UNIVERSITY OF CALGARY

Conservation of North American Bison: Status and Recommendations

by

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A MASTER'S DEGREE PROJECT
SUBMITTED TO THE FACULTY OF ENVIRONMENTAL DESIGN
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF ENVIRONMENTAL DESIGN
(ENVIRONMENTAL SCIENCE)

FACULTY OF ENVIRONMENTAL DESIGN

CALGARY, ALBERTA
APRIL, 2003

APPROVAL

FACULTY OF ENVIRONMENTAL DESIGN

The undersigned certify that they have read, and recommend to the Faculty of Environmental Design for acceptance, a Master's Degree Project entitled "Conservation of North American Bison: Status and Recommendations" submitted by Delaney P. Boyd in partial fulfillment of the requirements for the degree Master of Environmental Design (Environmental Science).

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ABSTRACT

Conservation of North American Bison: Status and Recommendations

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Delaney P. Boyd

Prepared in partial fulfillment of the requirements of the degree in the Faculty of Environmental Design, University of Calgary

Supervisor

C. Cormack Gates

The bison (*Bos bison*) was the dominant keystone herbivore on much of the North American landscape, providing sustenance and materials for many of North America's original human residents, and staple food for early explorers, fur traders, and European settlers. Political, economic, and environmental forces accompanying European colonization conspired to drive the species to near extinction by the close of the 19th Century. Recovery efforts during the 20th Century salvaged the species; now there are over 500,000 bison scattered across North America in remnant and reintroduced herds. At least 95% of the existing bison population is under commercial production.

This project was initiated by the Bison Specialist Group of North America (BSG), which is an assemblage of bison specialists, operating under the auspices of the Species Survival Commission (SSC). There is currently no unified conservation plan for bison in North America. The BSG requires a status survey as the basis for developing a bison conservation strategy for North America. This status assessment includes plains and wood bison herds managed by municipal, state, provincial, and federal governments, and several herds managed by private organizations with clear conservation objectives. Through a process of iterative consultation with members of the BSG and other collaborators, dialogue with conservation herd managers across North America, and extensive compilation and review of relevant literature, this document represents a current and comprehensive treatment of North American bison status. The survey addresses the taxonomic, numerical, geographic, demographic, habitat, genetic, disease, and legal status of bison. Although bison are no longer in imminent danger of extinction, there are threats to the persistence of bison as a wild species. The most evident pressures affecting bison include habitat loss from agricultural development and other intensive land use, reduction in genetic diversity, hybridization, domestication through commercial bison production, disease, and inconsistent legislation and policies. Current bison recovery initiatives are reviewed. The status survey concludes with a list of conservation action recommendations to assist the BSG with setting priorities for bison conservation.

Key Words: plains bison, wood bison, conservation status, recovery, IUCN, SSC, Bison Specialist Group.

Acknowledgements

Successful completion of this project relied on the contributions of numerous people from across North America and in Gland, Switzerland. I would like to acknowledge the support and feedback provided by members of the World Conservation Union Species Survival Commission's (IUCN/SSC) Bison Specialist Group. As well, IUCN/SSC staff members Carolina Caceres, Assistant to the Chair of the IUCN Species Survival Commission, in Hull, Quebec, and Mariano Gimenez Dixon, SSC Programme Officer at the IUCN Secretariat in Gland, Switzerland, were very helpful throughout development of the status survey. I would like to thank all bison herd managers and biologists who provided information on the plains and wood bison conservation herds included in this survey. Thanks also go out to other project collaborators including Al Arsenault of Saskatchewan Environment, Barry Opekokew of Canoe First Nation, and Pat Fargey, Dan Frandsen, Dave Poll, Rob Watt, and Cliff White of Parks Canada Agency.

I would like to express my gratitude to the funding partners for this project: Parks Canada, the United States National Parks Service, and University of Calgary.

My Master's Degree Project committee members were very enthusiastic and helpful. I would like to thank Kevin Lloyd for his insightful reviews of my manuscript and for providing international perspectives on the overall project. My supervisor Cormack Gates shared with me his enthusiasm for, and knowledge of, bison conservation. I would like to thank him for his support and encouragement throughout the project.

I would especially like to thank my husband Kevin Burton, my parents Ron and Joy Boyd, and my family and friends for their understanding and support of my educational goals.

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List of Common Abbreviations

APHIS	Animal and Plant Health Inspection Service
BSG	Bison Specialist Group (North America)
CFIA	Canadian Food Inspection Agency
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
EINP	Elk Island National Park
EIS	Environmental Impact Statement
ESA	US Endangered Species Act
FWS	US Fish and Wildlife Service
GTNP	Grand Teton National Park
GYA	Greater Yellowstone Area
HLWBRP	Hook Lake Wood Bison Recovery Project
ITBC	InterTribal Bison Cooperative
IUCN	World Conservation Union (legally registered as the International Union for the Conservation of Nature)
MDP	Master's Degree Project
MVP	Minimum Viable Population
NBR	National Bison Range
NCC	Nature Conservancy of Canada
NEPA	National Environmental Protection Act
NER	National Elk Refuge
NPS	US National Park Service
NWR	National Wildlife Refuge
PVA	Population Viability Analysis
SARA	Canadian Species At Risk Act
SSC	Species Survival Commission
SRL	Slave River Lowlands
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
WBRT	Wood Bison Recovery Team (now the National Bison Recovery Team)
YNP	Yellowstone National Park

State, Provincial, and Territorial Abbreviations

AK	Alaska	KY	Kentucky	NY	New York
AL	Alabama	LA	Louisiana	OH	Ohio
AR	Arkansas	MA	Massachusetts	OK	Oklahoma
AZ	Arizona	MD	Maryland	OR	Oregon
CA	California	ME	Maine	PA	Pennsylvania
CO	Colorado	MI	Michigan	RI	Rhode Island
CT	Connecticut	MN	Minnesota	SC	South Carolina
DC	District of Columbia	MO	Missouri	SD	South Dakota
DE	Delaware	MS	Mississippi	TN	Tennessee
FL	Florida	MT	Montana	TX	Texas
GA	Georgia	NC	North Carolina	UT	Utah
HI	Hawaii	ND	North Dakota	VA	Virginia
IA	Iowa	NE	Nebraska	VT	Vermont
ID	Idaho	NH	New Hampshire	WA	Washington
IL	Illinois	NJ	New Jersey	WI	Wisconsin
IN	Indiana	NM	New Mexico	WV	West Virginia
KS	Kansas	NV	Nevada	WY	Wyoming
AB	Alberta	NT	Northwest Territories	QC	Quebec
BC	British Columbia	NS	Nova Scotia	SK	Saskatchewan
MB	Manitoba	NU	Nunavut	YT	Yukon
NB	New Brunswick	ON	Ontario		
NL	Newfoundland/Labrador	PE	Prince Edward Island		

Chapter 1: Introduction

Context for Bison Conservation

The bison (*Bos bison*) is the largest land mammal in North America (Shaw 1999). Prior to European settlement there were likely over 30 million bison on the continent (Shaw 1995). The bison was the dominant herbivore of the Great Plains, providing sustenance and materials for many of North America's original human residents, and staple food for early explorers, fur traders, and European settlers. Political, economic, and environmental forces accompanying European colonization conspired to drive the species to near extinction by the close of the 19th Century. Recovery efforts during the 20th Century salvaged the species. Now in the 21st Century, over 500,000 bison are scattered across North America in remnant and reintroduced herds. At least 95% of the existing bison population is under commercial production. Although bison are no longer in imminent danger of extinction, there are threats to the persistence of bison as a wild species. The most evident pressures affecting bison include habitat loss from agricultural development and other intensive land use, reduction in genetic diversity, hybridization, domestication through commercial bison production, disease, and inconsistent legislation and policies.

Modern conservation of many species is often based on the goal of ensuring long-term persistence and ecological adaptation of viable populations in the wild (Soulé 1987a; Secretariat of the Convention on Biological Diversity 1992; IUCN/SSC 2002; IUCN 2003a). Viability relates to the capacity of a population to maintain itself without significant demographic or genetic manipulation for the foreseeable ecological future (Soulé 1987a). Natural selection, diverse genetic composition, and population regulating factors (e.g., predation) contribute to the maintenance of the wild character of a species, and the traits that enable an animal to survive in a natural setting with minimum human interference (Knowles *et al.* 1998). Given these parameters, 'wild' bison would be non-domesticated, subject to evolutionary adaptation through natural selection, and normally reside in free-ranging, naturally-regulated herds within original bison range. However, this survey demonstrates that most herds are confined by fences or socio-political forces in habitats of varying sizes, sometimes outside of original range, and are subject to varying levels of management intervention by humans. Although the ideal goal of bison conservation is to maintain the bison as a wild species, in contrast to the domesticated state, the realities of the developed landscape and existing human settlement limit opportunities for conserving bison under completely natural conditions.

Diverse values underlie modern conservation of bison, including the intrinsic existence value of the species, heritage and cultural value related to their historic importance to North American aboriginal people and European settlers, value as a North American icon, and value of the ecological functions bison provide within their natural habitat. The bison is a keystone species, increasing biodiversity by creating a mosaic of vegetation and microclimates through differential grazing, urine deposition, trampling, tree rubbing, and wallowing (Knapp *et al.* 1999; Truett *et al.* 2001). The presence of bison also increases faunal diversity, especially among small birds and mammals that flourish in vegetation mosaics (Truett *et al.* 2001).

One of the ecologically significant changes on the North American grasslands was the replacement of bison with domestic cattle (Licht 1997; Hartnett *et al.* 1997). There is a growing body of literature comparing the grazing behaviour and impacts of cattle and bison, much of it indicating that large scale bison grazing is more compatible with the maintenance of grassland ecosystems than is cattle grazing (Licht 1997; Hartnett *et al.* 1997; Wuerthner 1998; Knapp *et al.* 1999; Truett *et al.* 2001). Therefore, bison could play a pivotal role in larger, landscape level restoration initiatives.

Project Context

This project was initiated by the Bison Specialist Group of North America (BSG) (Appendix 3), which is an assemblage of bison specialists, operating under the auspices of the Species Survival Commission (SSC) (BSG 2003). The SSC coordinates a network of 7,000 volunteer experts in over 120 Specialist Groups to provide species conservation information and recommendations to managers, agencies, academia, and others capable of implementing conservation action (IUCN 2003a). The SSC is the largest of six commissions under the World Conservation Union (IUCN) (IUCN 2003b). The IUCN is an international conservation organization comprising 73 states, 107 government agencies, 755 non-governmental organizations, 35 affiliates, and over 10,000 scientists and experts from 181 countries (IUCN 2003a). The mission of the IUCN is to influence, encourage, and assist societies throughout the world to conserve the integrity and diversity of nature, and to ensure that any use of natural resources is equitable and ecologically sustainable (IUCN 2002b).

Research into the conservation status of bison is consistent with the IUCN/SSC Strategic Plan for 2000-2010, which called for the status assessment of all mammals by 2002 (IUCN 2000). A North American bison conservation status assessment was the basis for my Master's Degree Project (MDP), a required component of my degree program for a Master's of Environmental Design (Environmental Science) in the Faculty of Environmental Design at the University of Calgary. This project was partially funded by Parks Canada Agency, the United States National Park Service, and University of Calgary.

Purpose

There is currently no unified conservation plan for bison in North America. The BSG required a status survey as the basis for developing a bison conservation strategy for North America. The purpose of this project was to assemble and synthesize information on North American bison conservation and management, and to assist the BSG with setting priorities for bison conservation actions as part of an IUCN/SSC Conservation Status Survey and Action Plan document (Action Plan). IUCN/SSC Action Plans provide authoritative reference works on species within taxonomic groups, and recommend scientifically-based, prioritized conservation actions needed to ensure survival and recovery of the species (Gimenez Dixon and Stuart 1993). This assessment includes a review of the conservation status of the North American bison subspecies, plains bison (*Bos bison bison*) and wood bison (*Bos bison athabascae*).

Objectives

The project had four objectives:

- Inventory the current status of North American bison conservation herds
- Identify threats to bison conservation
- Identify opportunities to improve bison conservation status
- Provide recommendations for development of a bison conservation Action Plan

MDP Interventions

I established three interventions as outcomes for this project, consistent with the Master's Degree Project requirements specified by the Faculty of Environmental Design:

1. Establish a framework for collaboration among BSG members that supports status assessment development, and that could continue beyond the scope of this project to assist with Action Plan development.
2. Assemble conservation status information on North American bison into one concise reference that can later be incorporated efficiently into an IUCN Conservation Status Survey and Action Plan document.
3. Recommend bison conservation actions to the BSG for consideration during Action Plan development.

Scope of the Status Assessment

This assessment includes a review of the status of both wood bison and plains bison. Wood bison have been the subject of two recent status assessments (Gates *et al.* 2001c; Mitchell and Gates 2002), and a recovery plan produced by the Canadian National Bison Recovery Team (formerly the Wood Bison Recovery Team) (Gates *et al.* 2001c). This project emphasizes the acquisition and analysis of baseline plains bison status information, which has not yet been available in published form.

This status assessment includes bison herds managed by municipal, state, provincial, and federal governments. It also includes several herds managed by private organizations with clear conservation objectives (e.g., The Nature Conservancy). Throughout this document, these target herds are referred to as 'conservation herds.' The application of this term assumes that herds managed by governments and conservation organizations are maintained for conservation purposes. Conservation herds may be free-ranging or captive. For this survey, these terms are distinguished based on the absence or presence of a perimeter fence confining a herd's range. Criteria are needed to develop an enhanced definition of free-ranging to account for range size, and barriers to natural dispersal including fences, topographic features, water bodies, and socio-political forces (R. Walker 2003, pers. comm.).

This status assessment does not include commercial bison herds. Although not all commercial populations are devoid of conservation value, these herds are normally managed for high production and profit using management practices that are not necessarily consistent with conservation goals. Zoo populations are also excluded from the survey. These populations are typically small, exist in a non-natural setting, and have potentially developed genetic and behavioural adaptations that could affect their viability in the wild (Berger and Cunningham 1994; Snyder *et al.* 1996; Lande 1999). Zoo populations participated prominently in the early reestablishment of bison; however, there are now several conservation herds that can provide sufficient stock for augmentations and reintroductions, diminishing the need for contributions from zoo populations.

The rationale for delineating the scope for the survey relates to the mechanism for developing management policy for a herd. In a commercial operation, decisions may be made based on the personality of the owner, personal preferences, or potential for profit. Managers of conservation herds, however, must normally consider conservation science and public accountability in their decisions. Currently, there is no other method for objective identification of conservation populations. Therefore, the management of some herds within the scope of this survey may emulate commercial practices, while some commercial populations may warrant inclusion in conservation planning. As well, the size and management practices of some conservation herds may be similar to some zoo populations. Objective criteria are needed for assessing the conservation value of bison herds, and identifying populations that best support conservation objectives. Resolution of this issue is beyond the scope of this survey.

Definition of Status

For the purposes of this survey, 'status' encompasses several factors with respect to conservation herds:

- Historical status: historical distribution and numbers; historical importance
- Taxonomic status: naming conventions and uncertainties
- Numerical status: number of conservation herds; herd populations
- Geographic status: location; relation to original range
- Demographic status: sex ratio and age composition
- Habitat status: size and availability of habitat

- Ecological status: free-ranging or captive; level of human management
- Genetic status: genetic variability; degree of hybridization; genetic management
- Disease status: presence, prevalence, and impact of diseases
- Legal status and listings: classifications of vulnerability assigned by scientific listing organizations and under wildlife protection legislation; legal classification as livestock or wildlife

MDP Overview

Through a process of iterative consultation with members of the BSG and other collaborators, dialogue with conservation herd managers across North America, and extensive compilation and review of relevant literature, this MDP represents a current and comprehensive treatment of North American bison conservation status. As is common with IUCN species surveys (e.g., parrots (Snyder *et al.* 2000)), this assessment is not intended to be a treatise on bison biology. For enhanced comprehension, it should be read in conjunction with general bison biology references (e.g., (Meagher 1986; Reynolds *et al.* 2003). Chapter 2 outlines the methodology applied to complete this project, and outlines the framework for collaboration among BSG members (Intervention 1).

Each of the status factors for both plains and wood bison are discussed in subsequent chapters (Intervention 2). Chapter 3 addresses the historical status of bison in North America with reference to the pre-historic, historic, and cultural contexts. Chapter 4 reviews the uncertainties in bison taxonomy and their relevance to bison conservation. Chapter 5 summarizes the status information related to the numerical, geographic, demographic, habitat, and ecological status factors. Genetic, disease, and legal status are discussed in Chapters 6, 7, and 8, respectively. Chapter 9 addresses recovery opportunities for bison in North America. Chapter 10 presents considerations for the development of an IUCN/SSC Action Plan for bison in North America (Intervention 3). The appendices provide herd-specific details and supplemental information.

Chapter 2: Approach and Methods

Project Framework

In April 2001, the Chair of the North American section of the IUCN/SSC Bison Specialist Group (BSG) approached me regarding the need for research to clarify the conservation status of bison in North America. I investigated the requirements of the BSG and the process used by the Species Survival Commission (SSC) to produce species assessments. Each specialist group under the SSC produces a Conservation Status Survey and Action Plan (Action Plan). The BSG currently requires a status assessment for bison in North America as the basis for developing an Action Plan. I determined that I would research and produce the bison status assessment and develop recommendations for the action planning process to fulfill the Master's Degree Project component of my degree program. I articulated the purpose, objectives, and scope for the status survey, and created a working definition of 'status', upon which I could build the structure of the document (Chapter 1).

Although the scope of this project does not include Action Plan development, I felt it was important to tailor the project design to support the action planning process. To increase the efficiency of Action Plan development after the status survey is completed, I established two guiding principles: (1) the status assessment process should involve ongoing input from BSG members; and (2) the products of my project should be consistent with IUCN/SSC policies and guidelines.

MDP Interventions

Once I established a foundation for the project I developed three MDP interventions:

1. Establish a framework for collaboration among BSG members that supports status assessment development, and that could continue beyond the scope of this project to assist with Action Plan development.
2. Assemble conservation status information on North American bison into one concise reference that can later be incorporated efficiently into an IUCN Conservation Status Survey and Action Plan document.
3. Recommend bison conservation actions to the BSG for consideration during Action Plan development.

Methodological Framework

There were three primary processes that interacted to comprise the methodology for this project:

- Collaboration
- Acquisition of information
- Analysis and compilation of information

The application and interaction of these processes was not linear. Although one process may have taken precedence at any given point in project development, the processes often operated simultaneously to different degrees. This chapter describes the methodological processes and associated actions undertaken to fulfill the proposed interventions.

Collaboration Process

Design and Establishment

The Chair of the BSG formally appointed me as an Officer of the BSG through the IUCN head office in Gland, Switzerland. I then obtained a list of the BSG members from the BSG Chair, and created a database for member information including name, position, organization, address, phone number, fax number, and email address. I maintained the BSG membership database throughout the project. There are currently 21 BSG members, four of whom were added during the course of the project.

I proceeded to email all BSG members to introduce myself, establish rapport, verify member information, and discuss the details of the collaboration process and timeline. In this email I provided a brief project description, a flowchart outlining the process (Figure 2.1), my definition of status, and a preliminary outline for the survey document. I proposed that BSG members could contribute to the development of the status survey in three ways:

- As sources of status information
- As sources of additional contacts for acquiring status information
- As sources of feedback on the validity and completeness of draft material

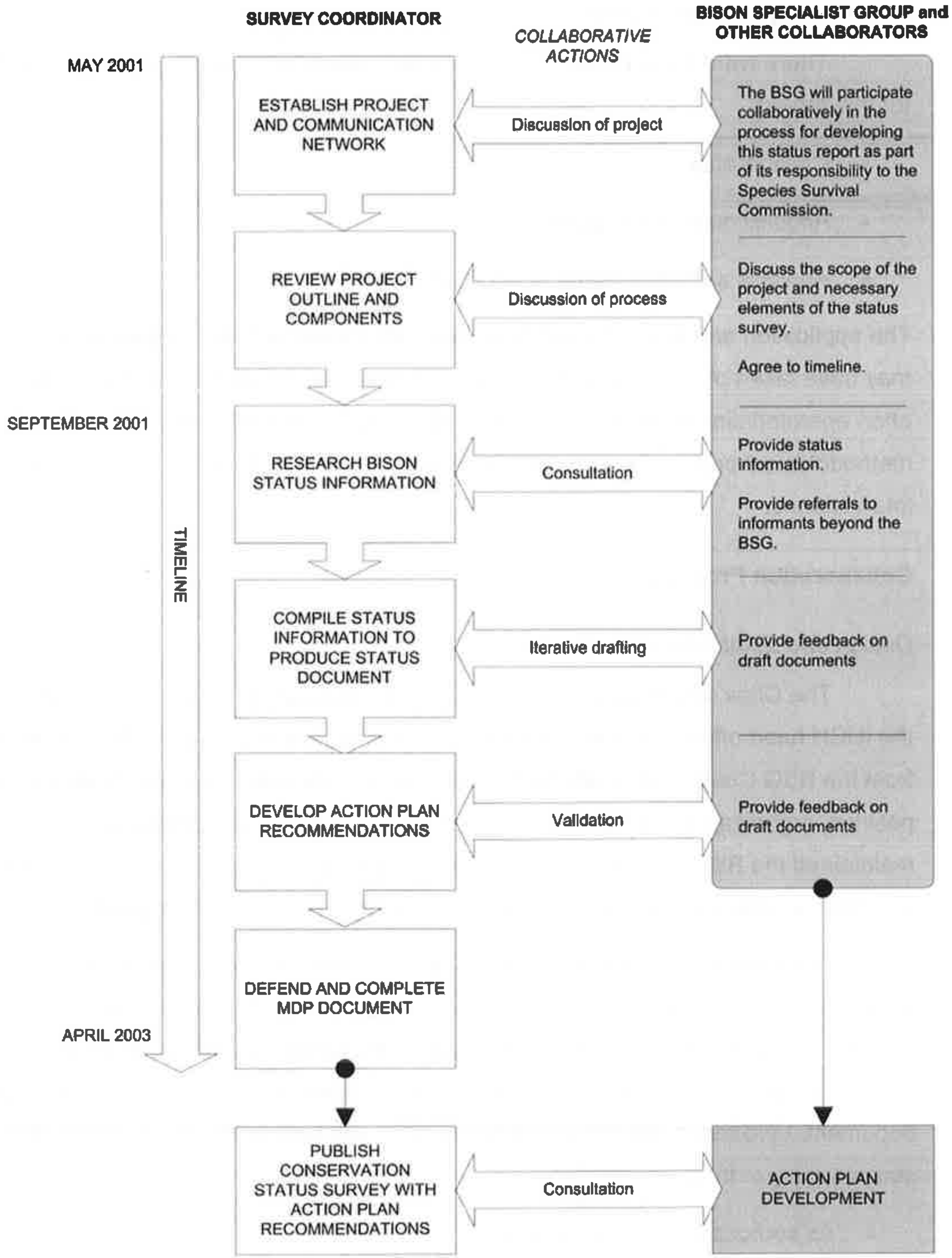

Figure 2.1: Project framework demonstrating the relative roles of the survey coordinator and collaborators.

I developed the collaboration process among BSG members to increase the effectiveness of the BSG as a conservation planning unit, and to increase the accuracy and comprehensiveness of the status survey.

Communication

A fundamental challenge involved with establishing collaboration among BSG members was the development of functional communication methods that enabled efficient and equal access by all members to information relevant to the project and its progress. The communication methods had to surmount the complications created by the geographical disparity of the members, as well as incorporate straightforward mechanisms for inclusion and orientation of additional members in the future.

I initially emphasized email as the primary mechanism for wide-scale distribution of information, and for individual contact, as appropriate. Email is a positive mechanism for communication because it is convenient, immediate in its delivery, and generally universal in its use. These attributes make an email distribution list a logical method for quick dissemination of information to all involved. The drawback to email is that it can be impersonal. As well, human nature dictates that recipients of email may be prone to inaction because of lack of direct contact with the sender (unlike a telephone conversation, which requires immediate response.) To counter the drawbacks associated with email, I used direct phone contact when addressing matters requiring a quick response.

In addition to regular project correspondence, I periodically produced progress reports called BSG Briefing Notes (Appendix 4). These one-page reports summarized the status of the project, announced the addition of new BSG members, and outlined upcoming project activities. I sent these reports by email and archived them on the project website.

Website

Once I established contact with all BSG members via email, I proceeded to develop a website for the BSG and the project (Appendix 5). This website was established on my personal web server at www.notitia.com/bison. I used Microsoft FrontPage (Version 2002) website development software to design and publish the site. The website comprised two primary components: (1) a publicly-accessible section describing the BSG, bison conservation, and the project for the interested public, and (2) a password-accessed area available to only BSG members and other selected collaborators. The public area of the website included several pages:

- Descriptions of the BSG, SSC, and IUCN
- Comparison of the two subspecies
- Description of the European bison
- Explanation of 'bison' versus 'buffalo'
- Contact information for the North American and European Chairs of the BSG
- Bison photo gallery
- Library of bison-related literature downloadable in Adobe Acrobat (PDF format)
- Description of the status survey project

My primary method for facilitating reviews of draft status survey material by BSG members was through iterative, Internet-based collaboration via the password-accessed area of the website, called the Member Forum. I established a Member Forum login screen requiring a Login ID and password, which I created and confidentially assigned to each BSG member and selected collaborator. The Member Forum featured access to member contact information, archived correspondence, and documents requiring BSG comment. The Status Survey Collaboration page accessible from the Forum page enabled members to review draft sections of the survey and to provide feedback. I posted all draft documents as downloadable Portable Document Files (PDF), which I created using Adobe Acrobat 5.0 software. These files were readable with the Adobe Acrobat Reader, available online without cost. I included a link to the Adobe website to enable BSG members to download Acrobat Reader, if needed. I posted the draft sections in reverse chronological order (i.e., newest at the top of the list), with the posting date, and my comments and questions for consideration during review. I provided a feedback form that allowed the reviewer to select the draft (e.g., Draft 1 – Genetics) from a drop-down list, enter comments, and then press 'Submit.' The feedback was sent directly to my email address with the selection from the drop-down list as the subject line. I revised the draft documents based on the feedback. I also posted the feedback to allow all collaborators to view each others' comments. After incorporating comments from the BSG, I posted the revised versions for further comment, thus creating an iterative review process.

Beyond the functionality described above, the website was important for three primary reasons: (1) it provided an electronic presence for the BSG and the project; (2) it enabled distribution of files and images that were too large to send by email; and (3) it enabled collaborators who joined the project after its inception to become orientated to the project at their own pace, through viewing current documents as well as archived correspondence. Once the website was fully operational, I phased out email as the mechanism for distribution of general information, and instead employed it to inform the BSG members of new postings on the website. I made individualized arrangements for any collaborators who could not regularly access email or the website.

Information Acquisition Process

I assembled information for this survey through an extensive literature review and dialogue with bison researchers and managers. I obtained information for the status survey from three main sources: (1) published literature, (2) questionnaire responses, and (3) outreach activities. In the following sections I describe my approach to literature acquisition and management, questionnaire development and application, and outreach.

Literature Acquisition

I began acquiring literature by searching the University of Calgary (U of C) library catalogue for items pertaining to bison. I then conducted a series of literature searches using electronic abstract databases (Wildlife and Ecology Studies Worldwide (formerly Wildlife Worldwide) and Biological Abstracts) accessed through the U of C Electronic Indexes webpage (University of Calgary 2001). I derived search terms based on bison conservation and ecology, and historical, numerical, geographical, demographic, taxonomic, habitat, genetic, disease, management, and legal status of bison. After obtaining a list of citations from a database, I searched for the location of each item using the U of C Library Catalogue, and obtained the material from the library holdings or through online subscriptions to full text journals. I used the U of C document delivery service to obtain material that the U of C could not provide. I often received copies of material or references through discussions with BSG members and other collaborators. I obtained additional material by reviewing the references cited in the literature I gathered;

a technique known as snowballing (Berg 2001). I also obtained citable information from Internet sources.

Questionnaire Development and Application

I conducted a status questionnaire for conservation plains bison herds (Appendix 6). Wood bison have undergone two recent status assessments (Gates *et al.* 2001c; Mitchell and Gates 2002). Plains bison, however, have not yet been the subject of a published status assessment. Therefore, I focused on assembling information on the status of plains bison.

I drafted a preliminary status questionnaire based on the definition of status developed for this survey (Chapter 1). I requested feedback on the draft questionnaire from two BSG members and the BSG Chair. I revised the draft based on comments from the reviewers to create the final version.

Before proceeding with application of the questionnaire, I obtained ethics approval for research involving human subjects from the University of Calgary Conjoint Faculties Research Ethics Board (Appendix 7). Prior to an interview, I explained the purpose of my study and the nature of the information I was requesting. In accordance with my ethics approval, I asked informants to consent to their participation in the status survey process. Consent was provided verbally during phone interviews, and in writing when I conducted the questionnaire in person (Appendix 8).

I directed the questionnaire to herd managers of the 50 conservation plains bison herds in North America identified for this survey. I obtained contact information for herd managers from the Internet or by phoning the administrative authority for the herd. I logged all contact with informants by herd and date, including phone messages, email correspondence, and questionnaire interviews. I conducted 30 questionnaire interviews by phone and email. I conducted the remaining 20 interviews in person during a six-week trip through the United States (May 12-June 26, 2002). During this trip I also met with researchers at Texas A&M University in College Station, Texas to discuss bison genetics issues. I pre-arranged meetings with herd managers as I travelled. I maintained contact with informants and collaborators via email and cellular phone. I also posted daily updates to a website I created for logging activities on the trip (www.notitia.com/roadtrip). I used a laptop computer and inkjet printer to provide mobile computing needs. I travelled to conduct the questionnaire in person to enable more relaxed and insightful interviews, improve rapport with the informants, and gather documents (Berg 2001).

Outreach

To support the processes of information gathering and collaboration I engaged in several outreach activities throughout the project. These activities allowed me to increase my profile in the bison management community, enhance rapport with BSG members and other status survey collaborators, share my project and preliminary findings, gather status information, and highlight the activities of the BSG.

- I attended the Symposium on Conservation Management of Bison in Northern Landscapes: Advances in Ecology and Epidemiology at The Wildlife Society Conference (September 25-29, 2001) in Reno, Nevada. During this conference, I organized a meeting with several members of the BSG to discuss status survey development.
- I volunteered as a summer worker at the Hook Lake Wood Bison Recovery Project (HLWBRP) (July 9-28, 2001).
- I presented the project to the Bison Research and Development Working Group (BRADWG) at the Bison Centre of Excellence, Leduc, Alberta (December 12, 2001).
- I participated in the wood bison round-up at Elk Island National Park (EINP) (January 7, 2002).
- I attended a meeting regarding the northern bison disease issue (January 25, 2002). Attendees included representatives from the Canadian Food Inspection Agency, Little Red River Tall Cree band, Fort Resolution, Fort Smith, Alberta Environment, Government of Northwest Territories, Canadian and Albertan cattle industries, Peace Country Bison Association, Canadian Wildlife Service, University of Calgary, University of Saskatchewan, and the Canadian Bison Association.

- I provided a distribution map of North American conservation plains bison herds for inclusion in the revised edition of Wild Mammals of North America (Reynolds *et al.* 2003).
- I presented the project at the Alberta Chapter of the Wildlife Society Conference in Edmonton, Alberta (March 8-9, 2002).
- I joined two park wardens from Banff National Park on an excursion up the Howse River to locate the Howse Bison Pound, an archaeological site described in the journals of David Thompson (September 20-22, 2002).
- I published two BSG activity reports in *Species*, the newsletter of the IUCN/SSC (Boyd and Gates 2001; Boyd and Gates 2002).
- I met with Carolina Caceres, Assistant to the Chair of the IUCN Species Survival Commission, in Hull, Quebec to establish contact and obtain IUCN literature and sample status surveys.
- I engaged in periodic dialogue with Wanda Olech, Chair of the European Bison Specialist Group, and with Mariano Gimenez Dixon, SSC Programme Officer at the IUCN Secretariat in Gland, Switzerland.

Information Analysis and Compilation Process

Data Organization

I used ProCite for Windows (Version 5.0) reference-organizing software to create a database of my literature findings and maintain citation information. Each entry in the database received a unique identification number, which I used to label the literature. I assigned keywords to each entry in the database after reviewing the documents for information relevant to the status survey. Keywords included status topic (e.g. genetics), location (e.g., Alaska), herd (e.g., Yellowstone), agency or organization (e.g., The Nature Conservancy), and name (e.g., Endangered Species Act). Citation information was entered into workforms that corresponded with the type of literature (Table 2.1). Roughly two-thirds of the literature used for this survey comprised peer-reviewed journals, books, and conference proceedings (Table 2.1). I organized herd-specific information, including documents, completed status questionnaires, consent forms, and notes, in files labelled by herd within portable filing boxes.

Table 2.1: Categories used to organize types of literature in ProCite 5.0.

Category	**Number of entries**
Peer-reviewed journals	163
Books and proceedings	130
Reports	52
Dissertations	9
Internet sources	52
Newspaper articles	2
General (brochures, unpublished materials)	10
TOTAL	**418**

I created a table in Microsoft Excel (Version 2002) to summarize the data obtained by the questionnaire process (Appendix 1). I used this table as a reference to obtain counts and calculate percentages for answering questions about trends that I wanted to include in the status chapters (e.g., how many (or what percentage) of herds are free-ranging?) I demonstrated some trends in the data by producing histograms and pie charts with Excel. I also created the data table with the intention of it being formatted as an appendix to the document. The status chapters focus on trends; those readers requiring detailed information on a specific herd can refer to the data in the appendix.

Mapping

I used maps to illustrate the geographic distribution of herds, and the original range of the species. All maps were created with MapInfo Professional 6.0 software.

Report Structure

I reviewed other IUCN status surveys to develop a logical structure for the bison status survey document. I determined that each IUCN survey has its own structure and components. Those surveys encompassing many species tend to discuss the general threats affecting the group of taxa, followed by species-specific and/or location-specific summaries (Shackleton 1997; Wemmer 1998; Snyder *et al.* 2000; Alberts 2000). Those with fewer conservation units tend to discuss each unit throughout several topic-specific chapters (Emslie and Brooks 1999). I opted for the latter format because this survey includes only two conservation units, plains bison and wood bison.

Early in project development I began outlining the status survey document. As described earlier, I sent the preliminary outline to the BSG when establishing the collaboration process. As the outline for the document evolved, I posted increasingly developed versions on the BSG website. The outline enabled me to visualize the entire document and establish realistic writing targets and schedules for document production.

Writing

I consulted references on technical communication and on strategies for writing a large document (Strunk and White 1979; Messenger and De Bruyn 1986; Rodman 1996; Zerubavel 1999). I used the outline for the document to provide a framework for the writing process. When writing a section I consulted the ProCite database to identify the literature relevant to subject. The analysis and compilation of the literature occurred simultaneously with the writing. I increased the efficiency of writing sessions by using the Cite While You Write™ feature in ProCite. This feature enables an author in Microsoft Word to insert the citation number from the ProCite database at the point where a citation is needed, and then scan the document at a later time to insert the formatted in-text citation.

As described in the collaboration process, I provided draft sections of the survey via the BSG website to members of the BSG for feedback and validation. Upon receipt of feedback I revised the drafts accordingly and repeated the process. This collaborative and iterative process enabled me to identify information gaps, issues, threats, and possible conservation actions, which I summarized in Chapter 10.

Chapter 3: Bison in the North American Context

Pre-historic Context

Bison have existed in various forms for over two million years (McDonald 1981; Danz 1997). Early forms originated in Asia and later moved into North America, by dispersing through Beringia, an unglaciated land mass that spanned eastern Siberia, Alaska, and the Yukon (Guthrie 1966; Cwynar and Ritchie 1980; van Zyll de Jong 1993). The evolutionary line leading to extant bison is controversial; however, there is general agreement on the basic sequence (van Zyll de Jong 1993). The Eurasian large-horned steppe bison (*Bison priscus*) invaded North America from Asia at least twice (Skinner and Kaisen 1947; Guthrie 1980; van Zyll de Jong 1993). The first invasion was during the Illinoian glaciation (beginning about 600,000 years ago) (Guthrie 1980; van Zyll de Jong 1993). When the ice sheets retreated, *B. priscus* moved south into the grasslands of central North America where it developed into the larger form *Bison latifrons*, which possessed a horn span of over two metres (Guthrie 1980; van Zyll de Jong 1993). *B. latifrons* dominated the Sangamonian interglacial period, but prior to the Wisconsin glaciation (approximately 90,000 years ago) it demonstrated a gradual reduction in size and horn span (Guthrie 1980; van Zyll de Jong 1993). The emergent smaller form, *Bison antiquus*, dominated the continent south of the ice sheet (Skinner and Kaisen 1947; van Zyll de Jong 1993). Concurrently, the Bering Land Bridge re-emerged allowing for a second northern invasion of the Eurasian *B. priscus* (van Zyll de Jong 1993). Therefore, during the Wisconsin glaciation two allopatric populations of bison existed in North America (van Zyll de Jong 1993).

During the remainder of the Pleistocene, beginning around 12,000-13,000 years ago, successive generations of *B. priscus* demonstrated a gradual reduction in size north of the ice sheet, leading to a new form, *Bison occidentalis* (Guthrie 1980; Stephenson *et al.* 2001). Evidence suggests that after the ice sheets retreated at the beginning of the Holocene, about 10,000 years ago, *B. occidentalis* may have invaded the southern grasslands and hybridized with *B. antiquus* (Wilson 1975; Guthrie 1980; van Zyll de Jong 1986). The modern plains bison likely evolved from these hybrids (van Zyll de Jong 1986). Concurrently, the northern *B. occidentalis,* being adapted to northern woodlands, became increasingly restricted to the northwestern parts of the range (van Zyll de Jong 1986). Fossil records suggest that extant wood bison (*B. bison athabascae*) are most similar to *B. occidentalis* and plains bison to *B. antiquus* (Guthrie 1980; van Zyll de Jong 1993), indicating that the wood bison is the more primitive of the two subspecies. Although the details of bison phylogeny are not completely understood, it is clear that the wood bison is the most recent northern variant and the plains bison the most recent southern variant of the species in North America (Stephenson *et al.* 2001).

Historical Context

Numbers

Historical and archaeological records demonstrate that plains bison thrived on the grasslands (Malainey and Sherriff 1996; Shaw and Lee 1997). Explorers, settlers, and buffalo hunters described massive herds of plains bison and provided population estimates ranging from 15 to 100 million (Dary 1989; Shaw 1995). The most commonly cited number is 60 million proposed by naturalist Ernest Thompson Seton in the early 1890s (Roe 1970; McHugh 1972; Dary 1989; Shaw 1995). There were several methods used to estimate pre-settlement bison numbers, including observation, carrying capacity calculations, and counts of bison killed for market; all of these methods were fraught with uncertainty, untested assumptions, and arbitrary guesses (Shaw 1995). Nevertheless, there is little doubt that prior to European settlement plains bison numbered in the millions, and more likely in the tens of millions (Shaw 1995). Wood bison were not as numerous as plains bison, although they inhabited a vast region of the boreal forest (Gates *et al.* 2001c). Soper (1941) estimated the total wood bison population in 1800 to be 168,000 animals.

