formed a Disease Risk Management Committee (DRMC) which requested the CFIA/Animal, Plant and Food Health Risk Assessment Network (APFRAN) to conduct a risk assessment. Similarly, Wood Buffalo National Park's (WBNP) Research Advisory Committee (RAC), which serves its Bison Research and Containment Program (BRCP 1996), identified the need for a disease risk assessment. APFRAN completed an assessment in September 1998. The CBA/DRMC and Parks Canada recognized that the assessment, though valuable, was limited in detail and management application. In particular, biophysical factors affecting bison movement and distribution and local ecological knowledge were not taken into consideration in the epidemiological model. APFRAN (1998) acknowledged this limitation in its report to the CBA, explaining that limited time and resources prevented its inclusion.

The purpose of this project was to compile and present local ecological knowledge in forms that make it available for planning and decision-making. This chapter demonstrates how participatory appraisal can provide insightful information on the distribution and movements of bison. Local information compiled during this study is presented with the intention that it could be used in a subsequent planning forum in which communities will continue to participate. Participatory research is a cyclical, ongoing process (Cornwall 1996) that compliments adaptive management. Therefore, participatory projects are dynamic by definition and evolve over time (Guijt and van Veldhuizen 1998). The information presented in this chapter describes the interests of local communities in participating in the management of diseased bison in northern Canada.

METHODS

The DRMC and RAC were comprised of stakeholders, including representatives from governments, national organizations, and local communities around WBNP. Participants in the RAC and DRMC defined the study areas for this study, consistent with the principle that communities are in the best position to define geographic boundaries relative to their own interests and concerns (Catley 1999). Three areas were identified for detailed analysis (Figure 2-1). The first area, the Slave River Lowlands (SRL), is located between WBNP and Fort Resolution on the south shore of Great Slave Lake. It has some of the most productive bison habitat in northern Canada and is a prime area of interest for a bison salvage and reintroduction project (Nishi et al. 2001). The second area is in northwestern Alberta. This area is one of the most likely regions for contact between infected bison and susceptible free-ranging and captive bison. The Caribou Lower Peace Region immediately west of WBNP is of particular interest to the Little Red River Cree Nation and the TallCree First Nation who have engaged with industry and government partners to develop a sustainable forest management vision in which bison conservation is a component. In addition, the area contains an important agricultural zone in which conventional animal production and bison ranching occurs. The third area was identified by the GNWT and Parks Canada primarily to generate information for managing the disease risk posed to the Mackenzie bison population. This area includes the area between WBNP and Fort Providence south of Great Slave Lake.

The focus of the research was to define local knowledge on the distribution and movement patterns of bison and factors influencing movements and distribution in the study areas. Participants in the RAC and DRMC were asked to identify initial contacts in the communities located within the study areas. These contacts were asked to identify knowledgeable people to be interviewed and to facilitate interviews in cooperation with the primary researcher (JM). As individuals were interviewed, they were asked to identify other people within the study area who had detailed knowledge of the area.

The nature of local knowledge requires informal survey methods and uses techniques that allow for exploration and expression of information in a meaningful fashion (Chambers 1994). For these reasons, a semi-structured interview with pre-determined topics was used for collecting information (Slim and Thomson 1994 and Pretty et al. 1995). National Topographic System maps (1:250,000) were used as visualization tool to focus discussion (McCracken et al. 1988). A sheet of acetate was overlaid on the map and was marked by the interviewee to record spatial information. Notes were also taken during interviews. This technique is known as 'interviewing the map'; it facilitates discussion of the geography and ecology of a local area (Catley 1999). The data from interviews was digitized into a GIS format using MapInfo Professional Version 6.0. A database (Microsoft Access 1997) was created to catalogue the records.

A list of factors influencing bison movement and distribution was developed based upon the literature (Larter and Gates 1991, Gainer 1985, Gates et al. 2001, Reynolds et al. 1978 and Tessaro 1988). This information was used to guide the semi-structured interviews. Biophysical characteristics of the landscape that were considered to be important included: vegetation pattern, foraging habitat quality, patch size, and distribution; terrain characteristics including slope, contour, and substrate; water bodies,



including width, flow characteristics and depth, seasonal factors such as frozen versus open water conditions; and human infrastructure such as fences, roads, cultivation, forestry, urban and industrial development. The wildlife management regime was also deemed to be important. Management of free-ranging bison was variable including strict protection, regulated hunting, open seasons, no regulation, and depopulation zones. Interviewees included local government employees (regional, provincial, federal, and first nations) and agriculturalists, including bison ranchers, who had specific knowledge of a local area. They provided information on bison surveys, incidental bison sightings and the locations of bison ranches. The Peace Country Bison Association provided information on the location of bison ranches and number of bison on each in April 2000. We added other ranches to the database as we became aware of locations from other sources, which included a pre-existing database from the Government of the NWT.

The process of validating data is an essential component of participatory research (Catley 1999, Mariner 1999 and Robinson et al. 1994). Three methods of data validation were used in this research. The first involved individual validation of the information discussed during the interview. During an interview, the participant was asked to illustrate their responses to questions on bison geography on an acetate overlay. Once the interview was complete, the information was recorded on the map, notes were referenced, then the participant was asked to verify the accuracy of the information. Secondly, data validation was conducted at the community level. Once the information from all interviews was incorporated into a spatial database and map, the preliminary results were presented for review at meetings of the RAC and DRMC, which were attended by community representatives. A third approach to validation established confidence in the information using a technique known as triangulation (Catley 1999). This method compares information generated during separate interviews with information pooled from other sources (Robinson et al. 1994). Centers of bison activity were identified as multiple overlapping polygons, points, or linear features representing areas of good or avoided habitat, trails and movement corridors, bison concentrations and water crossings.

RESULTS

Interviews

As the number of individuals interviewed increased, a point was reached where interviewees no longer identified new contacts (Figure 2-2). The asymptote was reached after interviewing nine individuals in the Slave River Lowlands and ten individuals in the Caribou Lower Peace. There were only three contacts identified who had knowledge about bison movements and distribution in the Hay River study area. Thirty-five knowledgeable people were identified overall and each was interviewed.



Figure 2-2. Relationship between the number of people interviewed and the number of new contacts identified in the three study areas.

Distribution of bison ranches

The Peace Country Bison Association (PCBA) identified 116 bison ranches in the Peace country of Alberta and British Columbia, north of a line from Dawson Creek, BC to Fort McMurray, AB, at approximately the 55.5^oN latitude (Figure 2-3). However, only 64 of farms in the database had adequate location information suitable for mapping (e.g. complete legal descriptions, positional information, etc.). Fourteen operations were mapped in the study area in northwestern Alberta where we modeled bison movement corridors (Chapter 3). Three other operations in the model area, near Manning and Dixonville, were not included because location data was not available. Two captive operations were located in the NWT near Fort Resolution, one of which was depopulated in 2001. In addition, we learned that a Metis Settlement is considering establishing a captive bison herd north of Manning.

We had access to a 1993 database on the locations of 34 ranches that the senior author had in his possession. The two databases were combined to illustrate the geographic distribution of captive bison populations in northern Alberta, British Columbia and the Northwest Territories (Figure 2-3). There may be some duplication of locations within the unified database; information in the 1993 database was not adequate to allow us to





eliminate duplicates. The old database provided mapped locations only and did not include any information that could be cross-referenced with the PCBA database (e.g. owner information).

Approximate Ranges of Free-Ranging Populations

There are five defined subpopulations of bison within WBNP (Joly 2001). In 1999 the number of bison counted in these populations were: Nyarling (184), Little Buffalo (79), Hay Camp (635), Delta (429) and Garden River (707) (Figure 2-4). In addition 117 bison were counted in an area of range overlap between the Hay Camp and Delta populations (Joly 2001). The Little Buffalo population ranges in the Slave River Lowlands inside WBNP and in the western SRL in the NWT. It uses the large meadows associated with the Little Buffalo River (Interviews # 15, 16 and 17). Bison from this herd often calve in the high ground between the large wet meadows on the east side of the Little Buffalo river (Interview # 16).

The Hook Lake population ranges east of the Slave River, completely outside WBNP. These bison are primarily found in the large meadows around Hook Lake including Ann's Prairie, Stan's Prairie and North Prairie (Interviews # 15, 16, 17, 18, and 23). Bison have been observed in the winter north of Talston Prairie near the Talston River and in the meadows around Hook Lake (Interviews #18 and 23). In 1997, a group of bison moved east across the Slave River at McConnell Island and occupied the meadows near Ring Lake and Rat Slough (Interviews # 18 and 23). The eastern range limit of bison in the Slave River Lowlands is the Talston River. Bison don't typically use the shield country to the east of the Talston River, however they have been reported to cross and return (Interviews # 4, 18, 23 and 24).

The wood bison in the Mackenzie Bison Range make up the largest disease free (Tessaro et al. 1993), free-ranging bison population in Canada. It was the first wood bison population to be reintroduced in the wild and the first to reach 400 animals, considered to be a minimum viable population (Gates et al. 2001). It was founded in 1963 when 18 bison were transferred from the Nyarling River region of WBNP (Gates and Larter 1990). It currently numbers over 2000 animals (J. Nishi pers. comm.). The population is expanding its range northward, with recent sightings approximately 30km south of Rae Edzo. Northwest Territories along the Mackenzie Highway (Interview # 7). Another disease-free, free-ranging wood bison population ranges in the Liard River drainage in the Northwest Territories and northern British Columbia. The Nahanni population was established through releases of wood bison from Elk Island National Park in 1980, 1989 and 1998, and is currently estimated at 170 animals (Gates et al. 2001). The specific disease status of this population has not been monitored. Another herd was reintroduced into northeastern British Columbia in March 1995 in the Nordquist Flats area (Aline Lake) in the Upper Liard River Valley, north of the Liard River. The Nordquist population is currently estimated to be 50 to 60 animals (B. Webster, pers. comm.). The location of the Nordquist population's range is approximately 80 km from the southern range of the Nahanni herd (along the Beaver River). The proximity of the two herds may eventually favor their amalgamation (Gates et al. 2001).

In northern Alberta the Wentzel herd ranges between Wentzel Lake, the southwest border of WBNP, and the Peace River (Figure 2-4). Animals from the Wentzel herd occasionally move in and out of the Park (Interviews # 9, 10, 12, and 13) but reside outside the park during the winter (Interview # 9). Supplemental winter feed and mineral licks have been placed in the Wentzel Lake area in recent years and the main herd is consequently becoming more resident in the Wentzel River area (Interviews # 9 and 12). One of the reasons for implementing this feeding program was to deter the movement of bison into the agricultural region (Interview # 12). Over 60 bison were tracked by members of the Little Red River Cree Nation in the Wentzel River area in the winter of 2000 (Interview # 9), mainly in areas east of the Wentzel River and down to approximately the 29th baseline north of the Peace River (Interview #13). The bison used to move down to the Foggy Tower Road, but do not regularly go there anymore (Interviews # 1 and 9). Currently, the Wentzel herd tends to be in three groups, with the main herd numbering about 26 animals (Interview # 13). V. Neal (pers. comm.) estimated the Wentzel River population to number about 110 animals. The disease status of the Wentzel population is unknown.

Bison from the Garden River population move along the Peace River into and out of WBNP (Interviews # 1 and 2). South of the Peace River, bison travel into and out of WBNP and were reported to range along Harper Creek and near the lakes along the Mikkwa River (Interviews # 1, 9 and 10). A herd of 40 bison came out of WBNP near Fox Lake in winter 2000, but returned to the park in response to hunting pressure (Interview # 9). A cow and a male calf were observed in 1997/98 at the edge of agricultural land in the Beaver Ranch area (Interview # 2). Bison are in two areas south of the Peace River west of the boundary of WBNP. The Wabasca herd was estimated at > 35 animals and the Mikkwa herd was estimated at > 50 animals (Interviews # 1, 9, 10, 11, and 12). Limited information has been reported from other sources for bison outside of WBNP in this area. However an aerial moose survey conducted by the Alberta Fisheries and Wildlife Management Division in 1996 provided an incidental count of 51 bison in two herds that range near the Mikkwa and Wabasca Rivers. These two groups are generally referred to collectively as the Wabasca/Mikkwa population. Tessaro (1988) tested six bison in this area for brucellosis and tuberculosis. One was seropositive for exposure to B. abortus.

The Hay-Zama herd became free roaming near Assumption, Alberta in 1993 (Morton 1999). The population has for the most part resided in suitable habitat associated with the Hay-Zama Lakes wetlands complex, the Hay River and the Chinchaga River (Wright and Markiewicz 2000). However, it was reported that bison from the Hay-Zama herd may range outside this area, south along the Chinchaga River (Interview # 26) and east into the Hay River drainage in northeastern British Columbia (Gates et al. 2001). Based on sightings it appears that the Hay-Zama population may also be expanding eastward into areas north and south of High Level (Interviews # 5 and 30 and bison observations database from the Government of the NWT). Alberta Fish and Wildlife personnel estimated the Hay-Zama population at 200 individuals in March 2001 (D. Moyles and K. Morton, pers. comm.). We calculated that the herd has increased at an average exponential rate of r = 0.18 since 49 bison were released in 1993. The disease status of this population is not monitored.

A wild plains bison population ranges in northeastern British Columbia. The Pink Mountain population resides in the Muskeg and Sikhanni Chief watersheds in northeastern BC. During a survey conducted in 1996 by the BC Ministry of Environment



Land and Parks 1278 bison were counted in the area (R. Woods pers. comm.). Regulated hunting of this population is permitted (120 LED tags). Unregulated hunting by Aboriginal People also occurs, but is not monitored. Very little information is available on population demography or spatial ecology. The disease status of the population is not monitored.

Sightings outside known population ranges

Based on information recorded during semi-directive interviews and from discussions with government employees we mapped bison locations outside of known herd ranges (Figure 2-5). Small resident herds were reported in the Talbot Lake area in the northern Buffalo Head Hills and in the Bison Lake area west of the south end of the Buffalo Head Hills; neither of these groups has been previously described. The Talbot lake herd was observed in winter 1999/2000 (Interviews # 11 and 12). The number of animals in the area was not described. It is hunted by a few local people from John D'or Prairie and La Crete. Both interviewees 11 and 12 indicated that this herd became established when bison from the Wabasca area moved along the Wabasca drainage then up a valley into Talbot Lake. Talbot Lake is about 40 km from the Wabasca population's range. In the 1980s, bison occasionally ranged west of the Buffalo Head Hills (Interview # 8), and were reported to be in the area in the late 1990s (Interview # 1). The latter Interviewee described a second hand account of 30 bison near Bison Lake located west of the Buffalo Head Hills (Interview # 1). There was no indication of the origin of the herd.

Bison were reported as far west as the Paddle Prairie Metis Settlement (Interview # 26). The origin of these animals is unknown. The closest known herd is the Hay-Zama population (77 km).

Gates at al. (1992) described a small herd in the Firebag River area north of Fort McMurray. S. Tessaro (pers. comm.) provided the senior author with an observation of 20 bison in the Firebag River area in 1984. W. Schaeffer of Fort Smith (pers. comm.) reported 65 bison in the area in 1990 and 42 bison in 1991. Employees with the Alberta Fish and Wildlife Division observed bison on two occasions near the Firebag River in winter 2001; a herd of 52 animals was seen in late January 2001 and 2 male bison were observed in early February 2001 (F. Kunnas and R. Ramcharita, pers. comm.), which confirms the continued presence of this herd.

The bison locations recorded during this study were added to an existing bison observations database (Government of the NWT, Resources Wildlife and Economic Development, Fort Smith, NT). The complete sightings database is illustrated in Figure 2-6. There are 215 sighting locations (bison groups) in the database.