Range

Bison originally ranged across most of North America (Figure 3.1). Plains bison were most abundant on the Great Plains, but they also radiated eastward into the Great Lakes region, over the Allegheny Mountains, and toward the eastern seaboard into Florida; westward into the Nevada, Cascade, and Rocky Mountains; northward to mid-Alberta and Saskatchewan; and southward along the Gulf of Mexico into Mexico (Reynolds *et al.* 1982; Danz 1997). There are also records of bison occurring at high elevations in mountainous regions (Fryxell 1928; Meagher 1986; Kay and White 2001).

Previous range designations for the wood bison divided the range into “prehistoric” and “historic” areas (van Zyll de Jong 1986). Recent research incorporating

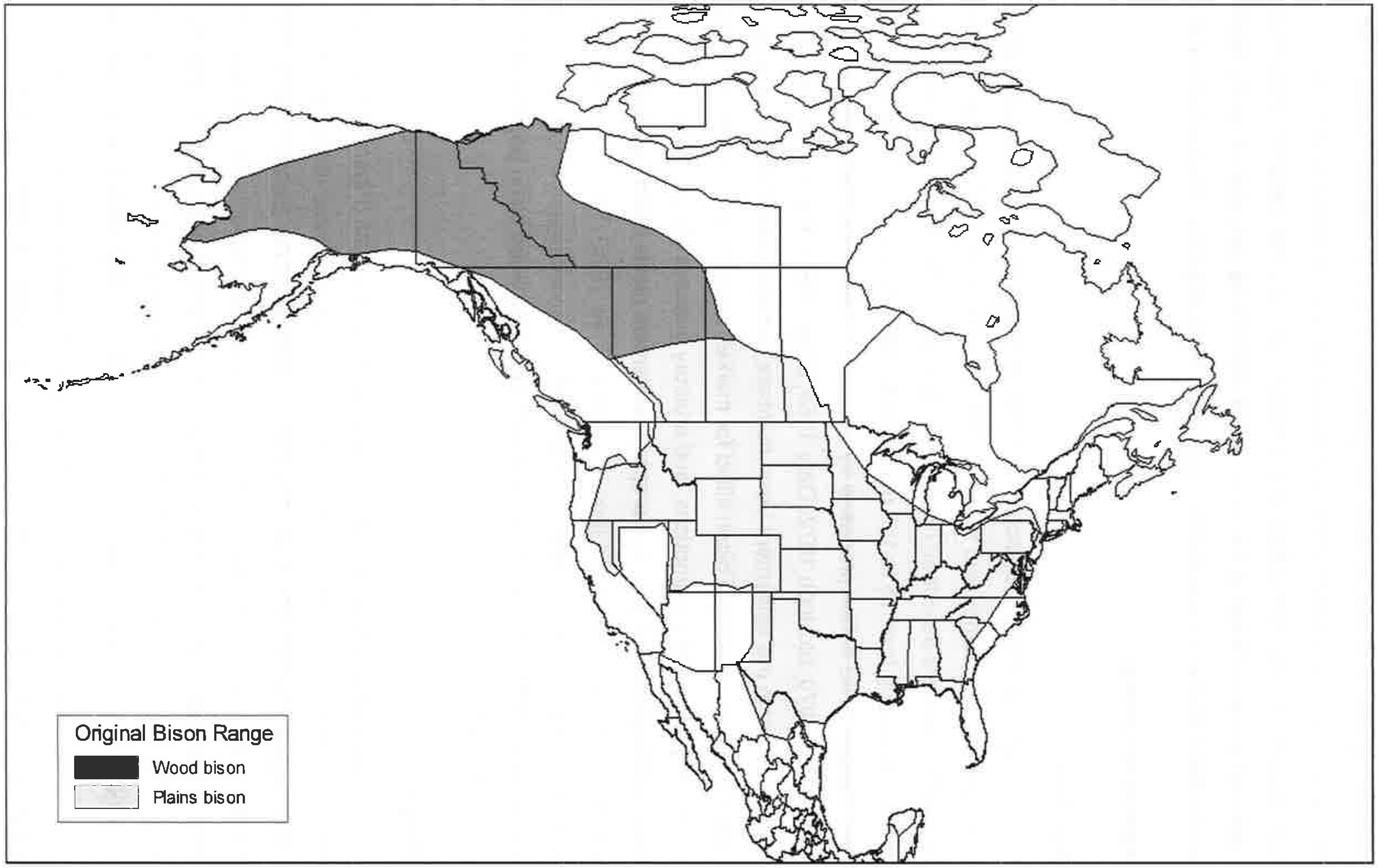

Figure 3.1: Original range of plains bison and wood bison. Recreated from van Zyll de Jong (1986) and Gates et al. (2001c).

oral narratives of aboriginal people in Alaska, Yukon, and Northwest Territories, as well as additional archaeological and paleontological evidence, demonstrates that wood bison were present in the Yukon and Alaska within the last two centuries (Lotenberg 1996; Stephenson *et al.* 2001). Therefore, these areas are part of the historic and original range of wood bison. The distinction between prehistoric and historic range is not based on objective and biologically meaningful criteria, and creates an artificial and confusing temporal dichotomy (Stephenson *et al.* 2001). Therefore, it is more practical and accurate to refer to the previous range of wood bison as "original" range (Gates *et al.* 2001c). The original range of wood bison included northern Alberta, northeastern British Columbia, a small area of northwestern Saskatchewan, the western Northwest Territories, Yukon, and much of Alaska (Gates *et al.* 2001c).

Decline

Bison were rapidly reduced in abundance following European settlement. The nomadic nature of bison may have temporarily masked the decline of the herds (Mayer and Roth 1958; Danz 1997); however, by the late 1800s it was clear that the North American bison population had been decimated. Commercial hunting by North American aboriginals and Euroamericans for meat and hides was the primary cause of the decline (Hornaday 1889; Isenberg 2000). Other contributing factors included subsistence hunting, indiscriminate slaughter for sport, and transection of the plains by railroads (Hewitt 1919; McHugh 1972; Dary 1989; Danz 1997; Isenberg 2000). Environmental factors such as regional drought, introduced bovine diseases, and competition from domestic livestock and domestic and wild horses also played a role (Flores 1991; Isenberg 2000). Additionally, because bison provided sustenance for North American aboriginals and commodities for their barter economy, the elimination of bison was viewed by Euroamericans as an efficient method to force the aboriginal population onto reserves and allow for continued western development (Mayer and Roth 1958; Geist 1996; Danz 1997; Isenberg 2000). To this end, the US government unofficially supported the slaughter of bison by providing ammunition and supplies to commercial buffalo hunters (Mayer and Roth 1958). Although it did not espouse an overt political policy to support the bison slaughter, the Canadian government did capitalize on the widespread hunger among aboriginal communities caused by the absence of bison, as a means to subjugate the aboriginal population (Geist 1996; Stonechild and Waiser 1997). By the late 19th Century it was estimated that there were fewer than 1,000 bison in North America (Hornaday 1889; Seton 1927). Wood bison were concentrated in northern Alberta and the Northwest Territories, and plains bison were scattered in isolated groups across their former range.

Recovery

As the great herds diminished there was limited public outcry, but few laws were enacted to protect the bison (Chapter 8) (Danz 1997). Most early bison conservation efforts occurred through the independent actions of private citizens. Prominent figures in the conservation movement included James McKay and Charles Alloway (Manitoba), Charles Goodnight (Texas), Walking Coyote (Montana), Frederick Dupree (South Dakota), Charles J. Jones (Kansas), and Michel Pablo and Charles Allard (Montana) (Coder 1975; Dary 1989; Geist 1996; Danz 1997). Their efforts to establish herds from the few remaining bison secured the foundation stock for most contemporary public and private plains bison herds.

Formed in 1905, the American Bison Society pressed Congress to establish several public bison herds at Wichita Mountains National Wildlife Refuge, the National Bison Range, Sullys Hill National Game Preserve, and Fort Niobrara National Wildlife Refuge (Coder 1975; Danz 1997). National parks in both the United States and Canada also figured prominently in bison recovery efforts (Ogilvie 1979; Danz 1997).

Once plains bison were protected from hunting, their numbers increased considerably, doubling between 1888 and 1902 (Coder 1975). By 1909, the subspecies was considered safe from extinction (Coder 1975). Initially sparked by reverence for the animal and nostalgia, motivations for bison recovery became increasingly driven by commercial value (Yorks and Capels 1998). By 1970, there were 30,000 plains bison in North America, with approximately half in public herds located in national parks, wildlife refuges, and state wildlife areas, and half in private herds (Shaw and Meagher 2000). As presented in this survey (Chapter 5), the number of plains bison currently residing in conservation herds is approximately 19,200, while the number under commercial ownership is approximately 500,000 and growing (Carter 2002, pers. comm.; Conacher 2002, pers. comm.).

The wood bison population reached a low of 250 animals, but then slowly grew to 1,500-2,000 by 1922 owing to the enforcement of Canadian laws enacted to protect the animal (Soper 1941; Gates *et al.* 2001c). This survey determined that the wood bison conservation population is approximately 8,945, 54% of which is in herds infected with bovine brucellosis and tuberculosis. It is estimated that commercial wood bison account for fewer than 2,000 animals (Conacher 2003, pers. comm.).

Cultural Significance

There are few animals that carry with them so much history, political significance, and cultural importance as bison. Various forms of bison have coexisted with human beings, providing sustenance and shaping human social and economic patterns. North American aboriginal cultures made the bison a central figure in many of their folktales, rituals, dances, and ceremonies (Wissler 1927). Politically, the presence of the animal represented a barrier to the control of aboriginal populations and, consequently, growth of Euroamerican civilization. Bison also have tremendous commercial significance, as demonstrated historically by the subsistence economies of aboriginals, and the market-driven slaughter of bison for meat and robes (Isenberg 2000), as well as in modern times by the exponential growth of commercial bison production.

The bison is an icon representing the vanished days of the West, strength and endurance, and even humanity's sometimes questionable reputation for wildlife management (Dary 1989). The bison is immortalized as a symbol on currency and stamps, and institutionalized as a logo by school sports teams, government departments, and businesses (Dary 1989; Berger and Cunningham 1994; Geist 1996). Every year millions of tourists visit various publicly-owned herds across North America to view these majestic animals. It is clear that North Americans, and indeed other societies around the world, are connected to, and fascinated by, this animal that has contributed in so many ways to shaping North American cultures.

Chapter 4: Taxonomy

Despite the notable commercial, historical, and iconic integration of bison into North American society, there is considerable confusion and disagreement about bison taxonomy. The issues range from a historical discrepancy over the common name, to ongoing scientific debate over the systematics for the genus and subspecies designations.

An Historical Misnomer

A logical way to begin the discussion of bison taxonomy is to clarify an often misunderstood distinction – the bison is not a buffalo. Although both bison and buffalo belong to the same family, Bovidae, true 'buffalo' are native only to Africa (cape buffalo, *Syncerus caffer*) and Asia (water buffalo, *Bubalus* sp.). The origin of 'buffalo' as a reference to North American bison is unclear. One view is that the word 'buffalo' is derived from terms in other languages used by explorers to describe the unfamiliar beast, including, *bisonte, buffes, buffelo, buffles, and buffilo* (Dary 1989; Danz 1997). These terms are similar to *bufle* and *buffe*, which were commonly used to refer to any animal that provided good hide for buff leather (Danz 1997). Despite the misnomer, the term 'buffalo' has been used interchangeably with 'bison' since early explorers first discovered the North American species (Reynolds *et al.* 1982), and has become entrenched as a colloquialism in North American culture and language.

Although bison historians, ranchers, biologists, and managers are aware of the correct name, the term 'buffalo' persists as an accepted convention for nostalgic reasons. The intermittent and continued used of the popular name 'buffalo' does create some confusion for the general public, prompting people to question the difference, or develop their own erroneous theories, such as 'plains bison are buffalo, and wood bison are bison'.

Genus: *Bos* vs. *Bison*

When Linnaeus first classified the bison in 1758 for his 10th Edition of the *Systema Naturae*, he assigned the animal to *Bos*, the same genus as domestic cattle (Wilson and Reeder 1993). During the 19th Century, taxonomists determined that there was adequate anatomical distinctiveness to warrant assigning the bison to its own genus (Shaw and Meagher 2000). Therefore, in 1827, C. Hamilton Smith assigned the sub-generic name *Bison* to the American bison and the European bison (wisent) (Skinner and Kaisen 1947). In 1849, Knight elevated the subgenus *Bison* to the level of genus (Skinner and Kaisen 1947). Since then, taxonomists have debated the validity of the genus. Some argue that bison are not sufficiently distinct from cattle, guar, yak, and oxen to warrant a distinct genus (Gardner 2002, pers. comm.). During the last two decades, as molecular genetic and evolutionary evidence emerged, scientists used *Bos* with increasing frequency, contributing to the long-standing debate. Discrepancies in the genus are reflected in the major cataloguing centres and books. For example, the Canadian Museum of Nature (Balkwill 2002, pers. comm.) and the Smithsonian National Museum of Natural History in its publication *Mammal Species of the World* (Wilson and Reeder 1993) use *Bison*, while the Royal Ontario Museum uses *Bos* (Eger 2002, pers. comm.).

The debate over the appropriate genus arises from the conflict between the traditional practice of assigning names based on similar features distinguishable by morphology (the phenetic approach) versus using evolutionary relationships (the phylogenetic approach) (Winston 1999; Freeman and Herron 2001). Systematists develop evolutionary trees by analyzing shared derived characteristics (Winston 1999; Freeman and Herron 2001). In this scheme, only monophyletic groups, or clades, which represent all descendants of a common ancestor, are named. A phenetic scheme might assign names to partial clades, or paraphyletic groups, which exclude one or more descendants (Freeman and Herron 2001). Some taxonomists and systematists suggest that the traditional naming system be replaced with a phylogenetic scheme (Freeman and Herron 2001). While not all biologists agree that this is wise, given that a strictly phylogenetic scheme would ignore many functionally and ecologically important differences among species (Freeman and Herron 2001), the phylogenetic approach does provide some useful insights about evolutionary relationships within Bovidae.

Bison reside within the family Bovidae, subfamily Bovinae, tribe Bovini, which currently contains four genera: *Bubalus* (Asian water buffalo); *Syncerus* (African buffalo); *Bos* (domestic cattle and their wild relatives), and *Bison* (bison) (Wall *et al.* 1992). Studies of both nuclear-ribosomal DNA (Wall *et al.* 1992) and mitochondrial DNA

(Miyamoto *et al.* 1989; Miyamoto *et al.* 1993) within this tribe have revealed that the genus *Bos* is paraphyletic with respect to the genus *Bison*. Mitochondrial DNA studies do not support the traditional organization of the tribe Bovini because the yak (*Bos grunniens*) is more closely related to bison than to its congener cattle (*Bos taurus)* (Miyamoto *et al.* 1989; Miyamoto *et al.* 1993). Ribosomal DNA studies have not fully clarified this relationship (Wall *et al.* 1992); however, skeletal analysis by Groves (1981) noted that bison and yak have 14 thoracic vertebrae while other bovids have only 13.

A comparison of various phylogenetic trees for the tribe Bovini illustrates the naming conflict. Figure 4.1(a) depicts a convention based on morphological characteristics (Bohlken 1958), while Figures 4.1(b-d) show different interpretations based on cranial or genetic evidence. Although Figures 4.1(b-d) do not share identical branching patterns for every species, the position of *Bison* is equally incongruous in all three alternatives to the conventional scheme (Figure 4.1(a)). Each alternative demonstrates that *Bos* is paraphyletic because it is lacking one of its descendant branches (*Bison*). Even if looked upon logically, it is apparent that the position of *Bison* is incongruous with the pattern of development. In the conventional scheme, *Bos* branched off the tree later than *Bison* (Figure 4.1(a)); however, the arrangements based on more recent evidence suggest that a *Bos* branch was followed by *Bison*, then by *Bos* again (Figure 4.1(b-d)). Under a phylogenetic scheme, bison would need to be included in the *Bos* clade to correct this incongruity.

For decades, there have been suggestions made to combine *Bison* and *Bos* into one genus (Stormont *et al.* 1961; van Gelder 1977; Gentry 1978; Groves 1981; Baccus *et al.* 1983). Studies of DNA, blood types, and chromosomal, immunological, and protein sequences demonstrate that *Bison* and *Bos* are genetically similar (Stormont *et al.* 1961; Bhambhani and Kuspira 1969; Dayhoff 1972; Wilson *et al.* 1985; Beintema *et al.* 1986; Kleinschmidt and Sgouros 1987). Additionally, the percent divergences among the mtDNA sequences of *Bison bison*, *Bos grunniens*, and *Bos taurus* are comparable to those calculated among other sets of congeneric species (Miyamoto *et al.* 1989). Reproductive information also supports the relationship between *Bos* and *Bison*, given that *Bison bison* and some members of *Bos* can hybridize to produce fertile female offspring (Miyamoto *et al.* 1989; Wall *et al.* 1992; Ward 2000).

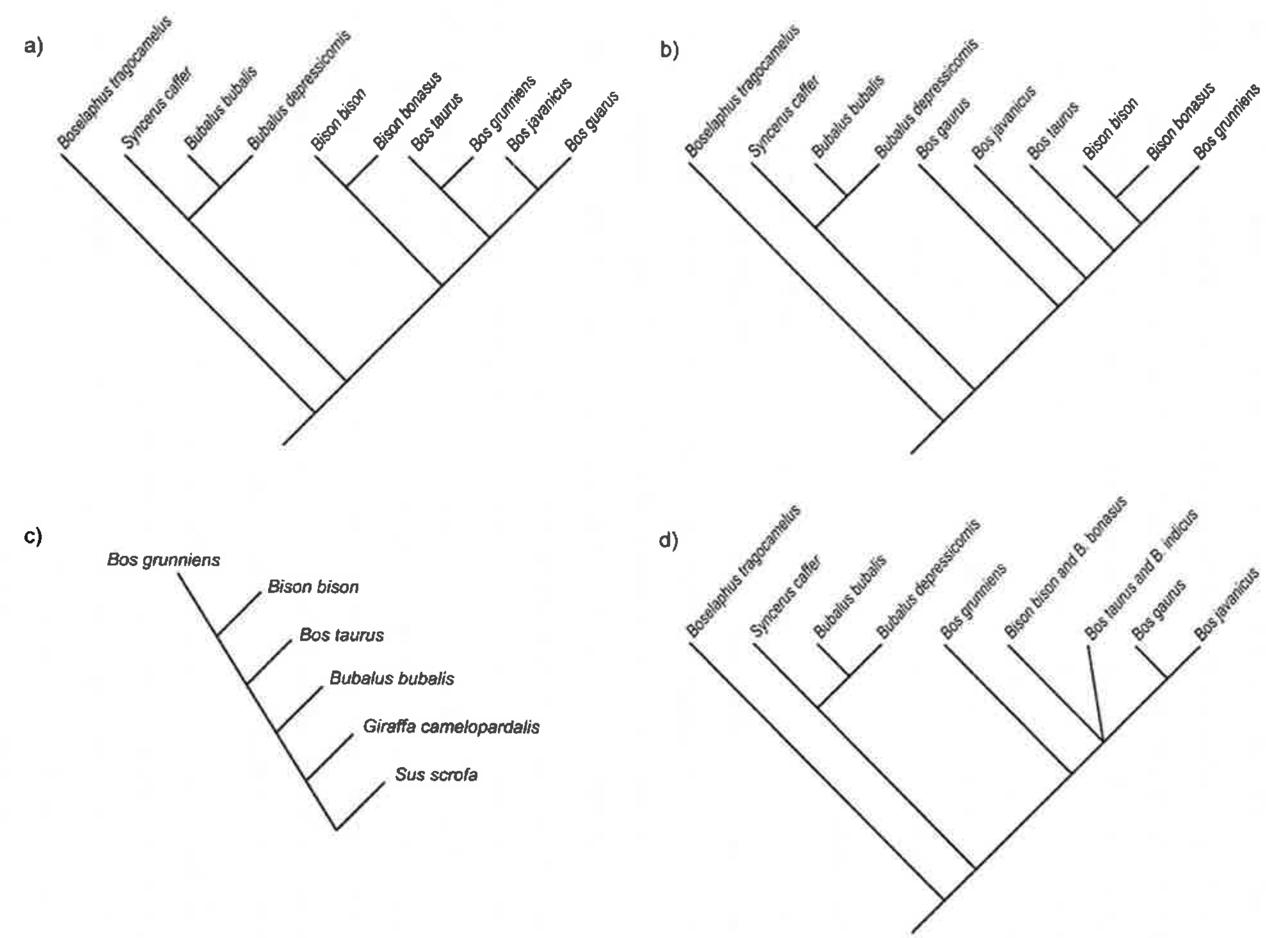

Figure 4.1: Comparison of phylogenetic hypotheses for the tribe Bovini based on: (a) conventional morphological analysis (Bohlken 1958); (b) cladistic analysis of cranial characteristics (Groves 1981); (c) mtDNA sequences (Miyamoto et al. *1989); and (d) ribosomal DNA analysis (Wall* et al. *1992).*

The assignment of genera in traditional naming schemes can be subjective (Gardner 2002, pers. comm.). The original assignment of bison to its own genus may reflect morphological evidence that does not qualify the bison forms for separate naming under a phylogenetic scheme. Changing generic names can create confusion and contravene the goal of taxonomy, which is to stabilize nomenclature (Winston 1999); however, Gardner (2002, pers. comm.) cautioned that maintaining a stable nomenclature should not occur at the expense of misrepresenting relationships. Despite the tendency to maintain the *Bison* genus for nostalgic reasons, it appears that converting bison to the genus *Bos* [Linnaeus 1758] will reflect evolutionary relationships and genetic similarities of bison and *Bos* species. This change would also provide continuity and stability to a species name that currently has two genera in common use.

Subspecies Debate

The most controversial aspect of bison taxonomy is the legitimacy of the subspecies designations for plains bison (*Bos bison bison*) and wood bison (*Bos bison athabascae*). The two subspecies were first distinguished in 1897 when Rhodes formally recognized the wood bison subspecies as *Bison bison athabascae* using descriptions of an animal (Geist 1991). Although it is clear that the two variants differ in outward morphology and pelage characteristics (Table 4.1), some taxonomists argue that these differences alone do not adequately substantiate subspecies designation. There are various lines of debate, which consider geographical variation, morphological traits, environmental influence, and molecular and genetic comparison. The issue is complicated by the human-induced hybridization between plains and wood bison forms that occurred in Wood Buffalo National Park (WBNP) during the 1920s. Furthermore, the concept of what constitutes a subspecies continues to develop.

The assignment of subspecific status varies with the organism, the taxonomist, and which of the various definitions of subspecies is applied. Mayr and Ashlock (1991:430) define a subspecies as *"an aggregate of local populations of a species inhabiting a geographic subdivision of the range of the species and differing taxonomically from other populations of the species."* Avise and Ball (1990:59-60) adapted their definition from the Biological Species Concept, which defines species as groups of organisms that are reproductively isolated from other groups (Mayr and Ashlock 1991): *"Subspecies are groups of actually or potentially interbreeding*

Table 4.1: Comparison of structural and pelage characteristics for the two bison subspecies.

Plains bison *Bos bison bison*	**Wood bison** *Bos bison athabascae*
	
Pelage characteristics	
Dense woolly bonnet of hair between horns	Forelock dark, hanging in strands over forehead
Thick beard and full throat mane, extending below rib cage	Thin beard and rudimentary throat mane
Well-developed chaps	Reduced chaps
Well-demarcated cape, lighter in colour than wood bison	No clear cape demarcation, hair usually darker than plains bison
Structural Characteristics	
Highest point of the hump over front legs	Highest point of the hump forward of front legs
Horns rarely extend above bonnet	Horns usually extend above forelock
Smaller and lighter than the wood bison (within similar age and sex classes)	Larger and heavier than plains bison (within similar age and sex classes)

populations phylogenetically distinguishable from, but reproductively compatible with, other such groups." Crucial to this definition is that the evidence for phylogenetic distinction must derive from multiple, independent, genetically-based traits (Avise and Ball 1990). Essentially, subspecies should demonstrate several conspicuous morphological differences, geographic allopatric population patterns, and normally possess genetic divergences at several genes (Winston 1999). Hybridization between subspecies is possible along contact interfaces; however, hybrids may experience reduced fitness (Winston 1999).

The fossil record and observations of variability among living bison suggest that the species exhibited considerable geographic variation. This variation led to claims identifying various forms of the species, most notably a northern and a southern plains bison, which differed in pelage and conformation (van Zyll de Jong 1993). Analysis of cranial, horn, and limb measurements for plains bison suggests clinal variation along a north-south axis (McDonald 1981; van Zyll de Jong 1993). It is possible that outward characteristics, such as pelage colouration, also varied along this axis (van Zyll de Jong *et al.* 1995). Therefore, while there may have been two forms of plains bison, they were linked by a continuous gradation of intermediate forms, making recognition of the north and south forms impossible.

Unlike the clinal variation among plains bison, a phenotypic discontinuity exists between plains bison and wood bison (van Zyll de Jong 1993), reflected in size and in morphological differences independent of size (van Zyll de Jong 1986; Gates *et al.* 2001c). Discontinuous variation occurs when a barrier impedes gene flow between populations of a species, causing genetic differences to accumulate on either side of the barrier (van Zyll de Jong 1992). Reproductive isolation caused by differing habitat preferences and seasonal movements, as well as the natural barrier formed by the boreal forest, contributed to maintaining the phenotypic differences between plains bison and wood bison (van Zyll de Jong 1986; van Zyll de Jong 1993; Gates *et al.* 2001c). The discontinuity is further substantiated by the evidence that wood bison are more closely related to the early Holocene bison *B. occidentalis*, which remained in the north, and plains bison are more closely related to *B. antiquus*, which ranged in the south (van Zyll de Jong 1993; Stephenson *et al.* 2001).

The allopatric distribution and quantified phenotypic differences between the bison subspecies are consistent with the subspecies concept. However, there has been the suggestion that the two subspecies are actually ecotypes, (i.e., morphological differences are a reflection of local environmental influences rather than heritable traits) (Geist 1991). However, this idea is not supported by the observations that wood bison transplanted from their original habitat near the Nyarling River in WBNP to very different environments in the Mackenzie Bison Sanctuary (in 1963) and Elk Island National Park (EINP) (in 1965), do not differ from each other, or from other specimens taken from the original habitat (van Zyll de Jong 1986; van Zyll de Jong *et al.* 1995). Further, despite the passing of nearly 40 generations, the EINP wood bison, which live under the same conditions as plains bison residing separately on the other side of the park, show no evidence of metamorphosing toward the plains bison form (van Zyll de Jong 1986; van Zyll de Jong *et al.* 1995). Similarly, plains bison introduced to Delta Junction, Alaska in 1928 from the National Bison Range in Montana have clearly maintained the phenotypic traits of plains bison (van Zyll de Jong 1992; van Zyll de Jong *et al.* 1995). Such evidence suggests that the morphological characteristics that distinguish plains and wood bison are genetically controlled (van Zyll de Jong *et al.* 1995).

Hybridization between the subspecies in WBNP after an introduction of plains bison during the 1920s complicates the consideration of subspecies designations. The controversial decision to move 6,673 plains bison from Wainwright Buffalo Park in southern Alberta to WBNP in 1925-28 resulted in the introduction of bovine diseases to the wood bison (Chapter 7), and threatened the distinctiveness of the subspecies. In 1957, Canadian Wildlife Service researchers discovered an isolated population of 200 wood bison near Nyarling River and Buffalo Lake. The researchers believed that this herd had remained isolated from the hybrid herds, and therefore, represented the last reservoir of original wood bison (Banfield and Novakowski 1960; Ogilvie 1979; van Camp 1989). In an effort to salvage the wood bison subspecies, in the 1960s bison from the Nyarling herd were used to establish the Mackenzie and EINP wood bison herds. Later analysis has indicated that the Nyarling herd, and bison elsewhere in WBNP and adjacent areas, did have contact with the introduced plains bison (van Zyll de Jong 1986; Aniskowicz 1990), but it was minimal enough that the animals continued to exhibit predominately wood bison traits (van Zyll de Jong *et al.* 1995). Studies on the impact of the plains bison introduction have determined that the hybridization did not result in a phenotypically homogeneous population, as was feared (van Zyll de Jong *et al.* 1995). Sub-populations within WBNP demonstrate varying degrees of plains bison traits depending on their proximity to, or ease of access from, the original plains bison introduction site (van Zyll de Jong *et al.* 1995).

Descriptive morphology and quantitative morphometry provide substantial evidence supporting the subspecific designations. Earlier analysis of blood characteristics and chromosomal homology, however, did not detect a difference (Stormont *et al.* 1961; Ying and Peden 1977; Peden and Kraay 1979). Preliminary analysis of growth regulating genes within the two subspecies suggests that the bison subspecies have reached a stage of geographic isolation in their evolutionary divergence (Bork *et al.* 1991); however, subspecies are normally defined at the next stage of speciation when hybrid offspring exhibit reduced fitness, which does not appear to be the case in WBNP (Bork *et al.* 1991). Further, analysis of mitochondrial DNA (mtDNA) from Nyarling River wood bison and plains bison did not distinguish the two subspecies (Strobeck 1991; 1992; 1993). This, however, does not mean that there is no difference. In isolated populations, mtDNA diverges at a rate of 1-2% per million years (Wilson *et al.* 1985). It is estimated that the two bison subspecies diverged approximately 5,000 years ago (Wilson 1969; van Zyll de Jong 1993); therefore, current genetic analysis techniques may not yet be able to detect the differences in the mitochondrial genome. Further, mtDNA is maternally inherited. Therefore, the mtDNA within the Nyarling River herd, as well as other herds in WBNP, reflects the contribution from the maternal population, which had a biased representation of plains bison cows (Gates *et al.* 2001c). Therefore, the inability to detect a difference in a molecular test comparing limited sequences of genomic material does not necessarily mean that there is no genetic difference.

Analysis of phenotypic variation among plains and wood bison, and their hybrids suggests genetic differentiation (van Zyll de Jong *et al.* 1995). Recent studies of DNA microsatellites indicate that the genetic distances between plains bison and wood bison are greater than those within either of the two subspecies (Wilson and Strobeck 1999; Wilson 2001). Further, the wood bison populations studied formed a distinctive group on a Nei's minimum unrooted tree; a strong grouping despite the pervasive hybridization with plains bison (Wilson and Strobeck 1999; Wilson 2001). Wilson and Strobeck (1999) and Wilson (2001) concluded that such a strong clustering indicates that wood bison are functioning as distinct genetic entities from plains bison, and should continue to be managed separately. Based on the available evidence, the National Wood Bison Recovery Team concluded that (1) historically, multiple morphological and genetic characteristics distinguished the wood bison from the plains bison; (2) wood bison and plains bison continue to be morphologically and genetically distinct, despite hybridization; and (3) wood bison constitute a subspecies of bison, and therefore, should be managed separately from plains bison (Gates *et al.* 2001c).

Taxonomy in Perspective

The purpose of naming organisms is to identify patterns and apply practical structure to the natural world. Taxonomy can assist with the conservation and sustainable use of biological diversity by contributing to identification, assessment, and monitoring programs (Environment Australia 1998). Taxonomy is also vital for the creation and interpretation of laws, treaties, and conservation programs, because it creates legal identities for organisms (Geist 1991). While it is important to strive for accuracy in taxonomic classification, semantic issues can create substantial management challenges by distracting conservation decision makers from the issues threatening a taxon or conservation unit.

While there appears to be sufficient grounds for formal recognition of the bison subspecies, the debate may continue. This, however, should not preclude conservation of the two forms as separate entities (van Zyll de Jong *et al.* 1995). Establishing definitive recognition of bison subspecies is complicated by the ongoing change of the species and subspecies concepts (Winston 1999). However, there are emerging classifications, such as the evolutionarily significant unit (ESU), that move beyond the traditional taxonomic regime and attempt to incorporate evolutionary considerations. Conservation biologists are also considering definitions of conservation units that incorporate both the history of populations through molecular analysis, and adaptive differences revealed by life history and other ecological information (DeWeerdt 2002). For example, the geminate evolutionary unit (GEU) identifies conservation units that are genetically similar but ecologically or behaviourally distinct (Bowen 1998). Each of these concepts presents challenges, as will any concept that attempts to divide the biological continuum for the convenience of human managers. Nevertheless, it is clear that there are many ways to divide the continuum. Therefore, differentiation on any level within a species will warrant a formal decision and recognition. Regardless of whether there is currently definitive genetic, chromosomal, biochemical, or other molecular evidence of a difference between bison subspecies, there are notable phenotypic differences, and potentially other types of variation that may not be detectable at this time. Geneticists predict that genetic analysis in the future will be able to better identify groupings within species (Wilson 2001). Therefore, it would not be prudent to prematurely dismiss existing groupings such as the plains and wood bison.

Although genetic and morphological evidence often correspond, this is not always the case (Winston 1999). This can lead to debate over recognizing non-genetically based variation. Nevertheless, all forms of geographic and ecological variation contribute to the biodiversity of an ecosystem (Secretariat of the Convention on Biological Diversity 2000). All variants may carry evolutionarily important ecological adaptations, and possess the potential to develop genetic isolating mechanisms and thereby become new species (O'Brien and Mayr 1991). Prediction of which variants will evolve to become species is not possible, as this is the role reserved for natural selection. Therefore, to maintain biodiversity and evolutionary potential, it is important to not dismiss any form of differentiation within a species, and to maintain the opportunity for evolutionary processes (Crandall *et al.* 2000). Debating whether a name is warranted within a relatively arbitrary taxonomic system does not absolve humans of the responsibility to recognize and maintain intraspecific diversity as the raw material for evolution.

Chapter 5: Population Status and Management

Population persistence is a probabilistic function of numerous factors including demographic, environmental, and genetic uncertainty, and natural catastrophes (Shaffer 1981; Shaffer 1987; Meffe and Carroll 1994). There are two central principles related to the probability of persistence of a population: (1) the smaller the population, the more likely it will become extinct; and (2) the longer the period of time the more likely a population will become extinct regardless of size (Shaffer 1987). The complexity and uncertainty inherent in population dynamics has stimulated ongoing study of how many individuals are required to maintain a viable population and to prevent extinction (Soulé 1980; Shaffer 1981; Soulé 1987b; Mangel and Tier 1993; Lynch and Lande 1998; Franklin and Frankham 1998; Reed and Bryant 2000). A viable population is one that maintains its vigour and its potential for evolutionary adaptation (Soulé 1987a). A minimum viable population (MVP) is the smallest population size that provides a high probability of persistence for a given time period (Soulé 1980; Shaffer 1981; Soulé 1987a). The MVP concept considers (1) levels of genetic diversity needed to maintain evolutionary processes; (2) effects of chance events; (3) the time frame for persistence; and (4) the degree of security sought for the target population (Shaffer 1987).

An MVP is the product of a population viability analysis (PVA), a systematic process that estimates the persistence of a population by examining the interacting factors that place a population at risk (Gilpin and Soulé 1986; Shaffer 1990). An MVP is also influenced by economic, social, cultural, and political values, which determine the acceptable probability and timeframe for persistence of a population or species (e.g., 95% probability of persistence for 100 years) (Shaffer 1987; Soulé 1987a; Meffe and Carroll 1994). Therefore, the requirement for population- or species-specific analysis to determine an MVP dictates that no single MVP is universally applicable to all populations or species (Gilpin and Soulé 1986; Soulé 1987a). As such, the theoretical guidelines for MVPs range from hundreds to millions (Shaffer 1987). Soulé (1987c) speculated that the lowest MVP for a vertebrate, assuming a 95% probability of persistence for several centuries, would be in the low thousands. Other authors have argued the need for higher MVPs to increase the genetically effective population size (N_e) (Lynch and Lande 1998). The N_e represents the ideal population that undergoes the same amount of change in genetic diversity as the actual population under consideration (Wright 1969; Berger and Cunningham 1994). An ideal population is a theoretical concept representing a large, randomly mating population with constant population size, non-overlapping generations, a 1:1 breeding sex ratio, even progeny distribution among females, and no selection (Meffe and Carroll 1994). Under these ideal conditions all individuals have equal probability of contributing their genes to the next generation (Meffe and Carroll 1994). Given that ideal conditions are not possible, the N_e represents the number of individuals in a population that are actually transmitting their genes to subsequent generations. There is no consensus on sufficient N_e values, which consider the genetic uncertainty incorporated into an MVP. Franklin (1980) suggested $N_e = 500$ for a population to retain its evolutionary potential, while more recent assessments suggest an increase to 1,000-5,000 (Lynch and Lande 1998). Through statistical review of N_e/N ratios for numerous species, Frankham (1995) determined that the average N_e is 10-34% of the actual population size (N). Therefore, for purposes of genetic maintenance the theoretical MVP would be approximately 1,500-5,000 (@ $N_e = 500$) or 15,000-50,000 (@ $N_e = 5,000$).

Theoretical values for MVPs are generally high and uncertain, varying by two or three orders of magnitude depending on the species, environment, timeframe, and chosen degree of risk (Soulé 1987c). Therefore, it is likely that a theoretical MVP could be too large to be achieved by a single bison herd. This situation may require interjurisdictional cooperation and management of several populations as metapopulations (Soulé 1987c). Nevertheless, empirical evidence suggests that reasonable persistence of bison populations may be achieved at a lower MVP. Berger (1990) found populations of 100+ bighorn sheep to persist for up to 70 years while populations under 50 went extinct in under 50 years. This finding supports the general understanding that populations with fewer than 50 individuals are often too small to remain viable because they rapidly lose genetic variation and are prone to extinction by a natural catastrophe (Meffe and Carroll 1994). Thomas (1990) provided further guidelines for MVPs by examining empirical evidence of bird extinctions. His analysis suggests that 10 is much too small, 100 is usually inadequate, 1,000 is adequate for populations exhibiting normal population fluctuations, and 10,000 should provide medium to long-term persistence for more variable populations of most birds and mammals. Large-bodied species with long life spans tend to experience less severe population fluctuations than do smaller short-lived organisms (Reed and Bryant 2000).

Therefore, it is possible that the MVP for bison is between 100 and 1,000. The Canadian National Wood Bison Recovery Team (WBRT) inferred an MVP of 400 for bison from a study of mammal populations in western North American national parks (Newmark 1995). No other MVP estimates currently exist for bison.

Numerical Status

Numerical status refers to the number of bison both within individual populations and in total in North America. Knowledge of numerical status is necessary for evaluating the persistence of individual populations and the two subspecies. There are currently over 500,000 bison in North America including both commercial and conservation populations (Carter 2002, pers. comm., Conacher 2002, pers. comm.). This survey enumerated only conservation herds. Populations with over 400 individuals are not automatically considered viable, as there may be mitigating factors affecting viability (e.g., disease). Nevertheless, the following numerical summary makes distinctions based on an MVP of 400. The recorded number of bison in each herd may differ from the actual number of animals because not all herds have undergone a recent census, census techniques may not account for every animal, herds are not always culled to the same number, and herd size varies annually.

There are 50 plains bison conservation herds in North America within the scope of this survey (Table 5.1). Thirty-two percent of these herds have 50 or fewer bison (Figure 5.1). Thirteen herds have populations greater than 400 (Figure 5.1). The number of plains bison in conservation herds is estimated at 19,200, with 90% in the United States, 10% in Canada, and none in Mexico (Table 5.1). Only 22% of plains bison conservation herds are currently increasing in size (Figure 5.2). There has been a report of a potential transboundary plains bison conservation herd straddling the Mexico-US border (Ceballos 2003, pers. comm.); the nature and status of this herd is unclear.

There are 16 wood bison conservation herds in North America within the scope of this survey (Table 5.2). Four of these herds have populations greater than 400 (Figure 5.1). The number of wood bison in conservation herds is estimated at 8,945 (Table 5.2). Fifty percent of wood bison conservation herds are increasing in size, while 25% have unknown population trends (Figure 5.3).

Table 5.1: Numerical status of plains bison conservation herds in North America. Numbers refer to locations on the map in Figure 5.4.

	HERD	Location	Jurisdiction	Managing Authority	Population	Trend
	UNITED STATES					
1	Badlands National Park	SD	Federal	US National Parks Service	750	Stable
2	Theodore Roosevelt National Park	ND	Federal	US National Parks Service	850	Stable
3	Wind Cave National Park	SD	Federal	US National Parks Service	375	Stable
4	Grand Teton National Park/Nat. Elk Refuge	WY	Federal/State	US NPS; US FWS; WY Fish and Game Dept.	700	Increasing
5	Yellowstone National Park	WY/MT	Federal/State	US National Parks Service, Forest Service, MT Fish and Parks, and MT Dept. of Livestock	4000	Stable
6	Fort Niobrara National Wildlife Refuge	NE	Federal	US Fish and Wildlife Service	352	Stable
7	National Bison Range	MT	Federal	US Fish and Wildlife Service	400	Stable
8	Neal Smith National Wildlife Refuge	IA	Federal	US Fish and Wildlife Service	35	Stable
9	Sullys Hill National Game Preserve	ND	Federal	US Fish and Wildlife Service	37	Stable
10	Wichita Mountains National Wildlife Refuge	OK	Federal	US Fish and Wildlife Service	565	Stable
11	Fermi National Accelerator Laboratory	IL	Federal	Department of Energy	32	Stable
12	Land Between the Lakes National Rec. Area	KY	Federal	USDA Forest Service	130	Decreasing
13	Chitina	AK	State	Alaska Department of Fish and Game	38	Stable
14	Copper River	AK	State	Alaska Department of Fish and Game	108	Stable or Increasing
15	Delta	AK	State	Alaska Department of Fish and Game	360	Stable
16	Farewell Lake	AK	State	Alaska Department of Fish and Game	400	Increasing
17	House Rock State Wildlife Area	AZ	State	Arizona Fish and Game Department	217	Increasing
18	Raymond State Wildlife Area	AZ	State	Arizona Fish and Game Department	72	Stable
19	Antelope Island State Park	UT	State	Department of Natural Resources, Division of Parks and Recreation	600	Stable
20	Blue Mounds State Park	MN	State	Department of Natural Resources, Division of Parks and Recreation	56	Stable
21	Finney Game Refuge	KS	State	Kansas Department of Wildlife and Parks	120	Stable
22	Maxwell Wildlife Refuge	KS	State	Kansas Department of Wildlife and Parks	230	Stable
23	Prairie State Park	MO	State	Missouri Department of Natural Resources	76	Stable
24	Fort Robinson State Park	NE	State	Nebraska Game and Parks	500	Stable
25	Wildcat Hills State Recreation Area	NE	State	Nebraska Game and Parks	10	Stable
26	Custer State Park	SD	State	South Dakota Game Fish and Parks Dept.	1100	Stable

Table 5.1 (continued)

	HERD	Location	Jurisdiction	Managing Authority	Population	Trend
27	Caprock Canyons State Park/Texas State Bison Herd	TX	State	Texas Parks and Wildlife Department	40	Increasing
28	Henry Mountains	UT	State	Utah Division of Wildlife Resources	279	Stable
29	Sandhill Wildlife Area	WI	State	Wisconsin Department of Natural Resources	15	Stable
30	Bear River State Park	WY	State	Wyoming State Parks and Historic Sites	8	Stable
31	Hot Springs State Park	WY	State	Wyoming State Parks and Historic Sites	11	Stable
32	Konza Prairie Biological Station	KS	State/ Foundation	K-State University, Division of Biology; The Nature Conservancy	275	Stable
33	Santa Catalina Island	CA	Foundation	Catalina Island Conservancy	225	Increasing
34	Cross Ranch Nature Preserve	ND	Foundation	The Nature Conservancy	140	Increasing
35	Medano-Zapata Ranch	CO	Foundation	The Nature Conservancy	1500	Decreasing
36	Niobrara Valley Preserve	NE	Foundation	The Nature Conservancy	473	Increasing
37	Ordway Prairie Preserve	SD	Foundation	The Nature Conservancy	255	Stable
38	Tallgrass Prairie Preserve	OK	Foundation	The Nature Conservancy	1500	Increasing
39	Clymer Meadow Preserve	TX	Foundation/ Private	The Nature Conservancy; Private rancher	320	Stable
40	Smoky Valley Ranch	KS	Foundation	The Nature Conservancy	45	Stable
41	Daniels Park	CO	Municipal	Denver Parks and Recreation	26	Stable
42	Genesee Park	CO	Municipal	Denver Parks and Recreation	26	Stable
				Sub-Total – United States	**17251**	
	CANADA					
43	Camp Wainwright	AB	Federal	Department of National Defence	16	Stable
44	Elk Island National Park	AB	Federal	Parks Canada Agency	430	Stable
45	Prince Albert National Park	SK	Federal	Parks Canada Agency	310	Increasing
46	Riding Mountain National Park	MB	Federal	Parks Canada Agency	33	Increasing
47	Waterton Lakes National Park	AB	Federal	Parks Canada Agency	27	Stable
48	Primrose Lake Air Weapons Range (Cold Lake)	AB/SK	Federal and Provincial	Department of National Defence; SK Environment, Fish and Wildlife Branch	100	Increasing
49	Pink Mountain	BC	Provincial	British Columbia Ministry of Water, Land and Air Protection	1000	Stable
50	Buffalo Pound Provincial Park	SK	Provincial	Saskatchewan Environment, Parks Branch	33	Stable
				Sub-Total – Canada	**1949**	
				TOTAL – NORTH AMERICA	**19200**	

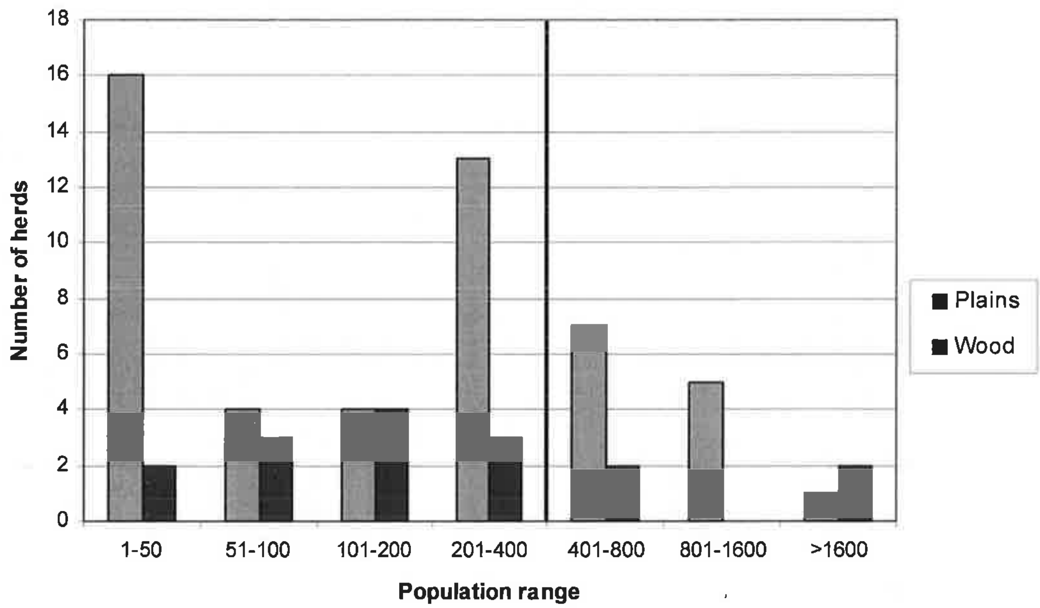

Figure 5.1: Frequency distribution of plains and wood bison conservation herds within selected population ranges relevant to the discussion of minimum viable population (MVP). Bars to the right of the bold vertical line represent herds larger than 400, the MVP currently estimated for bison (Gates et al. 2001c).

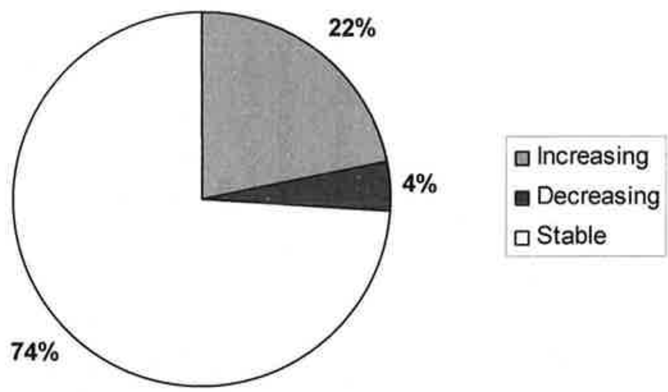

Figure 5.2: Population trends for plains bison conservation herds in North America.

Table 5.2: Numerical status of wood bison conservation herds in North America. Numbers refer to locations on the map in Figure 5.5.

	HERD	Location	Jurisdiction	Managing Authority	Population	Trend
1	Wood Buffalo National Park	AB/NT	Federal	Parks Canada Agency	4050	Unknown
2	Elk Island National Park	AB	Federal	Parks Canada Agency	345	Stable
3	Nordquist	BC	Provincial	British Columbia Department of Water, Lands and Air Protection	60	Stable or Decreasing
4	Etthithun Lake	BC	Provincial	British Columbia Department of Water, Lands and Air Protection	43	Increasing
5	Hay-Zama	AB	Provincial	Government of Alberta, Fish and Wildlife Division	234	Increasing
6	Caribou Mtns-Lower Peace: Wentzel	AB	Provincial	Government of Alberta, Fish and Wildlife Division	110	Unknown
7	Caribou Mtns-Lower Peace: Wabasca	AB	Provincial	Government of Alberta, Fish and Wildlife Division	51	Unknown
8	Chitek Lake	MB	Provincial	Government of Manitoba, Department of Natural Resources; Waterhen First Nation	70	Increasing
9	Nahanni	NT	Territorial	Government of NWT, Resources, Wildlife and Economic Development	170	Increasing
10	Mackenzie Bison Sanctuary	NT	Territorial	Government of NWT, Resources, Wildlife and Economic Development	2000	Increasing
11	Slave River Lowlands	NT	Territorial	Government of NWT, Resources, Wildlife and Economic Development	600	Stable or Decreasing
12	Hook Lake Wood Bison Recovery Project	NT	Territorial and Native	Government of NWT, Resources, Wildlife and Economic Development; Deninu Kue' First Nation	130	Increasing
13	Aishihik	YT	Territorial	Government of Yukon	530	Increasing
14	Heart Lake Wood Bison Recovery Project	AB	Native and Federal	Heart Lake First Nation; Environment Canada; Parks Canada	45	Stable or Decreasing
15	Waterhen Wood Bison Ranch	MB	Native	Waterhen First Nation	185	Unknown
16	Syncrude	AB	Native and Private	Syncrude Canada Ltd.; Fort McKay First Nation	322	Increasing
				TOTAL	**8945**	

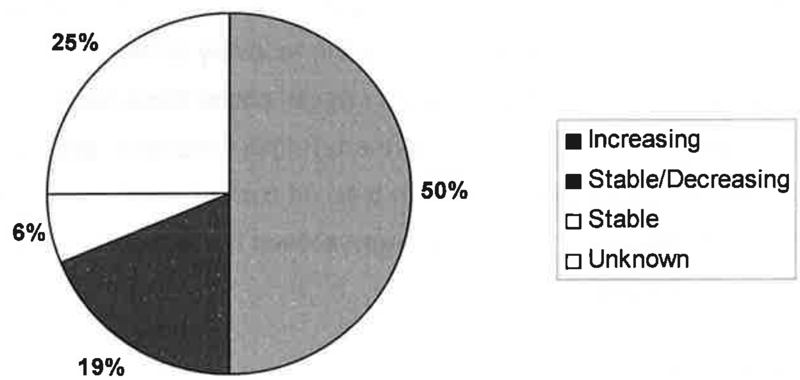

Figure 5.3: Population trends for wood bison conservation herds in North America.

Geographic Status

Geographic status refers to the distribution of bison populations across North America, and their locations with respect to the original range of each subspecies. Knowledge of geographic status is important for evaluating the conservation value of a population. A population of one subspecies outside its original range may potentially occupy range otherwise available for the recovery of the other subspecies. Most plains bison conservation herds fall within original plains bison range (Figure 5.4). Eight herds residing in Arizona, California, northern British Columbia, and Alaska are distinctly outside plains bison range (Figure 5.4). All current wood bison conservation herds reside within Canada (Figure 5.5). Twelve of sixteen herds reside within original wood bison range (Figure 5.5).

Demographic Status

Demography refers to the factors that contribute to the growth or decline of a population, including natality, mortality, immigration, and emigration (Meffe and Carroll 1994). The sex ratio and the age class structure are also demographic factors because they influence the birth and death rates for a population (Meffe and Carroll 1994). Demographic uncertainty results from random events in the survival and reproduction of individuals (Shaffer 1987). The resulting population fluctuations contribute to the viability of a population, and therefore, figure prominently in a PVA (Shaffer 1987; Lande 1988; Meffe and Carroll 1994). Other than a brief overview of the male to female ratios for plains bison, this survey did not inventory specific demographic information. Detailed demographic information would be required for conducting a PVA for a given herd (Shaffer 1987; Meffe and Carroll 1994).

In general, the fetal male to female ratio for bison tends to favour males (Rutberg 1986; Meagher 1986). Investigations of bison born to various herds over time have recorded the percentage of males ranging from 51% to 60% (Reynolds *et al.* 1982; Bragg *et al.* 2002). The sex ratio among adults tends to be more even because male bison generally have higher mortality rates (Bragg *et al.* 2002). Not all herds are managed for an even sex ratio. Thirty-four percent of plains bison conservation herds are maintained at male to female ratios lower than 1:2, while 30% fall between 1:2-1:9, and 18% are maintained at higher than 1:9 (Figure 5.6). The highest ratio is 1:16. For

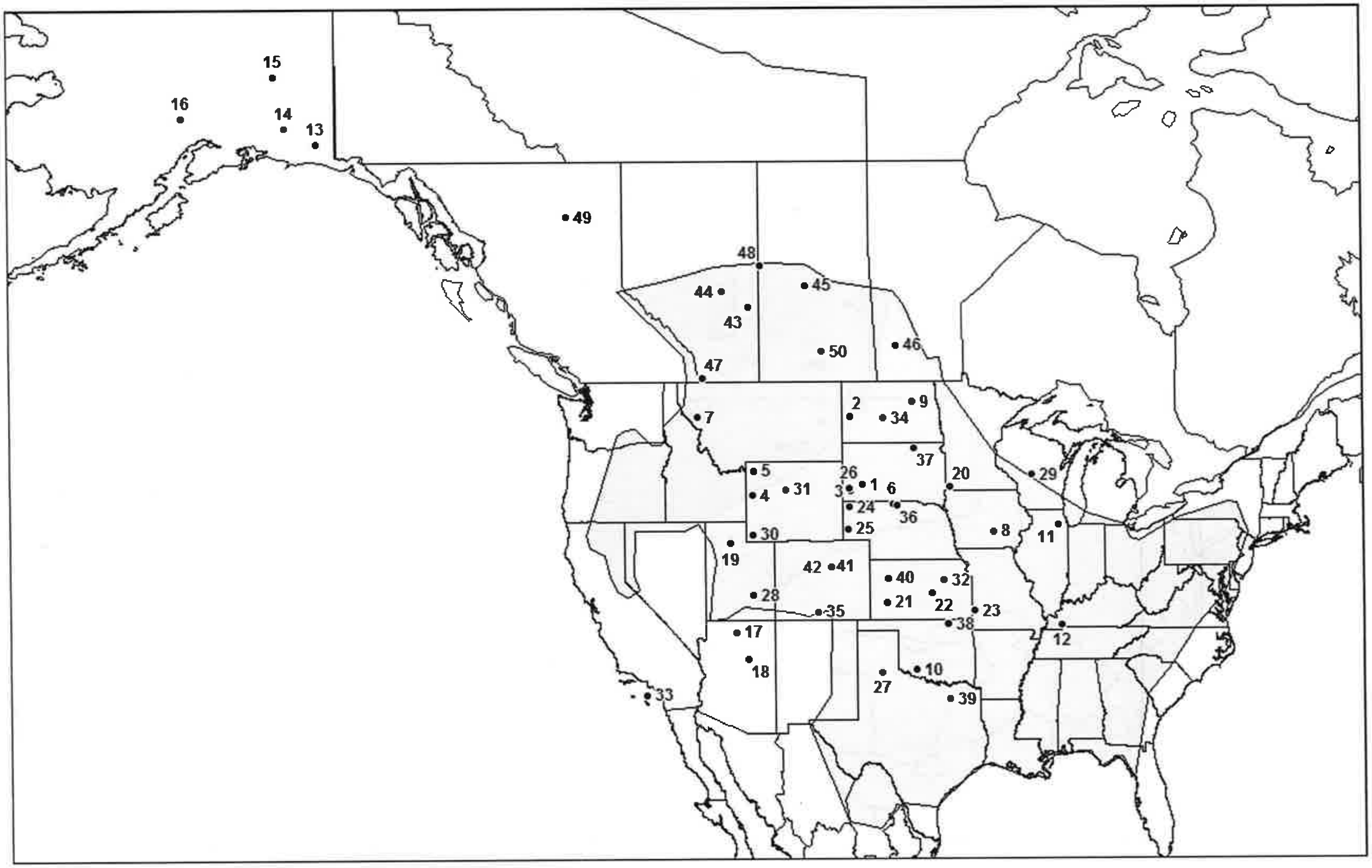

Figure 5.4: Distribution of plains bison conservation herds in North America. Numbers correspond with the herd list in Table 5.1. The shaded area represents original plains bison range.

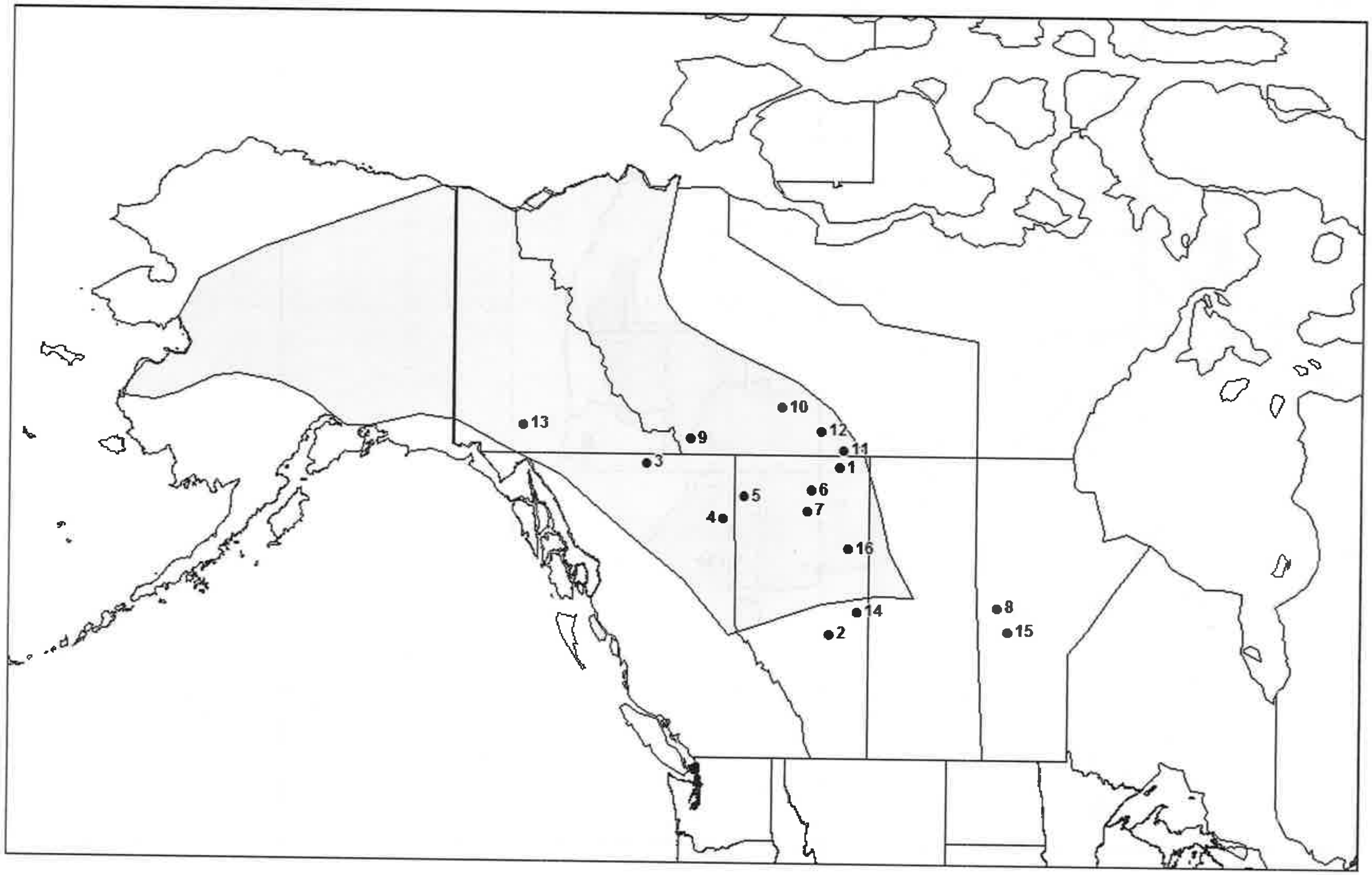

Figure 5.5: Distribution of wood bison conservation herds in North America. Numbers correspond with the herd list in Table 5.2. The shaded area represents original wood bison range.

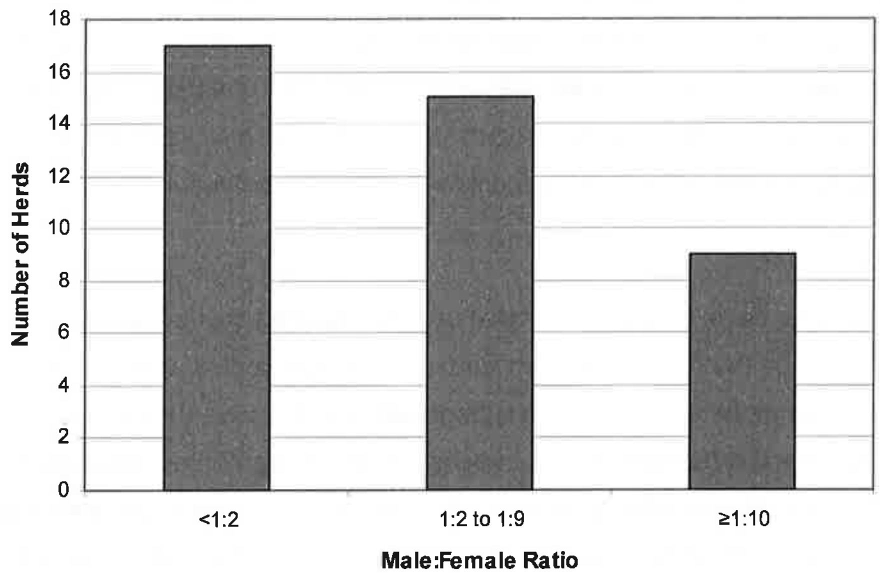

Figure 5.6: Frequency distribution of male to female ratios in plains bison conservation herds. Data were not available for nine herds.

captive herds, an even sex ratio may not be practical given the aggressive nature of older and rutting bulls. Managers may skew the male to female ratio by selectively culling bulls of all ages, leaving just enough males to facilitate reproduction in the herd. This also minimizes handling and containment problems associated with aggressive bulls, and forage use by unneeded bulls (Bragg *et al.* 2002). To achieve cost-effective management of a herd, some managers may increase the percentage of females to maximize calf production and, therefore, the number of surplus animals for sale. Such a practice is common for production management, as employed by many commercial herd managers, rather than management for species conservation (Bragg *et al.* 2002).

Habitat Status

The bison is a land-intensive nomadic species that once roamed over great distances on the North American landscape. Large-bodied animals are especially vulnerable to the effects of habitat fragmentation because they require a large amount of suitable habitat (Berger and Cunningham 1994). Fragmented populations can be more susceptible to inbreeding pressures, loss of genetic diversity, and extinction (Berger and Cunningham 1994; Mace *et al.* 2001). On the continental scale, natural habitats have been reduced to a fraction of their historical extent (Mace *et al.* 2001). Human population growth and development have led to the appropriation of extensive areas of land within original bison range for natural resource extraction, agriculture, ranching of both cattle and commercial bison, and urban and rural settlement (Johnson *et al.* 1994; Berger and Cunningham 1994; Mace *et al.* 2001). These competing land uses constrain possibilities for preserving or restoring large tracts of habitat for bison recovery.

Current plains bison conservation herds are largely scattered and isolated across the original range of the subspecies (Figure 5.4), and occupy ranges of varying sizes (Figure 5.7). Thirty-eight percent of plains bison conservation herds reside on ranges smaller than 10 km^2, and 60% have ranges smaller than 100 km^2 (Figure 5.7). This survey further reveals that there is no range expansion potential for 52% of the plains bison conservation herds. Of the herds with expansion potential, only 11 are currently expanding by natural dispersal or through active expansion management plans. Plains bison herd managers cited several socio-political, ecological, logistical, and financial barriers to expansion (Table 5.3). There are, therefore, limited opportunities for reintroduction of plains bison within their original range (Chapter 9). Amalgamation of

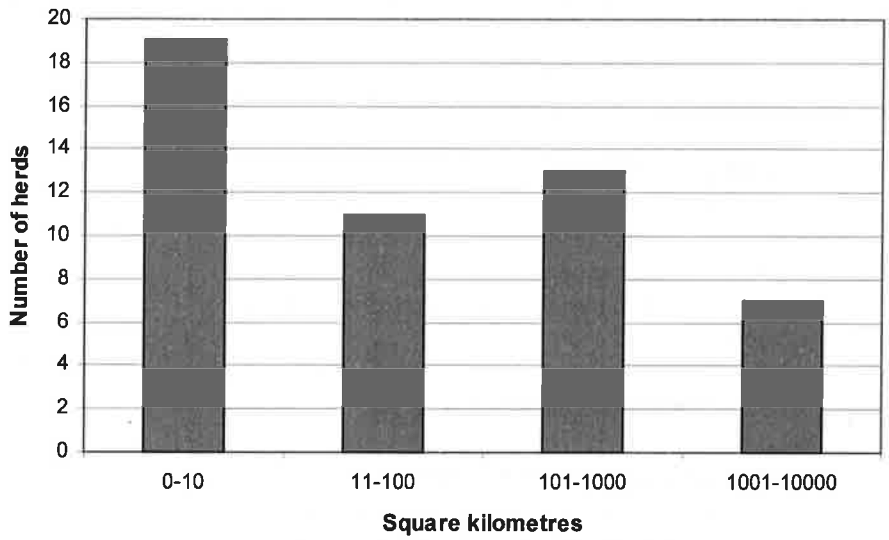

Figure 5.7: Frequency distribution of plains bison conservation herds according to range area.

Table 5.3: Barriers to range expansion summarized from comments by plains bison conservation herd managers.

Socio-political Barriers	**Number of Managers**
Lack of public support	2
Surrounded by private or tribal land	10
Conflicts with private land owners	5
Depredation of agricultural crops	*3*
Domestic livestock grazing and disease transfer	*2*
Ecological Barriers	
Disease	2
Infiltration of woodland and invasive species	1
Limited winter range	2
Requirement to balance bison with other herbivores	4
Topography	3
Island population	2
Fire required to create suitable range	1
Logistical and Financial Barriers	
Lack of funds for purchasing additional land	5
Lack of funds for fencing and personnel time	3
Current management goals do not call for expansion	7
No need for expansion (display herd)	7
Do not want to disrupt long-term experimental data sets	1
Public safety concerns	1

large areas of land for landscape-scale recovery projects will necessarily involve cooperative efforts with private landowners (Johnson *et al.* 1994).

Similar to plains bison, wood bison are alienated from large portions of their original range by agricultural and urban development (Gates *et al.* 2001c). There are at least 20,000 bison on 250 commercial ranches within original wood bison range, and this number is expected to increase (Gates *et al.* 2001c; Mitchell and Gates 2002). Additional habitat is unavailable because of the presence of plains bison conservation herds in wood bison range (Figure 5.8). Some of the highest quality habitat for wood bison is located in WBNP and the SRL (Gates *et al.* 2001c), which are inhabited by wood bison infected with bovine tuberculosis and brucellosis (Figure 5.8). These diseased herds occupy approximately 12% of original wood bison range in Canada (Gates *et al.* 2001c). Wildlife and agricultural management agencies have effectively increased the size of the affected area to 42% by discouraging the establishment of free-ranging herds adjacent to WBNP and surrounding areas because of infection potential (Gates *et al.* 1992).

Wood bison are dependent on early successional habitats (Chowns *et al.* 1998). Changes in the fire regime over the last century are believed to have contributed to succession of meadows to shrub land and forest (Chowns *et al.* 1998). Changes in the hydrological regime caused by the damming of rivers that feed areas of wood bison range may also have affected meadow succession (Gates *et al.* 2001c). The effects of changes in vegetation and hydrology on wood bison are currently under investigation (Gates *et al.* 2001c). Prescribed fire in some areas may assist with maintaining suitable wood bison habitat (Chowns *et al.* 1998). Large areas in northern Alberta disturbed for forestry and tar sands development and subsequently reclaimed as grasslands may be suitable for future wood bison reintroductions (Pauls 1995; Gates *et al.* 2001c).

The Canadian National Bison Recovery Team (formerly the Canadian Wood Bison Recovery Team) recently formed a Habitat Action Group to define and identify suitable and critical recovery habitat for wood and plains bison in Canada (Canadian National Bison Recovery Team 2002). This action supports the Canadian Species at Risk Act (SARA), which calls for the identification and protection of critical habitat for listed threatened, endangered, and extirpated species. The Habitat Action Group will define priorities for bison habitat research and assessment in Canada consistent with the guidelines established by the Secretariat for the Canadian Recovery of Nationally

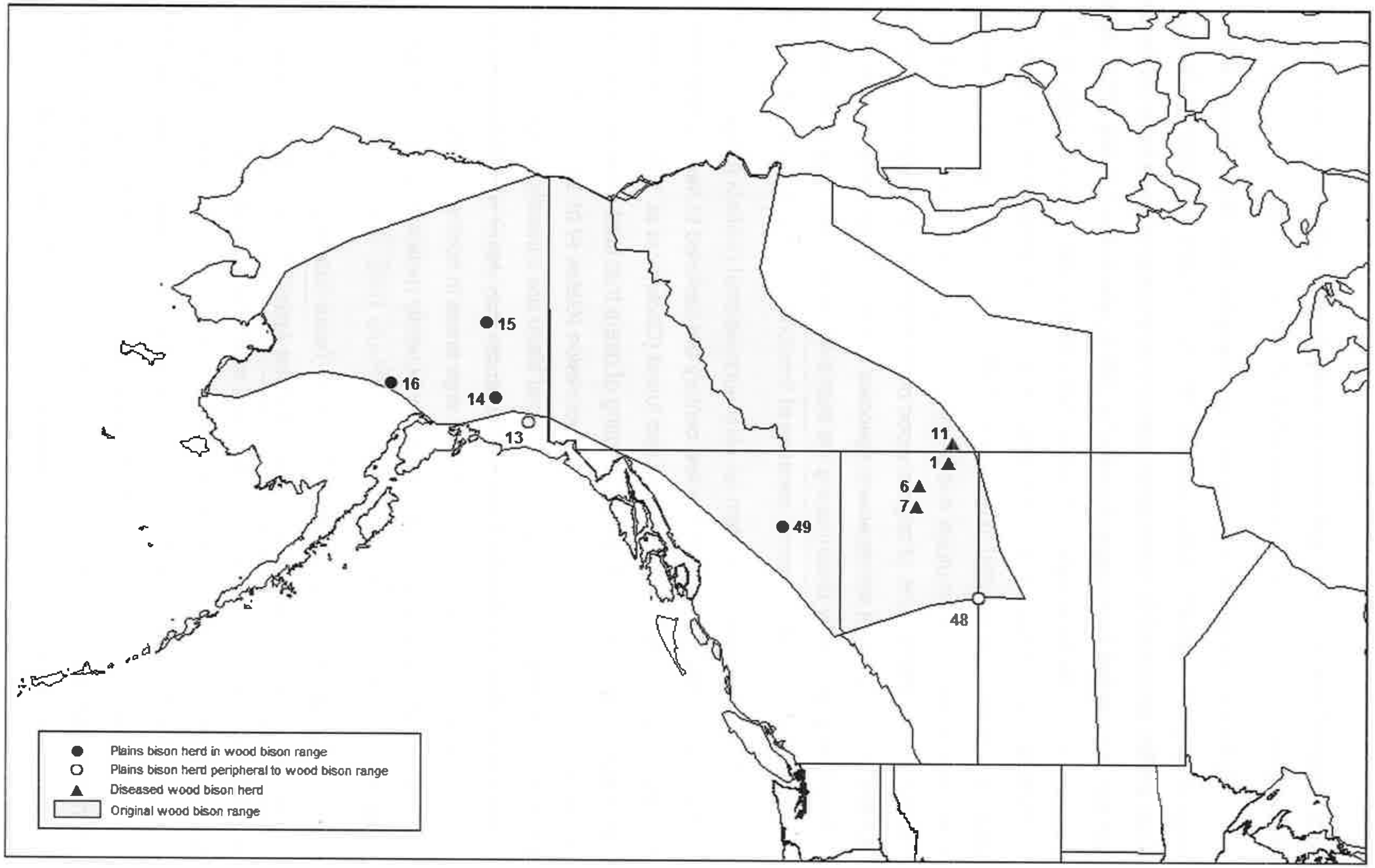

Figure 5.8: Distribution of plains bison conservation herds and diseased wood bison herds within original wood bison range. Numbers for plains bison herds correspond to Table 5.1. Numbers for wood bison herds correspond with Table 5.2.

Endangered Wildlife (RENEW) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The Habitat Action Group will investigate habitat selection by bison and develop landscape assessment models. Habitat research is currently underway for wood bison in the Yukon (Fischer 2003), and the area encompassing WBNP, SRL, and the Caribou-Lower Peace regions (Jensen 2001, pers. comm.). Relevant to plains bison, habitat research on the subalpine eastern slopes of the Rocky Mountains is underway in Banff National Park (Sachro 2003). Habitat assessment is required for Grasslands National Park, Waterton Lakes National Park, Prince Albert National Park, and the Nature Conservancy's Old-Man-on-His-Back project area (Canadian National Bison Recovery Team 2002).

Ecological Status

Ecological status within this survey refers to the state of the relationship between a herd and the processes of natural regulation and selection. The natural state of a herd is assumed to be on a continuum with the degree of human intervention. Therefore, ecological status worsens as the degree of human management imposed on the herd increases. This survey does not include an exhaustive investigation of ecological indicators and range management practices; however, discussions with bison herd managers reveal some preliminary trends.

Free-ranging herds are those not contained within a fence, although there may be topographic or socio-political barriers that prevent the herd from roaming freely over the landscape. Captive herds reside within a perimeter fence. Thirteen of 50 plains bison conservation herds are free-ranging, accounting for 8,337 bison (Table 5.4). Two major free-ranging populations are diseased (Chapter 7). Two free-ranging herds reside on islands. All of the free-ranging herds reside on open range, and are therefore not subject to forced rotation through pastures. Only one free-ranging herd is supplementally fed. Eleven herds experience, or potentially experience, predation by such animals as bears, wolves, coyotes, and mountain lions. Only the two island populations are subject to regular whole herd round-ups. Managers for some of the other herds may conduct periodic trappings for specific purposes such as disease testing. Hunting by humans is the primary mechanism for managing free-ranging herds; only two herds are not subject to hunting pressure. Free-ranging, disease-free populations that are potentially influenced by predators and are within original plains bison range account for only 1,289

Table 5.4: Numerical status of free-ranging plains bison with respect to geographical and disease status. Numbers refer to locations on the map in Figure 5.4.

Map Ref.	HERD	Population by Category
Free-ranging, disease-free, within original plains bison range		**1289**
19	Antelope Island State Park, UT	
28	Henry Mountains, UT	
45	Prince Albert National Park, SK	
48	Primrose Lake Air Weapons Range (Cold Lake), AB/SK	
Free-ranging, disease-free, outside original plains bison range		**2348**
13	Chitina, AK	
14	Copper River, AK	
15	Delta Junction, AK	
16	Farewell Lake, AK	
17	House Rock State Wildlife Area, AZ	
33	Santa Catalina Island, CA	
49	Pink Mountain, BC	
Free-ranging, infected with/exposed to brucellosis, within original plains bison range		**4700**
4	Grand Teton National Park/National Elk Refuge, WY	
5	Yellowstone National Park, MY/WY	
	TOTAL Free-ranging plains bison population	**8337**

plains bison, or 6.7% of the total conservation population (Table 5.4). Of this subset, three herds, or 689 bison, are not subject to regular handling; these herds have not attained populations meeting an MVP of 400. Therefore, there are few plains bison populations within original range that exist under natural conditions, and none that are considered viable by the current benchmark.