3

Only fifty groups were observed > 10 km outside of known herd ranges (Table 2-1). The size of these groups ranged from 1 to 30, and typical group size (Jarman 1982) was 12.4. Group size was not normally distributed (K-S Distance = 0.354, P <0.001), and was skewed towards small groups (Figure 2-7). The composition of bison groups showed a distinctive demographic pattern. Among groups (N=27) for which composition was recorded (bull-only, or mixed sex composition including at least one female or a calf), 30% of the individual bison observed were in mixed groups (24/80 bison) and 70% were in bull-only groups (56/80). However, 89% of groups were bull-only (24/27) and 11% were mixed (3/27) (Table 2-2).

Twenty-three of the 50 groups were not classified. We attempted to infer the composition of these groups based on what is known about group size dynamics of bison. Komers (1992) found that with increasing age, bulls are more often solitary and occur less frequently in mixed groups. He also provided evidence that at a typical group size of less than eight, a group will consist of only males (Komers 1992:20). From our observations (Figure 2-8), there was no significant difference in the frequency of groups in the size categories <8 and >7 bison for classified and unclassified groups (Fischer's exact test, P=1.000). Therefore we classified groups of unknown composition of less than eight bison as bull groups and groups of eight or more bison as mixed groups. We then pooled the data for groups of known composition with groups classified *a posteriori*. The derived proportion of bull groups in the pooled observations was 88% (44/50) (Table 2-2).

Table 2-1: The size and composition of bison groups observed >10 km outside known population ranges.

Region	Unknown*	Male	Female	
British Columbia	2			
	6			
	2			
	2			
	1			
NWT	1	1	2	
	1	1		
	6	4		
	1	2		
	1	12		
	6	1		
	1	7		
	1	2		
	1	1		
	20	1		
	1	1		
	1	1		
		3		
		1		
		1		
		1		
Alberta	11	2	2	
	1	1	20	
	5	2		
	30	2		
	1	2		
	1	1		
		5		
		1		
Number of bison sighted	103	56	24	
Number of bison	23	24	3	

Composition and Group Size of Bison Observations

* 'Unknown' represents observations for which the composition of the bison group was not recorded or was unavailable.



Figure 2-7. Frequency of the size of groups (intervals of 3) observed >10 km outside known bison population ranges (50 groups, size range 1 to 30), e.g. interval 1 includes groups of 1 to 3 bison, interval 2 groups of 4 to 6 bison, etc.



Figure 2-8. Frequency distribution of group sizes for bison observed >10 km outside of known herd ranges where groups were classified (bull-only or mixed groups) or were not classified.

Table 2-2. Number of groups observed outside of known herd ranges classified into bull-only or mixed sex groups and classification of groups of unknown composition into these categories based on a threshold group size of >7 bison.

		Mixed Groups	Percent bull groups	
	Bull groups		9.000	Ν
Observed	24	3	88.9%	27
Unknowns classified	20	3	87.0	23
Combined	44	6	88.0	50



The area west of WBNP has the greatest number of at-risk bison herds among the three areas of concern to managers and communities. In addition, there were two captive herds in the NWT and another one was located along the Athabasca River south of Wood Buffalo National Park. We considered that comparison of the distances of sightings of bison outside known herd ranges and bison ranches from the nearest infected population or possibly infected population would be instructive (Figure 2-9). We excluded sightings in BC from the analysis since they likely originated from reintroduction projects in northeastern BC and the Liard Valley in the NWT. We included sightings in the NWT south of Buffalo Lake. The maximum distance of a sighting from an infected herd was 167 km. There was no apparent trend in the frequency distribution of sightings within distances up to 170 km from infected populations (Figure 2-9). Sixteen percent of ranches were within this range while 84% of captive herds were further than 170 km from infected herds.



Figure 2-9. Frequency distribution (10 km intervals) of straight-line distances of bison sightings and bison ranches in northern Alberta, adjacent British Columbia, and the Northwest Territories (south of Buffalo Lake) from the nearest range of infected or possibly-infected bison herds.

Along with information recorded on bison during interviews, information was also conveyed on other important ungulate species. A large population of deer was reported in the Fort Vermilion area (Interview # 2) and elk have returned near the Peace River in the Caribou Lower Peace area (Interview # 10). Under certain circumstances, the potential exists for these two species to contract and maintain bovine tuberculosis and brucellosis.


Factors influencing movement and distribution

Detailed notes were taken during the interviews on movement patterns and factors influencing bison distribution and movements. Notes were transcribed into a database, which was organized into four categories: biophysical factors; movement corridors and water crossings; human infrastructure and disturbance; and habitat affinity.

Biophysical Factors

A number of biophysical factors were identified as influencing bison movement and distribution. Bison travel through the bush to get to meadows where they spend most of their time (Interviews # 2, 3, 5, 9,17 and 23). Poor habitat poses a partial barrier to bison movement; however they move quickly through it in search of favorable habitat (Interview # 6). Meadows are preferred by bison and are typically located in dried lakebeds, oxbows and sloughs associated with rivers, and old beaver meadows, where graminoid forage is plentiful (Interviews # 1, 4, 6, 12, 13, 14, 16, 18 and 23). In the summer bison use the edges of large meadows because the centre is often too wet for travel (Interview # 16). The wet centers of meadows are used in the winter when the ground is frozen. These sites provide high quality forage in the winter months (Interviews # 1, 6 and 16); these interviewees indicated that rotational use helps to maintain meadows.

Mobility increases in the winter because bison can cross frozen bodies of water and soft ground that they can't cross in the summer (Interview # 1). Bison cows and their calves disperse during the summer into smaller groups, then reassemble in the wintering areas (Interview # 23). Generally, bison outside of the main herds at the edges of the range tend to be bulls, which frequently travel alone (Interview # 23). This interviewee also indicated that bulls feed in sloughs along the river systems, a pattern that is evident along the Slave River in the NWT.

Another important biophysical factor noted during the interviews was the effect of fire on the landscape and habitat. Burns can provide important, good habitat for bison, which are quick to move into such areas after a fire (Interviewees # 1, 4, 5, 6, 7, 17 and 23). These participants indicated that vegetation in recently burned areas contains a number of plant species that attract bison. Interviewee # 4 indicated that bison tend to use old burns for both foraging and to escape predators. He suggested that depending on the intensity of the burn, downfall make these areas difficult for people and wolves to hunt effectively.

Water Crossings

Rivers impede bison movement when the banks are steep or the river is wide (Interviews # 1, 2, 3, 4, 5, 6, 9 and 16). Traditional river crossings are located at bends in the river where the banks are low (Figure 2-10a-d, Interviews # 1, 3, 4, 5 and 6). Meandering rivers provide many crossing points because banks are typically low. They provide good habitat that is associated with oxbows. It was reported that bison do not cross large expanses of water. The Mackenzie River in the NWT is a significant barrier because it is wide (Interviews # 5, 6 and 18). Ice jams also create a barrier to movement (Interview # 6). Bison don't cross the Slave River very often; they avoid crossing wide reaches of

open water and cross from time to time in locations where bank heights and slopes are low (Interviews # 3, 4, 5, 6, 16 and 18). The Little Buffalo River (SRL) is not a barrier to bison movements; they regularly cross into and out of WBNP, crossing the Little Buffalo River in many locations (Interviews # 3, 4 and 16). The area north of Alexander Falls on the Hay River (NWT) has steep banks and is a barrier to bison movement until near the town of Hay River. Upstream from Alexander Falls the Hay River is not a significant obstacle (Interview # 5 and 6).

Movement corridors

Bison movements tend to follow established corridors between patches of good habitat (Interviews # 1, 2, 3, 5, 12, 13, 16, 17 and 18). The interviewees indicated that movement corridors are distinct trails that bison use continuously over time. They often include established bedding areas along the edges of open grassy areas. Movement corridors can incorporate roads, seismic lines, and other linear disturbances (Interviews # 1, 5 and 13).

Bison cross the Salt River and the road out of WBNP near Salt Mountain and move between the meadows to the north (Mission Farm and Foxholes meadows) (Figure 2-10a) (Interviews # 3, 15, 16, 17 and 18). Information from the interviews indicates that some of these animals originate from Sweetgrass. Some animals travel up to Needle Lake, while others travel up and down the meadows and ridges between the Little Buffalo River and the Slave River to Grand Detour then follow the sloughs along the Slave River north to Hook Lake. Bison cross the Slave River at Point Brule (Interview # 3, 15 and 17). Other interviewees indicated that bison travel through small meadows between Needle Lake and Hook Lake, and bison have been observed along the banks near Point Ennuyeuse and north of Long Island on the Slave River (Interviews # 15 and 18).

West of WBNP the habitat between the John D'or reserve and the Peace River is densely wooded, however the habitat to the north of the reserve is better for bison (Interview # 2). Bison were reported to travel along the benchlands associated with the Wentzel River and the southern edge of the Caribou Mountains (Interviews # 1, 2 and 12). This may partially result from increasing development near John D'or Prairie, which has moved the bison to the north and east from traditional habitat near the reserve (Interview # 13). The meadows near John D'or were hunted intensively and are no longer occupied by resident bison. Two bison were seen moving through the area in 2000 (Interviews # 9 and 13) (Figure 2-10c).

Bison graze in cut blocks where grass has grown back (Interview # 1), and they have been observed grazing on the airstrip in Garden River (Interview # 14). Although, bison use cut areas in the NWT, fire plays a more important role in opening habitat (Interview # 6).









Human Disturbances

The most widely reported human activity affecting bison populations was hunting (Interviews # 1, 2, 3, 4, 5, 10, 11, 12 and 13). It was noted that bison move into the bush when hunting pressure increases (Interview # 13). Participants indicated that bison are more likely to be shot near developed areas, especially roads, and this has resulted in bison moving into areas of less optimal habitat (Interview # 1, 5 and 13). Construction of roads, seismic lines and other linear features has increased access to previously remote areas in northern Alberta. Unregulated hunting and improved access have resulted in increased hunting pressure on bison populations in these areas (Interview # 3, 4 and 10). Aboriginal hunting is also unregulated in the Slave River Lowlands in the NWT. In northern Alberta hunting pressure is greatest in late winter and early spring (March / April), because of the presence of snow for tracking and improved weather conditions (Interview # 1, 3 and 12). Between five and nine bison were taken from the Wentzel area in 2000 (Interviews # 11 and 13).

Personnel with the Little Red River Cree Nation have been feeding bison in the Wentzel River area in the winter for a number of years to habituate them for a future research project (Figure 2-11). Hunters shot some of the animals using the feeding stations maintained by Little Red River Cree Nation (Interviews # 11 and 13). The interviewees commented that the hunters were guided by outfitters and that they took only the heads and hides, leaving the meat (Figure 2-12). The bison feeding area is posted with 'no hunting' signs. However, there are no regulations governing bison hunting in this area and hunters frequently ignore the signs and hunt at the winter feeding sites (Figure 2-13). The personnel managing the feeding stations for the Little Red River Cree Nation feel that their safety is in danger. The community expressed a desire for community based management and research on this population.



Figure 2-11. Winter feeding site for bison operated by the Little Red River Cree Nation in the Wentzel River bison range (photo credit: M. Auger).



Figure 2-12. Bison carcass abandoned by trophy hunters near a winter feeding site in the Wentzel River bison range in winter 2000 (photo credit: M. Auger).





Figure 2-13. No hunting sign pushed over by bison hunters in the Wentzel River bison range in winter 2000 (photo credit: M. Auger).

Habitat Affinity

Information collected in the northern Alberta study area indicated that bison don't move onto the Caribou Mountains; higher elevation areas are too steep for bison to cross (Interviews # 1, 5, 9, 12 and 13). The top of the Caribou Mountains is mainly muskeg, which interferes with movement and provides no suitable habitat for bison (Interviews #1, 9, 12 and 13). There used to be bison north of the Caribou Mountains in WBNP along the south shore of Buffalo Lake (Interviews # 1, 5, 9, 12 and 13). There was a second hand account of trappers seeing bison south of Buffalo Lake, near the Yates River (Interview # 5). Bison were reported to follow the Peace River and the small meadows that are associated with it, west of WBNP (Figure 2-10c) (Interview # 1, 2 and 13). However, it was also noted that although the area close to the river has excellent habitat it is not currently occupied.

Participants in northern Alberta also identified factors relating to the hydrology of the region. The construction of the W.A.C. Bennett Dam in northern B.C. has significantly changed the flood pattern along the Peace River (Interviews # 10, 11 and 16). In the absence of flooding since the dam was constructed meadows are becoming overgrown with shrubs, particularly willows. The information gathered specific to the Hay River study area in the NWT indicates that the area south of the Mackenzie River is not good for bison. It is very wet, contains thick spruce and very little habitat and forage (Interview # 5 and 7). However, bison do occasionally move onto Big Island at the mouth of the Mackenzie River (Interview # 7) and patches of habitat exist along the south shore of

Great Slave Lake, but the bison don't venture too far inland (Interview # 6) (Figure 2-10b).

In the northern portions of WBNP the higher ground has some good habitat, but it is widely dispersed. The location and alignment of movement corridors in this area is influenced by the size of meadows and the distance between them (Interview # 5). Some bison have been seen outside of the northern border of WBNP on the road to Hay River, and are usually in the vicinity of a recent burn (Interview # 6).

Information collected for the Slave River Lowlands study area indicates that there are a number of good meadows between the Nyarling River and Grand Detour on the Slave River, all along the Little Buffalo River outside of WBNP, and east of the Slave River in the Hook Lake area (Figure 2-10a) (Interview # 3, 15, 16, 17 and 18). However, participants also commented on the encroachment of willows into these meadows and indicated that a burn would be required to restore the habitat (Interview # 16 and 17).

We mapped important areas for bison activity based upon the accumulated information from all interviews (Figure 2-10). These centers of activity highlight areas that were repeatedly and independently identified by Interviewees as being occupied by bison. The greater the number of times a site was referred to the greater the confidence that bison actually use the area.

DISCUSSION

Participatory appraisal

Participatory appraisal proved to be an effective method for identifying bison habitat, mapping bison observations and describing biophysical and human factors that influence bison movement. Local participants had a sound understanding of their environment and provided previously undocumented information. The biophysical information gathered during this study demonstrates the contribution that local knowledge can make to support and guide the process of inquiry. Local knowledge compliments scientific knowledge by offering a more complete understanding and definition of a landscape (Calheiros et al. 2000). The process of 'interviewing the map' allowed for a focused discussion around specific topics and investigation of spatial features identified by the participants.

Participatory methods for gathering and using local knowledge in research and decision making have been employed successfully in a variety of circumstances, e.g. veterinary research in Africa on epidemiology (Mariner 1999), Native communities in Alaska (Huntington 1998), and with the Sami people in the Russian Far North (Robinson and Kassam 1998). The complex nature of epidemiology and disease risk management for tuberculosis and brucellosis in northern Canada requires the participation by a wide range of interests including community members and leaders, government agencies at three levels, the livestock industry and environmental interests. Participatory appraisal provides for compilation of knowledge from local people and agency specialists, and is complimented by published sources. Local knowledge is detailed and geographically specific. It draws on the experience of individuals who have an intimate current



knowledge of the land within the context of history and tradition. Agency specialists were in many cases also local residents who contributed similar types of information. In addition, they provided knowledge that in most cases was not available in published form, including aerial survey data and sighting locations obtained during the course of fieldwork. It is hoped that the information documented from local knowledge sources in this study will be relevant and accepted by local communities because it represents the broad knowledge of those communities. This report makes local information accessible to communities, researchers and management agencies for developing management plans, designing additional research, teaching local knowledge on bison and for defining desired future conditions.