Captive herds account for 37 of 50 plains bison conservation herds. Captive herds are subject to various forms of management intervention (Figure 5.9). Population management in 95% of captive herds is achieved through culling followed by various methods of disposal (Table 5.5). Management practices that may impact the genetic integrity of a herd, such as selective breeding and culling, are discussed in Chapter 6.

The ecological status of wood bison is strongly related to the presence of bovine brucellosis and tuberculosis in several populations (Chapter 7). Therefore, to outline basic ecological status for this survey, wood bison conservation herds are delineated by their free-ranging status and then by the presence of disease (Table 5.6), a format adopted by the Canadian Wood Bison Recovery Team (Gates *et al.* 2001c). No other ecological status information on wood bison was gathered for this survey.

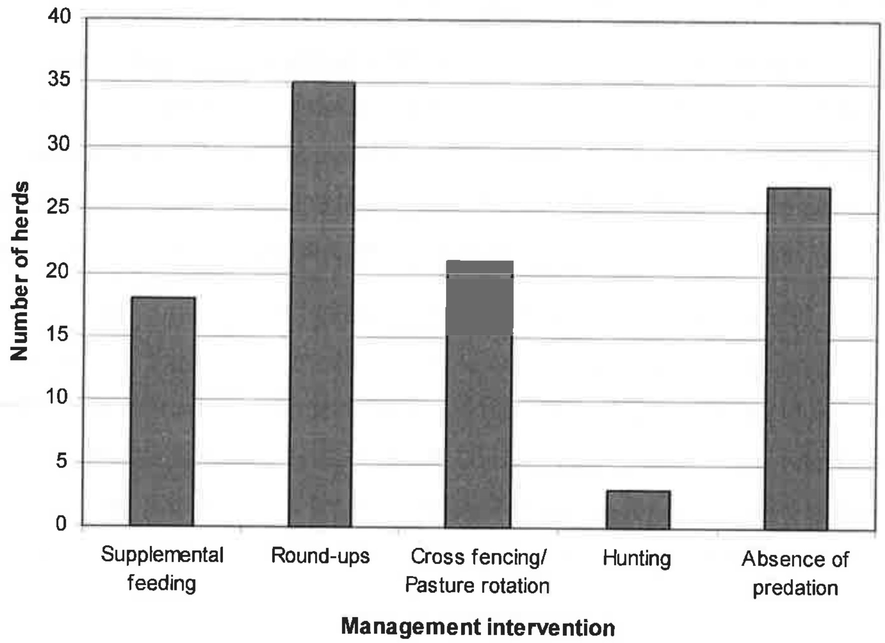

Figure 5.9: Frequency distribution of captive plains bison conservation herds with respect to five herd management interventions.

Table 5.5: Methods used by managers of captive plains bison conservation herds to dispose of surplus bison.

Method	Number of herds
Public auctions, live sales, sealed bids	21
Private sales	6
Trades with government herds	3
Agreements with native tribes	4
Donations	3
On-site slaughter	3
Conservation reintroduction projects	1

Table 5.6: Numerical status of wood bison conservation herds with respect to geographical and disease status. Numbers refer to locations on the map in Figure 5.5.

Map Ref.	HERD	Population by Category
Free-ranging, disease-free, within original wood bison range		**2994**
3	Nordquist, BC	
5	Hay-Zama, AB	
9	Nahanni, NT	
10	Mackenzie Bison Sanctuary, NT	
13	Aishihik, YT	
Free-ranging, disease-free, outside original wood bison range		**70**
8	Chitek Lake, MB	
Free-ranging, exposed to/infected with brucellosis and tuberculosis, within original wood bison range		**4811**
1	Wood Buffalo National Park, AB/NT	
6	Caribou Mtns-Lower Peace: Wentzel, AB	
7	Caribou Mtns-Lower Peace: Wabasca, AB	
11	Slave River Lowlands, NT	
Captive, disease-free, within original wood bison range		**495**
4	Etthithun Lake, BC	
12	Hook Lake Wood Bison Recovery Project, NT	
16	Syncrude, AB	
Captive, disease-free, outside original wood bison range		**575**
2	Elk Island National Park, AB	
14	Heart Lake Wood Bison Recovery Project, AB	
15	Waterhen Wood Bison Ranch, MB	
	TOTAL Wood bison conservation population	**8945**

Chapter 6: Genetics

Bison experienced a severe population decline in the 19th Century. Since then, they have undergone artificial hybridization, been subject to domestication, and been separated into isolated populations, all of which could have affected the integrity of the bison genome. As a result, preservation of the bison genome is a key conservation consideration. The following sections discuss the major genetic issues, and genetic management within conservation herds.

Genetic Diversity

Genetic diversity within a species provides the mechanism for evolutionary change and adaptation (Mitton and Grant 1984; Allendorf and Leary 1986; Meffe and Carroll 1994; Chambers 1998). Reduction in genetic diversity can result in reduced fitness, diminished growth, increased mortality, and reduced evolutionary flexibility of individuals within a population (Ballou and Ralls 1982; Mitton and Grant 1984; Allendorf and Leary 1986; Berger and Cunningham 1994). There are four interrelated mechanisms that can reduce genetic diversity: demographic bottlenecks, founder effects, genetic drift, and inbreeding (Meffe and Carroll 1994). Over the last two centuries, bison in North America have to some degree experienced all of these mechanisms.

North American bison approached extinction in the late 1800s and experienced a severe demographic bottleneck. This raises the concern that extant bison populations may have lower genetic diversity compared to pre-decline populations. The consequences of a genetic bottleneck depend on the severity of the decline and how quickly the population rebounds after the bottleneck (Nei *et al.* 1975; Meffe and Carroll 1994). The decline of bison was severe, with a reduction from millions to fewer than 1,000 individuals. Recovery efforts, however, enabled bison populations to grow quickly, more than doubling between 1888 and 1902 (Coder 1975). Although the effects of the bottleneck on the genetic diversity of the species are not clear (Wilson 2001), there are several possible repercussions. After a severe reduction in population size, average heterozygosity is expected to decline (Nei *et al.* 1975; Nei *et al.* 1975; Allendorf 1986). Heterozygosity is a measure of genetic variation, expressed as the frequency of heterozygotes expected at a given locus (Griffiths *et al.* 1993). Another considerable impact is the loss of alleles, which may inhibit natural selection and reduce the adaptive potential of a population (Robertson 1960; Nei *et al.* 1975; Allendorf 1986; Meffe and Carroll 1994).

After the demographic crash, several small bison herds remained in North America, many of which were derived from very few animals. According to the founder effect, genetic variation of a population varies directly with the number of founders (Meffe and Carroll 1994; Wilson and Strobeck 1999). Remnant populations may have had a biased representation of the original gene pool and suffered reduced genetic variability. As the remnant herds grew, founder effects may have been compounded by genetic drift and inbreeding, which can also reduce diversity. Genetic drift involves the random change in gene frequencies in small populations leading to the loss of certain alleles from one generation to the next (Allendorf 1986; Meffe and Carroll 1994). Inbreeding, or the mating of related individuals, can lead to the expression of deleterious alleles, decreased heterozygosity, lower fecundity, and developmental defects (Allendorf and Leary 1986; Meffe and Carroll 1994; Berger and Cunningham 1994; Lande 1999). Inbreeding is difficult to assess and does not always have measurable deleterious consequences (Meffe and Carroll 1994; Berger and Cunningham 1994); however, it is a potential cause of reduced diversity in bison. To decrease the effects of inbreeding, some bison herds were founded or augmented with animals from different regions (Wilson 2001). Over time, the translocation of animals among herds may have reduced the impacts of inbreeding and founder effects, which are most severe in small populations with low levels of genetic diversity. However, some herds have exhibited signs of inbreeding depression such as physical abnormalities and reduced growth (Berger and Cunningham 1994; Hebbring Wood 2000).

It is likely that North American bison experienced a reduction in genetic diversity; however, it may not have been as great as expected. McClenaghan, Jr. *et al.* (1990) found that plains bison have greater genetic variability than several other mammals that experienced severe demographic bottlenecks. Wilson (2001) found levels of DNA microsatellite variability in bison populations to be similar to other North American ungulates. Some authors speculate that prior to the bottleneck, the North American bison, with the possible exception of the wood bison, expressed surprising homogeneity despite its extensive range (Seton 1910; Roe 1970). Plains bison ranged over large areas; therefore, extensive gene flow may have existed between populations (Berger and Cunningham 1994; Wilson and Strobeck 1999). Similar to other large mammals, bison are expected to be less genetically diverse than small mammals (Sage and Wolff 1986). Recent studies demonstrate that the genetic distances between existing bison herds are lower than expected despite the pressures of founder effects and low gene flow, which increase genetic distance values, indicating that existing isolated populations are likely derived from one large gene pool (Wilson and Strobeck 1999; Wilson 2001). Further, foundation herds for contemporary bison originated from across the species' range, suggesting that much of the pre-existing diversity was likely sampled (Derr 2002, pers. comm.). Analysis of ancient DNA in subfossil specimens may provide an opportunity for assessing pre-bottleneck genetic diversity for comparative purposes (Chambers 1998; Amos 1999; Cannon 2001). Unfortunately, there is no existing technology for recovering genetic material lost as a result of the bottleneck in the form of living animals. Therefore, it is imperative to maintain the existing genome, and minimize future losses in genetic diversity.

Although existing bison populations may have derived from a largely homogeneous gene pool, recent studies using DNA microsatellites reveal that several bison herds are genetically distinguishable (Wilson 2001). This raises the issue of whether conservation herds should be managed as a large metapopulation, with translocation of bison among herds to maintain overall diversity, or maintain closed herds to preserve emerging localized diversity. Some populations may be adapting to non-native habitats or changing conditions in the natural environment, and would, therefore, benefit from localized diversity. Other populations may be adapting to, or inadvertently selected for, unnatural conditions, and would benefit from periodic augmentation (Wilson *et al.* 2002b). A precautionary approach may be to diversify conservation efforts by transferring randomly selected animals among some herds, to maximize intra-population genetic diversity, while maintaining other herds as closed populations, to preserve low frequency alleles (Chambers 1998). Managers should not implement a metapopulation management plan without supporting genetic diversity, morphological, behavioural, and physiological studies to avoid mixing genetically dissimilar populations (Ryder and Fleischer 1996; Lande 1999; Wilson *et al.* 2002b).

Ongoing genetic studies for the five US national park herds will help resolve this issue (Halbert 2002, pers. comm.).

Genetic analysis could help maintain genetic diversity by building an inventory of diversity held within conservation herds. There are several measures of genetic diversity including heterozygosity, alleles per locus, and proportion of polymorphic loci (Templeton 1994; Amos 1999; Wilson *et al.* 2002b). While early work on bison genetics involved blood groups (Stormont *et al.* 1961; Stormont 1982), some authors suggest that such studies are inappropriate for assessing genetic diversity because selection for blood group type may be high, violating the assumption of selective neutrality (Yamazaki and Maruyama 1974; Knudsen and Allendorf 1987; Berger and Cunningham 1994). More recent studies have used allozymes (Knudsen and Allendorf 1987; McClenaghan *et al.* 1990), mtDNA (Polziehn *et al.* 1996), nuclear DNA restriction fragment length polymorphisms (Bork *et al.* 1991), and DNA microsatellites (Wilson and Strobeck 1999) to assess diversity. Essentially, no single investigation of DNA can reflect the entire complement of diversity, thus the data from various techniques and DNA regions must be combined to provide the most accurate representation (Chambers 1998). Population geneticists suggest that an assessment of overall genetic diversity should examine 25-30 loci affecting different systems (Nei 1987; Chambers 1998). While the diversity for some herds has been assessed (Baccus *et al.* 1983; Knudsen and Allendorf 1987; Berger and Cunningham 1994; Wilson and Strobeck 1999), the information has not been compiled, and there are many conservation herds for which no genetic information exists. An inventory of genetic diversity would, therefore, assist managers with genetic management of bison, and assist in identifying localized diversity, such as unique alleles.

Selection for diversity in one system, such as blood group proteins, or biased selection for maintaining specific rare genetic characteristics could lead to reduced diversity in other parts of the genome (Hendrick *et al.* 1986; Chambers 1998). Biased selection for maintaining rare alleles is especially questionable if it is not known what the rare allele does or if it is detrimental (i.e., it may be rare because it is being expunged from the bison genome through natural selection.) Variation throughout the genome, rather than the maintenance of one specific rare allele, conveys evolutionary flexibility to a species (Vrijenhoek and Leberg 1991; Chambers 1998). Therefore, it is crucial for a genetic management plan to consider all available measures of genetic diversity in the policies and procedures for breeding and culling decisions.

Maintaining genetic diversity of North American bison also requires an understanding of herd population dynamics to assess the probability of persistence of that diversity. Normally, not all individuals in a population successfully contribute their genes to subsequent generations. The potential loss of genetic diversity from a population can be calculated from the effective population size (N_e), which accounts for non-random, non-panmictic mating, and represents the ideal population size that undergoes the same amount of change in genetic diversity as the actual population under consideration (Wright 1969; Meffe and Carroll 1994; Berger and Cunningham 1994). This is especially applicable to polygynous megaherbivores such as bison, among which males exhibit large variance in reproductive success (Berger and Cunningham 1994; Wilson *et al.* 2002a). In small populations, it is possible for one or two dominant males to be responsible for all of the mating, which impacts genetic diversity, especially in the absence of gene flow among populations (Berger and Cunningham 1994). The potential for disproportionate reproductive contributions emphasizes the importance of maintaining large herds, which accommodate mating by many males, and reduce potential loss of genetic diversity. Heterozygosity also tends to be higher at larger population sizes (Meffe and Carroll 1994). Assessment of genetic uncertainty, based on N_e, founder effects, genetic drift, and inbreeding, is a required component of a population viability analysis (PVA) (Gilpin and Soulé 1986; Shaffer 1987).

Hybridization

Hybridization involves the interbreeding of individuals from genetically distinct populations, which can represent different species, subspecies, or geographic variants (Rhymer and Simberloff 1996). Some authors argue that hybridization is a potentially creative evolutionary force, which generates novel combinations of genes adapted for habitat change, even though hybrids often experience reduced fitness (Ward 2000). However, hybridization through artificial manipulation or relocation of animals can compromise genetic integrity through genetic swamping of one genome over another and disruption of locally adapted gene complexes (Avise 1994). It can also produce offspring that are devalued by the conservation and legal communities (O'Brien and

Mayr 1991) (Chapter 8). The genetic legacy of introducing plains bison into a wood bison population, and cross-breeding bison and cattle has made hybridization a controversial topic in bison conservation.

Plains bison x Wood bison

It has been argued that introduction of plains bison into occupied wood bison range was a "negligible tragedy" (Geist 1996), p. 114, because they are only ecotypes (Geist 1991). Others maintain that the interbreeding of these two types should have been avoided to preserve geographic and environmental variation (van Zyll de Jong *et al.* 1995). Evidence is mounting that plains bison and wood bison are geographically and genetically distinct populations (Chapter 4); therefore, introduction of either species into the original range of the other could erode the genetic basis for adaptation to local environmental conditions (Lande 1999). Therefore, notwithstanding the ongoing debate over North American bison subspecies designations, hybridization between plains and wood bison should be considered detrimental to maintaining the genetic integrity and distinctiveness of the two forms, and the separation of their evolutionary paths.

While historically there may have been natural hybridization events between the subspecies in areas of range overlap, the current hybridization issue is the consequence of an ill-advised and irreversible decision made nearly 80 years ago. In 1925, the Canadian government implemented a plan to move more than 6,000 plains bison from the overcrowded Wainwright Buffalo Park to WBNP. Mammalogical and biological societies from United States and Canada strenuously challenged this action on the basis that interbreeding would eliminate the wood bison form, resulting hybrids might not be as fit for the environment, and tuberculosis would spread to formerly healthy animals (Anonymous 1925; Fuller 2002). Proponents of the plan countered the criticism by questioning the subspecies designations, arguing that the introduction site was isolated from and unused by the wood bison population, and suggesting that the introduced animals were too young to carry tuberculosis (Graham 1924; Anonymous 1925; Fuller 2002). These arguments did not consider the future habitat needs of the growing wood or plains bison populations, nor the likelihood that the two subspecies would not remain mutually exclusive. As well, a recommendation that only yearlings that passed a tuberculin test be shipped to WBNP was rejected (Fuller 2002). Nevertheless, the plan moved forward; between 1925 and 1928, 6,673 plains bison were translocated by rail and barge to WBNP (Ogilvie 1979; Gates *et al.* 2001c; Fuller 2002).

It was not until 1957 that the discovery of a seemingly isolated herd of 200 animals near the Nyarling River and Buffalo Lake alleviated fears that the wood bison was lost to hybridization (van Camp 1989). Canadian Wildlife Service researchers assessed that these animals were morphologically representative of wood bison (Banfield and Novakowski 1960). To salvage the wood bison subspecies, bison from the Nyarling herd were captured and relocated to establish two new herds. Eighteen animals were moved to the Mackenzie Bison Sanctuary north of Great Slave Lake in 1963 (Gates *et al.* 2001c; Fuller 2002), and 22 animals were successfully transferred to Elk Island National Park east of Edmonton, Alberta in 1965 (Blyth and Hudson 1987). Two additional calves were transferred to EINP between 1966 and 1968 (Blyth and Hudson 1987; Gates *et al.* 2001c).

Subsequent studies revealed that there was contact between the Nyarling herd and the introduced plains bison; however, hybridization within WBNP did not result in a phenotypically homogenous population (van Zyll de Jong *et al.* 1995). Nevertheless, genetic distances among subpopulations in the park are small, indicating that there is gene flow and influence of the plains bison genome throughout all regions of the park (Wilson and Strobeck 1999; Wilson 2001). Despite hybridization, DNA microsatellite studies reveal that genetic distances between plains and wood bison are greater than those within either subspecies, and that wood bison form a strong genetic grouping on a Nei's minimum unrooted tree (Wilson and Strobeck 1999; Wilson 2001). Therefore, although there is no way to reverse the genetic consequences of introducing plains bison into WBNP, care should now be taken to maintain separation between morphologically and genetically representative wood bison and plains bison herds and to prevent future hybridization from occurring in conservation herds.

Cattle x Bison

The concept of crossing bison with domestic cattle dates back to Spanish colonizers of the 16th Century (Dary 1989). Cross-breeding attempts were also recorded in Virginia, the Carolinas, and Pennsylvania during the 1700s (Ogilvie 1979; Dary 1989). In 1888, C. J. "Buffalo" Jones coined the term 'catalo' to refer to hybrids between cattle and bison. There are many historical accounts of attempts to hybridize bison and cattle

(McHugh 1972; Coder 1975; Ogilvie 1979; Dary 1989; Ward 2000). Private ranchers involved with salvaging bison had aspirations to combine through hybridization the hardiness and winter foraging ability of bison with the meat production traits of cattle (Ogilvie 1979; Dary 1989; Ward 2000). The Canadian government pursued the experimental production of crossbred animals from 1916-1964 (Ogilvie 1979; Polziehn *et al.* 1995).

Historical cross-breeding attempts have created a legacy of genetic issues related to the introgression of cattle DNA into bison herds. Introgression refers to gene flow between populations caused by hybridization followed by backbreeding of the hybrid offspring to their respective parental populations (Rhymer and Simberloff 1996). The introgressed DNA displaces sections of the original genome, thereby affecting the genetic integrity of a species, and hampering the maintenance of original genetic diversity. Many contemporary bison herds are founded on, and supplemented with, animals from herds with a history of hybridization. This history raises questions about the effect of cattle DNA introgression on conservation of the bison genome.

Fertility problems thwarted many of the original cross-breeding attempts because crosses result in high mortality for offspring and mother (Ward 2000). Experimentation has revealed that crosses of bison females with domestic cattle males produce less mortality than the more deadly reverse cross, which was more common because it is very difficult to compel domestic cattle bulls to mate with bison females (Ward 2000). All F1 generation hybrids experience reduced fertility and viability relative to either parent: F1 males are completely sterile, but the fertility of F1 females makes introgressive hybridization possible (Ward 2000).

Genetic studies have found no evidence of cattle Y-chromosome introgression in bison (Ward *et al.* 2001), explained by the sterility of F1 hybrid males from the cross of cattle males with bison females, and by the behavioural constraint preventing domestic bulls from mating with female bison (Ward 2000). However, studies have revealed both mitochondrial DNA (mtDNA) and nuclear DNA introgression. During an investigation of bison mtDNA, Polziehn *et al.* (1995) discovered the presence of cattle mtDNA among Custer State Park plains bison. Subsequent studies have revealed cattle mtDNA in 6 of 12 conservation plains bison herds (Ward *et al.* 1999; Ward 2000). Further studies using nuclear DNA microsatellites detected cattle nuclear DNA introgression in 4 of 6 conservation herds with mtDNA introgression and in one herd that did not indicate mtDNA introgression (Ward 2000). Three major wood bison populations (Mackenzie Bison Sanctuary, Wood Buffalo National Park, and Elk Island National Park) showed no evidence of cattle mtDNA or nuclear DNA introgression (Ward *et al.* 1999; Ward 2000).

Although only 14% of plains bison conservation herds currently demonstrate evidence of cattle DNA introgression, the high percentage of untested herds (68%) represents a large information gap in the understanding of hybridization prevalence among plains bison (Figure 6.1). Plains bison herds with no evidence of hybrids comprise all five US national park herds, two of five US National Wildlife Refuge herds, the state-managed Henry Mountains herd in Utah, and the Elk Island National Park herd in Canada (Ward 2000) (Derr 2002, pers comm.). These herds are important reservoirs of the plains bison genome, accounting for 7,984 bison, or 42% of the plains bison conservation population. The five US national parks with bison herds are currently involved in a 4-year study through Texas A&M University to assess genetic management strategies for maintaining the bison genome (Derr 2001).

While hybridization is often viewed as a maladaptive process, another view holds that interspecific hybridization can increase evolutionary flexibility by introducing genetic diversity, especially in populations of rare species (Rhymer and Simberloff 1996). While hybridization may be a last option for highly threatened species, bison are in a less extreme situation, owing to the number of herds and animals across North America. Further, results of investigations regarding the role of interspecific hybridization do not support the hypothesis that the introduction of cattle DNA has increased the evolutionary fitness of bison by providing critically needed genetic variation (Ward 2000). Conversely, the results also do not indicate that the introgression of cattle DNA is evolutionarily maladaptive. Currently, there is no means to determine if the presence of cattle genes in bison poses a threat to their fitness or productivity (Chambers 1998; Ward 2000). However, researchers at Texas A&M University are investigating the effects of cattle mtDNA introgression on metabolic function in bison (Derr 2001).

One management option is to disregard the presence of cattle DNA in the bison genome. Systematic culling of mtDNA hybrids may also remove bison nuclear DNA unique to certain maternal lineages, as mtDNA is maternally inherited, and would not eliminate nuclear hybrids in the herd. However, the indiscriminate inclusion of bison with

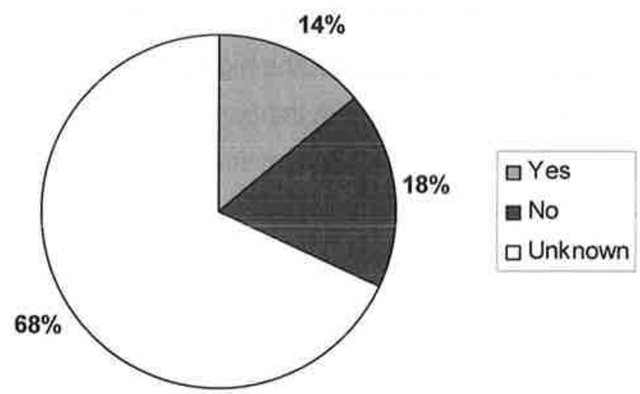

Figure 6.1: Current bison x cattle hybrid status of conservation plains bison herds based on cattle mtDNA and nuclear DNA introgression.

questionable genetic history or known to possess cattle DNA into bison conservation herds could facilitate the further infiltration of cattle DNA into the bison genome. As well, the presence of cattle DNA could preclude listing and protection of plains bison under wildlife protection legislation, such as the US Endangered Species Act (O'Brien and Mayr 1991). Given that there are several substantial bison herds so far found to be free of cattle DNA, it is possible to maintain these herds in reproductive isolation from herds containing hybrids until the prevalence and effects of cattle gene introgression are better understood. Elimination of herds with hybrid ancestry from conservation efforts is an option. This strategy, however, is prudent only if there are enough hybrid-free populations with adequate effective population sizes (N_e) to prevent loss of genetic diversity (Ward 2000). Resolution of this issue requires genetic inventories and information on population genetics for North American conservation herds.

Domestication

Many ranchers are entering the bison industry to capitalize on the economic opportunities offered by bison (Dey 1997). The increase in commercial bison production may reflect the recognition of advantages afforded by the adaptations and ecological efficiency of bison as an indigenous range animal. Bison possess several traits that make them preferable to cattle as a range animal, including greater ability to digest low quality forage (Peden *et al.* 1974; Hawley *et al.* 1981; Plumb and Dodd 1993), ability to defend against predators (Carbyn *et al.* 1993; Gese 1999), and low incidence of calving difficulties (Haigh *et al.* 2001). The commercial bison population in North America is at least 500,000 and growing. The Canadian Bison Association estimated that there were 200,000 commercial bison in Canada as of fall 2001, and reported a growing market for bison meat, with exports to the US up 54% from 2000 and up 61% to France during the same period (Conacher 2002, pers. comm.). Although the United States does not include bison in its agricultural census as Canada does, the National Bison Association conservatively estimates that there are approximately 300,000 commercial bison on 2000 ranches in the United States (Carter 2002, pers. comm.). Despite the current plateau in beef and bison meat prices, both associations predict very favourable long-term growth of the bison industry. The number of bison in conservation herds determined by this survey is estimated at only 19,200 for plains and 8,945 for wood bison. Therefore, approximately 95% of North American bison are under commercial production and experiencing some degree of domestication (Lott 1998).

Domestication is an evolutionary process involving the genotypic adaptation of animals to the captive environment (Price and King 1968; Price 1984). Purposeful selection for traits favourable for human needs over several generations results in detectable differences in morphology, physiology, and behaviour between domestic species and their wild progenitors (Darwin 1859; Clutton-Brock 1981; Price 1984). Humans have practiced domestication for at least 9,000 years (Clutton-Brock 1981). As agriculture precipitated the settlement of nomadic human cultures, the domestication of several wild mammal species made livestock farming possible (Clutton-Brock 1981). Intensive management practices and competition between domesticated animals and their wild ancestors often pushed wild varieties and potential predators to the periphery of their ranges or to extinction (Price 1984; Baerselman and Vera 1995; Hartnett *et al.* 1997). Examples of extinct ancestors of domesticated animals include the tarpan (*Equus przewalski gmelini*), the wild dromedary (*Camelus dromedarius*), and the aurochs (*Bos primigenius*) (Baerselman and Vera 1995).

The domestication of cattle provides a relevant history from which to consider the issues of bison domestication. Before cattle (*Bos taurus*) were introduced to North America they had experienced thousands of years of coevolution with human cultures in Europe (Clutton-Brock 1981; Hartnett *et al.* 1997). During the domestication process cattle were selected for docility and valued morphological and physiological traits, but not without adverse consequences. Genetic selection has produced an animal that is completely dependent on humans, is unable to defend itself against predators, and has anatomical anomalies such as a smaller pelvic girdle, which causes calving and walking difficulties (Pauls 1995; Kampf 1998; Knowles *et al.* 1998). Domestication has altered the wild character of cattle, producing animals maladapted to the natural environment. Further, because the aurochs, the wild ancestor of European domestic cattle, became extinct in 1627 (Silverberg 1967), domestic cattle have no wild counterpart to provide a source of genetic diversity for genetic enhancement and maintenance.

While it has been suggested that domesticated animals can be reintroduced into the wild and revert to a feral state (Lott 1998; Kampf 1998; Turnbull 2001), such attempts do not restore the original genetic diversity of a species (Price 1984; van Zyll de Jong *et al.* 1995). Experience has shown that recovery of original genetic diversity is difficult or impossible once domestic breeds are highly selected for specific traits and wild stocks are extinct (Price 1984; van Zyll de Jong *et al.* 1995; Turnbull 2001). For example, in the 1920s, two German brothers, Heinz and Lutz Heck, set out to "re-create" the aurochs by back-breeding domestic cattle with other cattle demonstrating aurochs-like qualities (Silverberg 1967; Turnbull 2001; Fox 2001). They produced one successful line, the Hellabrunn breed, also known as Heck cattle. This is an animal that looks very much like an aurochs, but is devoid of the wild traits and hardiness of the original wild form (Silverberg 1967; Fox 2001). Therefore, the original wild genotype is no longer available to the cattle industry for improving domestic breeds. The history of the aurochs offers a lesson for bison: domestication can lead to altered genetically-based behaviour, morphology, physiology, and function, and to the loss of the wild type and the genetic diversity it contains.

The primary goal of many commercial bison ranchers is to increase profits by maximizing calf production, feed-to-meat conversion efficiency, and meat quality (Schneider 1998). This requires non-random selection for traits that serve this purpose, including conformation, docility, reduced agility, growth performance, and carcass composition. Selection for these traits reduces genetic variation and changes the character of the animal over time (Schneider 1998). Although a growing number of consumers prefer naturally produced meat products without hormones, antibiotics, or intensive management (Morris 2001), the demand for bison cannot currently compete with the much larger scale of the beef industry. Therefore, many bison producers apply cattle husbandry practices and standards to bison. Artificial selection based on husbandry and economics may make good business sense in the short term, but it will not maintain the bison genome.

The goals of commercial bison production are generally not compatible with the conservation of the wild species. Further, commercial bison operations could pose a threat to conservation populations through a form of genetic pollution, if genetically selected commercial animals are mixed into conservation herds. The most prudent action is to identify and maintain existing conservation herds, and avoid mixing commercially propagated stock into those herds. Bison producers and the bison industry could benefit in the long term by supporting efforts to restore and maintain conservation herds, particularly those subject to a full range of natural selection pressures. Conservation herds secure the bison genome for the future use of producers – an option not available for most other domestic animals.

Genetic Management Within Plains Bison Conservation Herds

This section outlines the genetic management practices applied in the 50 plains bison conservation herds across North America. Information was obtained from herd managers through the questionnaire process described in Chapter 2. Many herd managers indicated that they do not have enough information to create a genetics management plan. Genetic testing to date has typically been for a specific study; measures have varied between studies and have not provided comprehensive genetic information. Approximately 68% of plains bison conservation herds have not been subject to any form of genetic testing. Consequently, management of the bison genome is impeded by the substantial lack of genetic inventory data for North American herds.

Most herd managers do not have well-defined goals for genetic management, but may employ some genetic management practices based on limited information. Based on questionnaire responses from herd managers, the most common management practice applied in conservation herds to maintain genetic diversity is augmentation (the addition of animals). Approximately half of plains bison conservation herds have received bison from various sources. The herds that do not receive new animals may not require additional genetic material, or the herd managers may not want to risk introduction of animals with hybrid ancestries or those influenced by domestication.

In both open and closed herds, many managers noted bull replacement as another method for maintaining genetic diversity and avoiding inbreeding. By culling previously dominant bulls, younger or recently introduced bulls have the opportunity to breed and contribute new genetic material. Several managers indicated that they select replacement bulls based on physical and behavioural traits, such as size, vigour, appearance, and aggressiveness. Therefore, even though these managers are not actively selecting which bull may mate, they make decisions that will influence the genome. Selective breeding for managing diversity is used in only one plains bison conservation herd. Only two herds currently experience purposeful selection for maintaining identified genetic characteristics, such as rare alleles and blood groups.

Selective culling may alter the genetic composition of a herd. Only 12 plains bison conservation herds are not actively culled by the managing authorities. Of these, 11 use hunting as a mechanism to manage numbers, allowing hunters to exert some selection pressure. Thirty-eight herds are culled regularly, normally on an annual basis, using various criteria and practices (Table 6.1). There is no standard culling method that would eliminate the risk of losing genetic diversity. Herd circumstances vary and many herds have not had a genetic assessment, making informed culling decisions difficult. Criteria such as appearance, body conformation, and weight are used by commercial producers who select for market traits and are not appropriate for conservation herds. Random culling or emulation of natural mortality patterns (e.g., mimicking natural predator choices) are preferable. More research is needed to develop appropriate culling practices and to evaluate how they impact the genetic composition of conservation herds.

Table 6.1: Common criteria and practices used by plains bison herd managers to selectively cull animals.

Criteria	Number of herds
Age class	25
Appearance	7
Reproductive success	2
Weight/size	3
Body conformation	3
Injured/deformed	3
Diseased	1
Practice	
Birth synchrony considerations	3
Genetic considerations	2
Health considerations	3
Opportunistic removal	3
Remove aggressive or "grumpy" animals	1
Mimic historic predators	1
Favour replacement animals	1
Remove all or some proportion of calves	7

Chapter 7: Disease

Bison are susceptible to numerous pathogens and parasites, many of which also occur in domestic cattle (see Tessaro (1989), Berezowski (2002), and Reynolds *et al.* (2003) for reviews.) There are three principles to note when considering the conservation significance of a disease: (1) exposure to a pathogen or parasite does not always result in disease or negative effects on the host; (2) varying host species may react differently to the same pathogen or parasite; and (3) the effects of a disease on an individual may not affect the population (Tessaro 1989; Shaw and Meagher 2000). Therefore, not all pathogens and parasites pose a threat to conservation of a species.

Two conservation concerns arising from diseases in bison are (1) the impact of a disease on the viability of a population, and (2) the potential threat a diseased herd poses to adjacent commercial livestock and humans. Livestock diseases that may restrict trade or pose a risk to human health may be designated as reportable under federal, provincial, or state legislation. The Canadian Health of Animals Act requires owners, and anyone caring for animals or having control over animals to immediately notify the Canadian Food Inspection Agency (CFIA) when they suspect or confirm the presence of a disease prescribed in the Reportable Diseases Regulations (CDOJ 2001; CFIA 2001). The CFIA reacts by either controlling or eradicating the disease based upon a program agreed to by all stakeholders (CFIA 2001). The US Department of Agriculture Animal and Plant Health Inspection Service (APHIS) also conducts federal eradication plans for several livestock diseases (USNARA 2002). Eradication in either country may involve test and slaughter regimes, or depopulation of an affected herd. Therefore, the presence of reportable diseases in free-ranging bison presents a serious economic threat to adjacent commercial livestock owners who risk partial or complete losses of their herds should transmission occur.

Diseases of Conservation Concern

Three contagious diseases of considerable concern for bison conservation are anthrax, bovine tuberculosis, and bovine brucellosis. These are reportable diseases in both the United States and Canada (CDOJ 2001; USNARA 2002). Chronic wasting disease (CWD) is an important emerging prion disease of wild ungulates in North

America. There is no evidence to date, however, that CWD affects bison (Williams *et al.* 2002).

Anthrax

Anthrax is an infectious bacterial disease caused by *Bacillus anthracis* (Dragon and Rennie 1995). It has been suggested that anthrax was introduced to North America through livestock brought by colonists during the 17th-19th Centuries (Tessaro 1989; Dragon *et al.* 1999). The disease is now endemic to many areas around the world including northern Canada (Dragon and Rennie 1995; Gates *et al.* 2001a). After inhalation or ingestion by a host, the endospores germinate and the vegetative form of the bacterium replicates in the bloodstream, releasing toxins causing septicaemia and death (Dragon and Rennie 1995; Gates *et al.* 2001a). Upon release from a carcass, highly resistant endospores can remain viable in the soil for decades before infecting a new host (Dragon and Rennie 1995). Under certain environmental conditions, concentrations of endospores can cause periodic outbreaks among wood bison in the Slave River Lowlands, Mackenzie Bison Sanctuary, and Wood Buffalo National Park (Pybus 2000; Dragon and Elkin 2001; Gates *et al.* 2001a). Between 1962 and 1971, anthrax and the associated depopulation and vaccination programs employed to control the disease, accounted for over 2800 wood bison deaths (Dragon and Elkin 2001). Further outbreaks occurred in the Mackenzie Bison Sanctuary in 1993, in the SRL in 1978 and 2000, and in WBNP in 1978, 1991, 2000, and 2001 (Gates *et al.* 1995; Nishi *et al.* 2002). There is no treatment for anthrax in free-ranging bison; however, captive bison can be vaccinated (Gates *et al.* 2001a). Despite the mass death of bison during anthrax outbreaks, the sporadic nature of the outbreaks and predominance of male deaths suggest that the disease plays a minimal role in long-term population dynamics, unless operating in conjunction with other limiting factors (Shaw and Meagher 2000; Joly and Messier 2001b).

Bovine Tuberculosis

Bovine tuberculosis is a chronic infectious disease caused by the bacterium *Mycobacterium bovis* (Tessaro *et al.* 1990). The primary hosts for bovine tuberculosis are cattle and other bovid species such as bison, water buffalo (*Bubalus bubalis*), African buffalo (*Syncerus caffer*), and yak (*Bos grunniens*). Primary hosts are those species that are susceptible to infection and will maintain and propagate a disease indefinitely under natural conditions (Tessaro 1992). Other animals may contract a disease but not perpetuate it under natural conditions; these species are secondary hosts. The bison is the only native species of wildlife in North America that can act as a true primary host for *M. bovis* (Tessaro 1992). Historical evidence indicates that tuberculosis did not occur in bison prior to contact with infected domestic cattle (Tessaro 1992). Bovine tuberculosis is primarily transmitted by inhalation and ingestion (Tessaro *et al.* 1990); the bacterium may also pass from mother to offspring via the placental connection, or through contaminated milk (FEARO 1990; Tessaro 1992). The disease can affect the respiratory, digestive, urinary, nervous, skeletal, and reproductive systems (FEARO 1990; Tessaro *et al.* 1990). Once in the blood or lymph systems the bacterium may spread to any part of the host and establish chronic granulomatous lesions, which may become caseous, calcified, or necrotic (Tessaro 1992; Radostits *et al.* 1994). This chronic disease is progressively debilitating to the host, and may cause reduced fertility and weakness; advanced cases are fatal (FEARO 1990). The disease manifests similarly in cattle and bison (Tessaro 1989; Tessaro *et al.* 1990). Both the United States and Canada perform nationwide surveillance of abattoir facilities to monitor tuberculosis infection in cattle and domestic bison (APHIS 1995; CFIA 2000). There is no suitable vaccine available for tuberculosis (FEARO 1990; APHIS 1995; CFIA 2000). The only definitive method for completely removing tuberculosis from a herd is depopulation (APHIS 1995; CFIA 2000).

Bovine Brucellosis

Bovine brucellosis, also known as Bang's disease, is caused by infection with the bacterium *Brucella abortus* (Tessaro 1989; Tessaro 1992). The primary hosts for bovine brucellosis are cattle and other bovid species (Tessaro 1992). Current evidence suggests that brucellosis was introduced to North America from Europe during the 1500s (Meagher and Mayer 1994; Aguirre and Starkey 1994). The disease primarily transmits through oral contact with aborted fetuses, contaminated placentas, and uterine discharges (Reynolds *et al.* 1982; Tessaro 1989). The impacts of brucellosis on female bison are abortion, inflammation of the uterus, and retained placenta (Tessaro 1989). Greater than 90% of infected female bison abort during the first pregnancy; however, naturally acquired immunity reduces this abortion rate to 20% after the second pregnancy, and to nearly zero after the third pregnancy (Davis *et al.* 1990; Davis *et al.* 1991). Male bison experience inflammation of the seminal vessels, testicles, and epididymis, and in advanced cases, sterility (Tessaro 1992). Both sexes are susceptible to bursitis and arthritis caused by concentrations of the bacterial organism in the joints, resulting in lameness, and possibly increased vulnerability to predation (Tessaro 1989; Tessaro 1992).

Serology is used to detect exposure to *B. abortus* by identifying the presence of antibodies in the blood. Seroprevalence is the percentage of animals in a herd that carry antibodies (Cheville *et al.* 1998). A seropositive result, indicating the presence of antibodies, does not imply current infection. The organism must be cultured from tissue samples to diagnose an animal as infected. Seroprevalence may overestimate the true level of brucellosis infection (Dobson and Meagher 1996; Cheville *et al.* 1998). However, a disparity between serology results and level of infection could also be attributed to false negative culture results related to the difficulties in isolating bacteria from chronically infected animals (Cheville *et al.* 1998; USDOI 2000).

There is currently no fully effective vaccine for preventing bovine brucellosis (Davis 1993; Cheville *et al.* 1998). Strain 19 (S19) was a commonly used vaccine administered to cattle from the 1930s until 1996 (Cheville *et al.* 1998). It was only 67% effective in preventing infection and abortion in cattle (Cheville *et al.* 1998). S19 was found to induce a high frequency of abortions in pregnant bison (Davis *et al.* 1991). Other studies failed to demonstrate efficacy of S19 as a bison calfhood vaccine (Templeton *et al.* 1998). A newer vaccine, strain RB51, is now preferred over S19 because it does not induce antibodies that can interfere with brucellosis serology tests (Cheville *et al.* 1998; Roffe *et al.* 1999a). RB51 protects cattle at similar levels to S19 (Cheville *et al.* 1993). Doses of RB51 considered to be safe in cattle were found to induce endometritis, placentitis, and abortion in adult bison (Palmer *et al.* 1996). However, Roffe *et al.* (1999a) found RB51 to have no significant adverse effects on bison calves. The efficacy of RB51 in bison is still unclear (Cheville *et al.* 1998).

Occurrence of Disease: Plains Bison

Based on this survey, two of 50 plains bison conservation herds in North America have significant chronic disease issues: Yellowstone National Park and the Jackson herd in Grand Teton National Park/National Elk Refuge. These herds, residing in the

Greater Yellowstone Area (GYA), harbour brucellosis and account for 4,700 bison, or 24% of the North American plains bison conservation population.

Yellowstone National Park

Brucellosis was first detected in the Yellowstone National Park (YNP) bison population in 1917 (Mohler 1917). The origin of brucellosis in the park is unclear (Meagher and Mayer 1994). Opportunistic and systematic serological surveys in the area revealed seroprevalence varying between 20% and 70%, while bacterial cultures indicated an infection prevalence of approximately 10% (Meagher and Mayer 1994; Dobson and Meagher 1996). More recent testing has revealed 74% seroprevalence and a 46% culture positive level among 26 female YNP bison (Roffe *et al.* 1999b). Although the true prevalence of the disease is unknown, the YNP bison population is considered to be chronically infected with brucellosis (Cheville *et al.* 1998). Nevertheless, studies have determined that brucellosis is not a threat to the long-term survival of the YNP bison (Mayer and Meagher 1995; USDOI and USDA 2000); the population is currently at 4,000 and increasing (Wallen 2002, pers. comm.).

Herd management is affected by the presence of brucellosis primarily because of the potential risk the disease poses to the livestock industry (Keiter 1997). Bison leaving the park could potentially transmit the disease to domestic cattle grazing on adjacent National Forest and private lands in Montana (USDOI and USDA 2000; USDOI 2000). Bison leave the park in the winter on the north and west boundaries with Montana; movement to the east and south is rare because of topographical barriers (Wallen 2002, pers. comm.). Transmission of brucellosis from bison to cattle has been demonstrated in captive studies; however, there are no confirmed cases of transmission in the wild (Cheville *et al.* 1998; Shaw and Meagher 2000; Bienen 2002). Nevertheless, the potential exists and has created a contentious bison management issue in the area.

The US Department of Agriculture Animal and Plant Health Inspection Service (APHIS) is responsible for preventing and controlling the spread of contagious livestock diseases in the United States. Montana currently maintains a brucellosis-free status as certified by APHIS (USDOI 2000). Transmission of brucellosis to cattle in Montana could indirectly affect all producers in the state if the APHIS status is altered because other states may refuse to accept cattle from Montana (Cheville *et al.* 1998; USDOI 2000).

Resolution of this issue requires the involvement of agencies in several jurisdictions: National Park Service (NPS), USDA Forest Service, APHIS, and the State of Montana Department of Livestock (MDOL) and Department of Fish, Wildlife, and Parks (MFWP). After many years of media and legal controversy over bison management, the agencies acknowledged the need to cooperatively develop a long-term bison management plan. In 1990, they commenced the process for an interagency environmental impact statement to develop alternatives for the plan (USDOI and USDA 2000). A series of interim plans ensued, which enabled NPS and MFWP personnel to shoot bison moving from YNP to Montana, but also progressively incorporated greater tolerance for bison outside the park in certain areas.

Legal disagreements between the federal agencies and the State of Montana dominated the process until 2000 when mediation resulted in a cooperative plan. The 15-year plan employs an adaptive management approach with three phased steps for each of the north and west boundary areas (USDOI and USDA 2000). The plan incorporates several elements including spatial and temporal separation of bison and cattle, capture, test, and slaughter of seropositive bison, hazing of bison back into the park, vaccination, and radiotelemetry monitoring of pregnant bison to locate possible sources of infection if a cow gives birth or aborts outside the park (USDOI and USDA 2000). The ultimate purpose of the plan is to maintain a wild, free-ranging population of bison while protecting the economic viability of the livestock industry in Montana by addressing the risk of brucellosis transmission; it is not a brucellosis eradication plan (USDOI and USDA 2000). Although eradication of brucellosis from bison in the park is a future goal, such an effort is complicated by retransmission potential from elk (*Cervus elaphus*) in the GYA, which also harbour the disease (Wallen 2002, pers. comm.). Development of more effective vaccines and vaccination methods for bison and elk are required before considering eradication alternatives (Baskin 1998; Cheville *et al.* 1998). Recent research on genes that control natural resistance to brucellosis may also provide future methods for eradicating brucellosis (Templeton *et al.* 1998).

Grand Teton National Park/National Elk Refuge (Jackson Herd)

The Jackson herd of approximately 700 animals resides in the southern end of the GYA (FWS/NPS 2001), migrating between Grand Teton National Park (GTNP) in the summer and the adjacent National Elk Refuge (NER) in the winter (Cheville *et al.* 1998).

As with the YNP herd, the Jackson herd is chronically infected with brucellosis. Williams *et al.* (1993) reported seroprevalence of 77% and infection prevalence of 36% for the herd. Serology tests over the past five years indicate a seroprevalence of 80% (Cain 2002, pers. comm.). Studies estimate an 8% reduction in fecundity; however, the population has been increasing since the 1970s despite the disease (Cain 2002, pers. comm.).

The Jackson herd began in 1948 with a reintroduction of 20 bison from YNP. These bison were confined to a display enclosure until 1963 when brucellosis was discovered in the herd (Cheville *et al.* 1998). All but 4-5 calves were destroyed. In 1964, Theodore Roosevelt National Park provided 12 brucellosis-free bison to augment the Jackson herd (Cheville *et al.* 1998). In 1968, the herd escaped from the progressively deteriorating enclosure facility (Williams *et al.* 1993; Cheville *et al.* 1998). From that point the park allowed the herd to roam freely. Although the herd was healthy when released, it is suspected that infected elk on the NER introduced brucellosis to the Jackson bison (Cheville *et al.* 1998).

Similar to the YNP herd, the free-ranging nature of the Jackson herd allows for the possibility of transmitting brucellosis to domestic livestock in the area. The NER excludes cattle; therefore, there is no contact between Jackson bison and cattle during the winter (Cheville *et al.* 1998). There is potential contact, however, during bison migration between GTNP and the NER, and in summer when cattle maintain grazing allotments on GTNP and adjacent Forest Service lands (Keiter 1997; Cheville *et al.* 1998).

There is currently no management plan in place for the Jackson bison herd. A bison management plan approved in 1996 after undergoing a National Environmental Policy Act Process (NEPA), was subject to litigation by an animal rights group that questioned the inclusion of a sport hunt to manage population levels (FWS/NPS 2001) (Cain 2002, pers. comm.). The court ruled that destruction of bison for population control could not be conducted until the involved agencies analyzed the effects of winter feeding on bison through an additional NEPA process (FWS/NPS 2001). The feeding grounds attract 90% of the Jackson bison and 6,000-8,000 elk into one small area, creating zones of high brucellosis transmission among elk and bison (Bienen 2002) (Cain 2002, pers. comm.). GTNP and the NER determined that a combined elk and bison management plan is needed to address the interconnected issues of the two species including winter feeding and disease management (FWS/NPS 2001). The Jackson bison and elk herds migrate across several jurisdictions including the NER, GTNP, YNP, Bridger-Teton National Forest, Bureau of Land Management areas, and Wyoming state and private lands (FWS/NPS 2001). The NPS and FWS are coordinating the involvement of the associated agencies, organizations, and private interests. Development of the plan and EIS are underway with completion expected in spring 2004 (FWS/NPS 2001). The FWS is currently assessing a proposal from the Wyoming Game and Fish Department to conduct an interim brucellosis vaccination program for the elk on the NER (US Fish and Wildlife Service 2002a).

Occurrence of Disease: Wood Bison

Wood bison herds in and around Wood Buffalo National Park (WBNP), the Slave River Lowlands (SRL), and the Caribou Mountains-Lower Peace area harbour bovine tuberculosis and brucellosis (Gates *et al.* 1992; Gates *et al.* 2001c). These diseased herds account for 54% of the total wood bison conservation population (Chapter 5). Joly and Messier (2001a) reported the seroprevalence of the diseases to be 31% for brucellosis and 49% for tuberculosis. Aggressive eradication programs in both the United States and Canada are progressively removing brucellosis and tuberculosis from domestic cattle and bison herds (CDOJ 2001; USNARA 2002). The diseased wood bison herds are the only known reservoirs of tuberculosis within all conservation bison herds (Shaw and Meagher 2000; Gates *et al.* 2001c; Reynolds *et al.* 2003).

Tuberculosis and brucellosis were probably introduced to the wood bison populations with the transfer of plains bison from Wainwright Buffalo Park in the 1920s (Fuller 2002). In 1925, the Canadian government implemented a plan to move 6,673 plains bison from the overcrowded Wainwright Buffalo Park to WBNP. The transfer proceeded despite opposition from mammalogical and biological societies in the United States and Canada, who warned of transmission of tuberculosis to the resident wood bison population (Anonymous 1925; Ogilvie 1979; Fuller 2002). Tuberculosis was first reported in WBNP in 1937 (Gates *et al.* 1992; Geist 1996). Although it is not known whether tuberculosis was endemic among wood bison prior to the transfer (Reynolds *et al.* 1982), evidence indicates that the disease was introduced to the wood bison with the transfer of plains bison (Fuller 1966). Brucellosis was also present in the plains bison herd and was reported in WBNP in 1956 (Gates *et al.* 1992).

The presence of tuberculosis and brucellosis threatens the recovery of wood bison in several ways. First, the infected animals are subject to increased mortality, reduced fecundity, and increased vulnerability to predation (Gates *et al.* 1992; Joly and Messier 2001a). In 1934, the bison population in WBNP was estimated at 12,000 (Soper 1941). The population decreased from approximately 11,000 in 1970 to 2151 in 1999 (Joly 2001). This decrease is believed to be attributed in part to the effects of the diseases (Fuller 1991; Carbyn *et al.* 1998; Joly and Messier 2001a). Recently, the WBNP population increased to 4,050; the reasons for this increase are unclear (Bradley 2002, pers. comm.).

Second, the potential exists for the infected herds to transmit the diseases to healthy herds, most notably the Mackenzie, Nahanni, and Hay-Zama herds (APFRAN 1998). Since 1987, the Government of the Northwest Territories has managed a 39,000 km^2 Bison Control Area south of the Mackenzie River to prevent movement of diseased bison into the Mackenzie Bison Sanctuary (MBS) (Nishi 2002). Recent analysis and modelling of bison movements on the landscape has demonstrated considerable risk potential for transmission of disease to healthy wood bison herds and bison ranches in the vicinity of the diseased herds (Gates *et al.* 2001b; Mitchell 2002).

Third, diseased herds preclude the reestablishment of wood bison in much of their original range in the Northwest Territories and Alberta. Diseased herds occupy approximately 12% of original wood bison range in Canada (Gates *et al.* 2001c). Wildlife and agricultural management agencies effectively increase the size of the infected area to 42% by discouraging the establishment of free-ranging herds adjacent to WBNP and surrounding areas because of infection potential (Gates *et al.* 1992).

Much debate and research has occurred to resolve the northern diseased bison issue. In 1990, the Federal Environmental Assessment Panel released its report on its analysis of the disease issues (FEARO 1990). The panel concluded that eradication of the diseased wood bison populations is the only method for eliminating the risk of transmission of bovine brucellosis and tuberculosis from bison to domestic cattle, non-diseased wood bison, and humans. The panel further recommended that healthy wood bison be reintroduced to the area following depopulation of the diseased herds. Sources of healthy bison for reintroduction could include the Elk Island National Park wood bison herd, and animals obtained from the area through genetic salvage operations (FEARO 1990). One such salvage operation, the Hook Lake Wood Bison Recovery Project, is currently underway in Fort Resolution, NWT (Chapter 9).

Several constituencies rejected the Panel's recommendations to depopulate; however, the Northern Buffalo Management Board (NBMB) was formed to develop a feasible eradication plan (Gates *et al.* 1992; Chisholm *et al.* 1998). The NBMB recommended further research into bison and disease ecology before planning management actions for the region (RAC 2001). In 1995, the Minister of Canadian Heritage formed the Bison Research and Containment Program (BRCP) to focus on disease containment and ecological and traditional knowledge research (RAC 2001). The Minister then created the Research Advisory Committee (RAC) to coordinate research activities under the BRCP (Chisholm *et al.* 1998). The RAC comprised a senior scientist appointed by Parks Canada, and representatives from the Alberta and Northwest Territories governments, Canadian Parks and Wilderness Association, and four aboriginal communities (Chisholm *et al.* 1998). During the mandated 5-year period (1996-2001), the BRCP funded projects to assess the prevalence and effects of the diseases on northern bison (Joly and Messier 2001a), and to investigate bison movements and the risk for disease transfer (Gates *et al.* 2001b). The RAC produced a future research agenda and budget for minimum research still required under the BRCP mandate (RAC 2001). Many of the research needs identified by the RAC align with the recommendations outlined in the National Recovery Plan for the Wood Bison prepared by the Wood Bison Recovery Team (Gates *et al.* 2001c).

Disease Management in Perspective

A preliminary consideration regarding disease management in wild populations is whether intervention is warranted (Gilmour and Munro 1991). It can be argued that parasitism by disease organisms is a crucial ecological and evolutionary force in natural systems (Aguirre *et al.* 1995; Wobeser 2002). Classification of a pathogen as indigenous or exotic to a species or ecosystem can influence whether a disease should be managed (Aguirre and Starkey 1994; Aguirre *et al.* 1995; National Park Service 2000). Bovine tuberculosis and brucellosis are believed to have been introduced to bison by domestic cattle. Therefore, management of these diseases in bison should be warranted based on their exotic origins, as well as the threat they pose to domestic animals.

Wobeser (2002) outlines four disease management philosophies: (1) prevention, (2) control, (3) eradication, and (4) *laissez-faire* (do nothing). Preventative measures are those designed to prevent the spread of disease to unaffected individuals or populations. For example, the Bison Control Area in the Northwest Territories is managed to prevent the movement of diseased bison from WBNP to the Mackenzie herd (Nishi 2002). Control measures reduce the frequency of occurrence or the effects of a disease within a population or contain the spread of the disease. Under this regime, a disease will normally persist indefinitely, requiring continued management. The YNP cooperative bison management plan incorporates numerous control measures including test-and-slaughter of diseased bison, hazing of bison back into the park, vaccination, and radio telemetry of pregnant bison (USDOI and USDA 2000). Total eradication of a disease is difficult, and in some cases, may not be possible given current technology and resources. Test-and-slaughter programs, in concert with vaccination, may eradicate a disease from a captive population (Nishi *et al.* 2002b); however, these techniques are difficult to apply to free-ranging wildlife (Wobeser 2002). Depopulation of an infected herd is a potential eradication option; however, there are considerable logistical challenges, genetic salvage considerations, and public resistance issues (Wobeser 2002; Nishi *et al.* 2002b). Selection of disease management techniques depends on the rationale for management, whether the disease is already present in a population, the availability of funding, and the likelihood of success (Wobeser 2002). Managers should also understand the ecology and pathology of the disease, and the dynamics of the pathogen-host relationship (Wobeser 2002; Bengis *et al.* 2002).

Management of wildlife diseases has often been undertaken to minimize risks to humans and domestic animals (Wobeser 2002; Nishi *et al.* 2002b). Disease management for agricultural purposes is based on eradicating a disease from a livestock population (Nishi *et al.* 2002b). The policy and legislative framework for managing reportable diseases in domestic animals is well-developed; however, the eradication protocols used by agricultural agencies are not necessarily compatible with conservation goals (e.g., maintaining genetic diversity) (Nishi *et al.* 2002b). Increasingly, the broader conservation community is examining wildlife disease issues in the context of their impact on the viability of wild populations, conservation translocation programs, and global biodiversity (Daszak and Cunningham 2000; Deem *et al.* 2001; Wobeser 2002). Research is needed on diseases in wildlife, and a framework is required for managing those diseases within the conservation context. An evaluation of the disease management methods presently applied to bison populations could assist with development of policies and protocols designed for managing the health of wildlife populations (Nishi *et al.* 2002b).

Chapter 8: Legal Status and Listings

History of Bison Protection

Prior to European settlement, there were tens of millions of plains bison (Shaw 1995), and over 168,000 wood bison in North America (Soper 1941). During the 1800s, the bison population was rapidly reduced by a combination of factors including commercial hunting by North American aboriginals and Euroamericans for meat and hides, indiscriminate slaughter for sport, regional drought, habitat degradation, hunting associated with expansion of the railroad, competition from domestic livestock, and introduced bovine diseases (Hornaday 1913; Coder 1975; Ogilvie 1979; Dary 1989; Flores 1991; Geist 1996; Danz 1997; Isenberg 2000). By the late 19th Century there were fewer than 1000 bison in North America (Hornaday 1889).

Numerous accounts exist of efforts made by individuals and governments to save the bison from extinction (Coder 1975; Dary 1989; Geist 1996; Danz 1997). The establishment of refuges and propagation of private herds contributed to the recovery of bison. There were also attempts to protect bison through legislation. Once it became evident that the bison was close to extinction, there was limited public protest calling for legislative action (Danz 1997). In the United States, numerous bills were introduced by members of Congress between 1871 and 1876, but no laws were enacted to protect bison (Ogilvie 1979; Dary 1989; Danz 1997). Legal protection for bison may have been stymied by the unofficial policy of the United States government to eliminate the bison as a means to force the aboriginal population onto reserves by removing a major source of sustenance and economy (Ogilvie 1979; Dary 1989; Danz 1997). Several state and territorial governments did enact legislation to protect bison; however, these laws were largely ineffective and unenforceable (Dary 1989; Danz 1997). In 1872, President Grant created Yellowstone National Park (YNP) to protect all natural resources, including bison, within its borders. By 1894, however, poaching had reduced the park bison population from 200 to 25 animals (Coder 1975; Dary 1989; Danz 1997). On May 7, 1894, President Cleveland signed the National Park Protective Act (Lacey Act), which was the first federal law protecting bison. The new law carried a two-year jail term and $1,000 fine for anyone removing mineral deposits, cutting timber, or killing game in YNP (Coder 1975; Dary 1989; Danz 1997).

In Canada, official protection of bison began in 1877 with the passing of *An Ordinance for the Protection of Buffalo* (Ogilvie 1979; MacEwan 1995). This act was nearly impossible to enforce by the small groups of Northwest Mounted Police scattered across the plains, and was later repealed (Ogilvie 1979; MacEwan 1995). In 1883, the *Ordinance for the Protection of Game* was passed, but it was also ineffective (Ogilvie 1979). The government of the Dominion of Canada enacted the *Unorganized Territories Game Preservation Act* in 1894 in part as a response to reports that the wood bison population had declined to 250 (Ogilvie 1979). Enforcement of this legislation was minimal, however, until the Northwest Mounted Police were given the enforcement mandate in 1897 (Soper 1941; Danz 1997; Gates *et al.* 2001c). In 1911, six game guardians appointed by the Dominion Forestry Branch relieved the police from duty, and supervised the protection of wood bison until Wood Buffalo National Park and its warden service were instituted in 1922 (Soper 1941). Under this protection regime, the wood bison population slowly increased to 500 by 1914, and 1,500-2,000 by 1922 (Ogilvie 1979; Gates *et al.* 2001c). Despite protective legislation, prior to 1907, plains bison in Canada were limited to a small herd in Rocky Mountains Park (Banff) and a few animals near Winnipeg (Ogilvie 1979). In 1907, the Dominion of Canada purchased the Pablo-Allard plains bison herd (~716 bison) from Michel Pablo of Montana. The first two shipments (~410 bison) were temporarily held at EINP until their transfer to Wainwright Buffalo Park in east-central Alberta; 48 remained at EINP (Coder 1975; Ogilvie 1979; Fuller 2002). The Pablo-Allard bison were subsequently used to establish herds in several national parks.

Listing and Legal Status

Listing and legal status refers to classifications of vulnerability assigned to a species by scientific listing authorities and under wildlife protection legislation. This section outlines the classifications assigned to the North American bison subspecies at the international and national levels. This survey did not investigate designations at the provincial and state level.

International

The World Conservation Union (IUCN) Species Survival Commission (SSC) uses the IUCN Red List Categories to classify species according to their extinction risk (IUCN

2001). The Red List Categories system is designed to provide an explicit, objective, and quantitative framework that can be consistently applied by various people to different taxa and produce an internationally recognized classification of extinction risk (IUCN 2001). The Red List Categories have undergone several revisions since they were first developed in 1991. Therefore, the classification assigned to a species must be discussed in the context of the version of the categories used to produce the assessment.

The current IUCN Red List of Threatened Species lists *Bison bison* as Lower Risk (Conservation Dependent) (LR/cd) (IUCN 2002a), as assessed under the 1994 Red List Categories (IUCN 1994). A taxon is Lower Risk (LR) when it does not satisfy the criteria for the categories Critically Endangered, Endangered, or Vulnerable (IUCN 1994). A Lower Risk taxon is Conservation Dependent when the cessation of focused conservation action would result in the taxon qualifying for a higher category of risk within five years (IUCN 1994). This assessment was conducted by the Bison Specialist Group in 1996 (IUCN 2002a). The current version of the Red List Categories no longer refers to taxa as Lower Risk, and does not include the Conservation Dependent caveat for Lower Risk taxa (IUCN/SSC Criteria Review Working Group 1999; IUCN 2001). Therefore, a reassessment of bison under the new categories is needed. There are currently no assessments at the subspecies level.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement among governments to ensure that international trade in wild animals and plants does not threaten their survival (CITES 2003c). CITES is legally binding on those countries (Parties) that join the convention. It is the responsibility of each Party to enact legislation that supports CITES on the national level (CITES 2003c). CITES regulates trade in wild species through a licensing system administered through local management authorities designated within each country (CITES 2003b). The level of control and licensing applied to a species depends on its classification under the CITES Appendices (CITES 2003a). Appendix I lists species that are threatened with extinction; trade is permitted only in exceptional circumstances. Appendix II lists species that are not currently threatened with extinction, but could become so if trade is unregulated; limited trade through licences is allowed for these species. Appendix III lists species at the request of any Party that controls trade in a species and requires cooperation from other member countries to avoid exploitation of that species (CITES 2003a). Appendix assessments are made in accordance with criteria set out in the convention (CITES 1994). The Conference of Parties must agree by two-thirds majority before a species may be added to, removed from, or moved between Appendices I and II; Appendix III may be amended by any Party at any time (CITES 2003a).

The wood bison was added to CITES Appendix I in 1975 and downlisted to Appendix II in June 1997 (UNEP-WCMC 2002). Downlisting of the CITES designation was based on 1) the absence of threat from international trade; 2) progress towards recovery in the wild; 3) rapid growth in the commercial wood bison industry; and 4) difficulties presented by the Appendix I listing with regard to regulating trade in commercial wood bison and their products (Gates *et al.* 2001c). The plains bison is not listed under CITES.

National (Canada and United States)

The United States Endangered Species Act (ESA) was enacted in 1973 to protect endangered and threatened species and the ecosystems they inhabit (US Fish and Wildlife Service 2001). The ESA prohibits activities using protected species unless authorized by permit from the US Fish and Wildlife Service (FWS) (US Fish and Wildlife Service 2002b). To receive protection under the ESA a species must first be added to the federal list of endangered and threatened species (Nicholopoulos 1999; US Fish and Wildlife Service 2001). The FWS is responsible for assessing and listing non-marine wildlife, and for developing recovery strategies to restore listed species to a level where protection is no longer required (US Fish and Wildlife Service 2001). Wood bison are listed as Endangered in Canada under the ESA; plains bison are not listed (US Fish and Wildlife Service 2003).

The ESA Endangered listing prevents the import of wood bison to the United States, except under permits issued for scientific research, or enhancement of propagation and survival of the species (US Fish and Wildlife Service 2002b). In 1998, a formal petition was submitted to the FWS to delist the wood bison, based on the proposal used to downlist wood bison from CITES Appendix I to Appendix II to allow commercial trade (Alvarez 1998). The FWS ruled that the petition did not provide substantial information to warrant delisting of wood bison (Alvarez 1998). The FWS indicated that it would consider a petition to downlist wood bison from Endangered to Threatened when the free-ranging disease-free populations of wood bison meet the recovery criteria established by the Canadian Wood Bison Recovery Team (Gates *et al.* 2001c). In 1998, the FWS indicated it would evaluate downlisting captive wood bison from Endangered to Threatened, with a special allowance for import of captive wood bison to the United States (Alvarez 1998); no further action was taken. The Canadian National Bison Recovery Team (formerly the Wood Bison Recovery Team) plans to submit a proposal to the US Fish and Wildlife Service requesting the downlisting of wood bison (Reynolds 2003, pers. comm.).

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is a committee of experts that determines the national status of wild Canadian species suspected of being at risk of extinction (COSEWIC 2002b). In 1978, COSEWIC listed wood bison as Endangered (Gates *et al.* 2001c), which is the category assigned to species facing imminent extirpation or extinction (COSEWIC 2002c). In 1988, the listing was downgraded to Threatened based on a status survey prepared by the Wood Bison Recovery Team (Wood Bison Recovery Team 1987). A Threatened species is one that is likely to become endangered if limiting factors are not reversed (COSEWIC 2002c). The COSEWIC listing for wood bison was last reviewed in May 2000 with no change (COSEWIC 2002a). Currently, there is no COSEWIC listing for plains bison. COSEWIC has commissioned a status survey for plains bison in Canada with expected completion by May 2004.

The Canadian Species at Risk Act (SARA) was passed in December 2002 after a nine year legislative process (Environment Canada 2002b). SARA will come into force in 2003 (Environment Canada 2002c). The goal of SARA is to prevent the extinction of wildlife species, and to assist in the recovery of species that are at risk as a result of human activities. Under this act, COSEWIC listings will be recognized under legislation. COSEWIC assessments will be published in the SARA public registry, and then reviewed by government officials for inclusion on the legal list of species at risk (Environment Canada 2002b). Development of recovery strategies, recovery plans, or management plans will be mandatory for all species listed as extirpated, endangered, threatened, or of special concern. The COSEWIC listing for wood bison and any future listing for plains bison will be considered for inclusion on the legal list under SARA.

The Canadian Endangered Species Conservation Council (CESCC) was formed in 1998 under the 1996 Accord for the Protection of Species at Risk in Canada. The council comprises provincial, territorial, and federal ministers responsible for wildlife. Its mandate is to oversee the status assessment of species and the recovery of species at risk (CESCC 2001). CESCC focuses on producing general status assessments, and acknowledges COSEWIC as an independent source of detailed scientific assessments of species at risk (CESCC 2001). A general status assessment integrates information on population size, distribution, and trends, and known threats to a species within its Canadian range (CESCC 2001). The criteria used to assess the general status of species were derived from the IUCN Red List Categories (IUCN 2001), and the CITES Criteria for Amendment of Appendices I and II (CITES 1994). In its publication *General Status of Species in Canada*, CESCC (2001) indicates that the species *Bos bison* is At Risk, May Be At Risk, or Sensitive depending on the province. The CESCC listings for bison are not detailed by subspecies.

Legal Recognition of Plains Bison

Plains bison are currently not recognized at the subspecific level on any international or national list for species at risk. This survey reveals trends in plains bison status demonstrating that plains bison warrant consideration for a listing. The North American plains bison population is over 500,000 and growing; however, approximately 95% of this population is under commercial production. Of the estimated 19,200 conservation plains bison (Table 5.1), only 8,337 are free-ranging. Further, free-ranging, disease free populations within original plains bison range account for only 1,289 plains bison, or 6.7% of the total conservation population (Table 5.4). Of this subset, three herds, or 689 bison, are not subject to regular handling; these herds have not attained populations meeting an MVP of 400. Therefore, there are few plains bison populations within original range that exist under natural conditions, and none that are considered viable by the current benchmark. Conservation issues related to genetic diversity, hybridization with domestic cattle, and domestication also support consideration of plains bison for listing.

There are potential complications that could accompany the process of listing plains bison. First, the presence of cattle DNA in plains bison herds may preclude listing under some legislation, such as the United States ESA. Hybrids are exempt from the

ESA when propagated in captivity and resulting from one listed parent and one non-listed parent (O'Brien and Mayr 1991; US Fish and Wildlife Service 2002b). Plains bison with hybridization histories could therefore be exempt from the ESA. Second, if all plains bison are considered, then the growing commercial population precludes any arguments for listing based on numerical status. Third, legislation supporting listings may prohibit commercial and captive propagation of a listed species; a situation that the current momentum of the bison industry would not allow. A distinction between wild and domesticated populations would be required under law to support protection of the wild form.

Legal recognition of the wild form is impeded by the classification of bison as livestock by many state and provincial governments. In the absence of protection by wildlife legislation, free-ranging plains bison could potentially be seconded into a private herd or hunted without regulation. The only legal protection afforded to free-ranging bison in this situation would be associated with the legal status of their habitat (such as a national park). Classification as non-wildlife could have implications for the success of attempts to reintroduce wild bison herds. For example, in its Northern Great Plains Management Plans Revision for national grasslands in Montana, North Dakota, South Dakota, Nebraska, and Wyoming, the USDA Forest Service dismissed a proposed alternative to restore free-ranging bison in part because the affected state governments classify bison as livestock (USDA Forest Service 2001; Matthews 2003). The involved states were not interested in accepting the responsibility for managing free-ranging bison or amending their legislation (USDA Forest Service 2001; Matthews 2003). Existing free-ranging plains bison herds in Alaska, Arizona, Montana, Utah, Wyoming, British Columbia, and Saskatchewan are managed as wildlife under state and provincial legislation. Revision of legislation may be required in other jurisdictions to provide for potential reintroductions of free-ranging plains bison.

Chapter 9: Recovery Initiatives

Recovery of a species is achieved through population growth, augmentation, and reintroduction. Recovery through population growth involves maintaining current free-ranging herds and expanding range, when possible, to allow for increased numbers without causing range degradation. Augmentation, also referred to as reinforcement or supplementation (IUCN/SSC Reintroduction Specialist Group 1995), involves the addition of animals to an existing herd to increase the size and genetic diversity of the population. Reintroductions attempt to re-establish viable, free-ranging populations of a species within its original range where it has been extirpated (IUCN/SSC Reintroduction Specialist Group 1995).

Bison recovery should ideally involve the maintenance and reintroduction of free-ranging herds in areas of the original range of the taxon; captive herds subject to minimal human intervention may also support conservation goals. To maximize conservation value, these herds should occupy large geographic areas, and should be of sufficient size and demographic composition to maintain population viability. The herds should be subject to forces of natural selection, including predation, and effective genetic, disease, and range management. They should also be protected under law and free of the previous causes of extirpation.

Recovery Limitations

The most fundamental limitation to bison recovery is lack of suitable habitat. Providing sufficient habitat is critical for avoiding supplemental feeding and for preventing overgrazing. Growth and augmentation of current bison herds are potential methods for bison recovery; however, 52% of plains bison conservation herd managers indicated there is no potential for expanding the range for their herds. The free-ranging nature of most current wood bison herds enables growth and expansion through natural dispersal; however, the presence of diseased herds, wild and commercial plains bison, and human development within original wood bison range impacts growth potential. Essentially, for both plains and wood bison the pressures of a developed landscape, a burgeoning commercial bison industry, and localized issues such as disease and absence of natural predators constrain the current possibilities for effective bison recovery. Identification and evaluation of potential recovery sites is needed for both plains and wood bison.

Plains Bison Recovery: Canada

Through interventions such as purchasing the Pablo-Allard herd, establishing the herd at Elk Island National Park (EINP), and providing sanctuary for the struggling species, the national parks in Canada played a pivotal role in rescuing the plains bison from extinction (Ogilvie 1979). Today, 50% of plains bison conservation herds in Canada are found within national parks. Despite the high level of protection within the national parks (e.g., prohibition of hunting, reduction or absence of large predators in response to high public use, and fences), which can cause a species to be managed intensively (Cool 2001, pers. comm.), protected public lands, including provincial parks, presently offer the best sanctuary for plains bison in Canada. There are also emerging opportunities for bison restoration on lands owned by conservation organizations. The following sections describe four potential plains bison recovery projects, which involve Parks Canada and The Nature Conservancy of Canada (Figure 9.1).

Banff National Park

Although bison were extirpated from the Rocky Mountains more than 100 years ago, archaeological evidence indicates that bison were present in Banff National Park (BNP) for at least 9000 years (Kay and White 2001). BNP is considering reintroducing bison to restore the significant prehistoric and historic role the species played in the Rocky Mountains (White *et al.* 2001). It is predicted that restoration would re-establish a complex set of predator-prey and herbivore interactions, which would in turn address the chronic problem of elk overabundance and intense herbivory in the park (White *et al.* 2001). Archaeological evidence also suggests that bison migrated seasonally between the plains and mountains. Bison may have found protection from harsh winters in the sheltered valleys; however, in those confined valleys they were also subject to high human and carnivore predation (Kay and White 2001). Therefore, to restore ecological integrity, which includes traditional human roles, Parks Canada intends to involve North American aboriginals in the management and restoration of bison through staff hiring programs for biologists and wardens, and by following the guidance of aboriginal advisory committees (White 2001, pers. comm.). Research is also underway to assess

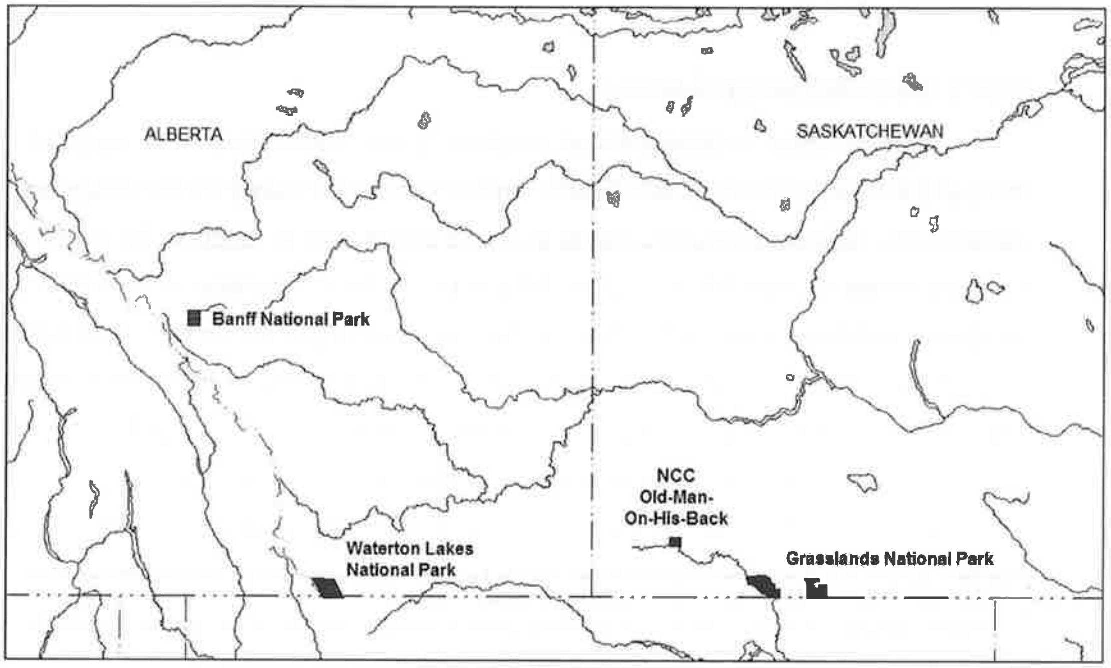

Figure 9.1: Locations of potential plains bison recovery projects in Canada. Grey areas do not necessarily represent actual area of potential bison range.

vegetation composition and develop models for prescribed burning regimes in the park to enhance habitat for ungulate populations; this research could potentially be applied to planning a bison reintroduction (Sachro 2003). Additional considerations include the need for mitigating conflicts with recreational and agricultural areas, assessing public safety, determining range carrying capacity, weighing intensive management versus natural regulation, and monitoring the effects of bison on the ecosystem (Shury 2000).