The identification of a community champion to assist with coordination and execution of the interviews proved to be a vital component of the project. Local facilitators helped to identify the initial participant list and to bridge the cultural gap between the researcher and the interviewees. They asked some of the questions and when necessary acted as translators during interviews. The technique employed for identifying interviewees proved to be highly effective. In the largest study area (the Slave River Lowlands), the total number of possible knowledgeable people (N=19) was identified after interviewing only nine individuals. Once the number of interviews reached a point where no new contacts were identified, we were confident that after all of the identified participants were interviewed, most of the available local information on the subject had been recorded. The information was verified with each participant, subsequently reviewed during meetings with community representatives and was validated through triangulation. We are confident that much of the available local knowledge on the movement and distribution of bison in the study areas was recorded. However, several uncertainties became apparent.

Distribution of bison ranches

In 2000 when data were collected, there were 116 ranches in the Peace Country Bison Association database. However, given the rapid growth of the industry (Figure 2-14) this likely under-represents the actual number of farms because not all ranchers choose to be members of the Peace Country Bison Association, and we were not able to identify all non-member operations. The current market for bison continues to be dominated by the sale of breeding stock rather than slaughter products. Although the industry is showing signs of maturing, we expect that there will continue to be a demand for breeding stock and that the number of new farms will continue to increase in the Peace Country in northern Alberta and British Columbia. This prediction is consistent with the observed trend in the number of bison on farms in Canada (Figure 2-14). The Peace Country Bison Association and the Government of Alberta have established a research farm in Fort Vermilion to assess the winter foraging ability of ranched bison in northern Canada and the potential for expansion of the industry in the region.



Figure 2-14. Trend in the number of bison on farms in Canada over time (Renecker et al. 1989, Hobbs and Sanderson 2001 and G. Conacher pers. comm. 2001).

There were inconsistencies and incomplete information on the number and location of bison ranches in northern Alberta and British Columbia. APHRAN (1998) listed 130 ranches while we documented only 116. There was uncertainty about the exact number and location of ranches and changes in those statistics since 1998. However, we feel that the general distribution of bison ranches is reasonably well represented in Figure 2-3, and that all bison ranches within 170 km of infected populations were identified from local knowledge sources (n=17). Locations for only three of them were not available (Manning and Dixonville area). We encourage the Governments of Alberta, BC and Canada, the Canadian Bison Association and the Peace Country Bison Association to actively maintain an accurate database on ranch locations, land areas and the number of bison on properties. Should any naïve herd become infected in northern Canada, control measures could be implemented more easily if the location and nature of bison ranches was documented. In addition, the industry may wish to consider managing the risk of infection by advising new operators to avoid establishing ranches in high risk areas, e.g. within 170 km of infected populations.

Distribution of free-ranging bison

Originally, wood bison ranged throughout northern Alberta, northeastern British Columbia, throughout the Mackenzie and Liard drainages in the NWT, and in most of the Yukon and interior Alaska (van Zyll de Jong 1986, Gates et al. 2001 and Stephenson et al. 2001). There is considerable documentary evidence of wood bison in northern Canada that is based on local knowledge (Soper 1941, Roe 1951, Novakowski 1957 and Gates et al. 1992). Local information documented in this study indicates that freeranging bison still occupy much of the area. However, outside known herd ranges they appear to exist at a very low density. Viable resident herds are only evident in locations that have been legally protected or are relatively inaccessible and therefore are subject to low hunting pressure (Gainer 1985 and Tessaro 1988). Both Gainer (1985) and Tessaro (1988) found evidence for significant hunting pressure outside of WBNP in the Caribou Lower Peace area, including an observation in March 1985 of 33 animal remains shot over a three-day period between the Wentzel River and Fox Lake Indian Reserve. In 1985, estimates for the number of animals shot in the area outside the southwest corner of WBNP range between 65 and 120 animals (Gainer 1985). Presently, the Wentzel River population is subject to unregulated hunting, against the wishes and interests of the Little Red River Cree Nation.

In the Assumption area of northwestern Alberta, the reintroduced Hay-Zama population reached 200 bison in 2001 and is increasing at an exponential rate of 0.18. The herd has expanded its range as population size increased. There is 500 km² of meadow habitat available within the Hay-Zama wetland complex (Wright and Markieweicz 2000). Bison observations accumulated during this research include several sightings of bison in locations between 70 and 140 km from Hay-Zama Lakes along Highway 35, north and south of High Level and in the Paddle Prairie area south of the Chinchaga River. Bison seen in these locations may have been dispersing from the Hay-Zama herd, a phenomenon that has been described for another reintroduced population (Gates and Larter 1990, Larter and Gates 1994 and Larter et al. 2000). The Hay-Zama herd is not hunted. Interaction or contact between bison originating from Hay-Zama and infected herds in and around WBNP could occur in the intervening area where bison have frequently been sighted. The potential for the Hay-Zama bison to interact with diseased



animals, combined with the behavioural pattern exhibited by male bison of moving to the periphery of the range then returning to the herd (Larter et al. 2000), presents a significant risk of infection for the Hay-Zama population.

Interviews in northern Alberta provided some information on population size for herds outside WBNP. However, estimates varied widely between individuals. Estimates for the Wentzel herd ranged from less than 60 to 110 animals. The Wabasca/Mikkwa herd was estimated at between 30 and 90 animals. Bison populations were identified in three areas outside defined herd ranges. A recent sighting of 52 bison in the Firebag River area north of Fort McMurray confirms the continued existence of a small population there. Earlier records indicate that the herd has resided there since at least 1984. A small herd likely resides in the northeastern Buffalo Head Hills near Talbot Lake, however it may not be a discrete entity separate from the Wabasca/Mikkwa population. Unregulated hunting threatens this population. Two informants indicated a small herd exists in the Bison Lake area southwest of the Buffalo Head Hills. One report was from the mid 1980s and the other was from the last couple of years.

The gender and age composition of bison that disperse away from known herd ranges is an important epidemiological factor. Dispersing bison may be vectors for M. bovis or B. abortus. Komers (1992) found that with increasing age bulls are more often solitary and occur less frequently in mixed groups during the spring, pre-rut, rut, late-rut and autumn. He also provided evidence that with a typical group size of less than eight, a group would consist of only males (Komers 1992:20). This is consistent with information gathered during the interviews suggesting that male bison disperse greater distances from established herds and tend to occur in small groups, or even as lone individuals. This is an important consideration due to the gender and age related characteristics of bovine tuberculosis and brucellosis. Joly and Messier (2001a) found that the rate of infection for both bovine tuberculosis and brucellosis increases with age, and that male bison were most likely to test positive for tuberculosis. Adult bulls tend to disperse in a random fashion, even at low population densities, and may move into unoccupied habitats as individuals or small groups, which are less detectable than larger groups would be. Therefore adult male dispersers represent a more likely vector for transmission of tuberculosis than do female and juvenile bison. The APFRAN (1998) risk assessment did not consider gender specific risk factors and as a result likely underestimated the risk of transmission of tuberculosis.

Factors influencing movement and distribution of bison

Movement Corridors

Movement corridors and trail networks described by local participants in this study are consistent with previously described patterns in other bison populations (Reynolds 1976, Meagher 1971, 1989a and Bjornlie and Garrott 2001). Bison typically travel between favored foraging habitat patches along the most direct and practical route and rapidly establish trails in these areas (Garretson 1927 and McHugh 1958). In the boreal forest, bison travel through forested areas and shrublands as they commute between meadows (Reynolds 1976). Local information compiled in this study indicated that bison use linear disturbances (roads, cut lines) as well as bison trails. Bjornlie and Garrott (2001) found that Yellowstone National Park bison used roads for winter travel only 19% of the time,



while 27% of movements occurred on trails and 54% of travel was off road and off trail. When traveling in deep snow bison move in line formation with lead animals breaking trail for followers (Meagher 1971).

Movement corridors may include water crossings. When crossing rivers, bison usually take shallow fords with gradual approaches. Local information indicates that crossing sites are usually associated with bends in the river where low banks have developed. Examples of water crossing sites were provided during the interviews and included areas near Grand Detour on the Slave River. Calef and Van Camp (1987) provided evidence that two mature bulls tagged east of the Slave River at Hook Lake crossed over to the west side of the river. However, it was not known if this occurred during the summer or winter months. Under the right conditions (low banks and gradual approaches) bison will ford swift flowing rivers in northern Canada, such as the Peace, Liard and Nahanni. However, certain points along these rivers can act as a barrier where the expanse is significant (e.g. the mouth of the Mackenzie River). It was also noted that bison tend to travel along river corridors. This may be a result of the distribution of riparian meadow habitat available along these routes. Bison have been known to forage on emergent vegetation along lakeshores in chest-deep water (McHugh 1958).

Tessaro (1988) identified areas in which bison moved across the boundary of WBNP onto adjacent lands. They included the Little Buffalo River/Slave River Lowlands and south of the Peace River in the southwest guadrant of the park. Two additional areas were identified from our research on local knowledge. Bison were reported as recently as winter 2000-01 in the Yates River area near the Alberta – Northwest Territories border to the west of WBNP. The Yates is a meandering river that may have suitable habitat and can be readily crossed by bison. Further investigation would be required to better define the distribution and movement patterns of bison in this area. People residing in Indian Cabins, Steen River or Meander River may have specific local knowledge of bison in this area, however they were not identified as possible informants. In addition, the Yates River was outside of the area under investigation. The second area is directly south of WBNP, in the vicinity of the Firebag River. Very little has been documented about bison movements and distribution in this area. However, records of a small population existing there date back to the early 1980s and a sighting of 52 bison in winter 2001 confirms the continued existence of a herd. This information may be of interest to Syncrude Canada Ltd., which manages a captive wood bison herd north of Fort McMurray.

Habitat Affinity

Informants consistently indicated that bison had a high affinity for grass and sedge meadows. This is consistent with published literature for bison in WBNP (Carbyn et al. 1993), the Slave River Lowlands (Reynolds et. al. 1987) and the Mackenzie bison population (Larter and Gates 1991). Local knowledge also indicated that bison avoid travelling through muskegs including those located high in the Caribou Mountains. In addition to muskeg, bison also typically avoid dense forest and steep terrain.

Historically, meadows were widely scattered across northern Alberta (Moss 1953). Seasonal flooding was an important factor in maintaining forage species preferred by bison. However, following construction of the W.A.C. Bennett Dam in northern British Columbia, the flood regime was altered in the Wabasca and Mikkwa River Lowlands, the Peace-Athabasca Delta (Muzik 1986) and along the Slave River. Succession of low-lying boreal meadows from graminoid dominated plant communities to willow and tree species, resulted in reduced bison habitat (Dirschl et al. 1974, English et al 1995, Jacques 1990 and Timoney et al 1997). In the Caribou Lower Peace Region, some interviewees commented on the change in the quality of riparian bison habitat and attributed increases in willow and decreases in meadows to altered hydrology following construction of the W.A.C Bennett dam.

Fire and Habitat

Fire is an important process that shapes landscapes in northern Canada and was used by early inhabitants to maintain meadow habitat before modern fire management practices were enforced (Lewis 1977, 1980 and Lewis and Fergusen 1988). A common reason for burning by aboriginal peoples was to provide better forage for herbivores. The timing of burns was an important factor in their success. They were typically set early in the spring after snowmelt when grasses in the open areas were dry but the forest floor was still wet. Information collected during this research suggests that burned areas are a significant factor in the movement and distribution of bison. The bison is one of the first species to enter an area after a fire. After WBNP was established, areas west of the Park were burned by local people to attract bison so that they could be hunted outside the park (Lewis 1977). Prescribed and naturally occurring fires could be an important factor in altering the distribution of bison on the landscape and could affect the probability of disease transmission if fires were to occur in areas where an increased bison presence would pose an increased risk of contact with other susceptible bovids or cervids, e.g. the agricultural area near Fort Vermilion.

Winter Conditions

Harsh winter conditions can influence dispersal from typical ranges. Under deep snow conditions in the winter of 1996-97, Peacock (1997) documented 1100 bison moving out of Yellowstone Park in search of food. Stress dispersal was also noted in 1976, when bison moved out of the traditional habitat occupied in the northern portion of the Park in search of new habitat, resulting in an overall expansion of their range (Meagher 1989a, 1993 and 1998). These are important considerations in assessing the disease risk in northern Canada. A particularly harsh winter has the potential to increase dispersal and rapidly shift the range of established herds increasing the probability of contact between non-diseased and diseased animals.

Bison management

"While international bodies continue to propose the use of computer-supported quantitative epidemiology, including risk analysis, disease modeling, geographic information systems and decision support systems... ultimately these methods will be of little relevance in important pastoral areas unless information collected at field-level is accurate and timely" (Catley 1999). This call for the use of local qualitative information in the assessment of disease highlights the value of community participation and the need for a broader view of epidemiological research and disease risk management. An important aspect of participatory research is that although some traditional knowledge has developed over a long period of time, the local knowledge referenced in this project and other work is not necessarily fixed and bound to tradition; it is based upon personal



experience and may change over time (Johnson 1972). Therefore it is difficult to define participatory research as a linear process since various groups of people participate in different ways and at different times (Guijt and van Veldhuizen 1998). It has been suggested that the process of participatory research includes people's involvement in decision-making and the implementation of resultant projects (Cohen and Uphoff 1980). For this reason, the ongoing use of the information by community groups (e.g. CBA, LRRTC) to develop their own processes and programs represents the true value of participatory research. Communication with and among communities is important for linking participation to ongoing project and program development. The definition of community used in this project included individuals within government and industry, in an attempt to facilitate future coordination of efforts on resultant projects with the acknowledgement that local people are often in the best position to help define and analyze problems in their own environment.

Bison management varies throughout northern Canada including protection (e.g. WBNP), regulated hunting (e.g. Mackenzie Bison Range and Alberta Wildlife Management Zone), depopulation (e.g. NWT Bison Control Area), unregulated Aboriginal hunting (Slave River Lowlands) and non-wildlife status and uncontrolled harvest (e.g. northern Alberta outside the wildlife management area). Within this complex management framework, a number of community initiatives have emerged with the common goal of reestablishing disease-free, free ranging wood bison. Brief descriptions of these community-based, participatory projects are presented below. Agency policies or indecision can have a significant effect, either positive or negative, on the outcome of community-based initiatives to restore disease-free populations.

Hook Lake

The Hook Lake Wood Bison Recovery Project (HLWBRP) is a conservation project implemented to salvage genetic resources from a diseased population in the Slave River Lowlands and to establish a captive breeding herd that can be used to re-establish a disease free free-ranging population in the SRL (Gates et al. 2001 and Nishi et al. 2001). This is a community-based collaborative project run by the Deninu Kue' First Nation, the Fort Resolution Aboriginal Wildlife Harvesters' Committee and the Government of the Northwest Territories. The captive herd was founded from 62 neonatal bison calves captured from the Hook Lake population in the SRL. Currently, 58 of the founders remain in the herd. In 2001, after a third successful calving season there were 107 bison in the herd (J. Nishi pers. comm.). The long-term goal of the project is to reestablish a disease-free population in the Hook Lake area, while conserving the existing genetic diversity of the current diseased population. The presence of diseased bison in the SRL and WBNP presents the most significant limitation to the success of the project. Known infected herds range within 25 km of the captive breeding location. To achieve the longterm goals of the community and other project partners, cooperation will be needed between the local community and its Aboriginal Wildlife Harvesters' Committee, and stakeholders at the territorial, regional and national levels (Nishi et al. 2001).