Grasslands National Park

Grazing by large herbivores, which has been excluded from Grasslands National Park (GNP), is an important source of disturbance in the mixed-grass prairie ecosystem (Parks Canada 2001). GNP has included bison reintroduction in its management plan as a key action for emulating a pre-settlement grazing regime within the park and restoring ecological integrity (Parks Canada 2001). The park would then also represent a microcosm of how bison use and influence the mixed-grass prairie through wallowing, rutting on prairie dog colonies, and grazing large contiguous blocks of prairie (Parks Canada 2001). Park managers have not yet established the size of the potential herd or range. There are several management issues to address including federal and provincial disease testing requirements, infrastructure requirements such as fencing, population management, location within the park, and evaluation of the effects of bison on other species in the park (Parks Canada 2001). The GNP Management Plan is in the final stages of the Parks Canada Agency approval process, and an internal working committee has been formed to commence development of a bison reintroduction plan in concert with a grazing management plan. These plans, prepared in cooperation with stakeholders and the public, will address the logistics of reintroduction and management of the bison (Fargey 2002, pers. comm.).

Waterton Lakes National Park

Waterton Lakes National Park (WLNP) is considering a reintroduction of bison to the Blakiston and Waterton Valleys to expand the ecological role of bison in the park, and potentially complement the existing prescribed burning program. The park currently maintains approximately 25 plains bison in fenced pasture. Managers will need to address several issues to ensure a successful reintroduction including traffic safety, public safety, and potential conflicts with recreational areas such as campgrounds and the golf course. Some of these conflicts might be mitigated through fencing. Managers for WLNP are now assembling information on bison grazing and ecology and the history of bison in the area before developing a reintroduction plan (Watt 2002, pers. comm.).

Old-Man-On-His-Back Prairie – The Nature Conservancy of Canada

The Nature Conservancy of Canada (NCC) has initiated a new prairie grassland project, the Old-Man-On-His-Back Prairie and Heritage Conservation Area (OMB), which comprises a 13,100 acre (53 km^2) area of intact semi-arid mixed-grass prairie in southwest Saskatchewan (NCC 2002). The NCC plans to restore plains bison as the natural grazer in this area to restore the functions of the mixed-grass prairie. The NCC intends this captive herd to be disease-free, genetically diverse, and subject to minimal intervention by managers. The NCC hopes that bison will also highlight the compatibility of ranching, grazing, and conservation goals (NCC 2002). This will be the only conservation herd in Canada managed by a conservation organization.

Plains Bison Recovery: USA

Seven plains bison conservation herds in the United States have active plans for range expansion and herd augmentation. Plans to reintroduce conservation bison populations in the United States are limited. The USDA Forest Service recently conducted an assessment of its management of national grasslands in Montana, North Dakota, Nebraska, South Dakota, and Wyoming; it dismissed a proposed alternative to restore free-ranging bison (USDA Forest Service 2001). Two appeals to this decision are being considered by the Chief of the Forest Service (Kessler 2003, pers. comm.). Four suitable areas of public land in Montana have been identified for potential bison reintroductions (Knowles 2001); however, Montana Fish, Wildlife and Parks has not pursued development of the environmental impact statement (EIS) that is required prior to proceeding with a reintroduction (Knowles 2003, pers. comm.). This survey identified no other specific bison reintroduction plans in the United States. There are, however, two landscape-level grassland restoration projects being planned that involve bison reintroduction: The Big Open and The Buffalo Commons' Million Acre Project.

The Big Open

The Montana Big Open project, managed by the non-profit organization Montana Big Open, Inc., involves the restoration of approximately 15,000 square miles (38,850 km^2) of steppe grasslands in eastern Montana to conditions analogous to pre-European settlement, with bison as the focal species (Scott 1998; Coffman 2000; Scott and Coffman 2001; Scott 2001). The concept suggests replacing the marginal economy of an area that has low human density with the development of a cooperative, wildlife-based economy, which would include hunting, recreation, and ecotourism (Scott 1998; Coffman 2000; Scott 2001). The Wild Bison Recovery Initiative is the phased bison management plan for the Big Open, which envisions the eventual existence of 125,000-250,000 bison managed as wildlife on upwards of 10,000,000 acres (40,500 km^2) of land (Scott and Coffman 2001). Although the Big Open project is ambitious, and must contend with the issues of land subdivision, agricultural development of grasslands, growth of commercial bison ranching, and the human tendency to resist change, the plan incorporates conservation science, acknowledges a diversity of viewpoints and competing land use ideas, and respects the power of private property rights (McDonald 2001).

The Buffalo Commons' Million Acre Project

In the late 1980s, Drs. Deborah and Frank Popper studied the demographics of the United States and noted that as many as ten of the Great Plains states had been experiencing drastic declines in human population (Callenbach 1996). As planners, they developed an idea – the Buffalo Commons - they believed could rejuvenate these economically declining regions by encouraging bison-oriented tourism and a wildlife-based economy through the reintroduction of free-ranging bison to a large expanse of grassland (Coffman 1995; Callenbach 1996; Great Plains Restoration Council 2002a).

Building on the idea of the controversial Buffalo Commons, the Great Plains Restoration Council (GPRC) has initiated the Million Acre Project. This million acres (4,050 km^2), representing the suggested minimum size for reconstructing a functioning prairie ecosystem (McDonald 2001; Great Plains Restoration Council 2002b), would encompass the protected core of a swath of land from Canada to Mexico, forming the Buffalo Commons. Although the idea of the Commons met with considerable opposition, the vision persists and is taking initial form through the Million Acre Project, and similar initiatives such as the Montana Big Open, both of which seek to restore free-ranging bison to large areas of contiguous grassland and restore the prairie ecosystem.

The GPRC is currently conducting geographic analysis to identify candidate sites for the Million Acres based on ecological, demographic, and political indicators

(McDonald 2001). Although the GPRC expects to establish this core zone within ten years, it currently lacks the grassroots discussion with, and representation by, local residents, which will be essential for successfully creating the preserve (McDonald 2001).

Wood Bison Recovery

Most early bison conservation efforts focused on plains bison because they were initially more numerous and closer to population centres. Concurrently, wood bison occurred in smaller numbers in more remote areas of northern Canada, making their plight less apparent. Nevertheless, history shows that through early legal measures and the creation of WBNP, wood bison received conservation attention and rebounded. Since 1975, the Canadian Wood Bison Recovery Team (WBRT) has promoted several wood bison reintroduction projects to support the recovery goal of establishing four viable, geographically separate, free-ranging, and tuberculosis- and brucellosis-free wood bison populations (Gates *et al.* 2001c). However, the recovery of wood bison in Canada is constrained by the presence of diseased bison herds in an around WBNP, limiting the availability of original wood bison range in Alberta, Northwest Territories, and British Columbia (Gates *et al.* 2001c). Opportunities are further decreased by the presence of plains bison in wood bison range, in areas such as Pink Mountain, BC, and Alaska.

There may be potential for wood bison recovery in the Mackenzie Valley from Camsell Bend to the Mackenzie Delta, and in all of the connecting mountain valleys, (estimated to be tens of thousands of square kilometres) (Chowns 2003, pers. comm.). Topographic barriers have stalled the expansion of the Mackenzie and Nahanni herds into the Camsell Bend area. If bison were established in this area, it is predicted that they would disperse into other areas of suitable habitat down the length of the Mackenzie Valley (Chowns 2003, pers. comm.). Management actions following forestry and tar sands development may also provide opportunities for wood bison reintroductions on reclaimed grasslands (Pauls 1995; Gates *et al.* 2001c). Resolution of the northern disease issue would considerably enhance the potential for wood bison recovery. Until that time, there are recovery projects underway that could mitigate the disease problem and others that could occur in parts of original range that are not threatened by disease.

Hook Lake Wood Bison Recovery Project

The Hook Lake Wood Bison Recovery Project (HLWBRP) seeks to establish a captive, disease-free herd of wood bison from a wild herd infected with bovine tuberculosis and brucellosis, and then reintroduce a disease-free population into the wild (Gates *et al.* 1998; Nishi *et al.* 2002a). This project, cooperatively managed by the Deninu Kue' First Nation, Fort Resolution Aboriginal Wildlife Harvesters' Committee, and the Government of Northwest Territories, Canada, endeavours to contribute to the resolution of the northern diseased bison issue. The long term objectives of the project focus on habitat management, disease eradication, genetic conservation, and wood bison recovery in the Slave River Lowlands (Nishi *et al.* 2001).

After three calf capture operations, followed by extensive disease testing and hand rearing, the captive herd now has 57 founders in three cohorts (Nishi *et al.* 2001; Wilson *et al.* 2002b). Conservation genetics studies on the herd reveal that 95% of the original genetic diversity in the wild Hook Lake herd is represented within the captive herd (Wilson 2001), making it more genetically variable than any other captive wood bison herd (Wilson *et al.* 2002b). Although this project represents a successful genetic salvage operation, studies have found that the variability held by the founding animals is not fully represented in the calves born to the population. This discrepancy is likely the result of the high variance in male reproductive success observed in this population (Wilson 2001). If differential reproductive success in males is not managed, over time, genetic drift will erode the diversity salvaged from the wild population (Wilson 2001). Therefore, studies have been underway to assess techniques for managing and maintaining the diversity currently held by the captive herd (Wilson *et al.* 2002b), and a genetic management plan has been designed to ensure that genetic diversity within the population is not lost at unacceptable rates (Wilson and Nishi 2003, pers. comm.). A recent risk assessment on the health status of the herd determined that it is improbable that brucellosis and tuberculosis are present (APFRAN 2003). Once the herd obtains official disease-free status it can be a source of bison for future wood bison reintroductions.

Heart Lake Wood Bison Recovery Project

In 2000, Elk Island National Park and the Canadian Wildlife Service entered into an agreement with the Alberta Tribal Chiefs Association and the Heart Lake First Nation to establish the Heart Lake Wood Bison Recovery Project. The project involves the transfer of up to 100 wood bison to establish a captive commercial herd for providing economic development opportunities for Heart Lake First Nation and a captive conservation herd for future recovery needs. Heart Lake First Nation has demonstrated its commitment to wood bison recovery by dedicating a considerable portion of the Heart Lake Reserve to the project. The plan is to generate revenue from the commercial operation for management of the two project initiatives. The long-term objective is to release the conservation herd into the wild as part of the national Wood Bison Recovery Program upon resolution of the northern diseased bison issue.

In February 2001, 57 wood bison from Elk Island National Park were transferred to an 80-acre fenced enclosure and fed year round until the facility was expanded and was large enough to allow the herd to graze without supplemental feeding. Funding shortfalls, delays in expanding the enclosure, and on-site management issues with overcrowding and poor animal condition have delayed the transfer of the remaining 43 wood bison until sufficient funding can be generated to continue expanding the enclosure and improve the habitat by prescribed burning and re-seeding of logged areas. A Heart Lake Wood Bison Advisory committee (comprised of First Nation, Alberta Pacific Forest Industries Inc. (ALPAC), Canadian Wildlife Service, and Parks Canada representatives) continues to be committed to developing funding initiatives to maintain the project. The Heart Lake First Nation and the member First Nations of the Tribal Chiefs Association remain firmly committed to the long-term success of the project (Reynolds and Cool 2002, pers. comm.).

Yukon Flats, Alaska

Since 1991, the Alaska Department of Fish and Game has investigated the reintroduction of wood bison to the Yukon Flats area of Alaska (Gates *et al.* 2001d). The Yukon Flats area offers high quality habitat with a carrying capacity of at least 2,000 bison (Gates 1992; Berger *et al.* 1995). As discussed in Chapter 3, Alaska was once thought to be in the "prehistoric" range of bison; however, recent archaeological and anthropological investigations have shown that wood bison were also present historically in Alaska, making Alaska part of the original range of the subspecies (Stephenson *et al.* 2001). This proposal has received a great deal of support from both the public and involved agencies; however, the US Fish and Wildlife Service has questioned the status of wood bison as a native animal, and whether this would be a reintroduction or an introduction (Gates *et al.* 2001d) (Stephenson 2002, pers. comm.). Heightened dissemination of recent information regarding the historical presence of wood bison in Alaska should alleviate these concerns, and make it clear that it would be a reintroduction (Gates *et al.* 2001d). Managers must still establish mechanisms for local involvement, harvest regimes, and cooperative management prior to implementation (Gates *et al.* 2001d). This project provides a potential opportunity to establish a shared transboundary population in Alaska and the Yukon, consistent with the 1997 international agreement *Framework for Cooperation between Environment Canada and the US Department of the Interior in the Protection and Recovery of Wild Species at Risk* (US Fish and Wildlife Service and Environment Canada 1997; Gates *et al.* 2001c).

Pleistocene Park, Republic of Sakha (Yakutia), Russian Federation

Pleistocene Park is a 160 km^2 reserve set aside in Siberia through a collaborative effort between the Government of the Republic of Sakha (Yakutia) and the Pleistocene Park Association, a non-profit consortium of international scientists. The government and Park Association are restoring grazing mammals within a fenced area to recreate the grazing system of the former Mammoth Steppe and evaluate the effects of herbivory in the northern environment (Gates *et al.* 2001c; Gates *et al.* 2001d). Although debated (Cwynar and Ritchie 1980), evidence suggests that Beringia, the unglaciated land mass spanning eastern Siberia, Alaska, and the Yukon during the Wisconsin glaciation, supported a productive grassland known as the Mammoth Steppe (Guthrie 1990; Zimov *et al.* 1995; Catling 2001). The wood bison is morphologically similar to the steppe bison (*Bison priscus*), the most recent bison form to inhabit Siberia 5,000-6,000 years ago (van Zyll de Jong 1993). As well, wood bison have been successfully reintroduced to northern regions of Canada (Gates *et al.* 2001d), making the wood bison an appropriate candidate for inclusion in Pleistocene Park. Although this reintroduction is outside the original range of wood bison, the Canadian Wood Bison Recovery Team (WBRT) supports this initiative because it provides another geographically separate wood bison population, which would help secure the survival of the subspecies (Gates *et al.* 2001c). Under the IUCN/SSC Guidelines for Reintroductions, this initiative could be considered as a Conservation/Benign Introduction: "an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within appropriate habitat and eco-geographical area" (IUCN/SSC Reintroduction Specialist Group 1995). The governments of Canada and the Republic of Sakha (Yakutia) are establishing a protocol for this project. The WBRT recommends that the bison transfer agreement include the condition that wood bison will not be released to the wild in Siberia unless skeletal and DNA analyses indicates Siberian Holocene forms are related to North American Holocene bison (Gates *et al.* 2001c; Gates *et al.* 2001d). A transfer of wood bison from Canada to Pleistocene Park is expected, pending funding and completion of the protocol.

For further information on wood bison recovery, refer to the Canadian National Recovery Plan for the Wood Bison (Gates *et al.* 2001c).

Grasslands Ecosystem Restoration

The grasslands of the Great Plains comprise one of North America's most threatened ecosystems (Knopf and Samson 1997). Plains bison restoration has the potential to unite Great Plains residents, encourage a shift from cattle to bison grazing, and effectively support ecological and economic restoration of the grasslands (McDonald 2001). In Canada, the governments of Alberta, Saskatchewan, and Manitoba developed action plans building on the World Wildlife Fund's 1988 Prairie Conservation Action Plan, which focused on prairie-wide conservation and management efforts (Environment Canada 2002a). More recently, the Living Grasslands Initiative has emerged out of the Northern Plains Conservation Network, an informal coalition of 22 organizations dedicated to plains conservation (Teel 2002) (Proctor 2002, pers. comm.). This initiative, which envisions the formation of a large prairie protected area spanning two provinces and five states, still requires decades of planning and cooperative work with scientists, economists, and local communities to become feasible (Wallis 2002); however, small scale actions over time can contribute to large scale visions. For example, the Department of National Defence and Environment Canada are collaborating to establish a National Wildlife Area (NWA) on the Canadian Forces Base Suffield in southeastern Alberta (Johnson 2002). This NWA is currently independent of landscape-level projects, but could one day be part of a larger protected area that houses numerous wildlife species including bison. Although ambitious, concepts such as Montana's Big Open, the Million Acre Project, and the Living Grasslands Initiative consider landscape-level processes and, to different degrees, focus on multi-stakeholder networks to facilitate positive economic and environmental rejuvenation of the prairie region and re-establish free-ranging bison on the North American landscape.

Bison and Aboriginal People of North America

Although beyond the scope of this survey, there is also recovery potential through the process of repatriating bison to the lands of North American aboriginal people (Torbit 2001). The InterTribal Bison Cooperative (ITBC), comprising over 50 tribes, was formed in 1992 to facilitate the reintroduction of bison within tribal communities and restore the cultural and spiritual ties between aboriginal people and bison (Cournoyer 1996; McDonald 2001). Through the efforts of the ITBC, there are emerging examples of bison restoration, and consequently ecosystem and cultural restoration, on reservations in the United States (Chadwick 1998; Torbit 2001). Further, many reservations are adjacent to public lands, presenting the potential for collaborative management of bison herds that roam between tribal and public lands (Torbit 2001). In Canada, there are wood bison herds managed by aboriginal communities in cooperation with private interests or government agencies (Table 5.2). As with commercial herds, criteria are needed to evaluate bison herds on aboriginal lands for congruence with conservation goals.

Chapter 10: Considerations for an Action Plan

Role and Components of the Action Plan

The IUCN Species Survival Commission (IUCN/SSC) established its action planning process to determine species conservation priorities through the production of Conservation Status Survey and Action Plan documents (Action Plans). An Action Plan provides an authoritative reference work on species within a taxonomic group, and recommends scientifically-based, prioritized conservation actions needed to ensure survival and recovery of the species (Gimenez Dixon and Stuart 1993). Action Plans are used in several ways (Gimenez Dixon and Stuart 1993):

- as references for planning by conservation organizations;
- as information sources for allocating funds;
- as models for other Action Plans and documents; and
- as fundraising tools.

Recommendations for the Action Planning Process

The status assessment information on bison presented in preceding chapters provides a foundation, which the BSG can use to develop an Action Plan. The following section provides recommendations, presented in a logical sequence, for the BSG to consider when developing the Action Plan.

- Contract or hire a coordinator to facilitate Action Plan development and manage BSG administrative needs. The coordinator would be responsible for ensuring that the action planning process does not lose momentum.
- Continue using the website collaboration process to facilitate coordination of the Action Plan.
- Convene the BSG for at least one formal planning session.
- Establish a vision statement for the Action Plan to support overall direction of the planning process.
- Set recovery goals and objectives, and then develop conservation actions to fulfill each goal and objective. Broad, long-term, and general conservation actions

should be accompanied by specific actions on the smaller, short-term scale to increase effectiveness of the Action Plan.

- Consider the appropriateness and practicality of potential conservation actions. There are several questions to consider when assessing conservation actions for any species (Snyder *et al.* 2000):
    - Is the action appropriate to the ecology of the species?
    - Is the action effective in promoting survival and recovery?
    - Is the action compatible with the local human political, economic, and social environment?
    - Does the action make efficient use of funding? Does it produce a favourable cost-benefit ratio?
    - Is the action beneficial to multiple species, overall biodiversity, and landscape-level conservation?
- Develop a description, justification, timescale, and predicted budget for each conservation action or group of actions.
- Discuss strategies for integrating the Action Plan with the bison conservation initiatives of government agencies, conservation organizations, recovery teams (e.g., the Canadian National Bison Recovery Team), and others involved in bison conservation. The Action Plan could include a collaborative framework for establishing linkages and organizing responsibilities for conservation action within the North American bison conservation community. This framework would potentially contribute to unifying continental bison conservation efforts, increasing comprehensiveness of recovery on the continental scale, and minimizing duplication of effort.
- Incorporate an implementation process and schedule for the Action Plan. One criticism of some IUCN/SSC Action Plans is that they do not actually result in conservation action because they are too general, disorganized, and do not provide specific direction on how to implement recommended actions (Gimenez Dixon and Stuart 1993). Successful implementation requires that the Chair maintain an active and contributing Specialist Group. After publication of the

Action Plan, Specialist Groups are responsible for promoting implementation through contacts with government agencies, conservation organizations, and funding sources (Gimenez Dixon and Stuart 1993).

Recommendations for Bison Conservation

The intent of the following recommendations is to assist the BSG in creating a continental bison conservation Action Plan for North American bison; the recommendations do not account for all research needs and conservation issues for individual herds. These recommendations are derived from the information on conservation issues, threats, recovery opportunities, and information gaps presented in the preceding status chapters. The general recommendations relate to overriding issues of bison conservation in North America; therefore, these recommendations are presented first to imply their priority. The remaining recommendations are organized by status factor, and are not prioritized.

General Recommendations

- Clarify the goals for North American bison conservation. This exercise should outline the characteristics of wild bison and address the relative roles of free-ranging and captive herds in supporting conservation goals.
- Develop a communication strategy to emphasize the wildlife conservation value of bison. This strategy should address differences between wild and domesticated bison.
- Develop a set of objective criteria to evaluate the priority of bison conservation projects that emerge from the Action Plan. The goal of the criteria would be to increase the effectiveness of limited resources available to the BSG. Refer to criteria developed by the African Rhino Specialist Group as an example (Emslie and Brooks 1999).
- Develop a process to evaluate the conservation value of bison herds. The goal of this evaluation process is to identify bison populations, whether privately, publicly, or tribally owned, that should be included in conservation planning. The process could also establish the relative conservation value of the identified conservation herds to assist with prioritizing conservation actions. There are

several factors that could be incorporated into a process for evaluating the conservation value of bison herds:

- Herd size and composition
- Range management
- Genetic composition and lineage
- Genetic management (culling practices and selection pressures)
- Emulation of historic range use pattern
- Degree of natural selection and the nature of population limiting and regulating forces
- Disease management
- Legal protection
- Geographic factors (size of range, physical and socio-political barriers)
- Management policy development (persistence of policies, scientific advisory process)

The BSG could refer to the following established evaluation and assessment methods to develop an evaluation process suitable for bison:

- The African Rhino Specialist Group has developed procedures for identifying rhino populations according to their conservation value (Emslie and Brooks 1999).
- The Nature Conservancy's 5-S Framework for site assessment uses decision matrices to apply relative weights and ranks to assessment factors (The Nature Conservancy 2000).
- The Conservation Breeding Specialist Group has developed the Conservation Assessment and Management Plan process (CBSG 2002), which could be applied to individual bison herds to compare conservation status (Byers 2002, pers. comm.).
- The Analytic Hierarchy Process (AHP) provides a mathematical framework for quantifying subjective judgements and assigning priority

values among a set of factors or alternatives (Saaty 1990; Schmoldt *et al.* 1994; Saaty 2001). This process could be used to make pairwise comparisons among bison herds according to criteria for a conservation herd, and then objectively rank bison herds by their conservation value.

- Establish the need to increase the number of viable, free-ranging and minimally-managed plains bison conservation herds within the original range of the subspecies.
- Develop conservation actions specific to wood bison consistent with the goals and objectives outlined in the Canadian National Recovery Plan for wood bison (Gates *et al.* 2001c).
- Identify herd-specific and ecological research needs to complement conservation actions.

Taxonomy

- Maintain the use of 'buffalo' as a reference to North American bison whenever appropriate for historical or nostalgic reasons.
- Use the true common name 'bison' for all scientific and conservation purposes to eliminate confusion.
- Clarify the difference between buffalo and bison through interpretation and displays wherever bison-related education occurs.
- Discontinue using the genus *Bison*. Incorporate all species of bison into the genus *Bos* to best reflect the genetic and evolutionary relationships between bison and other bovids.
- Maintain the subspecies designations for both plains bison (*Bos bison bison*) and wood bison (*Bos bison athabascae*).
- Conduct further DNA analyses to identify specific genetic differences between the subspecies.
- Evaluate the applicability of non-traditional taxonomic classifications such as the evolutionarily significant unit (ESU) and the geminate evolutionary unit (GEU) for elucidating a distinction between wood and plains bison.

Population Status and Management

- Monitor the numerical status of free-ranging herds to identify trends in population fluctuation.
    - Conduct a baseline survey for the plains bison herd residing on the Primrose Lake Air Weapons Range. Little is known about the status of this herd, which is one of only three free-ranging plains bison herds in Canada (Appendix 2).
    - Conduct baseline surveys for the Caribou Mountains-Lower Peace wood bison herds (Wentzel and Wabasca). Relatively little is known about these herds (Appendix 2).
- Establish population recovery goals for plains bison (e.g., how many free-ranging, disease-free, viable populations should there be?). The MVP for bison is currently estimated at 400 (Gates *et al.* 2001c). This value could act as the benchmark for viability until population viability analyses (PVAs) are conducted for bison.
- Collect demographic data for conservation herds for which a population viability analysis (PVA) is recommended. A PVA should not be conducted for a population without solid data on demographic parameters and population fluctuations, and consideration of potential catastrophic events (Beissinger and Westphal 1998). Research also suggests that a PVA should be conducted using several different models, because varying assumptions and structure used in alternate models can produce different results for the same data (Mills *et al.* 1996; Beissinger and Westphal 1998). Model assumptions and predictions should be field tested before basing management actions on the results of a PVA (Reed *et al.* 1998; Beissinger and Westphal 1998).
- Evaluate strategies for managing several conservation herds as a metapopulation (i.e., a group of discrete populations treated as one herd). Metapopulation management would involve translocation of bison among the sub-populations. Inventories of genetic diversity and cattle gene introgression are necessary before implementing metapopulation management.

- Identify areas of suitable habitat for both subspecies within their original ranges. Assess the potential of each area to allow for free-ranging herds and natural selection pressures.
- Evaluate the feasibility of replacing plains bison conservation herds within original wood bison range with wood bison herds. Consider the ramifications of herd replacement for plains bison conservation.

Genetics

- Inventory the genetic variation of all conservation herds. This may include compiling information on founding lineages to establish relatedness of conservation herds. Evaluate strategies for preventing loss of genetic diversity in conservation herds.
- Identify plains and wood bison herds best suited to provide stock for reintroductions.
- Conduct demographic studies to establish the genetically effective population size (N_e) for all conservation herds. Use N_e to estimate the change in genetic diversity for each herd, and apply it to population viability analyses, which incorporate other extinction factors including demographic and environmental uncertainty, and natural catastrophes (Meffe and Carroll 1994).
- Test all conservation herds for the presence of mitochondrial and nuclear cattle DNA.
- Evaluate the conservation significance of cattle gene introgression into bison conservation herds, and develop strategies for managing this issue.
- Investigate and minimize possibilities for hybridization between commercial and conservation bison, and between wood and plains bison.
    - Monitor and contain the Pink Mountain herd to prevent hybridization with nearby free-ranging wood bison herds.
- Pursue genetic salvage opportunities in concert with disease management actions in and around WBNP and the GYA. Evaluate methods such as embryo manipulatory procedures for conserving germ plasm from infected bison

(Robison *et al.* 1998). Refer to the IUCN Technical Guidelines on the Management of *Ex Situ* Populations for Conservation (IUCN/SSC 2002), and the Convention on Biological Diversity (Article 9) (Secretariat of the Convention on Biological Diversity 1992) when planning genetic salvage programs.

- Evaluate culling strategies used in conservation herds. Develop culling guidelines that align with genetic management goals.

Disease

- Identify existing disease management methods and protocols for captive and free-ranging wildlife. Inventory and evaluate the methods presently applied to bison conservation herds.
- Support efforts to resolve the northern diseased bison issue.
- Re-evaluate the conservation significance of brucellosis in the Greater Yellowstone Area (GYA).
- Support research on effective vaccines and vaccination methods for brucellosis in bison and elk. Knowledge and evaluation of vaccines is needed prior to developing an eradication program for brucellosis in the GYA.
- Develop standardized disease monitoring programs for bison herds at risk of infection with brucellosis and tuberculosis. Preliminary investigation of wood bison disease monitoring in the Northwest Territories is underway (Nishi and Elkin 2002).

Legal Status and Listings

- Conduct an IUCN Red List assessment for plains and wood bison using the IUCN Red List Categories system (IUCN 2001). The IUCN Red List Categories system is widely used for classifying species at risk of global extinction, and the category of threat provides an internationally recognized classification of extinction risk. The Red List process requires quantitative assessments of population size and fluctuation, geographic range, and population persistence in the wild (IUCN 2001). The IUCN/SSC Red List Programme has approved the use of RAMAS Red List software (Applied Biomathematics 2001) to obtain Red List assessments. The software evaluates data entered by the user against the rules of the IUCN Red List criteria (IUCN 2002c), and incorporates and propagates uncertainties in the entered data (Akcakaya *et al.* 2000; Applied Biomathematics 2001).

- Evaluate the impact of classifying bison as domestic livestock under provincial and state legislation on wild bison recovery.
- Evaluate the legal barriers to protecting conservation bison herds that have hybridization histories (between subspecies and between bison and cattle).

Recovery

- Identify and prioritize potential locations for reintroducing plains and wood bison. Avoid reintroductions of one subspecies into the original range of the other.
- Refer to the IUCN/SSC Guidelines for Reintroductions when evaluating potential reintroduction projects (IUCN/SSC Reintroduction Specialist Group 1995). Reintroduction of animals to re-establish an extirpated population, establish a new population, or augment existing populations is an essential element of bison recovery. Translocation of animals, however, can involve risks for both the released animals and the recipient ecological communities (IUCN/SSC Reintroduction Specialist Group 1995; Wolf *et al.* 1996). The guidelines, based on broad interdisciplinary consultation and extensive review of case studies, are designed to help managers design and implement justifiable and feasible reintroduction projects (IUCN/SSC Reintroduction Specialist Group 1995).
- Consider specific reintroduction principles identified through previous experience with bison (e.g., younger stock is better than older stock, mature bulls do not translocate well, and soft releases are more effective than hard releases) to avoid reintroduction failures (IUCN/SSC Reintroduction Specialist Group 1995; Gates 2000). Develop a set of bison reintroduction guidelines to assist with future recovery projects.
- Consider the historical and cultural context for recovery efforts to assess the validity and appropriateness of a given action. This might include referring to historical documents and archaeological evidence to understand the conditions prior to the need for conservation efforts, including ecological factors, levels and

season of bison presence, and interactions with North American aboriginal populations. In many cases, it may not be practical or possible to re-create the previous conditions (e.g., hunting and setting of prescribed fires by aboriginals within national parks) (Truett 1996); however, investigation and acknowledgement of those conditions can produce a more robust recovery action.

- Consider existing protocols for reducing disease risk associated with translocations and reintroductions (Davidson and Nettles 1992; Griffith *et al.* 1993; Corn and Nettles 2001).
- Ensure that bison stock used for reintroductions originates from sources of known genetic composition (i.e., no cattle DNA, genetically diverse, and non-domesticated).
- Assess the potential for human-bison conflicts for each reintroduction proposal and develop a risk mitigation plan. Consult with managers of existing herds on the frequency of human-bison conflicts and methods to minimize conflicts.
- Identify and evaluate strategies for cooperation with private landowners and North American aboriginal communities to facilitate bison recovery (Johnson *et al.* 1994; Simonetti 1995).

Next Steps

The BSG should develop a strategy for acquiring funding for Action Plan development. The strategy should identify potential funding agencies and foundations with wildlife conservation objectives, and potential sources of in-kind support. The BSG could pursue block funding for the entire action planning process. Another option is to develop a phased approach that identifies the immediate, short-term, mid-term, and long-term funding needs of the action planning process. Once initial support is secured, the BSG could proceed with contracting or hiring an Action Plan coordinator. The coordinator could then organize the action planning process, facilitate communication among collaborators, maintain the website, and secure additional funding according to the funding strategy.

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Appendix 1: Plains Bison Conservation Herd Status Summary Tables

Map Ref.	HERD	Location	Jurisdiction	Managing Authority	Objective		Survey Count	Trend
					Min	Max		
UNITED STATES								
19	Antelope Island State Park	UT	State	Department of Natural Resources, Division of Parks and Recreation	450	600	600	Stable
1	Badlands National Park	SD	Federal	US National Park Service	600	750	750	Stable
30	Bear River State Park	WY	State	Wyoming State Parks and Historic Sites	8	8	8	Stable
20	Blue Mounds State Park	MN	State	Department of Natural Resources, Division of Parks and Recreation	44	56	56	Stable
27	Caprock Canyons State Park (Texas State Bison Herd)	TX	State	Texas Parks and Wildlife Department		50	40	Increasing
13	Chitina	AK	State	Alaska Department of Fish and Game	50		38	Stable
39	Clymer Meadow Preserve	TX	Foundation and Private	The Nature Conservancy; private rancher			320	Stable
14	Copper River	AK	State	Alaska Department of Fish and Game	60		108	Stable
34	Cross Ranch Nature Preserve	ND	Foundation	The Nature Conservancy	120	140	140	Increasing
26	Custer State Park	SD	State	South Dakota Game Fish and Parks Department	820	1090	1100	Stable
41	Daniels Park	CO	Municipal	Denver Parks and Recreation, Mountain Parks Department	27	27	26	Stable

Map Ref.	HERD	Location	Jurisdiction	Managing Authority	Objective		Survey Count	Trend
					Min	Max		
15	Delta Junction	AK	State	Alaska Department of Fish and Game		360	360	Stable
16	Farewell Lake	AK	State	Alaska Department of Fish and Game	300		400	Increasing
11	Fermilab National Accelerator	IL	Federal	Department of Energy	30	35	32	Stable
21	Finney Game Refuge	KS	State	Kansas Department of Wildlife and Parks	100	200	120	Stable
6	Fort Niobrara National Wildlife Refuge	NE	Federal	US Fish and Wildlife Service	350	400	352	Stable
24	Fort Robinson State Park	NE	State	Nebraska Game and Parks	500	500	500	Stable
42	Genesee Park	CO	Municipal	Denver Parks and Recreation, Mountain Parks Department	27	27	26	Stable
4	Grand Teton National Park/National Elk Refuge	WY	Federal and State	US National Park Service, US Fish and Wildlife Service, Wyoming Department of Fish and Game			700	Increasing
28	Henry Mountains	UT	State	Utah Division of Wildlife Resources		275	279	Stable
31	Hot Springs State Park	WY	State	Wyoming State Parks and Historic Sites		11	11	Stable
17	House Rock State Wildlife Area	AZ	State	Arizona Fish and Game Department		600	217	Increasing
32	Konza Prairie Biological Station	KS	State and Foundation	Division of Biology, K-State University; The Nature Conservancy	275	300	275	Stable
12	Land Between the Lakes National Recreation Area	KY	Federal	US Department of Agriculture, National Forest Service		50 80	50 80	Decreasing

Map Ref.	HERD	Location	Jurisdiction	Managing Authority	Objective		Survey Count	Trend
					Min	Max		
22	Maxwell Wildlife Refuge	KS	State	Kansas Department of Wildlife and Parks	165	230	230	Stable
35	Medano-Zapata Ranch	CO	Foundation	The Nature Conservancy		1100	1500	Decreasing
7	National Bison Range	MT	Federal	US Fish and Wildlife Service	370	390	400	Stable
8	Neal Smith National Wildlife Refuge	IA	Federal	US Fish and Wildlife Service	30	35	35	Stable
						250	250	Stable
36	Niobrara Valley Preserve	NE	Foundation	The Nature Conservancy		250	223	Increasing
37	Ordway Prairie Preserve	SD	Foundation	The Nature Conservancy		250	255	Stable
23	Prairie State Park	MO	State	Missouri Department of Natural Resources			76	Stable
18	Raymond Wildlife Area	AZ	State	Arizona Fish and Game Department			72	Stable
29	Sandhill Wildlife Area	WI	State	Wisconsin Department of Natural Resources	10	15	15	Stable
33	Santa Catalina Island	CA	Foundation	Catalina Island Conservancy		225	225	Increasing
40	Smoky Valley Ranch	KS	Foundation	The Nature Conservancy			45	Increasing
9	Sullys Hill National Game Preserve	ND	Federal	US Fish and Wildlife Service	25	40	37	Stable
38	Tallgrass Prairie Preserve	OK	Foundation	The Nature Conservancy	2100	3200	1500	Increasing

Map Ref.	HERD	Location	Jurisdiction	Managing Authority	Objective		Survey Count	Trend
					Mix	Max		
2	Theodore Roosevelt National Park	ND	Federal	US National Parks Service	150	250	250	Stable
					400	600	600	
10	Wichita Mountains National Wildlife Refuge	OK	Federal	US Fish and Wildlife Service	380	600	565	Stable
25	Wildcat Hills State Recreation Area	NE	State	Nebraska Game and Parks		10	10	Stable
3	Wind Cave National Park	SD	Federal	US National Parks Service	350	450	375	Stable
5	Yellowstone National Park	WY/MT	Federal and State	US National Parks Service in agreement with USDA, NFS, APHIS, MT Fish and Parks, and MT Department of Livestock	2300	3000	4000	Stable
CANADA								
50	Buffalo Pound Provincial Park	SK	Provincial	Saskatchewan Environment, Parks Branch			33	Stable
44	Elk Island National Park	AB	Federal	Parks Canada Agency	472	504	430	Stable
49	Pink Mountain	BC	Provincial	BC Department of Water, Lands and Air Protection		1800	1000	Stable
48	Primrose Air Weapons Range (Cold Lake)	AB/SK	Federal and Provincial	Department of National Defence, Saskatchewan Environment, Fish and Wildlife Branch			100	Increasing
45	Prince Albert National Park	SK	Federal	Parks Canada Agency			310	Increasing
46	Riding Mountain National Park	MB	Federal	Parks Canada Agency		50	33	Increasing
43	Wainwright (Western Area Training Centre)	AB	Federal	Department of National Defence		16	16	Stable
47	Waterton Lakes National Park	AB	Federal	Parks Canada Agency	12	25	27	Stable

Map Ref.	HERD	Male:Female	Original range?	Range area (km^2)	Expansion potential	# founders	Origin	Genetics Management
UNITED STATES								
19	Antelope Island State Park	1 to 5	Peripheral	113.40	None	12	Private	Frequent introductions to improve diversity, selection to conserve rare allele
1	Badlands National Park	1 to 1	Yes	259.20	Yes - Active	53	Theodore Roosevelt National Park, Fort Niobrara NWR, private	DOI/TAMU study underway
30	Bear River State Park	1 to 8	Yes	0.20	None	8	Hot Springs State Park	Trades with Hot Springs State Park
20	Blue Mounds State Park	NA	Yes	2.59	None	3	?	Bull replacement
27	Caprock Canyons State Park (Texas State Bison Herd)	1 to 10	Yes	1.34	None	32?	Goodnight	Managing to maintain unique diversity
13	Chitina	NA	No	259	Limited by winter range	35	Delta Junction, AK (originally from NBR)	None
39	Clymer Meadow Preserve	NA	Yes	4.86	None	40	Private, Tallgrass Prairie Preserve	?
14	Copper River	NA	No	1036	Limited by winter range	17	Delta Junction, AK (originally from NBR)	None
34	Cross Ranch Nature Preserve	1 to 2	Yes	12.39	Yes - Active	15	Private (originally from Custer State Park)	Bulls culled at 6-8 yrs, bull replacement
26	Custer State Park	1 to 7	Yes	287.55	None	3 inputs: 36, ?, 800	Private, Tribal, Wind Cave National Park	Selection for blood groups, bull replacement
41	Daniels Park	1 to 12	Yes	3.24	None	7	Genesee Park (originally from YNP)	Bull replacement; heifer trades with Genesee Park herd

Map Ref.	HERD	Male:Female	Original range?	Range area (km^2)	Expansion potential	# founders	Origin	Genetics Management
15	Delta Junction	1 to 1.5	No	1087.8	None	22	National Bison Range	None
16	Farewell Lake	NA	No	7770	Yes - Active	38	Delta Junction, AK (originally from NBR)	None
11	Fermilab National Accelerator	1 to 10	Yes	0.28	None	12	Private	Bull replacement
21	Finney Game Refuge	1 to 7	Yes	14.86	None	11?	Wichita Mountains National Wildlife Refuge, private	Bull replacement
6	Fort Niobrara National Wildlife Refuge	1 to 1	Yes	56.70	Yes	21	Private, YNP, Custer State Park, National Bison Range	FWS study underway
24	Fort Robinson State Park	1 to 16	Yes	36.45	Yes	~28	National Bison Range	Movement of animals among three separated herds
42	Genesee Park	1 to 12	Yes	2.03	Yes	7	Yellowstone National Park	Bull replacement; heifer trades with Daniels Park herd
4	Grand Teton National Park National Elk Refuge	1 to 1.2	Yes	750	None	16	Theodore Roosevelt National Park, Yellowstone National Park	DOI/TAMU study underway
28	Henry Mountains	1 to 1.75	Yes	2590	Yes	~37-45	Yellowstone National Park	None
31	Hot Springs State Park	1 to 4.5	Yes	2.84	None	16	Yellowstone National Park, Kansas Botanical Gardens	Bull replacement; trades with Bear River State Park
17	House Rock State Wildlife Area	1 to 1	No	243.00	Yes	Unknown	Yellowstone National Park	Bull replacement

Map Ref.	HERD	Male:Female	Original range?	Range area (km^2)	Expansion potential	# founders	Origin	Genetics Management
32	Konza Prairie Biological Station	1 to 1.7	Yes	10.04	None	48	Fort Riley. Maxwell State Park, private	Augmentation to supplement genetics
12	Land Between the Lakes National Recreation Area	1 to 10	Yes	2.84	Yes	?	Theodore Roosevelt National Park	Bull replacement
				0.73	None	?		
22	Maxwell Wildlife Refuge	1 to 3	Yes	9.11	Yes - Active	10	Wichita Mountains National Wildlife Refuge	Bull replacement
35	Medano-Zapata Ranch	1 to 5	Yes	182.25	Yes	20-100	Private	Bull replacement
7	National Bison Range	1 to 1.2	Yes	74.93	None	38	Private	FWS study underway
8	Neal Smith National Wildlife Refuge	1 to 1	Yes	2.84	Yes	32	NBR, Fort Niobrara NWR, Wichita Mountains NWR	FWS study underway
36	Niobrara Valley Preserve	1 to 10	Yes	30.38	None	55	Private, CSP, FNNWR	Bull replacement
				18.76	Yes - Active	132	Private	
37	Ordway Prairie Preserve	1 to 6	Yes	12.72	Yes	<20	CSP, private	Bull replacement, quality bull selection
23	Prairie State Park	1 to 1.5	Yes	15.64	Yes	16	Fort Niobrara NWR, Wichita Mountains NWR, private	None
18	Raymond Wildlife Area	1 to 1	No	60.75	Yes	~100	House Rock Wildlife Area	Bull replacement
29	Sandhill Wildlife Area	1 to 1.5	Peripheral	1.01	Yes	~5	State game farm	None
33	Santa Catalina Island	1 to 2.5	No	129.50	None	24	Private	None
40	Smoky Valley Ranch	1 to 15	Yes	12.60	Yes	NA	Private	None

Map Ref.	HERD	Male:Female	Original range?	Range area (km^2)	Expansion potential	# founders	Origin	Genetics Management
9	Sullys Hill National Game Preserve	1 to 2	Yes	3.65	None	6	Portland City Park, Oregon (1903)	None
38	Tallgrass Prairie Preserve	1 to 2.3	Yes	58.32	Yes - Active	300	Private	Bull replacement, quality bull selection
2	Theodore Roosevelt National Park	1 to 2	Yes	97.48 186.82	None None	29	Fort Niobrara NWR	TAMU study underway
10	Wichita Mountains National Wildlife Refuge	1 to 1	Yes	174.19	None	15	Fort Niobrara NWR, NY Zoo	FWS study underway
25	Wildcat Hills State Recreation Area	1 to 1.5	Yes	1.46	None	5	Private, Fort Niobrara NWR	None
3	Wind Cave National Park	1 to 1	Yes	114.41	Yes - Active	20	NY Zoo, Yellowstone National Park	TAMU study underway
5	Yellowstone National Park	1 to 1	Yes	9315.00	None	46	25 native, 3 Goodnight, 18 Allard	TAMU study underway
CANADA								
50	Buffalo Pound Provincial Park	1 to 10	Yes	1.92	None	10	Elk Island National Park	Bull replacement, quality bull selection
44	Elk Island National Park	1 to 1	Yes	140	None	50	Pablo-Allard	None
49	Pink Mountain	NA	No	2000	Yes - Active	41	Elk Island National Park	None
48	Primrose Air Weapons Range (Cold Lake)	NA	No	10360	Yes - Active	17	Elk Island National Park	None
45	Prince Albert National Park	NA	Yes	500	Yes - Active	4 to 10	Elk Island National Park	Opportunistic sampling to determine genetic diversity
46	Riding Mountain National Park	NA	Yes	5.00	None	?	Elk Island National Park	Bull replacement
43	Wainwright (Western Area Training Centre)	1 to 2	Yes	0.65	Yes	4	Elk Island National Park	Bull replacement
47	Waterton Lakes National Park	1 to 2	Yes	2.02	Yes - Active	6	Elk Island National Park	Bull replacement

Map Ref.	HERD	Selectively breed?	Genetic testing?	Hybrids with cattle?	Inbreeding signs?	Genetic defects?	Unique factors?	Regular augmentation?
19	Antelope Island State Park	No	Yes	Yes	None now, historically yes	No	Rare allele	Yes
1	Badlands National Park	No	Yes	No	Yes	Yes	Unknown	No
30	Bear River State Park	No	No	Unknown	No	Unknown	Unknown	Yes
20	Blue Mounds State Park	No	No	Unknown	Unknown	Unknown	Unknown	Yes
27	Caprock Canyons State Park (Texas State Bison Herd)	Yes	Yes	Yes	No	No	Yes, diversity	Planned
13	Chitina	No	No	Unknown	Unknown	Unknown	Unknown	No
39	Clymer Meadow Preserve	?	?	?	?	?	?	?
14	Copper River	No	No	Unknown	Unknown	Unknown	Three white calves in 24 years	No
34	Cross Ranch Nature Preserve	No	No	Unknown	No	No	Unknown	Yes
26	Custer State Park	No	Yes	Yes	No	No	Hemoglobin ratio (80/20)	No
41	Daniels Park	No	No	Unknown	No	Unknown	Unknown	Yes
15	Delta Junction	No	No	Unknown	No	Unknown	Unknown	Yes, escaped domestic bison have joined the herd

Map Ref.	HERD	Selectively breed?	Genetic testing?	Hybrids with cattle?	Inbreeding signs?	Genetic defects?	Unique factors?	Regular augmentation?
16	Farewell Lake	No	No	Unknown	No	Unknown	Unknown	No
11	Fermilab National Accelerator	No	No	Unknown	No	Unknown	Unknown	Yes
21	Finney Game Refuge	No	Yes	Yes	No	No	No	Yes
6	Fort Niobrara National Wildlife Refuge	No	Yes	Yes	No	No	Unknown	No
24	Fort Robinson State Park	No	No	Unknown	No	No	Unknown	No
42	Genesee Park	No	No	Unknown	No	Unknown	Unknown	Yes
4	Grand Teton National Park National Elk Refuge	No	Yes	No	No	No	Unknown	No
28	Henry Mountains	No	No	No	No	No	Unknown	No
31	Hot Springs State Park	No	No	Unknown	No	Unknown	Unknown	Yes
17	House Rock State Wildlife Area	No	No	Unknown	Unknown	Unknown	Unknown	Yes
32	Konza Prairie Biological Station	No	No	Unknown	No	Rabbit-hocked legs in past	Unknown	Yes
12	Land Between the Lakes National Recreation Area	No	No	Unknown	No	Unknown	Unknown	Yes
22	Maxwell Wildlife Refuge	No	Yes	Yes	No	No	Unknown	Yes

Map Ref.	HERD	Selectively breed?	Genetic testing?	Hybrids with cattle?	Inbreeding signs?	Genetic defects?	Unique factors?	Regular augmentation?
35	Medano-Zapata Ranch	No	No	Unknown	No	Unknown	Unknown	Yes
7	National Bison Range	No	Yes	Yes	No	No	Unknown	No
8	Neal Smith National Wildlife Refuge	No	Yes	No	No	No	Unknown	Yes, within FWS Refuges
36	Niobrara Valley Preserve	No	No	Unknown	No	Unknown	Unknown	Yes, within TNC herds
37	Ordway Prairie Preserve	No	No	Unknown	No	Unknown	Unknown	Yes
23	Prairie State Park	No	No	Unknown	Unknown	Unknown	Unknown	No
18	Raymond Wildlife Area	No	No	Unknown	Unknown	Unknown	Unknown	Yes
29	Sandhill Wildlife Area	No	No	Unknown	No	Unknown	Unknown	Yes
33	Santa Catalina Island	No	No	Unknown	Possible	Unknown	Unknown	No
40	Smoky Valley Ranch	No	No	Unknown	No	Unknown	Unknown	No
9	Sullys Hill National Game Preserve	No	No	Unknown	No	Unknown	Unknown	Yes
38	Tallgrass Prairie Preserve	No	No	Unknown	No	Unknown	Unknown	Yes
2	Theodore Roosevelt National Park	No	Yes	No	No	No	No	No
10	Wichita Mountains National Wildlife Refuge	No	Yes	No	No	No	Unknown	No

Map Ref.	HERD	Selectively breed?	Genetic testing?	Hybrids with cattle?	Inbreeding signs?	Genetic defects?	Unique factors?	Regular augmentation?
25	Wildcat Hills State Recreation Area	No	No	Unknown	No	Unknown	Unknown	Trades with Fort Robinson State Park
3	Wind Cave National Park	No	Yes	No	No	No	Unknown	No
5	Yellowstone National Park	Nc	Yes	No	No	No	High diversity	No
CANADA								
50	Buffalo Pound Provincial Park	No	No	Unknown	No	Unknown	Unknown	Yes
44	Elk Island National Park	No	Yes	No	No	No	No	No
49	Pink Mountain	No	No	Unknown	No	Unknown	Unknown	No
48	Primrose Air Weapons Range (Cold Lake)	No	No	Unknown	Unknown	Unknown	Unknown	No
45	Prince Albert National Park	No	In progress	Unknown	No	Unknown	Unknown	No
46	Riding Mountain National Park	No	No	Unknown	No	No	Unknown	Yes
43	Wainwright (Western Area Training Centre)	No	No	Unknown	No	No	Unknown	Yes
47	Waterton Lakes National Park	No	No	Unknown	No	No	Unknown	Yes

Map Ref.	HERD	Range management	Fencing	Predation	Supplemental feed?	Round-ups	Culling	Disposal
UNITED STATES								
19	Antelope Island State Park	Open	None	Coyotes	No	Annual	selection by age class	Live sales, hunting
1	Badlands National Park	Open	Perimeter	Mountain lions	No	Opportunistic when carrying capacity reaches 1/3	random, opportunistic	MOU with native tribe
30	Bear River State Park	Open	Perimeter	None	Yes	2-3 times annually	all calves	Live sales
20	Blue Mounds State Park	Rotated through pastures	Perimeter and cross	None	Yes, winter	Annual	selection by age class	Live sales
27	Caprock Canyons State Park (Texas State Bison Herd)	Two pastures, males and females	Perimeter and cross	None	Yes	Annual	No culling	NA
13	Chitina	Open	None	Wolves and grizzly bears	No	No	No culling	Hunting
39	Clymer Meadow Preserve	Rotated through pastures	Perimeter and cross	None	?	Yes	?	?
14	Copper River	Open	None	Wolves and grizzly bears	No	No	No culling	Hunting
34	Cross Ranch Nature Preserve	Two pastures	Perimeter and cross	None	No	Annual	selection by age class, health, appearance	Live sales, field cull
26	Custer State Park	Some pasture rotation	Perimeter and cross	Mountain lions	No	Twice annually	selection by age class, fertility, weight	Live sales, sealed bids, CSP meat company contract, hunting

Map Ref.	HERD	Range management	Fencing	Predation	Supplemental feed?	Round-ups	Culling	Disposal
41	Daniels Park	Some rotation during dry seasons	Perimeter and cross	Mountain lions, black bears, coyotes	Yes, 6 mo/yr	Annual	selection by age class	Live sales
15	Delta Junction	Open	None	Wolves and grizzly bears	Fall/winter forage is grown to deter the herd from moving into agricultural areas	No	No culling	Hunting
16	Farewell Lake	Open	None	Wolves and grizzly bears	No	No	No culling	Hunting
11	Fermilab National Accelerator	Fenced pasture	Perimeter and cross	None	Yes, winter	Annual	all calves	Live sales
21	Finney Game Refuge	Rotation through 3 pastures	Perimeter and cross	None	Yes, winter and drought	Annual	selection by age class, condition, conformation, appearance	Live sales
6	Fort Niobrara National Wildlife Refuge	17-unit pasture rotation every 4-7 days	Perimeter and cross	Coyotes	No	Annual	selection by age class, weight, appearance, condition, health, reproductive success	Live sales, donations
24	Fort Robinson State Park	Three pastures	Perimeter and cross	None	Yes, if snow is deep	Annual	selection by age class, appearance, conformation	Live sales, slaughter as meat for restaurant
42	Genesee Park	Some rotation during dry seasons	Perimeter and cross	Mountain lions, black bears, coyotes	Yes, 6 mo/yr	Annual	selection by age class	Live sales

Map Ref.	HERD	Range management	Fencing	Predation	Supplemental feed?	Round-ups	Culling	Disposal
4	Grand Teton National Park National Elk Refuge	Open	None	Wolves and grizzly bears	Yes, 70 days in winter	No	Not since 1996, except hunting on state lands	Hunting on state lands only; population control measures currently in litigation
28	Henry Mountains	Open	None	Mountain lions	No	No	random through hunting permits	hunting
31	Hot Springs State Park	Open	Perimeter	None	Yes	2-3 times annually	selection by age class, calves, temperament	Live sales
17	House Rock State Wildlife Area	Open	Only on BLM boundary	None	No feed. Water is provided by pipeline	No	No culling. Hunters make selection decisions	Hunting
32	Konza Prairie Biological Station	Rotated by burn regimes	Perimeter and cross (with gates open)	None	No	Annual	selection by age class, favour newly introduced bulls to allow for change in breeding dominance	Live sales
12	Land Between the Lakes National Recreation Area	Open Pastures	Perimeter Perimeter and cross	None	No No	Annual	all calves, animals that calve late, injured, appearance	Live sales, sealed bids
22	Maxwell Wildlife Refuge	Open	Perimeter	None	Yes	Annual	selection for conformation, animals that produce early spring calves	Private sales, slaughter for special events, trades with government herds

Map Ref.	HERD	Range management	Fencing	Predation	Supplemental feed?	Round-ups	Culling	Disposal
35	Medano-Zapata Ranch	Open	Perimeter	Coyotes, mountain lions, black bears, bobcats	No	Annual	selection by age class	Private sales, video auctions
7	National Bison Range	Rotational	Perimeter and cross	Unknown	No	Annual	random selection by age class, health	Live sale, transfers to native tribes
8	Neal Smith National Wildlife Refuge	Open	Perimeter	None	No	Annual	selection for genetics, appearance	?
36	Niobrara Valley Preserve	Open	Perimeter	None	No	Annual	selection by age class	Live sales, individual sales, sealed bids, hunting
37	Ordway Prairie Preserve	Open	Perimeter	Coyotes	Yes, if hard winter	Annual	selection by age class	live sales, private sales
23	Prairie State Park	Rotated through 4 pastures, mature bulls separate	Perimeter and electric cross	None	Yes, if hard winter	Annual	selection by age class	live sales
18	Raymond Wildlife Area	Open	Perimeter	None	No	No	Hunters make selection decisions	Hunting
29	Sandhill Wildlife Area	Open, except as required for mgmt of other species	Perimeter and cross with gates open	None	Yes, winter	Annual	selection by age class	exchanges, donations
33	Santa Catalina Island	Open	Cross fencing for other purposes	None	No	Every 2 years	no system	shipped to mainland on pre-arranged contracts
40	Smoky Valley Ranch	Open	Perimeter	None	No	Yes	criteria under development	under development

Map Ref.	HERD	Range management	Fencing	Predation	Supplemental feed?	Round-ups	Culling	Disposal
9	Sullys Hill National Game Preserve	Open	Perimeter	None	Yes, winter	No	selection by age class	sales to non-profit groups at cost
38	Tallgrass Prairie Preserve	Open	Perimeter	None	No	Annual	selection to mimic historic predators, deformed	Live sales, sealed bids, private sales
2	Theodore Roosevelt National Park	Open	Perimeter	Mountain lions	No	Every 3 years	selection by age class	Bureau of Indian Affairs brokers animals to tribes
10	Wichita Mountains National Wildlife Refuge	Three pastures	Perimeter and cross	Coyotes	No	Annual	selection by age class; random selection for calves, injured	Live sales, ITBC for cost
25	Wildcat Hills State Recreation Area	Open	Perimeter	None	Yes, winter	Every 2 years	all calves, old bulls, age class, selection by bull size and appearance	Live sales, slaughter as meat for restaurant
3	Wind Cave National Park	Open	Perimeter	None	No	Annual	selection by age class	Dispersal to Native tribes, and state and federal agencies at cost
5	Yellowstone National Park	Open	None	Wolves and grizzly bears	No	Periodic trappings	opportunistic selection for disease mgmt	Shipped live to Native tribes for slaughter
CANADA								
50	Buffalo Pound Provincial Park	Two pastures with no rotation	Perimeter and cross	None	Yes, winter	Annual	all calves, selection by age class	private sales
44	Elk Island National Park	Open	Perimeter	None	No	Annual	selection by age class	live sales, conservation reintroduction projects

Map Ref.	HERD	Range management	Fencing	Predation	Supplemental feed?	Round-ups	Culling	Disposal
49	Pink Mountain	Open	None	Wolves and grizzly bears	No	No	No culling	hunting
48	Primrose Air Weapons Range (Cold Lake)	Open	None	Wolves and bears	No	No	No culling	hunting
45	Prince Albert National Park	Open	None	Wolves	No	No	No culling	Some hunting by Natives outside the park
46	Riding Mountain National Park	Winter-summer rotation through two pastures	Perimeter and cross	None	No	Annual	selection by age class	Live sales
43	Wainwright (Western Area Training Centre)	Pasture rotation	Perimeter and cross	None	Yes, winter	Annual	Selection to avoid inbreeding	Live sales
47	Waterton Lakes National Park	Winter-summer rotation through two pastures	Perimeter and cross	None	Yes, if harsh winter	Every 2 years	random, opportunistic	Live sales

Map Ref.	HERD	Disease presence	Disease testing	Vaccination	Parasite treatment
UNITED STATES					
19	Antelope Island State Park	None	Sale animals	brucellosis	Yes
1	Badlands National Park	None	During round-ups	brucellosis	As required by vet
30	Bear River State Park	None	No	Yes, on remaining animals	Yes, remaining animals annually
20	Blue Mounds State Park	None	TB, annually	No	?
27	Caprock Canyons State Park (Texas State Bison Herd)	None	Yes, all animals annually	Yes, all animals annually	Yes, all animals annually

Map Ref.	HERD	Disease presence	Disease testing	Vaccination	Parasite treatment
13	Chitina	None	No	No	No
39	Clymer Meadow Preserve	None	Yes	Yes	As needed
14	Copper River	None	No	No	No
34	Cross Ranch Nature Preserve	None	Sale animals	brucellosis	Annual testing, no treatment required to date
26	Custer State Park	None	Sale animals	brucellosis, 7-way, pink eye,	Calves wormed
41	Daniels Park	None	Sale animals	8-way	Sale animals treated
15	Delta Junction	Parainfluenza 3	Yes, blood samples from hunters	No	No
16	Farewell Lake	None	No	No	No
11	Fermilab National Accelerator	None	Annually	brucellosis	Yes, annually
21	Finney Game Refuge	None	Sale animals	brucellosis on sale animals	No
6	Fort Niobrara National Wildlife Refuge	None	Sale animals	hemorrhagic septicaemia, blackleg, malignant edema	No
24	Fort Robinson State Park	None	Sale animals	brucellosis	No
42	Genesee Park	None	Sale animals	8-way	Sale animals treated
4	Grand Teton National Park National Elk Refuge	Brucellosis, BVD	Opportunistic	No	No
28	Henry Mountains	None	Opportunistic from samples collected by hunters	No	If outbreak detected
31	Hot Springs State Park	None	No	Yes, brucellosis on remaining animals	Yes

Map Ref.	HERD	Disease presence	Disease testing	Vaccination	Parasite treatment
17	House Rock State Wildlife Area	None	Opportunistic from samples collected by hunters	No	No
32	Konza Prairie Biological Station	None	Sale animals	brucellosis	No
12	Land Between the Lakes National Recreation Area	None	Sale animals	7-way on sale animals	Yes
22	Maxwell Wildlife Refuge	None	Sale animals	No	No
35	Medano-Zapata Ranch	None	Sale animals for brucellosis and TB	brucellosis	Yes
7	National Bison Range	Johnes	Annual plus symptomatic animals	No	No
8	Neal Smith National Wildlife Refuge	None	All animals during round-ups	No	No
36	Niobrara Valley Preserve	None	Sale animals	brucellosis	Yes
37	Ordway Prairie Preserve	None	Sale animals	brucellosis	Yes
23	Prairie State Park	None	All animals during round-ups	as required by state vet	as required by state vet
18	Raymond Wildlife Area	None	Yes, blood samples from hunters	No	No
29	Sandhill Wildlife Area	None	Visual inspection annually	No	Yes
33	Santa Catalina Island	None	All animals during round-ups	sale animals	No
40	Smoky Valley Ranch	None	Yes	Yes	As needed
9	Sullys Hill National Game Preserve	None	Yes, all animals annually	as required by state vet	as required by state vet

Map Ref.	HERD	Disease presence	Disease testing	Vaccination	Parasite treatment
38	Tallgrass Prairie Preserve	None	Subsample for anaplasmosis (1999-2000)	Yes	Yes
2	Theodore Roosevelt National Park	None	All animals during round-ups	No	No
10	Wichita Mountains National Wildlife Refuge	None	sale animals	sale animals	Every few years
25	Wildcat Hills State Recreation Area	None	Yes	No	No
3	Wind Cave National Park	None	All animals during round-ups	No	No
5	Yellowstone National Park	Brucellosis	Opportunistic	No. Under consideration	No
CANADA					
50	Buffalo Pound Provincial Park	None	Yes on sale animals	Yes	Yes, all animals
44	Elk Island National Park	BVD episode in 96-97 (treated)	Annually for TB and brucellosis, 25% of herd tested	Yes	On surplus animals
49	Pink Mountain	None	Yes, blood samples from hunters	No	No
48	Primrose Air Weapons Range (Cold Lake)	Unknown	No	No	No
45	Prince Albert National Park	One case of BVD (1997) (treated)	Opportunistic	No	No
46	Riding Mountain National Park	None	Yes, annually	Yes	No
43	Wainwright (Western Area Training Centre)	None	Yes, biannually	Yes	Yes
47	Waterton Lakes National Park	None	Whole herd every 5 years	No	No

Appendix 2: Herd Profiles

Plains Bison: USA

The following conservation plains bison herd profiles are in alphabetical order according to herd name. Numbers in parentheses refer to locations on the map in Figure 5.4. Refer to Appendix 1 for tabular information on each herd.

Antelope Island State Park, UT (19) *Free-ranging*

The Antelope Island State Park (AISP) bison herd, comprising approximately 600 animals, ranges freely on the 28,000 acre (113 km^2) island in the Great Salt Lake. Although, AISP is on the extreme western edge of plains bison range, aboriginal accounts reveal that bison used to pass from the mainland to the island when the waters of Great Salt Lake were low (AISP Wildlife Management Plan Update Team 2001). The AISP herd was established in 1893 with 12 founders (Hebbring Wood 2000). It was managed as a private herd until the state of Utah purchased the animals in 1981. The animals demonstrated signs of inbreeding prior to augmentation with bison from numerous federal, state, and private sources throughout the 1990s. Nevertheless, large genetic distances between AISP bison and all other bison populations in North America suggest low genetic diversity (Wilson and Strobeck 1999). Blood testing of the herd in the 1980s revealed that the animals carry a rare double allele (Hebbring Wood 2000; Hebbring Wood 2000). The function and phenotypic expression of this allele is unclear. The primary role of this herd is to provide viewing and interpretive opportunities for the public (AISP Wildlife Management Plan Update Team 2001). AISP uses proceeds from the sale of surplus bison for bison management purposes (S. Bates 2002, pers. comm.). The state also issues hunting permits for older bulls. The Utah Division of Parks and Recreation recently developed a wildlife management plan for the island, which identified four main bison management issues: (1) timing and procedures for round-ups, (2) continuation of bison hunting, (3) determination of the bison carrying capacity, and (4) genetic maintenance of the rare allele (AISP Wildlife Management Plan Update Team 2001).

Badlands National Park, SD (1) *Captive*

The herd at Badlands National Park (BLNP) began in the 1960s with the transfer of 50 animals from Theodore Roosevelt National Park and 3 bulls from Fort Niobrara National Wildlife Refuge (BLNP 2001). An additional 20 animals from the Colorado National Monument herd (Genesee Park) were added in 1983 (Hebbring Wood 2000; BLNP 2001). The park currently maintains a semi-free-ranging herd of approximately 600-750 bison within the Sage Creek Unit of the Badlands Wilderness Area, totalling 64,144 acres (260 km^2) (BLNP 2001). There is potential for future expansion of bison presence to other areas of BLNP (Childers 2002, pers. comm.). The BLNP herd has been subject to extensive genetic and behavioural ecology studies (McClenaghan *et al.* 1990; Berger and Cunningham 1994). McClenaghan, Jr. *et al.* (1990) reported low levels of genetic variation within the BLNP population. The results of studying several fitness indicators and observations of several bison with leg deformities by Berger and Cunningham (1994) suggest that the BLNP population may be exhibiting inbreeding depression; however, this is inconclusive at this time. BLNP is one of five US national parks taking part in a study of bison genetics and management conducted by researchers at Texas A&M University (Childers 2002, pers. comm.) This study is part of a larger effort by the Department of the Interior to investigate managing the federal bison herds as a metapopulation (BLNP 2001). Further research needs for the park include determining a current carrying capacity for the bison range, evaluating long-term viability of the population, determining optimum age and sex ratios to fulfill goals for vegetation management, biodiversity, and population size, and assessing the need for additional genetic material (BLNP 2001). BLNP is currently revising its bison management plan.

Bear River State Park, WY (30) *Captive*

Bear River State Park (BRSP) maintains a small herd of 8 animals in a fenced paddock of approximately 50 acres (0.2 km^2). Periodically, BRSP trades bison with Hot Springs State Park, which also maintains a small herd. The primary role of the BRSP herd is for educational and historical display of bison (Stevenson 2002, pers. comm.).

Blue Mounds State Park, MN (20) *Captive*

The herd at Blue Mounds State Park (BMSP) consists of 56 bison on approximately 640 acres (2.6 km^2) of range. The park maintains an informal range management plan that involves prescribed burning and rotation of animals through cross-fenced paddocks (Sawtelle 2002, pers comm.). The park manages genetic diversity by periodically augmenting the herd with bulls from other locations (Sawtelle 2002, pers comm.). The primary role of the BMSP herd is for educational and historical display of bison, although the herd does provide some ecological maintenance within its limited range (Sawtelle 2002, pers comm.).

Caprock Canyons State Park, (Texas State Bison Herd), TX (27) *Captive*

The Texas State Bison Herd (TSBH) at Caprock Canyons State Park descends directly from animals gathered from the wild in Palo Duro Canyon by Charles Goodnight during 1878 (Swepston *et al.* 2002). Goodnight managed the herd and conducted cattalo experiments on the JA Ranch until 1887 when he moved the operation to his own ranch (Swepston 2001). After his death in 1929, and several unsuccessful attempts to convince the Texas or United States governments to assume responsibility for management and preservation of the herd, the bison passed through several owners (Swepston 2001). Suggestions to remove the herd through hunting met with severe public objection. In the 1930s, the herd escaped and ranged freely in the Palo Duro Canyon on the JA Ranch for over 60 years. In 1996, the JA Ranch donated the bison to Texas Parks and Wildlife Department (TPWD), which proceeded to establish a bison facility at Caprock Canyons State Park (Harvey 1998). The herd now resides on 300 acres (1.2 km^2), divided into two pastures for males and females. The herd is believed to be genetically representative of southernmost plains bison (Swepston 2001). Genetic testing by researchers at Texas A&M University (TAMU) reveal that this herd contains unique genetic material not found in any other bison herd tested to date, but also that the genetic diversity is very low compared to other bison herds (Swepston 2001) (Derr 2002, pers. comm.). Low genetic diversity is likely the result of generations of inbreeding compounded by a chronically small population size (Swepston *et al.* 2002). Genetic testing has also found traces of cattle mtDNA in the herd. No nuclear cattle DNA has been found to date. Managers of the TSBH are attempting to increase the population size and maintain genetic diversity through intensive selective breeding. TAMU researchers concluded that continued management of the TSBH as an isolated and closed population would likely result in further fertility and genetic problems (Swepston *et al.* 2002) (Derr 2002, pers comm.). If TSBH mangers choose to augment the herd, TAMU researchers recommend that all incoming animals possess some relationship to the original Goodnight foundation herd to maintain the genetically unique characteristics. Over the next few decades, TWPD hopes to increase the size of the herd and establish a free-ranging herd within the Texas Panhandle (Harvey 1998).

Chitina, AK (13) *Free-ranging*

The Chitina River herd inhabits an area of approximately 260 km^2 along the Chitina River in Alaska. This is one of four free-ranging herds of plains bison in Alaska. Alaska is not within the original range of plains bison. The Chitina River herd originates from 35 animals transferred in 1962 from the herd at Delta Junction, AK, which originated from a transfer in 1928 from the National Bison Range, MT. Although the Chitina River herd resides entirely within the Wrangell-St. Elias National Park established in 1980, the Alaska Department of Fish and Game (ADFG) maintains responsibility for management of the herd (Scotton 2002, pers. comm.). ADFG monitors the population and herd composition through aerial surveys. The management objective for the herd is to maintain a minimum of 50 overwintering adults (Tobey 2000a). Severe winters with deep snow are considered limiting factors for productivity and survival of Chitina River bison (Tobey 2000a). Regulated hunting of this herd commenced in 1976; however, in 1989 population declines prompted a 10-year closure on hunting (Tobey 2000a). Annual lottery permit harvests for bulls resumed in 1999. Trappers and local residents have reported wolf predation on bison, and observed brown bears feeding on bison carcasses (Tobey 2000a). High costs and remoteness of the herd have prevented research on wolf and brown bear predation on Chitina River bison (Tobey 2000a). No genetic testing has been conducted on this herd (Scotton 2002, pers. comm.).

Clymer Meadow Preserve, TX (39) *Captive*

The Nature Conservancy (TNC) operates the 1,200 acre (4.9 km^2) Clymer Meadow Preserve as a center for study of the Blackland Prairie region. In 1999, TNC commenced a lease arrangement with the Moseley Bison Ranch to reintroduce bison grazing to the preserve on an experimental basis (Eidson 2002, pers. comm.). During the growing season, a herd of 300 bison grazes approximately 400 acres (1.6 km^2) of tallgrass prairie (Bragg *et al.* 2002). The short-duration rotating grazing program is designed to enhance investigation of the relationship between bison and healthy prairies

(The Nature Conservancy 2002). TNC is not responsible for management of the bison beyond the grazing program. This herd is included in the list of conservation plains bison herds for this survey because it is partially used for conservation purposes on the Clymer Meadow Preserve. However, the herd is privately-owned and managed for commercial purposes, and therefore, does not strictly fall within the scope of this survey. Management practices applied to the herd while the bison are not on the TNC property were not reviewed for this survey.

Copper River, AK (14) *Free-ranging*

The Copper River herd inhabits an area of approximately 1,036 km^2 adjacent to the Copper River between the Dadina and Chetaslina Rivers in Alaska (Scotton 2002, pers comm.) This is one of four free-ranging herds of plains bison in Alaska. Alaska is not within the original range of plains bison. The Copper River herd originates from 17 bison transferred in 1950 from the herd at Delta Junction, AK, which originated from a transfer in 1928 from the National Bison Range, MT. The Alaska Department of Fish and Game (ADFG) monitors the population and herd composition through aerial surveys. The management objective for the herd is to maintain a minimum of 60 overwintering adults (Tobey 2000b). Severe winters with deep snow are limiting factors for productivity and survival of Copper River bison (Tobey 2000b). Regulated hunting of this herd commenced in 1964; however, in 1989 population declines prompted a 10-year closure on hunting (Tobey 2000b). Annual lottery permit harvests for bulls resumed in 1999. The increase in size and productivity of the herd observed during the last few years is attributed to mild winters (Tobey 2000b). Wolves, black bears, and grizzly bears are numerous within the range of the Copper River herd; however, the impacts of predation on the herd have not been researched (Tobey 2000b). No genetic testing has been conducted on this herd (Scotton 2002, pers. comm.).

Cross Ranch Nature Preserve, ND (34) *Captive*

The bison herd at the Cross Ranch Nature Preserve is managed by The Nature Conservancy (TNC), a non-profit conservation organization. The herd originated from 15 animals purchased from a private rancher in 1986 (Bragg *et al.* 2002). The lineage of the herd traces back primarily to Custer State Park (Bragg *et al.* 2002). TNC maintains bison in the central and south units of the preserve on a total area of 3060 acres (12 km^2). Bison were reintroduced to the preserve to restore natural grazing influences.

Custer State Park, SD (26) *Captive*

Custer State Park (CSP) maintains 1,500 bison (summer population) on approximately 17,800 acres (72 km^2) of rangeland. The herd was established in 1913 with 36 bison from Scotty Philips and Fred Dupree. There was also an augmentation in the 1950s of approximately 800 bison that moved through an open gate between CSP and Wind Cave National Park. CSP bison possess a unique haemoglobin ratio (R. Walker 2002, pers. comm.). Genetic management within the herd currently focuses on increasing the diversity of blood types, as per research conducted by Stormont (1982). Introgression of both cattle mitochondrial and nuclear DNA has been detected in CSP bison. CSP is now evaluating the results the blood type selection program, and is developing a genetics programs that addresses conservation genetics and cattle DNA introgression (R. Walker 2002, pers. comm.). Bison management at CSP emphasizes herd productivity (Walker *et al.* 1995). Supplemental feed is provided to the cow herd six weeks prior to calving to improve cow condition and calf formation (Walker *et al.* 1995). As well, calves are weaned in midwinter to promote high conception rates in cows. Since 1966, CSP has played a prominent role in establishing bison in the private sector. CSP obtains 25% of its operating budget from the sale of bison (CSP 2002). The park holds three sales per year to dispose of surplus bison, and removes 10 mature bulls through a guided hunt (Walker *et al.* 1995). The park is also planning to sell non-pregnant cows as wholesale meat to the Custer State Park Resort Company. An additional management goal is to promote tourism to the park by providing opportunities for public viewing of bison (CSP 2002).

Daniels Park, CO (41) *Captive*

The Denver Mountain Park system, managed by the City and County of Denver, includes two mountain bison preserves, Genesee Park (1912) and Daniels Park (1930s). In 1937, seven bison were transferred from Genesee Park to create a bison herd at Daniels Park (Denver Parks and Recreation Department 1999a). The herd is now maintained at 26 animals on 800 acres (3.2 km^2) of high-plains/shrubland range (Tripp-Addison 2002, pers. comm.). The primary role of this herd is for educational and historical display of bison (Tripp-Addison 2002, pers. comm.). All parks within the Denver Mountain Park system are considered natural areas with all wildlife and plants protected and preserved (Denver Parks and Recreation Department 1999b).

Delta, AK (15) *Free-ranging*

The Delta herd is one of four free-ranging herds of plains bison in Alaska. Alaska is not within the original range of plains bison. The Delta herd originates from 23 bison transferred in 1928 from the National Bison Range, MT. During the summer, the herd inhabits an area of approximately 298 km^2 near Delta Junction along the Delta River floodplain and adjacent uplands. In the winter, the herd migrates to the Delta Junction Bison Range (DJBR), a 90,000 acre (364 km^2) area allocated to free-ranging bison. As agriculture developed within the established range of the Delta herd, the bison began to add hay and cereal grains to their fall and winter diets (DuBois 2000). Depredation by bison on agricultural crops prompted Alaska to establish the DJBR in 1979. The Alaska Department of Fish and Game cultivates oats and bluegrass on the DJBR to deter the bison from moving to agricultural fields (DuBois 2000). ADFG monitors the population and herd composition through aerial surveys. The management objective for the herd is to maintain a minimum of 360 bison (precalving) (DuBois and Rogers 2000). ADFG issues 100-130 hunting permits per year to manage the size and composition of the Delta herd (DuBois and Rogers 2000). Wolves, black bears, and grizzly bears are present within the range of the Delta herd; however, predation is not a major mortality factor (DuBois and Rogers 2000). No genetic testing has been conducted on this herd. Escaped domestic bison have joined the herd in recent years (DuBois 2002, pers. comm.). The Delta bison management plan for 2000-2005 outlines goals, objectives, and management actions for managing herd health, size and composition, human-bison conflicts, and bison viewing (DuBois and Rogers 2000).

Farewell Lake, AK (16) *Free-ranging*

The Farewell Lake herd inhabits an area of approximately 7,770 km^2 in the Farewell area of Alaska (Boudreau 2000). This is one of four free-ranging herds of plains bison in Alaska. Alaska is not within the original range of plains bison. The Farewell Lake herd originates from 18 bison transferred in 1965 from the herd at Delta Junction, AK, which originated from a transfer in 1928 from the National Bison Range, MT. The

Farewell Lake herd was supplemented in 1968 with an additional 20 bison from the Delta Junction herd. The Alaska Department of Fish and Game (ADFG) monitors the population and herd composition through aerial surveys. The last complete census for the herd was conducted in 1988; however, limited survey and hunting data indicate that the population has recently increased to approximately 350-400 bison (Boudreau 2000). The management objective for the herd is to maintain a minimum of 300 bison (Boudreau 2000). Regulated hunting of this herd commenced in 1972. The herd is managed to provide an optimal sustainable harvest while maintaining uncrowded and aesthetic hunting conditions (Boudreau 2000). Wolves, black bears, and grizzly bears are present within the range of the Farewell herd; however, little to no predation on bison has been observed (Boudreau 2000). No genetic testing has been conducted on this herd (Boudreau 2002, pers. comm.).