Etthithun Lake

In collaboration with the Doig First Nation, the Government of British Columbia initiated a wood bison recovery project in northeastern BC. The habitat in the area consists primarily of a mixture of domestic and native grasses occurring in natural meadows and on disturbed sites associated with road allowances, logging, seismic lines, pipelines and

well sites. The area is adjacent to the bison management area created in northwestern Alberta. In March 1996, 18 wood bison were released to the wild in northeastern British Columbia in the proximity of Etthithun and Kantah Lakes. These animals had been maintained for two years at Northern Lights College in Dawson Creek, British Columbia. The initial attempt to establish a wild herd failed when the released animals joined a small group of feral plains bison that had escaped from a farm. The mixed herd including 26 feral plains bison and wood bison was captured in late 1997, placed in quarantine and tested for disease. They were sold into private ownership. In 1999, a second effort was launched. Forty-three bison from EINP were placed in a fenced pasture and are being maintained there until they habituate to the area.

Hay-Zama

A cooperative community-based program was initiated in 1981 between federal and provincial governments and the Dene Tha First Nation (DTFN) to reestablish a disease free, free-ranging herd of wood bison in their original range near Assumption, Alberta. Twenty-nine wood bison were transported to the site from EINP and increased to 49 animals by 1993. Although the release of Wood Bison to northern Alberta was initially scheduled to occur in 1988, the risk of infection with bovine tuberculosis and brucellosis from free-ranging bison in the greater WBNP area resulted in a delay of this plan. The population became free roaming in 1993 after portions of the fence surrounding the enclosure collapsed. The herd has generally remained in suitable habitat near the Hav-Zama Lakes complex and the vicinity of the Chinchaga River. The Government of Alberta created a wildlife management area approximately 40,350 km2 in size in the northwestern corner of the province from the border with the NWT to Highway 35, and south to the western turn in the Chinchaga River. This area was established to enable management of the Hay-Zama population and was supported by the High Level Tribal Council (HLTC, now called the North Peace Tribal Council) in a motion that agreed to no hunting of bison in the management area (Morton 1999). In 1985, an agreement between the government of Alberta (Alberta Fish and Wildlife Division), the Canadian Wildlife Service and the Dene Tha First Nation, stated that the herd will be maintained through hunting at approximately 250 animals until the WBNP disease issue is resolved (Gates et al., 2001). Information presented during this study indicates that the Hay-Zama population is at high risk of infection. If the population were to contract bovine tuberculosis or brucellosis the long-term goal of a viable free-ranging population in the area would be compromised.

Caribou Lower Peace

The Little Red River Cree Nation and the Tall Cree First Nation have developed an approach to disease management and bison recovery in the Caribou Lower Peace referred to as 'Buffalo RESQU' (Webb 2001) The acronym reflects the approach that they wish to take:

- <u>Round-up</u> small groups (12-15) of bison in the region through use of passive herding and portable corrals;
- <u>Examination</u> of these animals by veterinary specialists and testing for disease;
- <u>Slaughter</u> of bison testing positive for bovine tuberculosis and brucellosis;

- Quarantine of bison testing negative in a quarantine facility; and
- <u>Use</u> of slaughtered animals (where it can be done safely) to sustain their communities, and the use of quarantined animals as the basis for a genetic salvage project.

As a first step in this initiative, these two First Nation communities wish to undertake biological studies on bison, particularly the Wentzel River herd, as part of the Caribou-Lower Peace Aboriginal Model Forest program. The proposed project will contribute greater understanding of epidemiological factors, including habitat, topography and management regime, contributing to further understanding of disease management in the area. The project will enhance the capacity of the communities to manage bison, including capture and handling, disease testing, improving the depth of understanding of ecology and population management, and managing habitat to maintain sustainable bison populations. Results of the project will be used by the First Nations and other partners to develop plans to restore wood bison and to manage habitat in the Caribou Lower Peace Region. The project will contribute additional detailed information on bison distribution and movements to enhance and validate the model developed during the current project (Chapter 3). It is designed to integrate traditional, local and scientific knowledge in a manner that will draw from a wide range of available expertise. Advice was sought from within the First Nations, and from Alberta Fisheries and Wildlife Management and Canadian Wildlife Service personnel to define the study area, logistics, cultural and community sensitivities and to ensure that the study design is in keeping with the needs of all parties. The proposed project is an example of community-based. applied research and illustrates the dynamic nature of participatory research. The absence of regulatory control of bison hunting in the Caribou Lower Peace Region needs to be addressed to make implementation of the project feasible. The conflict between First Nation bison managers and outfitters and bison hunters in the area needs to be resolved.

Other host species for M. bovis and B. abortus

In addition to information compiled on bison, local knowledge was gathered on other ungulate species that could be important for management of the diseases in northern Canada. A large deer population was reported in the agricultural area near Fort Vermilion and John D'or Prairie. Elk were also reported in the vicinity of the Peace River southeast of Fort Vermilion. According to local information, elk were present historically, however they were not observed for a number of years until the spring of 2000. Elsewhere in North America deer and elk serve as reservoirs for bovine tuberculosis or brucellosis. In the state of Michigan, high-density deer populations serve as a reservoir for bovine tuberculosis (Schmitt et al. 1997). High-density elk populations in and around Yellowstone National Park, Grand Teton National Park and the National Elk Refuge are a reservoir for bovine brucellosis (Meagher and Meyer 1994). The original source of the diseases in these areas was cattle. Brucellosis infection in elk has been linked to both cattle and bison, indicating cross-species transmission (Meagher and Meyer 1994). Both the deer and elk disease situations involve artificial congregation on winter feedgrounds. Although elk and deer are not fed in the winter in northern Canada, the potential for congregation of wild cervids on agricultural lands during harsh winters is a possibility. Therefore, the presence of these two potential host species should not be ignored when considering disease risk management.

CHAPTER 3

A LANDSCAPE MODEL OF BISON MOVEMENTS IN NORTHERN ALBERTA

Host-borne contagious pathogens like *M. bovis* and *B. abortus* are dependent for transmission opportunities upon movement of the host and its interactions with other susceptible individuals (Morris et al. 1994, Dobson and Meagher 1996). Understanding and predicting host movement patterns is therefore, an important aspect of epidemiology and disease risk management. Movements outside of home ranges occupied by defined host populations are of special interest to epidemiology where susceptible, uninfected populations occur within the same landscape. The wide distribution of incidental sightings of bison of unknown disease status in the area west of Wood Buffalo National Park (Chapter 2) illustrates the potential for extralimital movements in a region that is much broader than WBNP. Although the origin or continuing association of these animals with known populations is poorly understood and their disease status is unknown, it is important to consider the possible nature of bison movements through the landscape to provide some understanding of the observed pattern of sightings.

In an earlier disease risk assessment for northern Canada (APHRAN 1998), bison were modeled to move equally in all directions without consideration for vegetation. topography, hydrography, barriers (natural and man made) and pathways or movement corridors (cut lines and roads) density effects or sociobiology. The assumption was made that the influences of biophysical characteristics of the landscape and other factors were implicitly reflected in current data, i.e. contributed to the general variability in movement of radio tracked bison in Wood Buffalo National Park. The authors argued that more detailed models, e.g. those including biophysical variables, would result in 1) more and finer scale data needs for which no hard data exist: 2) increased model complexity requiring more assumptions and conditions, making verification or validation difficult; 3) more parameters in the model which would reduce variability at the expense of bias due to model mis-specification: and 4) a lack of hard data at lower levels would lead to the use of soft data and subjective information to derive parameters, resulting in an increase in the uncertainty and variability of predictions. However, APHRAN (1998) acknowledged that a model including biophysical environmental influences "is an interesting and potentially promising direction, particularly with the availability of many satellite and other remote sensing data... A lack of time and resources was the major reason for not pursuing it further." We considered that it was possible to develop a model of bison movements based in large part on quantitative relationships that would provide some insights and that could be validated with published information and local knowledge of patterns of movement and distribution.

Bison movements occur at different spatial and temporal scales and patterns are typically expressed as movement rates, distances and directions traveled (vectors), and home ranges. Animals move in response to intrinsic needs for forage, to seek mates or to avoid predation. Local movements may occur between habitat patches within a season in an annual home range, as density dependent or density independent range expansion, as seasonal migration between centers of activity within home ranges or as dispersal. Unlike range expansion or seasonal migration, dispersal involves a unidirectional movement away from a natal home range (Caughley 1977). The spatial ecology of various sex and age classes in a bison population may differ. Gates and Larter (1990) explained that range expansion by bison occurred through different mechanisms for mature males than for female/juvenile segments. Environmental factors may interact with density to influence range expansion and dispersal (Meagher 1989a, 1998). The wood bison is an obligate grazer, requiring habitat that provides grasses and sedges, which make up the majority of the diet (Reynolds et al. 1987, Larter and Gates 1991). Therefore, the size, quality and juxtaposition of habitat patches can be expected to influence movement and dispersal patterns (Chapter 2 of this paper, Larter et al. 2000).

Based on published information and local ecological knowledge (Chapter 2) we suggest that bison distribution, range expansion and dispersal in northern Canada are most strongly influenced by the distribution of meadows and adjacent willow/aspen meadow complexes. Terrain slope may also influence bison movements. Information obtained through participatory rural epidemiology indicated that steep areas with rugged terrain and no foraging habitat, were avoided by bison (see Chapter 2).

The purpose of this chapter is to provide an assessment of the potential patterns of movement of bison in the area west of WBNP in northern Alberta using a spatial model and to provide estimates of movement distances along 'least cost pathways' from potentially infected herd locations to susceptible wild and captive bison herd locations. The calculated pathway lengths may be used as input in the quantitative risk assessment model developed by APHRAN (1998). The movement corridor maps developed from this analysis for northern Alberta may be used to qualitatively evaluate the risk of invasion based on the juxtaposition of corridors and vulnerable captive or wild herd locations. The assessment could not be carried out for the two NWT study areas because the Government of the Northwest Territories has not yet provided the required geographical data.

METHODS

We based the bison movement corridor model on the "least cost" principle which states that wildlife movement is most likely to follow a path of least resistance along a vector defined by the juxtaposition of relatively high quality habitat patches weighted by distance. The geographic analysis and image processing software IDRISITM 32 (Clark Labs 2001) provides an example of a program that calculates the route of least cost distance (path of least resistance) between one or more points.

The analysis consisted of two distinct components. First we developed a bison habitat model (a habitat probability map), based on quantitative relationships between bison radio locations collected by Joly and Messier (2001a) in Wood Buffalo National Park and greenness, a surrogate for habitat classification. The habitat probability map formed the basis for defining habitat juxtaposition patterns. Secondly, we simulated a suite of bison movement pathways using a model that combined habitat probability, distance and terrain elements to define bison movement corridors. We calculated distances along least cost pathways from points of origin within infected bison populations to locations representing potential or existing susceptible free-ranging or captive bison. Finally we transposed movement corridors, locations of agricultural areas, commercial bison and



free-ranging bison, and incidental sightings of bison on maps for qualitative assessment of invasion risk. SPSS version 8.0 for Windows (SPSS Inc. 1998) was used for all statistical procedures.

Habitat model

In the absence of spatially continuous digital vegetation maps for the Alberta study area we used Landsat Thematic Mapper (TM) and Landsat 7 scenes to develop a seamless greenness map (tassel cap transformation of spectral data that emphasizes the vegetation component). Greenness is correlated with phytomass or Leaf Area Index and is a linear combination of bands 1 through 5 and band 7 using coefficients that emphasize the vegetation component of spectral data. This concept was developed in the 1970s and 1980s for crop assessment purposes. High greenness values correspond with the abundance and vigor of living vegetation.

We were unable to obtain cloud and snow-free images for the area North and West of Fort McMurray. Figure 3-1 illustrates the TM scenes used in the analysis. The scenes were radiometrically corrected using a regression technique that uses an offset component of a linear regression between the bands affected by atmospheric scattering (usually bands 1 to 3) and scatter-free band 7. Given the differences in the acquisition dates of the scenes (late May through September) we also needed to adjust greenness scores among the scenes. We used the area of overlap between the central scene and adjacent scenes to extract paired greenness values to develop and apply a regression function relating the greenness values among the scenes (Figure 3-2). For statistical analysis we used both the raw greenness scores and re-scaled 8-bit greenness scores; the latter was used in the modeling phase. The algorithm transforms an input image to a near-symmetric distribution with the median input level transformed to the mid-point of the output range. The algorithm applies a smooth nonlinear function to gradually compress the extreme high or low portions of input range. The middle portion of the data range is mapped with little distortion. This algorithm is robust in handling 32-bit input images.





p43r19 Mean Greenness Score = 0.89 + 1.34 * gr4419 R-Square = 0.93

Figure 3-2. The regression function used to adjust greenness scores for seasonal differences.

We used National Topographic Database (NTDB) digital data (1:250,000 scale) to generate other biophysical and human use-related layers for the study area: lakes, rivers, streams, as well as human access and land use. For WBNP we used the NTDB contour lines to develop 1:250,000 Digital Elevation Model (DEM). For the areas within Alberta we used provincial DEM at 1:20,000 scale. We used the DEM and software developed by Geomar Consulting Ltd. to generate solar insolation layers – the layers quantifying the amount and duration of solar radiation within the study area. In all calculations we used the 5-day period, hourly sun angle and azimuth increment and assumed a standard transmission model under a generally clear sky condition.

The original projection of all GIS layers (satellite imagery, NTDB, provincial data) was Universal Transverse Mercator Zone 11 and 12. We consolidated the layers into a seamless coverage by re-projecting them into the Equal Area Albers projection using projection parameters listed in (Table 3-1).
 Table 3-1.
 Parameters of the Albers Equal Area projection used in the project.

Origin of Longitude	-116.00
Origin of Latitude	55 Deg N.
1 st Standard Parallel	58 Deg N.
2 nd Standard Parallel	62 Deg N.
False X	250000
False Y	0

We developed a bison habitat probability model within the portion of WBNP where a cloudless Landsat TM scene and bison radio telemetry locations were available. We used the bison radio-telemetry database compiled between 1997 and 2000 (Joly and Messier 2001a) for bison locations. We used confidence 1 (error not exceeding 500m) locations grouped into two seasons: winter – October through April, and summer – May through September, and two sex/age groups: adult males and females with juvenile males. For habitat availability we used a random sample (N = 1521) of locations generated within the cumulative bison home range. Use and availability points falling within the "water" category were removed from the analysis.

To understand the relationship of greenness scores to mapped land cover categories, we compared greenness scores for selected Alberta Ground Cover Classification (AGCC) land cover types and WBNP Landsat MSS-derived Vegetation Map (VM) classes. We evaluated habitat relationships by analyzing the distribution of bison locations from the radio telemetry data set with respect to the WBNP land cover classes. Adjusted standardized residuals derived from a log-linear analysis of the use and availability classes and vegetation classes were used to determine the selection pattern.

A resource selection function model was developed for the summer season using multivariate logistic regression in which the dependent variable was represented as a binary value for "selected" and "available" classes. The independent variables considered in developing the model were greenness score, elevation, distance to water, solar irradiation and number of solar hours for summer and winter bison locations. The resolution of the DEM (1:250,000) combined with the topographically monotonous character of the cumulative home range used to define the area for developing the model ruled out using terrain ruggedness (Nelleman and Thomsen 1994), an otherwise promising variable. The winter model was not statistically robust and was deemed inadequate for mapping winter habitat. Descriptive statistics were used as an additional tool to screen variables that could potentially be used in the model. The log likelihood ratio was used as a criterion for removal of variables. Wald's statistic was used for entry of variables into the model. Coefficients for the selected independent variables are presented as coefficients and as odds ratios (i.e., e^{coefficient}) and 95% confidence intervals to facilitate interpretation of effects. The odds ratio approximates how the odds for the



outcome increase or decrease with a change of one unit of an independent variable. We developed the model using a spatially constrained sample of bison radio telemetry locations and a limited set of variables.

Bison Movement Model

We based the bison movement model on the principle of "least cost/least resistance" which considers that movement is most likely to follow a path of least resistance along a vector defined by the juxtaposition of high quality habitat patches weighted by distance and constrained by terrain steepness. Friction models define in a spatially explicit and quantitative manner, the degree of resistance, or friction, of the surface of the landscape to movement. The method was used previously to model the potential for movement of wolves in the Rocky Mountain National Parks in Canada (Page et al. 1996, Wierzchowski and Callaghan 1997, Paquet et al 1999) and the movement of barrenaround caribou in the Northwest Territories (Gates et al. 1998). The model is deterministic and best describes long-range movements of dispersing animals. It should not be confused with localized foraging movement models. For the habitat component of the model we used the bison summer habitat model, which was generated as a spatial dataset. Local knowledge (Chapter 2) indicated that bison movement is strongly affected by relatively steep slopes. The Digital Elevation Model was used to map a topographic constraint on movement. We extracted and treated slopes exceeding a 15 percent grade as a relative barrier to movements. We selected this slope angle as it best matches known topographic features along the Peace River.

We simulated bison movement patterns by generating 7 potential "entry" and 25 "exit" points located on the perimeters of the study area (Figure 3-3). The entry points were placed on the South and North side of the Peace River, within WBNP, spaced at about 12 kilometer intervals. The exit points were located about 10 km apart, on the outer perimeter of the study area. We simulated movement trajectories (or pathways) from all entry to all exit points in the regional study area. For any given pair of entry-exit points there were five iterations resulting in five different pathways. The first iteration simulated the least-cost movement pathway with no obstructions imposed. In the second iteration, the first pathway was blocked forcing the creation of a new pathway distinct from the original. In the third iteration the first two pathways were blocked and an alternative route calculated, and so on. The five distinctive model runs can be thought of as producing the primary, secondary, tertiary, etc. movement trajectories. This multiple iteration approach allowed a broad spectrum of potential movement pathways to be generated and quantified. We simulated a total of 875 movement routes. For analytical and display purposes we then generated a pathway density map using a moving window technique with a kernel width of 1.2 km. This map identified potential bison movement corridors in which higher density corridors indicated zones through which bison would be most likely to move.

For each entry point we also calculated the average length of the pathways to each of the exit points. This data can be used directly to calculate the invasion risk probability for a given exit point. We repeated this procedure using starting points (sources) in centers of activity (Chapter 2) for known or potentially infected herds outside WBNP (Wentzel herd and two locations in the Wabasca herd's range) and destinations representing susceptible herd locations including the Hay Zama herd, some existing



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captive bison locations, and two proposed captive herds (Paddle Prairie Metis Settlement project and the Fort Vermilion Grazing lease) (Figure 3-4).

Movement simulations were computationally intensive, with computing time geometrically correlated with pixel size. We used parallel processing on three networked Intel P IV and P III computers (700 Mhz to 1.4 Ghz clock) to run the simulations. Given the finite capability of the available computer equipment we selected 200 m by 200 m pixels for the movement runs.

RESULTS

Habitat Model

Vegetation Classes and Greenness

We compared the greenness values of vegetation classes in selected Alberta Ground Cover Classification (AGCC) land cover types (Table 3-2) and WBNP Landsat MSSderived Vegetation Map (VM) classes (Table 3-3). Previous studies have demonstrated selection by bison for graminoid (grass and/or sedge) meadows and deciduous/graminoid complexes (grass/sedge and willow/aspen). The tabulation of greenness scores revealed that the Willow/Aspen VM class and the Closed Deciduous and Riparian Poplar AGCC classes contained the highest greenness values (median of 170 and >185, respectively) (Tables 3-2 and 3-3). The distribution of greenness values had a median value of 127 for the WBNP VM Sedge class and 148 for the Alberta Ground Cover Classification (AGCC) Graminoid Wetlands class.

		Shrubby Wetlands	Riparian Poplar	Graminoid Wetlands	Cropland	Closed Deciduous	Closed Black Spruce	Cutblocks - Gramino d
Statistics		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
Mean		136.90	176.90	149.39	98.59	180.86	128.13	145.93
95% ConfidenceLower BoundInterval for MeanUpper Bound	Lower Bound	136.69	176.40	149.01	98.18	180.64	127.93	143.99
	Upper Bound	137.11	177.40	149.78	99.00	181.07	128.33	147.87
5% Trimmed Mean		135.67	178.07	149.89	96.24	181.92	126.82	146.58
Median		134.00	185.00	148.00	100.00	186.00	125.00	142.00
Std. Deviation		18.15	37.25	30.32	51.88	27.46	14.71	32.62

Table 3-2. Selected descriptive statistics for greenness values within Alberta Ground Cover

 Classification (AGCC) land cover classes.



Table 3-3. Selected descriptive statistics for greenness values within WBNP VM land cover classes.

	Willow/Aspen	Wet Black	Dry Black	White Spruce	Sedge	Mixed	Jack Pine	Birch/Willow
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
Mean	166.44	134.71	124.07	122.79	130.93	135.76	114.59	132.16
95% Confidence Lower Bound	166.14	134.08	123.74	122.26	130.55	135.41	114.27	131.82
Interval for Mean Upper Bound	166.74	135.35	124.40	123.33	131.31	136.11	114.91	132.49
5% Trimmed Mean	167.92	134.03	123.18	122.12	130.15	135.54	113.81	131.31
Median	170.00	133.00	122.00	120.00	127.00	133.00	114.00	129.00
Std. Deviation	37.94	32.74	28.22	32.36	37.40	29.78	28.07	30.11

Habitat selection

Male and female bison exhibited pronounced use of sedge meadows and willow/aspen VM classes in both the summer and winter in WBNP (Figure 3-4). While sedge meadows were clearly selected (residual = 8.5), willow/aspen complexes were used in proportion to their availability (residual = 0.3) (Table 3-4). Coniferous and mixed forest vegetation (except for wet black spruce) and birch/willow complexes were avoided.



Figure 3-4. Proportional use of WBNP VM land cover classes by bison during summer and winter.

Table 3-4. Adjusted standardized residuals showing selection (*) and avoidance (**) of WBNP vegetation classes by bison in summer.

WBNP Vegetation Class	Adjusted standardized residual	Median Greenness	
Sedge	8.5*	127	
Birch/Willow	-2.9**	129	
Wet Black Spruce	6.4*	133	
Dry Black Spruce	0.8	122	
White Spruce	-6.8**	120	
Jack Pine	-6.2**	114	
Willow/Aspen	0.3	170	
Mixed	-4.1**	133	
Mud Flats	6.3*	N/A	

Among a suite of biophysical variables (greenness score, elevation, distance to water, solar irradiation and number of solar hours) only greenness and distance to water were significantly different (both univariate and multivariate comparisons) at used locations compared to random locations on the landscape (Tables 3-5 and 3-6, Figures 3-6 and 3-7). These variables were therefore selected to include in the habitat selection model.

			Sex/Sample Type		
			Females	Adult	Random
			and Juv.	Males	Sample
			Statistic	Statistic	Statistic
Elevation (meters)	Mean		227.0	220.2	230.6
	95% Confidence	Lower Bound	226.0	219.0	229.9
	Interval for Mean	Upper Bound	228.0	221.3	231.4
	5% Trimmed Mean		226.0	219.2	230.2
	Median		218.0	218.0	223.0
	Std. Deviation		15.7	8.0	15.4
Distance to Water	Mean		1421.8	1152.1	2795.4
	95% Confidence	Lower Bound	1303.1	945.0	2676.3
	Interval for Mean	Upper Bound	1540.4	1359.2	2914.5
	5% Trimmed Mean		1146.6	947.0	2612.8
	Median		707.0	636.0	2163.0
	Std. Deviation		1843.5	1447.0	2367.7
Greenness Score	Mean		42.8	47.2	32.8
	95% Confidence	Lower Bound	41.5	43.8	32.0
	Interval for Mean	Upper Bound	44.1	50.6	33.6
	5% Trimmed Mean		42.7	48.3	32.6
	Median		42.1	53.3	30.1
	Std. Deviation		20.0	23.6	16.3
Direct Solar Radiation	Mean		538480.1	538017.6	538528.4
(Kwh/m2)	95% Confidence	Lower Bound	538407.6	537929.8	538455.8
	Interval for Mean	Upper Bound	538552.5	538105.5	538600.9
	5% Trimmed Mean		538448.3	538002.6	538523.1
	Median		538034.0	538034.0	538106.0
	Std. Deviation		1125.5	613.9	1442.0
Global Solar Radiation	Mean		732795.4	732141.8	732933.9
(Kwh/m2)	95% Confidence	Lower Bound	732696.1	732026.1	732843.3
	Interval for Mean	Upper Bound	732894.7	732257.4	733024.4
	5% Trimmed Mean		732737.8	732099.0	732914.4
	Median		732104.0	732104.0	732206.0
	Std. Deviation		1543.1	808.2	1799.8
Number of Hours of	Mean		2802.8	2803.2	2801.2
Sunshine	95% Confidence	Lower Bound	2802.5	2802.9	2801.0
	Interval for Mean	Upper Bound	2803.0	2803.5	2801.4
	5% Trimmed Mean	11	2803.3	2803.5	2801 B
	Median		2804.0	2804.0	2803.0
	Std. Deviation		3.4	1.9	4.2

Table 3-5. Descriptive statistics for biophysical variables at locations used by bison during summer and locations selected at random.





Table 3-6. Descriptive statistics for biophysical variables at locations used by bison during winter and locations selected at random.

			Sex/Sample Type		
			Females	Adult	Random
			and Juv.	Males	Sample
			Statistic	Statistic	Statistic
Elevation (meters)	Mean		225.4	221.2	230.6
	95% Confidence	Lower Bound	224.5	219.8	229.9
	Interval for Mean	Upper Bound	226.4	222.7	231.4
	5% Trimmed Mean		224.8	220.1	230.2
	Median		219.0	218.0	223.0
	Std. Deviation		14.8	10.7	15.4
Distance to Water	Mean		2413.0	1397.1	2795.4
	95% Confidence	Lower Bound	2280.7	1175.2	2676.3
	Interval for Mean	Upper Bound	2545.3	1619.0	2914.5
	5% Trimmed Mean		2206.8	1210.8	2612.8
	Median		2000.0	700.0	2163.0
	Std. Deviation		2079.4	1611.4	2367.7
Greenness Score	Mean		36.7	39.8	32.3
	95% Confidence	Lower Bound	35.5	36.9	32.0
	Interval for Mean	Upper Bound	37.9	42.7	33.6
	5% Trimmed Mean		35.8	40.3	32.6
	Median		31.8	41.5	30.1
	Std. Deviation		18.5	21.1	16.3
Direct Solar Radiation	Mean		75993.3	76173.2	76289.4
(Kwh/m2)	95% Confidence	Lower Bound	75927.4	76041.9	76226.5
	Interval for Mean	Upper Bound	76059.1	76304.6	76352.3
	5% Trimmed Mean		76021.7	76249.7	76352.7
	Median		76055.0	76692.0	76636.0
	Std. Deviation		1034.8	953.9	1251.0
Global Solar Radiation	Mean		119189.1	119332.2	119533.8
(Kwh/m2)	95% Confidence	Lower Bound	119119.3	119198.8	119468.3
	Interval for Mean	Upper Bound	119259.0	119465.6	119599.2
	5% Trimmed Mean		119212.0	119394.1	119587.3
	Median		119215.0	119825.0	119830.0
	Std. Deviation		1097.5	968.8	1301.5
Number of Hours of	Mean		1481.1	1482.5	1482.2
Sunshine	95% Confidence	Lower Bound	1480.8	1481.7	1481.9
	Interval for Mean	Upper Bound	1481.5	1483.3	1482.6
	5% Trimmed Mean		1481.5	1483.1	1482.8
	Median		1482.0	1485.0	1485.0
	Std. Deviation		5.5	5.6	6.7

Summer

Winter



Figure 3-5. Boxplots of descriptive statistics for selected biophysical variables (greenness and distance from water) at locations used by bison during summer and winter, and locations selected at random.

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It is worth noting the apparent lack of congruity between greenness scores and VM habitat class selection. The VM habitat selection analysis, showed selection for sedge meadows (Table 3-4, Figure 3-4), and the greenness analysis indicated selection of relatively high greenness scores (Tables 3-5 and 3-6, Figure 3-5). Yet the distribution of greenness scores within the sedge meadow complex had a much lower value (median = 127) than the median greenness value of the distribution of bison radio-telemetry locations (median = 170). We explained this discrepancy by examining histograms of the greenness scores associated with bison locations and histograms of greenness scores representing the "sedge" and willow/aspen" vegetation classes (Figure 3-6). The "sedge meadow" histogram had a symmetric distribution with a central tendency around 130, which likely indicates a fairly good MSS classification accuracy for this vegetation class. The willow/aspen complex, however, showed an asymmetric distribution with the majority of greenness scores found between 120 and 190. This range encompasses the values characteristic of both the sedge meadows and willow/aspen classes. Even though Table 3-3 shows classes other than sedge meadows having a similar central tendency value, we interpreted greenness scores within the 120-140 range to represent mostly the sedge meadows, as the deciduous vegetation is most likely to form an association with this particular class. We interpret this as an indication of a classification error of commission for sedge meadows within the willow/aspen class; i.e., small sedge meadow patches were present within areas classified as willow/aspen. The pronounced bimodality of greenness scores associated with summer bison locations further corroborated this conclusion (Figure 3-6). A peak centered at 130 indicates a likely association with the sedge meadow complex, and a peak centered at 170 indicates an association with the willow/aspen/sedge complex.

Despite the acknowledged shortcomings of the greenness layer to explicitly identify selection by bison for greenness indicative of sedge meadow communities and overemphasizing greenness associated with deciduous vegetation classes, greenness is a sufficiently robust substitute for a methodologically homogenous and spatially continuous digital data layer (vegetation/terrain classification) for the disease risk assessment area. This interpretation was reinforced through development of the habitat selection function and habitat model.





Bison Habitat Model

We used a forward stepwise regression to build a habitat selection model (Equation 1) and the likelihood ratio as the conditional statistic for removal of variables. Selection of the variables greenness and distance to water resulted in the most parsimonious model for habitat selection in the summer (Table 3-7). A winter model produced a very low classification accuracy and was deemed to be inadequate for mapping winter habitat. The habitat selection function coefficients indicated that the probability of summer bison habitat use increases with an increase in the greenness score and decreases with distance to water (Table 3-7). The relatively small odds ratios and R values for both variables indicate a rather subtle influence on habitat probability (Table 3-8). A change of 10 scores in greenness results in an eight percent increase in the odds of the location being good summer habitat. A one km increase in proximity to water results in a 30 percent reduction in the odds of the location being good summer habitat. The logistic regression resulted in 60.6% of the cases being correctly classified into the "habitat" group, and 75.3% of the cases classified into the "available" group, with a classification accuracy of 69.1%.

P(summer habitat) = _____1___[Equation 1]

1+e^{-(-0.8857 + 0.0079 * Greenness - 0.0003 * Waterdist)}

Inclusion of the two statistically significant variables produced a moderately convincing habitat probability model of the study area (Table 3-7) of which a portion is illustrated in Figure 3-7.
-2 Log likelihood	Goodness of Fit	Cox and Snell R ²	Nagelkerke R ²
3236.519	2835.739	0.129	0.173
	Chi-Square	df	Significance
Model	363.562	2	<0.005
Block	363.562	2	<0.005
Step	69.561	1	<0.005

Table 3-7. Selected statistics for the bison summer habitat logistic regression model.

Model if term removed, based on conditional parameter estimates

Removed	Log Likelihood	-2 Log	LR	df	Sig. of L	.R
Greenness	-1653.073	69.62	7	1	<0.005	i
Dist. to water	-1700.063	163.60	163.607		<0.005	
Variable	В	S.E	Wald	df	Sig	R
Greenness	0.0079	0.001	67.46	1	<0.0005	0.135
Dist. To Water	-0.0003	0.00002	132.49	1	<0.0005	-0.19
Constant	-0.8857	0.167	28.14	1	<0.0005	

Table 3-8. Logistic regression odds ratios for variables used in the bison summer model.

Variable	Exp (B)	Lower 95% CI	Upper 95% CI
Greenness	1.0079	1.006	1.0098
Dist. To Water	0.9997	0.9997	0.9998





We validated the model using two approaches. First, we overlaid an independent set of radio-telemetry observations on the habitat probability surface and extracted the associated probability values (Figure 3-8). Secondly, we visually tested the fit of the core use areas derived from local knowledge to the empirical habitat probability surface (Figure 3-9). Based on these tests we concluded that the generated empirical bison summer habitat surface fits fairly well with the independent sample of radio-locations (median = 71% probability), local knowledge on areas of good habitat, and areas used by bison.



Figure 3-8. Histogram of bison summer habitat probability values associated with an independent (of model development) bison radio-telemetry database (N= 1273). Median = 0.71, or 71%.

Movement Model

The movement model generated groups of pathways (movement corridors) between designated origin and destination points (Figure 3-10). In the northern section of the study area the highest density corridors paralleled the Peace River in the vicinity of Fort Vermilion. Another high-density corridor ran from WBNP southwest across the south end of the Buffalo Head Hills. The broadest network of corridors was defined between High Level and the Peace River.

Certain landscape features had a significant influence on the location of corridors. The Buffalo Head Hills was traversed only on the extreme northern and southern ends of the landform. A low-density corridor was defined west of the Buffalo Head Hills and east of the Peace River. Steep gradients along the Peace River resulted in corridors crossing this water body only at a few specific points. There was only one crossing point defined



on the Peace River on the reach below Deadwood. Corridors deflected around the intensively cultivated and roaded agricultural area near LaCrete and Fort Vermilion, which were characterized by low greenness (Figure 3-11). The less intensively cultivated and roaded agricultural area north of the Peace River between Fort Vermilion and High Level had a dense network of pathways through it.

Distances were calculated along two sets of pathways: 1) from seven points of origin in the range of the Garden River herd in WBNP to exit points on the western and south western edges of the study area (Appendix A), and 2) from points of origin in the core of the Wentzel and Wabasca/Mikkwa herds to specific captive or wild bison herd destinations (Table 3-9). The bison research project in Fort Vermilion was the least distance on a pathway from a potentially infected wild bison herd (64 km, Table 3-9). The Ft. Vermilion bison research project was also the closest disease free herd to the Wentzel herd (117 km). Bison ranches in the Deadwood agricultural area were the furthest destinations from the potentially infected wild bison herds (range 259 to 383 km). For comparison we calculated the straight-line distance of each of the destinations to the nearest wild bison observation (Table 3-9). Wild bison had been seen on the proposed project site at the Paddle Prairie Metis Settlement; therefore the distance was zero. Likewise, the distance for the Hay Zama herd was zero by definition since it is a wild herd. The other distances ranged from 11 to 53 km, substantially shorter than any of the distances generated by the movement model.

	Wild Bison Origin			
Destination	Wentzel	Wabasca 1	Wabasca 2	Nearest sighting
Ft. Vermilion Grazing Lease	120	86	133	28
PCBA/AB Project	117	64	114	26
LaCrete Ranch	158	86	128	37
High Level ranch 1	167	127	176	26
High Level ranch 2	184	146	194	38
Hay/Zama herd	234	190	239	0
Paddle Prairie	225	162	204	0
Deadwood ranch 1	364	293	330	28
Deadwood ranch 2	329	259	295	9
Deadwood ranch 3	344	273	310	24
Deadwood ranch 4	383	312	349	11

Table 3-9. Distances (km) along least resistance pathways from three representative locations within the ranges of wild bison herds west of WBNP and destination herds or project sites of interest. Straight-line distances to the nearest location of a wild bison observation are presented for comparison.





DISCUSSION

Habitat Probability Model

Habitat requirements and selection patterns influence the distribution and movement patterns of bison. Wood bison are obligate grazers requiring habitat that provides grasses and sedges, which make up the majority of their diet (Reynolds et al. 1987, Larter and Gates 1991). In the summer, wood bison occupy grass and sedge meadows until mid-to late-summer when they form small herds and move to adjacent coniferous and mixed forests (Larter and Gates 1991). In addition to grasses and sedges, the early-to mid-summer diet may contain a large quantity of willow leaves (Reynolds et al. 1978, Reynolds and Peden 1987, Larter and Gates 1991). Wetland-associated meadows, savanna-like shrublands, and to a much lesser extent dry grasslands, are the most important habitats for wood bison in the boreal forest (Reynolds et al. 1978, Larter and Gates 1991). In northern Canada these habitats are associated with lowland areas surrounding watercourses and lakes. Hogenbirk and Wein (1991) described three riparian vegetation zones in lowlands in the region, including a sedge (Carex) marsh in the wettest sites, a bluejoint (*Calamagrostis* spp.) meadow in the next upslope area, followed by a willow (Salix spp.) savanna zone in the driest sites. These zones correspond to habitat types used by bison in the Slave River Lowlands (Reynolds et al 1978), the Mackenzie Wood Bison range in the Northwest Territories (Larter and Gates 1991), Wood Buffalo National Park (Carbyn et al. 1993), and indeed characterize the historic ranges of wood bison (Gates et al. 1992).

The results of our study were reflected this expected pattern of habitat selection. Radio collared bison in the WBNP study area exhibited strong selection for sedge meadows mapped as a vegetation cover class from MSS satellite data. There was no selection for the aspen/willow class despite high proportional use. However, when distance to water was controlled for in the habitat model, there was a clear selection for high greenness areas that likely represented deciduous tree and shrub cover. In lowland areas near water bodies, aspen/willow complexes are interspersed with and typically contain graminoid meadows (Hogenbirk and Wein 1991). This spatial relationship provides an explanation for the derivation of the summer habitat model in which greenness and distance from water were the significant contributing variables. Local knowledge of factors influencing bison movements and distribution in current herd ranges in the Slave River Lowlands, WBNP and the Caribou Lower Peace Region west of WBNP (Chapter 2) were generally consistent with the habitat selection pattern defined in this study and also validated the habitat model.

If the vegetation and terrain classification systems used for WBNP (MSS classification) and for the Alberta (Alberta Ground Cover Classification) portions of the study area had been compatible, we would have been able to develop a habitat model based on vegetation classification and selection rather than having had to use greenness as a surrogate for habitat. Instead, we created a continuous landscape data set for greenness spanning the WBNP and Alberta area of interest for modeling bison movement corridors, then we applied the habitat model to develop a continuous summer habitat probability surface for the corridor analysis.



Movement Corridor Analysis

By definition, "least resistance" pathways follow the most efficient travel routes. Therefore the distances generated in the corridor analysis can be thought of as representing the most conservative assessment of the distance a bison from an infected herd must travel to contact a susceptible herd. In other words, given the parameters of the model, any other movement trajectory would likely produce pathways exceeding the calculated distances. However, it is important to note that the corridors represented in our analysis are not the only areas through which bison may move or be distributed outside known population ranges and many other factors can influence bison movements.

Environmental factors may interact with density to influence movement and dispersal patterns of bison. Meagher (1989a, 1998) suggested that increasing population density, unusually deep snow and a thawing/freezing event that created a hard layer of snow at the ground surface in Yellowstone National Park, led to a rapid shift of bison out of traditional ranges in the northern section of the park in the mid 1970s. In the winter of 1996-97 above-average snow depths and thick ice layers in the snow pack impeded foraging by bison in Yellowstone National Park, forcing the movement of a large number of animals out of the park in search of food (Cheville et al. 1998). In the Mackenzie bison population (NWT), female/juveniles moved to areas of unoccupied suitable habitat (new ranges) in response to intraspecific competition for food as density increased in occupied areas (Gates and Larter 1990, Larter and Gates 1994, Larter et al. 2000). The reduced overall density of the Mackenzie population following range expansion by females and juveniles resulted in a temporary increase in the intantaneous rate of population growth, followed by a decrease in growth rate as density rose, then by repetition of the cycle of dispersal and growth (Larter et al 2000). This form of range expansion was defined by Caughley (1977) as density-dependent pressure threshold dispersal.

In contrast to the dispersal pattern of females and juveniles, adult male bison have been shown to disperse in a density independent manner. The mechanism for mature males can be considered as innate dispersal (sensu Howard 1960). In the Mackenzie population, bison bulls were the first to disperse during range expansion, and were followed later by groups of mixed ages and sex (Gates and Larter 1990; Larter and Gates 1994). Larter et al. (2000) documented an expansion area that was initially occupied by adult males that spent autumn and winter in the peripheral area, then moved in the spring and summer to areas occupied by mixed-sex groups. One of the males moved a minimum distance (straight line) of 98 km between seasonal ranges. In that study five bulls radio-collared in peripheral locations had home ranges that were significantly larger than 31 males radio-collared in core areas of the population, i.e. peripheral males had larger home ranges than males residing in core areas. Similarly, Joly and Messier (2001a) documented the dispersal of two bulls among 14 radiocollared male bison in WBNP. A four-year old male that was collared near Baril Lake in the Peace-Athabasca Delta in February 1997 was relocated near the south-west corner of the park where it was shot in March 1999, a straight line distance of approximately 128 km. Another four-year old male that was originally collared west of Hay Camp in March 1999 was found in February of 1999 in the Slave River Lowlands north east of WBNP, approximately 150 km from the capture site. Each of these bulls exhibited

evidence of infection with bovine diseases. Joly and Messier (2001a) also documented the long-range movement of a two-year-old female. It was collared near Murdoch Creek in the Hay Camp region in March 1997 and was relocated alive in February 1999 near Robertson Lake in the northern region of the park, approximately 190 km from the initial capture site.

Several long distance movements were also observed during a telemetry study in WBNP conducted in the early 1990s (Wood Buffalo National Park 1995). A bull initially radio-tagged in the Garden River area in August 1990 was relocated near Hornaday River in the Pine Lake range in September 1990, and over-wintered in this new area. The following spring (May 12 – 28, 1991), this bull was recorded travelling 125 km back to the Garden River range (Wood Buffalo National Park 1995). Four other bison (2 cows and 2 bulls) also traveled from the Pine Lake range to the Garden River range during the study. Bison herds have been observed moving between the Needle Lake, Garden River and Pine Lake ranges. Local knowledge was provided in Chapter 2 describing movement corridors between the Peace Athabasca Delta and the Slave River Lowlands and between the Nyarling area of WBNP and the eastern Slave River Lowlands. Movement between sub-populations in the WBNP metapopulation provides a mechanism for disease transmission to susceptible populations outside of the WBNP metapopulation.

APHRAN (1998) analysed radio tracking data from WBNP bison and estimated the maximum distance traveled by males to be 125 km (mean 46, median 52) and the maximum distance traveled by females at 106 km (mean 44, median 49). The distances reported above for individual dispersers generally agree with the APHRAN estimates. However, given that bison sightings mapped in our study (Chapter 2) occurred much further from known populations than either of these estimates, we suggest that maximum dispersal distances are much larger than the estimates provided by APHRAN (1998). Based on observations reported in our study we suggest a reasonable estimate of the zone of dispersal is 170 km.

Male bison groups were predominant (88%) over female/juvenile groups among bison reported >10 km outside of known herd ranges (Chapter 2). The high proportion of males is a significant factor when considering the differential probability of transmission of tuberculosis and brucellosis to susceptible bison populations. *B. abortus* is primarily transmitted by adult females through contact by herd members with contaminated fluids and tissues associated with abortions or parturition (Rhyan et al. 2001). In contrast, tuberculosis is transmitted primarily by aerosol and contact with nasal discharges (Tessaro 1989, Morris et al. 1994). In addition, the prevalence of positive tests for tuberculosis increased more steeply with age and to a higher level in male bison than in females in WBNP. In excess of 70% of adult males tested positive for tuberculosis (Joly and Messier 2001a). Given the over representation of adult male bison among incidental sightings of bison groups observed outside of defined herd ranges, tuberculosis is more likely to be carried beyond defined herd ranges and transmitted by male bison than by females and juveniles. The lower proportion of female groups among bison sighted outside of known ranges (Chapter 2) in combination with lower seroprevalence and strong seasonality of transmission of *B. abortus*, act in combination to reduce the risk of transmission of *B. abortus* relative to transmission risk for *M. bovis*. The risk assessment by APHRAN (1998) provided estimates of transmission risk that are consistent with this conclusion, i.e. higher in each case for tuberculosis, despite the

fact that the effects of disproportionate representation of males among dispersing bison was not considered in that study. If gender over representation is considered, we expect that the risk of infection of susceptible bison herds with *M. bovis* would be higher than that predicted by APHRAN.

The movement corridors calculated in our study represent likely routes of travel for bison dispersing from populations in and near WBNP and correspond reasonably well with the distribution of bison sightings west of WBNP (Figure 3-12). The movement model assumed that the juxtaposition of areas with high habitat value (high habitat probability), was an important factor in defining least cost pathways, subject to a terrain steepness constraint defined through participatory appraisal (Chapter 2). Movement corridors have been described previously for bison. On a local scale, bison typically travel along the most practical and direct route between favored habitat patches and rapidly establish trails between them (Garretson 1927; McHugh 1958). In northern Canada, Reynolds (1976) described daily and seasonal travel corridors that traversed through forest and shrub areas between meadows.

Based on discussions with area residents, Reid, Crowther & Associates Limited (1982) reported that bison migrated out of WBNP's west-boundary and that the rate of migration may have been increasing at the time of their study because of fires and associated changes in food availability. Gainer (1985) described an east/west corridor on the north side of the Peace River west of WBNP. The movement model developed in our study generated corridors following these alignments. We conclude that susceptible populations of bison near this corridor are more likely to experience incursions by free ranging bison than those located further south in the Fort Vermilion agricultural zone (Figure 3-13). Given the lack of any barriers to movement and the low density of development along the northernmost corridors we suggest that the Hay-Zama herd is particularly likely to experience incursions or to encounter bison from infected herds as it expands. Indeed, a wild bull was seen outside the fence surrounding the temporary holding pasture prior to the translocation of bison from EINP to the area in 1984.

Concern has been expressed over the impacts of a proposed winter road on the bison population in Wood Buffalo National Park, particularly in the Garden River range in the southwest corner of the park (Westworth and Associates 2000). One concern is that the ploughed road corridor will provide a travel route for bison to move to areas adjacent to the park, as proposed by Meagher (1993,1998) for winter roads in Yellowstone National Park. However, this hypothesis was rejected by Bjornle and Garrott (2001) who found that bison in Yellowstone Park used roadways only when they were aligned with natural corridors between favored habitat patches. From their work and inferences from other situations, we suggest that bison may follow roads leading out of WBNP only when the roads are aligned with natural corridors. However, if road allowances are made attractive (sufficiently wide and seeded with forage species), bison may use them as habitat. The authors know of several examples of this phenomenon. In the Yukon, the Alaska highway right of way attracted 36 wood bison which became a hazard to vehicle traffic (M. Hoefs pers. comm.). In the Northwest Territories, the seeded right of way along Highway No. 5 north of the Mackenzie River is used as habitat by large numbers of bison. Similarly, bison use sections of highway rights-of-way near Fort Liard and in Wood Buffalo National Park. The attractiveness of such areas to bison can be reduced by applying appropriate vegetation management measures (Government of Yukon 1998).





Other land use activities and natural disturbances could improve habitat and influence bison movements in the transboundary area. In particular, large-scale forestry in seven FMUs in the Caribou Lower Peace Region west of WBNP has the potential to alter understory vegetation, increase forage biomass density and attract bison. Presently, all merchantable timber resources in the Caribou/Lower Peace Special MA have been allocated in support of two mills situated in High Level. Harvest levels have doubled in the past 10 years and industrial forestry operations will continue to expand including road construction, cut-block harvesting and reforestation. The oil and gas sector has explored along the western border of WBNP and within the Caribou Mountain Plateau. There are several existing oil and gas tenures in the northern portion of the Wentzel River sub-population's range which have not been subject yet to activity. The mineral sector has established a pattern of precious metal tenures along the western boundary of WBNP and on the Caribou Mountain Plateau. Industrial activity will increase human access, alter habitat suitability and increase disturbance associated with exploration and resource development. Potential future effects on the bison may include increased forage in disturbed or reclaimed areas, reduced habitat availability, increased risk of mortality from hunting associated with improved human access and lack of bison hunting regulations, displacement and disruption of movements.

Agricultural areas in which crop production predominates should pose more of a barrier to bison movements than pasturelands or natural areas. Crop production areas have a higher density of roads, fences and dwellings than the other areas. We expect that bison would not be attracted to or easily move through croplands because of the lack of suitable forage, the barriers posed by fences and disturbance by people. The agriculture areas near LaCrete and Deadwood were characterized in the habitat model as low probability areas because of the extreme low greenness of croplands. The movement corridors calculated through these through these agricultural areas followed undeveloped (non-cropland) habitat patches. We consider that this represents a realistic pattern of movement for bison. Bison have been sighted in the agricultural area north of the Peace River near Fort Vermilion (Chapter 2). In these cases, bison were seen in pasture areas near the periphery of the agricultural area, not on croplands. We suggest that captive bison herds located on pastures or grazing leases outside of or near the edges of intensive agricultural areas would be at greater risk of contact with wild bison than herds surrounded by intensive agriculture. The Government of Alberta (Public Lands) is reviewing the interest of the bison industry in using public grazing leases for commercial bison. Clearly, if a grazing lease in the northern Alberta study area is surrounded by natural areas or non-cultivated private lands it is at risk of invasion and may already experience occasional use by free-ranging bison. In addition, if commercial bison are grazed in this type of lease, they would attract any free-ranging bison in the vicinity.

When crossing rivers, bison usually take shallow fords with gradual approaches; however, they are known to occasionally cross large, swift flowing rivers in northern Canada, such as the Peace, Liard and Nahanni. Calef and Van Camp (1987) provided data indicating that two tagged mature bulls moved across the Slave River in the vicinity of Hook Lake. It was not known if the river was crossed during the summer or the winter. Joly and Messier (2001a) documented movement of radio collared bison in the Delta herd crossing the Peace River into an area that overlapped with the Pine Lake herd. Water crossing sites characterized by low banks are scarce along the Peace River upstream of WBNP. In particular, the reach of the Peace River near Deadwood and Manning is characterized by a very steep valley, which we represented as a barrier in the movement model. Given that the Deadwood/Manning agricultural area is >300 km from the nearest infected bison population along a least cost pathway, and that the Peace River valley likely represents a barrier to movement from the east, invasion is likely much lower for susceptible bison herds there than in the LaCrete/Fort Vermilion agricultural area. However, with continued growth and expansion of the free-ranging Hay Zama bison herd, there will be an increasing likelihood of incursions from the northwest.

Distance, terrain and habitat features influence bison movements. In addition, the size of a population will influence the number of emigrants. If populations known or suspected to be infected with *M. bovis* and *B. abortus* are managed for growth, we expect that the number of adult male bison moving into the areas of concern would increase linearly with population density and the number of females and associated juveniles would increase non-linearly with population density. The current trend of bison populations in and around WBNP is stable at low density or declining (Joly and Messier 2001b). Although it may be desirable to maintain infected populations at a low density to minimize egress, even this limited intervention would prevent local communities in the surrounding area from restoring bison for cultural, conservation and economic development projects. The long-term success of community based projects in the Caribou Lower Peace and Slave River Lowlands (Chapter 2) will depend on elimination of *M. bovis* and *B. abortus* from bison.

The least cost pathway distances calculated in this study should be interpreted with caution. To provide a reality check we calculated the minimum distance from a susceptible herd to the nearest sighting. In two locations the distance was zero, i.e. bison have been seen at the location. The maximum distance to a sighting was only 38 km. We conclude that while the risk of invasion by bison originating from an infected herd varies in the Alberta study area, risk mitigation is required for susceptible herds throughout the area. Indeed the Hay-Zama herd may have already experienced contact with emigrants from other herds. We provide specific management recommendations in the final chapter of this report.

CHAPTER 4 CONCLUSIONS AND MANAGEMENT IMPLICATIONS

COMMUNITY PARTICIPATION IN KNOWLEDGE AND MANAGEMENT

Local knowledge recorded and mapped in this study has contributed to a higher level of understanding of bison ecology, movements and distribution in the areas of concern than would have been possible through the application of western science alone. In addition, the project provided an opportunity for residents to express ideas about their visions for the future of bison conservation in the region. Support for improving the state of bison conservation was evident among participants in each of the three study areas. The Hook Lake Wood Bison Recovery Project in the Slave River Lowlands (Gates et al. 1998, Nishi et al 2001) provides an example of local action supported by government and offers encouragement that interventions are possible in other communities where the presence of brucellosis and tuberculosis constrains the recovery of healthy bison.

Community based disease management initiatives are more likely to receive both local level and broader societal support than large-scale government interventions. The massive depopulation and reintroduction of disease-free stock proposed by the Environmental Assessment and Review Panel in 1990 failed to consider the importance of local participation in evaluating and planning interventions, proposing an agencybased approach instead. The strong negative response by communities to the recommended action was predictable. The Hook Lake wood bison recovery project has demonstrated the importance of local participatory action (Nishi et al. 2001). The Little Red River Cree Nation and the Tall Cree First Nation have proposed a project named Buffalo RESQU, a salvage, recovery and conservation initiative that would restore bison in the Caribou Lower Peace ecosystem and as a vital element of the subsistence economy. The National Wood Bison Recovery Plan (Gates et al. 2001) supports research that would set the stage for an intervention in the Caribou Lower Peace region. Support would be required from resource management and agricultural agencies to allow the research and intervention to proceed. In addition it would be helpful for the Canadian Bison Association to provide support in principle for the initiative. The bison industry may be able to offer technical advice on capture, handling, and captive breeding. It will be essential to define a bison management area in regulation to ensure the success of the program and the long-term recovery of a healthy population. Detailed information on Buffalo RESQU is available from Mr. Jim Webb. Little Red River Cree Nation.

RISK ASSESSMENT

The least cost pathway distances generated from our study may be used as an estimate of the parameter 'd' (d = distance between the diseased herd and the *At Risk* group) in the invasion probability equation in the APHRAN (1998) model (see insert below).



However, the algorithm should be modified to account for the directionality implicit in least cost pathways. It would also be necessary to change the effect of the contact angle 'a' between the diseased herd and the 'at risk' group in the APHRAN equation to account for terrain and habitat effects. In addition, we suggest that maximum dispersal distances (NORMSDIST) may be much larger than the estimate used by APHRAN (1998), i.e. the dispersal or extreme movement distance assumed by APHRAN likely underestimates the potential for extreme movements. The bison sightings mapped in our study (Chapter 2) occurred further from known populations than the distances reported from several other studies (Chapter 3).

From APHRAN (1998):

For each diseased herd, the Pr (*Invasio*n) is calculated using the model :

Pr (Invasion) = (1-(NORMSDIST((Ln(d)-3.8413)/0.3827))) x (a/360) h

We are willing to work with APHRAN to adjust the invasion risk calculation if management authorities deem this to be necessary and useful. However, we suggest that risk management measures and planning to develop a long-term comprehensive solution are urgently needed. Recalculating the risk of infection is of secondary importance to the immediate need for risk management and long-term planning.

RISK MANAGEMENT FOR WILD BISON POPULATIONS

The Hay Zama population was established in 1993 in an area that was probably already occupied by a low number of free-ranging bison. Evidence concerning a possible movement corridor west of WBNP (Gainer 1985, and this study) and of bison distribution and movements in the region between WBNP and the Hay Zama range (this study), lead us to suggest that the Hay-Zama population is at a high risk of becoming infected if it is not already infected. We recommend immediate implementation of a tuberculosis and brucellosis monitoring program for this herd. The population is increasing rapidly (r = 0.18) and now numbers 200 animals. A limited annual supervised harvest of up to five adult bulls would not affect population growth and would allow testing for the two diseases. Harvesting of adult males would be particularly important for detecting tuberculosis. Implementation of a project like Buffalo RESQU would reduce the potential for movement of bison west of WBNP. A community-based, participatory approach to management would provide opportunities to foster local support and incorporation of local ecological knowledge. Information on training and disease testing protocols is available from the Government of the Northwest Territories, which has implemented such programs involving community participation in the SRL and in the Mackenzie Bison Range (B. Elkin, pers. comm.). Disease testing has been limited in other free-ranging herds in northern Canada. We recommend that disease monitoring be implemented for the Nordquist, Pink Mountain and Etthithun populations in British Columbia, and the Nahanni population in the NWT.



Control measures for bison in the area between WBNP and the Mackenzie bison population in the Northwest Territories have been undertaken annually since the late 1980s. Bison have been detected or reported by the public near both bison ranges and some animals have been removed. Although it is unlikely that all bison in this vast area can be detected with only limited surveillance, the active control program does provide a means for preventing the southward range expansion of the large Mackenzie population and egress from the WBNP population. This program should be continued to manage the risk of infection of the Mackenzie and Nahanni populations.

The recent demographic study of bison in WBNP indicates that the population will likely continue to decline to a low density throughout WBNP as a consequence of the synergistic effects of *M. bovis*, *B. abortus* and wolf predation (Joly and Messier 2001b). In the absence of a direct intervention to eliminate the diseases, a low-density state will result in less egress from the system than would a management regime supporting growth of the infected populations. However, even if infected bison populations persist at a low density in WBNP in the long term, the state of the ecosystem would be different from the high density system that would occur in the absence of the diseases (Joly and Messier 2001b). Differences between low and high density bison systems are expected at all trophic levels including plant-microorganism (Merrill et al. 1994), plant-herbivore (Polley and Collins 1984, Frank and McNaughton 1992, Frank and Evans 1997), predator-prey (Larter et al. 1994) and scavenger-carcass interactions (Green et al. 1997). Bison probably play a role in maintaining meadow habitats and overall biodiversity in the areas they inhabit (Campbell et al. 1994, Zimov et al. 1995). In addition to the negative effects of the two pathogens on the integrity of the ecosystem within WBNP, the persistence of infected bison populations constrains the conservation and recovery of bison on adjacent lands, e.g. the bison control program in the NWT, the lack of management for SRL bison, and the non-wildlife status of bison in northern Alberta.

Should the Hay Zama or other apparently non-infected, free-ranging bison populations become reservoirs for *M. bovis* and/or *B. abortus*, the risk to other adjacent susceptible populations would increase significantly as would the geographic extent of the region at risk. We expect that the current support of the livestock industry for bison conservation in northern Canada would be severely tested by such an event as would the already tenuous support of some government agencies.

There is a strong interest by communities surrounding Wood Buffalo National Park in bison recovery outside the park. The persistence of infected populations at low density inside the park limits the opportunity for recovery of viable, ecologically meaningful populations that could contribute to the resource-based economies of the communities. Disease eradication, conservation and continued recovery of disease-free wild bison will benefit communities. In particular, efforts proposed in the Caribou-Lower Peace Model Forest Project – vision for bison recovery (Webb 2001), and undertaken in the Slave River Lowlands (Nishi et al. 2001) provide examples of positive community-based interventions.

RISK MANAGEMENT FOR COMMERCIAL HERDS

The risk of transmission for tuberculosis and brucellosis could be recalculated using the distance values from this study using the APHRAN risk model. However, based upon the information gathered from industry, government, and community sources, and the results of the modeling exercise, it is already clear that risk management measures are required immediately. Participants in the commercial bison industry expressed their view that risk management measures should not focus only on bison and that other commercial livestock (bovid and cervid species) in the area should be subject to the same surveillance and risk management measures as bison.

An author of this report (JM) participated in the Risk Management Guidelines Subcommittee of the Disease Risk Management Committee of the Canadian Bison Association. We drew upon the deliberations of the sub-committee to construct several recommendations for risk mitigation two levels, regional management and on-farm management.

Regional management

Designation of a High-Risk Zone for bison production (and other livestock) would establish the foundation for further regional interventions, including surveillance for wild bison, special market surveillance, livestock transport regulations and record keeping, special fencing standards, limitations for the location of ranches, and periodic testing protocols. A regional risk management zone would allow regulatory bodies to establish increased surveillance for high-risk areas rather than imposing industry-wide measures. Risk management zones should be defined collaboratively between government and industry associations. The definition should take into consideration movement corridors calculated in this study, geographic barriers and impediments to movement, and the maximum distance that bison have been observed from infected populations.

Tuberculosis and brucellosis monitoring in domestic animals is the responsibility of the Canadian Food Inspection Agency (CFIA). The Captive Ungulate Policy gives the CFIA the ability to monitor non-traditional livestock, including bison, for these diseases with closer scrutiny than other livestock in Canada. The purpose of the Captive Ungulate Policy is to maintain an "enhanced domestic early detection program to mitigate the possible damage to the Canadian livestock industry and the developing captive ungulate industry posed by tuberculosis, brucellosis, and transmissible spongiform encephalopathies in captive wild ungulates" (CFIA 1999). Presently, maintenance of tuberculosis and brucellosis negative status for a bison herd requires either: 1) a whole herd test (animals eighteen months of age or older) every five years, or 2) an annual surveillance of at least 10% of the total herd (animals 18 months of age or older) each year. Bison producers are also required to permanently identify all animals in the breeding herd with tamper resistant identification, and ensure that all animals are tagged with an approved unique identifying device before the animal leaves the premises for any reason. Records of movement for all bison are provided under a voluntary program managed by the Canadian Bison Association. This program should be reinforced by regulation. It should be the responsibility of the industry, the individual producer and



regulatory agencies to ensure that animals are tested prior to entering a farm and that they are and remain disease free.

The required level of testing is the minimum level necessary to detect tuberculosis and brucellosis in farmed animals in risk areas. The Captive Ungulate Policy, as it was first developed, provides a way to monitor and identify disease problems. This type of program allows for closer surveillance than do random checks at slaughter, because a minimum proportion of the herd is tested. At the present time the number of cull animals from breeding herds sent to slaughter is still low in the bison industry. Once sufficient numbers of animals are available for testing at slaughter, the requirement for testing breeding herds could be reduced. The CFIA should continue to place a high priority on maintaining, at a minimum, the surveillance measures prescribed in the Captive Ungulate Policy. In addition, all animals that can be traced back to the high risk region should be tested for disease at slaughter. If this is logistically too difficult to administer, it may be necessary to test all bison at slaughter.

Geography is a necessary consideration in the development and application of disease risk management measures. In addition to creating a disease risk management zone, bison ranches in the north should not be developed within 170 km of infected herds, particularly within the movement corridors identified in this study. If a bison ranch has to be located in a high-risk area, natural barriers to movement should be utilized whenever possible to reduce the probability of contact with free-ranging bison. Special fencing requirements should be required for ranches in high risk areas and regulations for controlling stray or feral commercial animals should be improved and enforced.

Bison ranchers need to be made aware of high-risk locations for bison ranching and of the consequences of disease transmission to the livestock industry and to other disease free, free-ranging bison populations. The development of an effective public awareness campaign should include an organized surveillance program as an integral component. This program should have two elements; the first element is a public monitoring program to track sightings of wild bison in northern Canada. The second element could involve regulated hunting of free-ranging bison in designated areas and a program to test harvested animals for diseases. In addition to surveillance programs that rely on the help of the public, an organized surveillance program by government agencies is needed for detecting wild bison in designated areas (e.g. Bison Control Area in the NWT). In Alberta, such measures would require listing bison as wildlife and defining new bison management zones.

On-farm Management

Additional preventive measures should be developed for commercial bison herds in a defined high-risk region in northern Canada. The measures can be considered in two categories.

Disease-free source: Ensure that animals coming onto the farm are from a disease-free source by making sure that:

• the source herd has no risk of exposure to wild or otherwise untested bison;

- the source herd has maintained disease free status through testing; and
- there will be due diligence by industry associations and individual producers to prevent entry of untested animals into the commercial industry.

Contact prevention: Prevent contact with free-ranging bison and other potential host species by:

- maintaining appropriate barriers; and
- locating ranches in reduced risk areas such as in the center of agricultural developments rather than in peripheral uncultivated or natural areas;

Efforts to prevent contact could include electric outriggers on perimeter fences to provide minimum buffer zones and increased surveillance of pastures and facilities to monitor potential contact with free ranging bison. Double fencing around pasture perimeters may be required in areas where the risk of contact is high. Groups of livestock producers may decide to share a buffer fence or double fencing around the periphery of livestock production zones to create a suitable buffer zone between livestock and free ranging bison herds. In addition to the type of fence used, ranchers should maintain a clear view of the perimeter fence on pastures so that any disruption of the fence (e.g. fallen tree, animal disruption) will be detected quickly. Along with physical barriers to movement, pasture rotation that allows use of interior pastures at times when risk of contact is greater or when access for observing animals is difficult, could be implemented as an additional measure to minimize the risk of contact. Use of interior pastures would increase the buffer zone between farmed and free ranging animals.

Deer are abundant in the agricultural area west of WBNP and elk have been seen in the area. Both species can serve as reservoirs for *M. bovis* and *B. abortus*. However, artificial concentration seems to be a necessary condition for this to occur. We suggest that the abundance and seasonal aggregation patterns of cervids should be monitored and managed in the agricultural area near WBNP to reduce the risk of these populations becoming a reservoir for the two disease organisms. Commercial cervid farming is probably not wise in the agricultural area near WBNP under current circumstances.

Continued growth of the commercial bison industry in the North could negatively affect free-ranging bison populations. The Government of Alberta is currently considering allowing grazing of commercial bison herds on grazing leases. In the absence of a long-term commitment to conservation of free-ranging wild bison, commercial herds could compromise reintroduction of wild populations on public lands. Conventional fence materials would not be expected to withstand simultaneous pressure from bison inside and outside a fence. Other factors such as falling trees, broken posts, staple failure, gate failure, and fences broken by panicking bison will also compromise the integrity of fences, making escapes inevitable. Examples of this already exist in the region, e.g. accidental escape of the Pink Mountain herd in 1971, the Ettithun Lake herd in 1998, the Hanging Ice herd in 1993, the Edjericon Ranch herd in 1999, and the Hay Zama herd in 1993. Interactions between wild and stray commercial bison could result in disease transmission in either direction, e.g. tuberculosis and brucellosis to commercial bison, other cattle diseases from commercial to wild bison including BVD, IBR, and anaplasmosis. Stray domestic bison are ecologically competent to thrive in northern

Alberta and there are no provisions under the Alberta Wildlife Act and only limited provisions under the Public Lands Act to deal with them once they become free ranging.

Commercial operators should be informed of the consequences of disease transmission and should be made aware of the distribution of known populations and history of sightings in the area of interest. Although we did not include the landscape south of WBNP in the movement model, the confirmation of a wild bison population in the Firebag River area north of Fort McMurray may be of interest or concern to Syncrude Canada Ltd. which operates a commercial bison ranch approximately 83 km away.

RESOLUTION OF THE DISEASE ISSUE

In August 1990, the federal government accepted the Federal Environmental Assessment and Review Panel's report on diseased bison in northern Canada and gave it a qualified approval-in-principle (Fuller 1991). The Panel recommended:

"23. After considering the alternatives, all free-ranging bison now living in Wood Buffalo National Park and surrounding areas be removed and replaced by disease-free wood bison."

Public reaction was strongly negative and there was an overwhelming rejection of the Panel's recommendation. The communities in the region stated that there was little meaningful public involvement in the process (Chisholm et al. 1998). In 1991, the Government of Canada in collaboration with Aboriginal groups, provincial wildlife and agriculture agencies, and the livestock industry established a committee to examine options for disease eradication. Over the next two years, the Northern Buffalo Management Board (NBMB 1993) reviewed existing information and concluded:

"The NBMB has come to recognize that significant knowledge gaps exist in its understanding of the epidemiology of the two diseases, the ecological role of the diseases, other fundamental aspects of the ecosystem and the effect of potential management actions. The NBMB therefore recommends that these knowledge gaps be addressed as a prerequisite to developing a final action plan."

The report emphasized the important role of communities in implementing research and management activities.

Since 1993, research has been completed on the role of the two diseases in limiting population growth of northern bison (Joly 2001, Joly and Messier 2001 a,b) and a

disease risk assessment was completed by APHRAN (1998). Our research has added to this body of information by compiling and mapping local ecological knowledge of bison in the NWT and Alberta, describing community-based initiatives and interests and calculating spatially explicit movement corridors through northern Alberta. We suggest that the information gained from these studies provides a sufficient basis for initiating a planning process to define actions to deal with disease risk management and bison conservation.

Since the presence of the diseases affects a region and communities much larger than WBNP, it would be unreasonable to expect that a single agency or government could by itself develop an action plan that would be acceptable to the broad range of interests involved. Furthermore, there is a growing consensus among ecosystem managers that a more inclusive decision making process leads to better policy (Daniels and Walker 1996, VanNijnatten 1999). Therefore, we recommend that a collaborative planning process be developed in which the interests of communities, the livestock industry, conservation groups, and government agencies are represented. We suggest a process similar to the Collaborative Resource Management (CRM) process described by Wondolleck and Yaffee (2000), a stakeholder consensus decision-making process which involves people using resources (affected interests) in developing decisions about those resources. Through collaborative learning, CRM integrates local wisdom and technical expertise (Daniels and Walker 1996). A key feature is that it involves agency decision-makers sitting shoulder-to-shoulder with other stakeholders, rather than at arm's length. A CRM team works together from the beginning of planning rather than being presented with a draft or completed plan on which to comment. Appointments to teams are made locally; participation is voluntary. CRM affords opportunities for inter-agency coordination, rather than agencies acting autonomously. The process is non-regulatory, in contrast to being driven by rigid rule making. CRM is the most open and accessible process available for planning and decision making in natural resource management and has the potential to produce the most widely endorsed plan. Communities are provided the tools for capacity building, empowerment and the opportunity to participate meaningfully in determining the future management of a local resource or ecosystem.

CHAPTER 5

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PERSONAL COMMUNICATIONS

- Conacher, G. Canadian Bison Association, Regina, SK
- Elkin, B. Government of the Northwest Territories, Yellowknife, NT
- Hoefs, M. Yukon Department of Renewable Resources, Whitehorse, YK
- Kunnas, F. Alberta Fish and Wildlife Division, St. Paul, AB
- Morton, K. Alberta Fish and Wildlife Division, High Level, AB
- Moyles, D. Alberta Fish and Wildlife Division, Peace River, AB

Neal, V. Little Red River Cree Nation Representative, Rocky Mountain House, AB

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- Scott, D. Canadian Food Inspection Agency, Calgary, AB
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Woods, R. BC Ministry of Water, Land and Air Protection, Fort St. John, BC



APPENDIX A

DISTANCES ALONG LEAST COST PATHWAYS FROM SEVEN ENTRY POINTS IN WBNP TO 25 EXIT POINTS IN THE ALBERTA STUDY AREA.

Exit Point	Mean	Std. Deviation	Std. Error
	317.5	3.3	1.5
2	313.5	3.3	1.5
3	314.1	3.1	1.4
4	323.3	2.6	1.2
5	305.7	3.8	1.7
6	300.9	2.4	1.1
7	300.0	2.2	1.0
8	303.7	2.0	0.9
9	310.3	1.6	0.7
10	311.5	1.4	0.6
11	315.0	1.6	0.7
12	317.1	1.8	0.8
13	324.8	1.8	0.8
14	313.5	6.2	2.8
15	322.4	8.0	2.5
16	338.6	8.5	2.7
17	355.7	8.4	2.7
18	435.1	9.9	3.1
19	419.4	9.7	3.1
20	430.5	9.0	4.0
21	332.6	3.6	1.6
22	314.7	3.8	1.7
23	300.7	3.3	1.5
24	293.9	3.4	1.5

3.5

Table A-1. Length of least cost pathways to exit points from Entry 1.

25

287.6

1.6
Exit Point	Mean	Std. Deviation	Std. Error
	317.8	7.6	3.4
2	313.8	7.3	3.3
3	314.3	6.5	2.9
4	309.2	7.5	3.3
5	306.0	7.4	3.3
6	301.6	4.1	1.8
7	300.3	3.5	1.6
8	305.0	4.0	1.8
9	311.7	2.8	1.3
10	314.4	1.6	0.7
11	317.8	1.6	0.7
12	320.0	1.5	0.7
13	327.0	2.0	0.9
14	315.8	5.4	2.4
15	324.6	7.8	2.5
16	340.8	8.1	2.6
17	357.9	8.0	2.5
18	437.4	10.5	3.3
19	421.7	10.2	3.2
20	432.8	9.7	4.3
21	336.1	1.8	0.8
22	318.1	2.2	1.0
23	304.2	1.5	0.7
24	297.5	2.0	0.9
25	291.0	22	1 0

 Table A-2.
 Length of least cost pathways to exit points from Entry 2.

Exit Point	Mean	Std. Deviation	Std. Error
1	312.4	5.3	2.4
2	308.4	5.3	2.4
3	308.9	5.2	2.3
	305.8	9.9	4.4
5	301.6	7.9	3.5
6	297.6	5.8	2.6
7	296.4	6.4	2.9
8	300.8	6.5	2.9
9	308.9	6.1	2.7
	310.2	6.6	3.0
	314.6	8.9	4.0
12	317.4	9.8	4.4
13	321.7	7.0	3.1
	310.9	0.9	0.4
15	320.5	5.8	1.8
16	336.7	5.9	1.9
	353.8	5.8	1.8
18	435.9	14.8	4.7
19	420.2	14.6	4.6
20	431.6	13.2	5.9
21	338.6	3.3	1.5
22	320.7	3.1	1.4
23	306.7	3.3	1.5
24	300.0	3.2	1.4
25	293 5	3.1	1 /

Table A-3. Length of least cost pathways to exit points from Entry 3.

Exit Point	Mean	Std. Deviation	Std. Error
1	300.9	7.2	3.2
2	296.9	7.5	3.3
3	297.2	5.6	2.5
	294.7	3.1	1.4
5	292.6	4.2	1.9
6	288.4	4.4	2.0
7	288.4	3.6	1.6
8	294.5	4.1	1.8
9	302.7	3.3	1.5
10	303.2	3.2	1.4
11	307.7	1.2	0.5
12	310.1	1.4	0.6
13	318.2	2.8	1.2
14	307.1	7.2	3.2
15	319.4	5.7	1.8
16	336.3	5.6	1.8
17	354.0	6.6	2.1
18	431.4	9.7	3.1
19	415.8	9.5	3.0
20	427.2	7.8	3.5
21	352.5	6.5	2.9
22	334.5	7.1	3.2
23	320.5	6.5	2.9
24	314.0	7.2	3.2

Table A-4. Length of least cost pathways to exit points from Entry 4.

Exit Point	Mean	Std. Deviation	Std. Error
1	291.1	1.1	0.5
2	287.1	1.0	0.4
3	287.4	1.8	0.8
4	289.2	5.2	2.3
5	287.2	8.9	4.0
6	282.8	4.3	1.9
7	282.9	4.1	1.8
8	287.0	4.2	1.9
9	295.4	4.1	1.8
10	297.2	4.3	1.9
11	302.5	4.4	2.0
12	304.7	4.2	1.9
13	309.8	3.4	1.5
14	300.1	3.5	1.6
15	310.4	3.6	1.2
16	327.8	4.1	1.3
17	345.0	4.1	1.3
18	424.4	10.7	3.4
19	408.8	10.4	3.3
20	420.2	8.7	3.9
21	358.7	14.0	6.3
22	335.3	2.8	1.3
23	321.3	1.8	0.8
24	314.8	2.6	1.2
25	308.4	2.4	1.1

Table A-5. Length of least cost pathways to exit points from Entry 5.

Exit Point	Mean	Std. Deviation	Std. Error
1	290.2	1.3	0.6
2	286.2	1.1	0.5
3	286.5	1.8	0.8
4	286.5	2.5	1.1
5	286.7	9.3	4.2
6	282.7	6.0	2.7
7	282.6	5.2	2.3
8	286.7	5.3	2.4
9	294.8	5.0	2.2
10	295.5	2.7	1.2
	302.1	4.8	2.1
12	304.1	4.5	2.0
13	309.6	4.8	2.2
14	299.0	2.4	1.1
15	311.8	4.3	1.4
16	329.2	4.7	1.5
17	346.9	5.2	1.7
18	423.5	8.9	2.8
19	407.8	8.6	2.7
20	419.2	6.7	3.0
21	366.7	13.7	6.1
22	346.0	15.6	7.0
23	325.7	1.8	0.8
24	319.1	1.4	0.6
25	312.7	1.2	0.5

Table A-6. Length of least cost pathways to exit points from Entry 6.

Exit Point	Mean	Std. Deviation	Std. Error
1	290.9	5.1	2.3
2	286.9	4.8	2.2
3	288.8	2.5	1.1
4	288.0	3.7	1.7
5	283.7	5.7	2.5
6	282.1	1.2	0.5
7	283.2	1.3	0.6
8	286.5	1.3	0.6
9	294.8	1.2	0.5
10	297.5	2.7	1.2
11	303.3	3.3	1.5
12	305.5	3.0	1.3
13	312.2	5.4	2.4
14	301.6	1.7	0.7
15	314.0	4.4	1.4
16	331.4	5.0	1.6
17	349.1	5.2	1.6
18	425.7	8.7	2.7
19	410.0	8.4	2.6
20	421.4	6.5	2.9
21	377.8	11.0	4.9
22	355.9	12.4	5.6
23	336.7	4.3	1.9
24	330.1	4.9	2.2
25	323.9	4.5	2.0

 Table A-7.
 Length of least cost pathways to exit points from Entry 7.