Fermi National Accelerator Laboratory, IL (11) *Captive*

The Fermi National Accelerator Laboratory (Fermilab), managed by the US Department of Energy (DOE), maintains a small herd of 30-35 bison in a fenced paddock of approximately 70 acres (0.28 km^2). The herd began in 1969 when Robert Wilson, the first director of the 6,800 acre (27.5 km^2) physics laboratory, introduced the animals to recognize and strengthen Fermilab's connection to its prairie heritage (Fermilab 2001a). The primary role of the Fermilab herd is for educational and historical display of bison (Becker 2002, pers. comm.). Fermilab also coordinates an on-site prairie restoration program (Fermilab 2001c), and has been designated as a National Environmental Research Park for studying ecosystems representative of the American Midwest (Fermilab 2001b).

Finney Game Refuge, KS (21) *Captive*

Bison were added to the Finney Game Refuge (FGR) (sometimes referred to as the Garden City State Game Refuge) in 1924, originating from three bison from the Wichita Mountains National Wildlife Refuge and approximately 10 bison from a private source (Norman 2002, pers. comm.). The current herd of approximately 120 bison rotates through three pastures of sandsage prairie totalling 3,670 acres (14.9 km^2). Genetic testing has detected the presence of cattle DNA introgression in this herd (Ward 2000). The herd provides an important grazing influence for the management of this remnant tract of sandsage prairie (Norman 2002, pers. comm.). A volunteer organization, Friends of Finney Game Refuge (FOFGR), conducts tours of the refuge for the interested public (FOFGR 2001b) and administers the Adopt a Buffalo donation program to support bison management on the refuge (FOFGR 2001a).

Fort Niobrara National Wildlife Refuge, NE (6) *Captive*

This bison herd at Fort Niobrara National Wildlife Refuge (FNNWR) is one of several herds formed in the early 1900s through the actions of the American Bison Society (Coder 1975). In 1913, the herd began with a reintroduction of eight bison (six from private donation and two from YNP) (US Fish and Wildlife Service 1999). Thirteen bison were added to the herd between 1935 and 1952; there have been no further augmentations (McPeak 2002, pers. comm.). FNNWR now maintains the herd at approximately 350 animals on 14,000 acres (56.7 km^2). The range is divided into a winter pasture of 3,938 acres (15.9 km^2), and the remainder into 17 units for the controlled grazing program. During April to September, the herd moves to a new grazing unit every 4-7 days. The management philosophy applied through time has been to maintain a representative herd under reasonably natural conditions and at a population level sufficient to ensure persistence (US Fish and Wildlife Service 1999). Current management actions include culling, controlled herd movements, branding, disease testing, and limited genetic monitoring (US Fish and Wildlife Service 1999). Studies testing for the presence of cattle DNA found no mtDNA introgression in the FNNWR herd; however, cattle nuclear DNA has been detected (Ward 2000). Development of a genetic management program for FWS herds is underway. This is one of five bison herds managed by the FWS.

Fort Robinson State Park, NE (24) *Captive*

Fort Robinson State Park (FRSP) maintains approximately 500 bison on three pastures totalling 9,000 acres (36.5 km^2). The herd was established in the early 1970s with approximately 28 bison, most of which were from the National Bison Range in Montana. The herd is rounded up annually to remove surplus animals and wean and vaccinate calves. Surplus animals are sent to live sale; some bulls are slaughtered to provide meat for the on-site restaurant. The FRSP bison herd is important for educational and historical display, as well as maintenance of the species within its natural habitat (Morava 2002, pers. comm.).

Genesee Park, CO (42) *Captive*

The Denver Mountain Park system, managed by the City and County of Denver, includes two mountain bison preserves, Genesee Park (1912) and Daniels Park (1930s). In 1914, seven bison from Yellowstone National Park were transferred by rail to Genesee Park (Denver Parks and Recreation Department 1999a). The primary purpose for establishing the preserve was for wildlife conservation, although the scarcities of World War I provided additional motivation to create a possible source of supplemental meat (Denver Parks and Recreation Department 1999a). Today, the primary role of this herd is for educational and historical display of bison (Tripp-Addison 2002, pers. comm.). The herd is currently maintained at 26 animals on 500 acres (2.0 km^2) of mountain grassland range at an elevation around 8,000 feet (2,438 m). All parks within the Denver Mountain Park system are considered natural areas with all wildlife and plants protected and preserved (Denver Parks and Recreation Department 1999b).

Grand Teton National Park/National Elk Refuge (Jackson herd), WY (4) *Free-ranging*

The Jackson herd of approximately 700 animals resides in the southern end of the Greater Yellowstone Area (US Fish and Wildlife Service and US National Park Service (FWS/NPS) 2001), migrating between Grand Teton National Park (GTNP) in the summer and the adjacent National Elk Refuge (NER) in the winter (Cheville *et al.* 1998). The Jackson was established in 1948 with a transfer of 20 bison from YNP. These bison were confined to a display enclosure until 1963 when brucellosis was discovered in the herd (Cheville *et al.* 1998). All but 4-5 calves were destroyed. In 1964, Theodore Roosevelt National Park provided 12 brucellosis-free bison to augment the Jackson herd (Cheville *et al.* 1998). In 1968, the herd escaped from the progressively deteriorating enclosure facility (Williams *et al.* 1993; Cheville *et al.* 1998). From that point the park allowed the herd to roam freely. Although the herd was healthy when released, it is suspected that infected elk on the NER introduced brucellosis to the Jackson bison (Cheville *et al.* 1998). The Jackson herd is now chronically infected with brucellosis (Chapter 7). The free-ranging nature of the herd allows for the possibility of transmitting brucellosis to domestic livestock grazing in the area. There is currently no management plan in place for the Jackson bison herd. GTNP and the NER determined that a combined elk and bison management plan is needed to address the interconnected issues of the two species including winter feeding and disease management (FWS/NPS 2001). Development of the plan and EIS are underway with completion expected in spring 2004 (FWS/NPS 2001). This is one of the five national park bison herds participating in a genetic management study led by Texas A&M University. There has been no cattle DNA introgression detected in this herd.

Henry Mountains, UT (28) *Free-ranging*

The free-ranging herd of approximately 279 bison in the Henry Mountains of southern Utah originates from a transfer of 18 bison from Yellowstone National Park in 1941 (Berger and Cunningham 1994). The herd ranges over approximately 1,000 square miles (2,590 km^2) at elevations ranging from 1,000 m to 3,500 m. This is a minimally managed herd, therefore little is known regarding its status. The population is controlled through regulated hunting. Opportunistic disease testing occurs on hunted animals. Genetic testing by Ward (2000) found no cattle DNA introgression. No other genetic testing has been conducted on the herd. The topography and the wariness of these bison provide a challenging hunt; therefore, the herd is a valuable hunting resource to the sportsmen of Utah (B. Bates, 2002, pers comm.)

Hot Springs State Park, WY (31) *Captive*

Hot Springs State Park (HSSP) maintains a small herd of 11 animals in a fenced paddock of approximately 700 acres (2.84 km^2). Periodically, HSSP trades bison with Bear River State Park, which also maintains a small herd. The primary role of the HSSP herd is for educational and historical display of bison (Stevenson 2002, pers. comm.).

House Rock State Wildlife Area, AZ (17) *Free-ranging*

In Arizona, bison herds managed by the Arizona Fish and Game Department (AFGD) are found on the House Rock State Wildlife Area and the Raymond State Wildlife Area. The House Rock herd of approximately 217 bison is free-ranging on 60,000 acres (243 km^2) of land cooperatively managed by the AFGD and the US National Forest Service. This herd is not within the original range of the plains bison. The stock for the House Rock herd originated in Yellowstone National Park. The herd is naturally limited to the wildlife area by unsuitability of surrounding habitat, and by one section of fence preventing movement onto adjacent Bureau of Land Management (BLM) lands to the north. Hunting via sport permits for sex and age classes is used to control the population, which is increasing by 10-15% per year (Darr 2002, pers. comm.). The AFGD is currently developing a state bison management plan (Darr 2002, pers. comm.).

Konza Prairie Biological Station, KS (32) *Captive*

Konza Prairie Biological Station is an 8,610 acre (34.9 km^2) native tallgrass prairie preserve. The Nature Conservancy leases the land to the Kansas State University Division of Biology, which administers the preserve as a field research station. The preserve is divided into 60 units, which receive combinations of long-term experimental treatments (prescribed burning at various intervals and grazing by cattle and bison) (van Slyke 2002, pers. comm.). Kansas State University owns and manages a bison herd of approximately 275 animals on 2,480 acres (10 km^2) of the preserve. The primary role of the Konza herd is to assist with long-term ecological research on ungulate grazing and fire in tallgrass prairie ecosystems (van Slyke 2002, pers. comm.).

Land Between the Lakes National Recreation Area, KY (12) *Captive*

Bison were reintroduced to the Land Between the Lakes National Recreation Area (LBL) in 1969 with the transfer of 19 animals from Theodore Roosevelt National Park (TRNP) (USDA Forest Service 2003). In 1996, 39 bison were moved to establish a second herd at LBL on the newly-formed Elk and Bison Prairie area (Ray 2003, pers. comm.). LBL, managed by the USDA Forest Service, now maintains approximately 130 bison on two pastures, the original South Bison Range (180 acres, 0.73 km^2), and the Elk and Bison Prairie (700 acres, 2.8 km^2). Managers periodically augment the LBL herds with animals from other federal bison herds (Ray 2002, pers. comm.). No genetic testing has been conducted for the LBL bison. LBL established the herds to provide historical and educational display of bison, and to assist with restoration of prairie ecosystem (Ray 2002, pers. comm.).

Maxwell Wildlife Refuge, KS (22) *Captive*

The Kansas Department of Wildlife and Parks maintains approximately 230 bison on 2,250 acres (9.1 km^2) of range at the Maxwell Wildlife Refuge (MWR). The refuge has purchased an additional 320 acres (1.3 km^2) that will become available for bison after

2004 (Peterson 2002, pers comm.). The MWR herd was established in 1951 with a transfer of 10 bison from Wichita Mountains National Wildlife Refuge. This herd is periodically augmented with animals from various national, state, and private sources. Range cubes are provided to the herd during the fall and winter as a supplement for nutrients not available in tallgrasses during the dormant seasons (Peterson 2002, pers comm.). The primary roles of this herd are educational and historical display of bison, and maintenance of the grassland ecosystem within the park (Peterson 2002, pers comm.).

Medano-Zapata Ranch, CO (35) *Captive*

The Nature Conservancy (TNC) purchased the Medano-Zapata Ranch and resident bison herd in 1999. The herd originated from several private and state sources (Bragg *et al.* 2002). The herd of approximately 1,500 bison ranges on 45,000 acres (182.3 km^2) of open high mountain shrubland with interspersed meadows (Bragg *et al.* 2002). TNC currently grazes cattle on an additional 30,000 acres (121.5 km^2), which could be converted to bison range in the future (Bragg 2002, pers. comm.). There is no genetic information for this herd; management goals must be set prior to conducting genetic testing (Bragg 2002, pers. comm.). The primary role of bison on the ranch is to maintain the grassland ecosystem.

National Bison Range, MT (7) *Captive*

The bison herd at the National Bison Range (NBR) is one of several herds formed in the early 1900s through the actions of the American Bison Society (Coder 1975). In 1909, 37 bison were released onto the newly established NBR (Coder 1975). The NBR now maintains approximately 400 bison on 18,500 acres (75 km^2) of range. The bison periodically move through a series of eight pastures as part of a rotational grazing program. Annual round-ups are used to remove surplus animals and conduct disease testing. The removal of surplus animals emulates the expected age and sex structure of a natural population (Wiseman 2002, pers. comm.). Studies testing for the presence of cattle DNA found both mtDNA and nuclear DNA introgression in the NBR herd (Ward 2000). Development of a genetic management program for FWS herds is underway. The NBR herd is important for maintaining the species and providing public viewing opportunities of bison in their natural habitat. The NBR maintains a 40-acre pasture with 4-5 bison to ensure year-round display of bison. This is one of five bison herds managed by the FWS.

Neal Smith National Wildlife Refuge, IA (8) *Captive*

Neal Smith National Wildlife Refuge maintains a herd of 37 bison on 700 acres (2.8 km^2) of restored tallgrass prairie. The herd was established in 1996 with 32 bison from three US Fish and Wildlife (FWS) Service Refuges (NBR, FNNWR, and WMNWR). This is one of five bison herds managed by the FWS. Development of a genetic management program for FWS herds is underway. The primary role of bison is to assist with the restoration of tallgrass prairie from land that was previously tilled (Smith 2002, pers. comm.). The herd also provides opportunities for public viewing of bison.

Niobrara Valley Preserve, NE (36) *Captive*

The Nature Conservancy (TNC) maintains a herd of approximately 421 bison on two grazing units at the Niobrara Valley Preserve (NVP). Approximately 250 bison are maintained on the east unit (7,500 acres, 30.4 km^2), and 223 on the west unit (4,633 acres, 18.8 km^2). An expansion of the west unit from 4,633 acres to 12,000 acres (48.6 km^2) is underway. Upon range expansion, the west herd population will be allowed to grow to 250 (Egelhoff 2002, pers comm.). The east herd was established on the preserve in 1985 with 55 animals from private and public herd sources. The west herd was established in 2000 with 132 bison of private origin (Egelhoff 2002, pers. comm.). Both herds are augmented every 3-4 years with bulls from other TNC herds. No genetic testing has been conducted on these populations. The primary role of bison at NVP is to maintain the grassland ecosystem.

Ordway Prairie Preserve, SD (37) *Captive*

The Nature Conservancy (TNC) maintains a bison herd on the Samuel H. Ordway Memorial Prairie (Ordway Prairie preserve). Bison were first introduced to the preserve in 1978 under a year-round grazing lease arrangement with a private bison rancher (Bragg *et al.* 2002). In 1984, TNC acquired 18 bison from a private rancher to establish a TNC-owned herd at the Ordway preserve (Bragg *et al.* 2002). Currently, the herd of 255 resides on 3,140 acres (12.7 km^2) of northern mixed-grass prairie. More range could be allocated to bison if the preserve managers choose to replace cattle grazing with bison grazing on the outer ring of the preserve (Miller 2002, pers comm.).

No genetic testing has been conducted on this population. The primary role of bison at the Ordway preserve is to maintain the grassland ecosystem.

Prairie State Park, MO (23) *Captive*

Bison were first introduced to Prairie State Park (PSP) in 1985 (Prairie State Park 1985), but were removed in 1990 upon detection of brucellosis in herd (Evans 2002, pers. comm.). The current disease-free herd of 76 bison originated from 16 animals reintroduced to the park during the early 1990s (Evans 2002, pers. comm.). The park maintains four 600-800 acre (2.4-3.2 km^2) electrically-fenced pastures, through which they rotate three separate groups of animals: the main bison herd (70 bison), the mature bison bulls, and a herd of elk. Prescribed burning is also applied as part of this range management plan. The primary roles of bison at PSP are educational and historical display of bison, and to manage and restore the prairie resource within the park (Evans 2002, pers. comm.).

Raymond State Wildlife Area, AZ (18) *Captive*

In Arizona, bison herds managed by the Arizona Fish and Game Department (AFGD) are found on the House Rock State Wildlife Area and the Raymond State Wildlife Area. The Raymond herd ranges within a perimeter fence on 15,000 acres (60.8 km^2) of state-owned land, 9,000 acres (36.5 km^2) owned by AFGD and 6,000 acres (24.3 km^2) on a grazing lease from the Arizona State Land Department. This herd is not within the original range of the plains bison. Approximately 100 bison from the House Rock herd, which originated from Yellowstone National Park, were transferred to create the Raymond herd. Hunting via sport permits for sex and age classes is used to maintain the population at around 72 (Darr 2002, pers. comm.). The AFGD is currently developing a state bison management plan (Darr 2002, pers. comm.).

Sandhill Wildlife Area, WI (29) *Captive*

The Wisconsin Department of Natural Resources (WDNR) manages a herd of 15 bison at the Sandhill Wildlife Area. The herd normally ranges over the total 250 acres (1.0 km^2) of pasture, except during prescribed burns and mating periods for the endangered Karner blue butterfly (*Lycaeides melissa samuelis*), when sections of pasture may be closed to the herd (Robaidek 2002, pers comm.). There is currently no formal bison management plan for this herd. The herd assists with the management goal of restoring the enclosed area to a native oak savannah (WDNR 2001), and provides educational and historical display value (Robaidek 2002, pers. comm.).

Santa Catalina Island, CA (33) *Free-ranging*

In 1924, 14 bison were introduced to Santa Catalina Island, an island in the Channel Islands Archipelago of the coast of California, to support the movie production *The Vanishing American* (Constible 2002, pers. comm.). The herd was left on the island, and has since been augmented several times. The Catalina Island Conservancy (CIC), which is responsible for the conservation of the natural heritage of the island, maintains the bison herd at around 225 animals. Topography limits the herd to roughly the central two-thirds of the island, which comprises approximately 32,000 acres (129.5 km^2). Understanding and managing the impacts of non-native species on Santa Catalina Island is the primary management challenge of CIC (Catalina Island Conservancy 2002b). Bison are not indigenous to any part of California. Research is underway to evaluate the effects of bison on the ecology of the island (Catalina Island Conservancy 2002a). The results of these studies will contribute to the development of future bison management actions (Constible 2002, pers. comm.).

Smoky Valley Ranch, KS (40) *Captive*

In 2000, The Nature Conservancy (TNC) entered into a year-round grazing lease arrangement with a private bison rancher to introduce a grazing influence to TNC's Smoky Valley Ranch (Bragg *et al.* 2002). In December 2002, TNC discontinued the grazing lease after receiving a donation of 45 bison to create a TNC-owned herd. The new herd ranges on approximately 3,110 acres (12.6 km^2). TNC has not yet developed management objectives for this herd; however, the population is expected to increase (Palmer 2003, pers. comm.).

Sullys Hill National Game Preserve, ND (9) *Captive*

Sullys Hill National Game Preserve maintains a bison herd of 25-40 animals on 900 acres (3.6 km^2) of range. In 1919, six bison were transferred from the City Park of Portland, Oregon to establish the herd at Sullys Hill. This herd is one of several herds formed in the early 1900s through the actions of the American Bison Society (Coder 1975). The primary role of the Sullys Hill herd is for educational and historical display of bison (Maxwell 2002, pers. comm.). This is one of five bison herds managed by the FWS. Development of a genetic management program for FWS herds is underway.

Tallgrass Prairie Preserve, OK (38) *Captive*

The Nature Conservancy (TNC) maintains a herd of 1,500 bison on 14,400 acres (58 km^2) of its Tallgrass Prairie Preserve (TGPP). TNC has planned a gradual expansion of the bison grazing unit to 32,000 acres (130 km^2), and an increase in herd size to 3,000 bison by 2005 (Bragg *et al.* 2002). The TGPP herd was established in 1993 with a donation of 300 bison from a private rancher (Hamilton 2002, pers. comm.). This herd is periodically augmented with animals from various national, state, and private sources. Randomly selected growing and dormant season prescribed burns are used to improve forage quality and to maintain biodiversity by promoting landscape heterogeneity (Bragg *et al.* 2002). Bison are free to move throughout the grazing unit, and are rotated naturally by the prescribed burns. The primary role of the TGPP bison is to assist with the restoration of a spatially and temporally dynamic tallgrass landscape regulated by fire and herbivory (Hamilton 1996). The herd also provides opportunities for public viewing of bison.

Theodore Roosevelt National Park, ND (2) *Captive*

Theodore Roosevelt National Park (TRNP) maintains two bison herds: approximately 250 bison on 24,070 acres (97.5 km^2) in the North Unit, and approximately 600 bison on 46,128 acres (186.8 km^2) in the South Unit. The South Unit herd was established in 1956 with 29 bison from Fort Niobrara National Wildlife Refuge; 20 bison from the South Unit were translocated to the North Unit in 1962 (Hebbring Wood 2000). There has been no outside augmentation of the herds or movement between the North and South Unit herds (Oehler 2002, pers. comm.). TRNP conducts herd round-ups every three years to control the population; the North and South Unit herds are not rounded up in the same year. This is one of the five national park bison herds participating in a genetic management study led by Texas A&M University. Genetic testing to date has not detected any cattle DNA in this herd (Oehler 2002, pers. comm., Derr 2002, pers. comm.). The TRNP herd is important for ecological maintenance of the species and ecosystem, and as a reservoir for the bison genome.

Wichita Mountains National Wildlife Refuge, OK (10) *Captive*

The bison herd at Wichita Mountains National Wildlife Refuge (WMNWR) was established in 1907 with 15 bison from the New York Zoological Society (Coder 1975). One bison was added to the herd in 1940; there have been no other augmentations (Kimball 2002, pers. comm.). WMNWR now maintains approximately 600 bison on 43,000 acres (174.2 km^2) of range divided into three pastures. Yearlings are rotated through the three pastures. Genetic testing has found no cattle DNA introgression in this herd (Ward 2000). This is one of five bison herds managed by the FWS. Development of a genetic management program for FWS herds is underway.

Wildcat Hills State Recreation Area, NE (25) *Captive*

The Nebraska Game and Parks Department maintains a small herd of 10 bison on 360 acres (1.45 km^2) of range at the Wildcat Hills State Recreation Area (WHSRA). To avoid inbreeding, managers periodically augment the herd with bison from the main state herd at Fort Robinson State Park (McKeehan 2003, pers comm.). The primary role of the WHSRA herd is for educational and historical display of bison (McKeehan 2003, pers. comm.).

Wind Cave National Park, SD (3) *Captive*

The bison herd at Wind Cave National Park is one of several herds formed in the early 1900s through the actions of the American Bison Society (Coder 1975). In 1913, 14 bison from the New York Zoological Society were released into the park; six more bison from YNP were added to the herd in 1916 (Hebbring Wood 2000). There have been no other augmentations to this herd (Muenchau 2002, pers. comm.). WCNP currently maintains 350-450 bison on 28,250 acres (114.4 km^2) of open range. WCNP conducts annual round-ups to control the population; surplus bison are distributed at cost through the InterTribal Bison Cooperative (ITBC) to native tribes across the United States (Muenchau 2002, pers. comm.). The WCNP herd is one of the five national park bison herds participating in a genetic management study led by Texas A&M University. There has been no cattle DNA introgression detected in this herd.

Yellowstone National Park, WY/MT (5) *Free-ranging*

The Yellowstone National Park bison herd is the only population of plains bison in North America that has existed continuously in the wild (Coder 1975; Ward 2000).

During the early 1900s, the remnant herd was augmented with bison from the Goodnight and Allard herds (Wallen 2002, pers. comm.). The YNP bison population is considered to be chronically infected with brucellosis (Cheville *et al.* 1998). Nevertheless, studies have determined that brucellosis is not a threat to the long-term survival of the YNP bison (Mayer and Meagher 1995; USDOI and USDA 2000); the population is currently at 4,000 and increasing (Wallen 2002, pers. comm.). Herd management is affected by the presence of brucellosis primarily because of the potential risk the disease poses to the livestock industry (Chapter 7). The current cooperative management plan incorporates several elements including spatial and temporal separation of bison and cattle, capture, test, and slaughter of seropositive bison, hazing of bison back into the park, vaccination, and radiotelemetry monitoring of pregnant bison (USDOI and USDA 2000). The ultimate purpose of the plan is to maintain a wild, free-ranging population of bison while protecting the economic viability of the livestock industry in Montana by addressing the risk of brucellosis transmission; it is not a brucellosis eradication plan (USDOI and USDA 2000). Bison in YNP are subject to predation by wolves (Smith *et al.* 2000; Laundré *et al.* 2001). This is one of the five national park bison herds participating in a genetic management study led by Texas A&M University. Genetic testing to date has found no evidence of cattle DNA introgression in YNP bison (Ward 2000).

Plains Bison: Canada

Buffalo Pound Provincial Park, SK (50) *Captive*

Buffalo Pound Provincial Park (BPPP) maintains approximately 35 bison on two pastures totalling 475 acres (1.92 km^2). The herd was established in 1972 with 12 bison from Elk Island National Park (Minter 2002, pers. comm.). There is no movement of animals between the two pastures; however, managers periodically augment the herds with replacement bulls from other conservation bison herds (Minter 2002, pers. comm.). No genetic testing has been conducted on this herd. The primary role of the BPPP herd is for educational and historical display of bison.

Elk Island National Park, AB (44) *Captive*

During 1907, Elk Island National Park (EINP) acted as the temporary location for the first two shipments (~410 animals) of the Pablo-Allard plains bison herd purchased by the Canadian government from Michel Pablo of Montana (Coder 1975; Fuller 2002).

These bison descended from the four yearlings rescued by Walking Coyote, and 26 geographically-diverse bison from "Buffalo" Jones (Blyth and Hudson 1987). In late 1909, all but 48 bison were removed from EINP and relocated to their originally intended destination of Wainwright Buffalo Park (Fuller 2002). The remaining bison herd at EINP experienced exponential growth until the early 1920s when the park implemented regular culling to control the population. The population reached a peak of 2,479 in 1936 (Blyth and Hudson 1987). After 1970, live sales and donations replaced slaughters for managing herd size and structure (Bergeson 1990). In 2000, the park implemented the first year of a 3-5-year ungulate reduction strategy to control ungulate populations in the park (EINP 1999). This strategy called for the maintenance of the plains bison population at 472-504 (EINP 1999). The herd ranges on approximately 34,568 acres (140 km^2) (Cool 2002, pers. comm.). Genetic testing has detected no cattle DNA introgression within this herd (Ward 2000). The EINP herd is the primary captive breeding plains bison herd in Canada. EINP maintains a wood bison herd separately on the other side of the park.

Pink Mountain, BC (49) *Free-ranging*

The Pink Mountain herd was established in 1971 with the escape of 48 privately-owned plains bison originally purchased at an Elk Island National Park (EINP) surplus bison sale (Reynolds 1991). Since the accidental introduction, the herd has increased considerably in distribution and abundance. The population is currently estimated at 1,000 animals potentially ranging over an area of 2,000 km^2 (Elliott 2002, pers. comm.). The herd mainly resides in the grass/sedge meadows of the upper Sikanni and Halfway River valleys (Harper *et al.* 2000); this area is part of original wood bison range. The population is stable owing to prescribed sustenance harvest by natives (Harper *et al.* 2000). Although the Pink Mountain herd has less genetic variation than the EINP herd, genetic studies show a close relationship between the two herds, demonstrating that founder effects are minimal (Wilson and Strobeck 1999; Wilson and Strobeck 1999). The potential for hybridization of plains and wood bison exists because of the proximity of the Pink Mountain plains bison herd to four free-ranging wood bison herds. British Columbia has outlined measures to prevent the northward movement of Pink Mountain bison toward the wood bison herds by directing sustenance hunting by natives (Harper *et al.* 2000); however, the effectiveness of this strategy remains unknown. The Pink Mountain herd is the largest free-ranging tuberculosis- and brucellosis-free plains bison herd in North America.

Primrose Lake Air Weapons Range (Cold Lake), AB/SK (48) *Free-ranging*

A free-ranging bison population resides on the Primrose Lake Air Weapons Range (also known as the Cold Lake Air Weapons Range), which comprises 3 million acres (12,150 km^2) straddling the Alberta-Saskatchewan border. This herd is normally referred to as the Primrose Lake or Cold Lake herd, and occasionally as the McCuster River herd (Arsenault 2002, pers. comm.; Opekokew 2002, pers. comm.). In 1969, the Saskatchewan Department of Natural Resources (SDNR) reintroduced 50 bison from Elk Island National Park to the Thunder Hills region north of Prince Albert National Park (Bergeson 1990). When this reintroduction failed, SDNR recaptured the herd, and released seventeen of the original 50 bison from EINP near Vermette Lake north of the weapons range (Frandsen 2000, pers. comm.). The Primrose herd has since migrated onto the weapons range and increased in size (Arsenault 2002, pers. comm.). The Primrose herd sits on the southeastern limit of original wood bison range (Gates *et al.* 2001a). This herd is not managed or monitored, therefore, the conservation status is poorly known. Current population estimates range between 70-100 bison (Beaulieu 2002, pers. comm.). The herd is subject to hunting by local First Nations bands (Opekokew 2002, pers. comm.).

Prince Albert National Park, SK (45) *Free-ranging*

There have been two herds of plains bison at Prince Albert National Park (PANP). From 1936 to 1995 the park maintained a captive display herd until the 1995 Park Management Plan called for the dispersion of the herd to refocus resources on management of the wild bison herd (Parks Canada 2000). Of that herd, four went to a local First Nations Band, four were sent to Wanuskewin Heritage Park, and the remaining twelve were sold at an auction to offset the costs of habitat rehabilitation in the bison paddocks. The bison paddock fences and handling facilities were dismantled in the spring of 1996 (Parks Canada 2000). The free-ranging herd originated from a reintroduction in 1969 to the Thunder Hills region north of the park conducted by the Saskatchewan Department of Natural Resources (SDNR). Rather than establishing themselves in the Thunder Hills region, the 50 introduced bison from EINP migrated south toward the park, causing difficulty for private land owners along the way (Bergeson 1990). As such, SDNR shot some of the bison, and rounded up others for re-transplant north of the Primrose Air Weapons Range. A few remaining animals (~4-10) moved into PANP to form the nucleus of the current wild herd (Bergeson 1990) (Frandsen 2002, pers. comm.). The herd is growing steadily and currently consists of over 310 animals (Frandsen 2002, pers. comm.). This is the only free-ranging herd of plains bison within its original range in Canada that is protected within a national park (Parks Canada 2000). It is a closed herd, and is subject to very little human intervention. The genetic status of the herd is unknown; however, it is likely that the genetic diversity is low having been based on only 4-10 animals. Genetic testing is in progress for the herd (Frandsen 2002, pers. comm.).

Riding Mountain National Park, MB (46) *Captive*

The bison herd at Riding Mountain National Park (RMNP) was established with a transfer of 20 bison from Wainwright Buffalo Park in 1931 (Tabulenas 1983). In 1937, tuberculosis was detected in the herd. After 1946, when the Elk Island National Park (EINP) herd was determined to be tuberculosis-free, the RMNP herd was destroyed and restocked with bison from EINP (Ogilvie 1979). RMNP now maintains a herd of 33 animals on 1,235 acres (5 km^2) divided into winter and summer pastures. The females, immature bulls, and calves winter separately from the mature bulls. The population is increasing by approximately six bison per year. The maximum stocking rate for the range is 50 animals (D. Walker 2002, pers. comm.). The primary role of the RMNP herd is for educational and historical display of bison (D. Walker 2002, pers. comm.).

Camp Wainwright, AB (43) *Captive*

The Camp Wainwright bison herd is managed by the Canadian Department of National Defence at the Western Area Training Centre in Alberta. Sixteen bison range on 160 acres (0.65 km^2), divided into pastures for rotation. The herd was established with four bison from Elk Island National Park. Managers periodically augment the herd with replacement bulls from private sources. Two female calves were added to the Wainwright herd in 1993 when the bison herd at the Suffield military base was dispersed (Anderson 2002, pers. comm.). The primary role of the Wainwright herd is for educational and historical display of bison. The herd is maintained as a symbol of the bison that resided in Wainwright Buffalo Park from 1909 to 1939 (Anderson 2002, pers. comm.). The Bud Cotton Buffalo Paddock, a name sometimes associated with the Camp Wainwright herd, refers to one of the grazing pastures named after the first manager of the Wainwright herd.

Waterton Lakes National Park, AB (47) *Captive*

Waterton Lakes National Park (WLNP) maintains a herd of approximately 27 bison on 499 acres (2.0 km^2) divided into summer and winter pastures. The herd was established in 1952 with six bison from Elk Island National Park (EINP). WLNP periodically augments the herd with bulls from EINP (Watt 2002, pers. comm.). The primary role of this herd is for educational and historical display of bison (Watt 2002, pers. comm.). WLNP is considering a reintroduction of bison to a larger area of the park. Managers for WLNP are currently assembling information on bison grazing and ecology and the history of bison in the area before developing a reintroduction plan.

Wood Bison

The following conservation plains bison herd profiles are in alphabetical order according to herd name. Numbers in parentheses refer to locations on the map in Figure 5.5.

Aishihik, YT (13) *Free-ranging*

In 1980, the Yukon government contributed to the national wood bison recovery effort by establishing a free-ranging herd. Habitat assessment by the Canadian Wildlife Service determined that the Nisling River watershed offered the best wood bison range in the southern Yukon with a carrying capacity of at least 400 animals (Government of the Yukon 1998). Between 1988 and 1992, 172 bison were released to the wild after a habituation period in a 5 km^2 enclosure (Gates *et al.* 2001a). The majority of the founding stock was from EINP (142 bison); the remaining animals were transferred from Moose Jaw Wild Animal Park and Metro Toronto Zoo (Gates *et al.* 2001a). During the phase of population growth, 1988-1998, 49 bison were removed from the population because of conflicts along the Alaska Highway, vehicle collisions, and problem wildlife complaints (Government of the Yukon 1998). Since 1998, the herd has been regulated at about 500 animals through hunting. The Government of Yukon monitors the size of the herd through aerial census (Government of the Yukon 1998). The Aishihik herd is sometimes referred to as the Nisling River herd or the Yukon herd.

Caribou Mountains-Lower Peace: Wabasca, AB (7) *Free-ranging*

There is limited information available on the herds in the Caribou Mountains-Lower Peace region southwest of WBNP. The Wabasca herd is located between the Mikkwa and Wabasca Rivers. An incidental aerial survey conducted in 1996 by the Alberta Fish and Wildlife Division counted 51 bison in this region (Gates *et al.* 2001a; Mitchell 2002). *Brucella abortus* was cultured from one bison of six tested for brucellosis and tuberculosis in the area of the Wabasca herd (Tessaro *et al.* 1990).

Caribou Mountains-Lower Peace: Wentzel, AB (6) *Free-ranging*

There is limited information available on the herds in the Caribou Mountains-Lower Peace region southwest of WBNP. The Wentzel herd ranges between the WBNP boundary and Wentzel Lake, north of Peace River. The population is estimated between 25 and 110 (Gates *et al.* 2001a). The disease status of the Wentzel herd is unknown; however, movement has been noted between the herd and WBNP, therefore infection is possible (Mitchell 2002).

Chitek Lake, MB (8) *Free-ranging*

The Chitek Lake herd is a component of the Waterhen Wood Bison Project, which involved the establishment of a wood bison ranch (Waterhen Wood Bison Ranch) and a free-ranging herd in the northern Interlake region of Manitoba (Stock 1998). The project endeavours to contribute to wood bison conservation while generating economic benefits for the local aboriginal community (Huck 1995). In 1991, 13 bison from the Waterhen Ranch were released near Chitek Lake; nine additional animals were released in 1993 (Stock 1998). The 2000 winter population was estimated at 70 animals (Gates *et al.* 2001a). The Chitek Lake area is approximately 1,024 km^2 (Stock 1998); it has the potential to support 400-500 bison (Gates *et al.* 2001a). The Government of Manitoba and the Waterhen First Nation cooperatively manage the Chitek Lake herd (Gates *et al.* 2001a). The wood bison is a protected species under Manitoba wildlife legislation. Manitoba is outside the original range of wood bison.

Elk Island National Park, AB (2) *Captive*

In an effort to salvage the wood bison subspecies, bison from the Nyarling region of WBNP were captured and relocated to establish two new herds at the Mackenzie Bison Sanctuary and Elk Island National Park. In 1965, 22 animals were successfully transferred to EINP (Blyth and Hudson 1987). Two additional calves were transferred to EINP between 1966 and 1968 (Blyth and Hudson 1987; Gates *et al.* 2001a). EINP currently maintains 300-340 wood bison on 12,345 acres (50 km^2) of fenced range (Cool 2002, pers. comm.). The herd is subject to annual round-ups to remove surplus animals. EINP has played a pivotal role in the recovery of wood bison in Canada by providing stock for the establishment of wild and captive wood bison herds (Gates *et al.* 2001a). A herd of plains bison is held separately on the other side of the park.

Etthithun Lake, BC (4) *Captive*

The Etthithun Lake captive herd was established in 1999 with the transfer of 21 wood bison from EINP to a 2,100 acre (8.5 km^2) enclosure in within the Etthithun Bison Area (EBA) in northeastern British Columbia (Harper *et al.* 2000). In 2000, the herd was augmented with an additional 24 bison from EINP, bringing the total population to 43 bison (Gates *et al.* 2001a). There are plans to increase the size of the enclosure, and release the herd to the wild (Harper *et al.* 2000; Gates *et al.* 2001a). A habitat evaluation within the EBA indicates that the area would be able to support a population of 400 wood bison (Harper *et al.* 2000). A previous reintroduction attempt within the EBA in 1996 failed after the released wood bison hybridized with feral commercial plains bison in the area (Harper *et al.* 2000). The potential presence of feral plains bison would need to be addressed prior to any further reintroduction attempts.

Hay-Zama, AB (5) *Free-ranging*

In 1981, a program was initiated, in cooperation with the Dene Tha' First Nation, to re-establish wood bison in northwestern Alberta. The Hay-Zama herd was established as a captive herd in 1984 with 29 wood bison from EINP. The herd was scheduled to be released to the wild in 1988; however, the release was postponed until 1993 because of the risk of infection with bovine tuberculosis and brucellosis present in the greater WBNP area (Mitchell and Gates 2002). In 1993, the herd became free-ranging when portions of the fence collapsed; the herd population was 49 animals (Gates *et al.* 2001a; Mitchell and Gates 2002). The 2002 population estimate is 234. To protect this herd, the Alberta government established a 36,000 km^2 bison management area (Gates *et al.* 2001a). Outside the bison management area, bison in Alberta are not considered wildlife under the *Alberta Wildlife Act*. Therefore, the area between the bison management area and WBNP is an effective buffer against disease transmission because bison are not protected from hunting when moving through the area (Gates *et al.* 2001a).

Heart Lake Wood Bison Recovery Project, AB (14) *Captive*

In 2000, Elk Island National Park and the Canadian Wildlife Service entered into an agreement with the Alberta Tribal Chiefs Association and the Heart Lake First Nation to establish the Heart Lake Wood Bison Recovery Project. The project involves the transfer of up to 100 wood bison to establish a captive commercial herd for providing economic development opportunities for Heart Lake First Nation and a captive conservation herd for future recovery needs. Heart Lake First Nation has demonstrated its commitment to wood bison recovery by dedicating a considerable portion of the Heart Lake Reserve to the project. The plan is to generate revenue from the commercial operation for management of the two project initiatives. The long-term objective is to release the conservation herd into the wild as part of the national Wood Bison Recovery Program upon resolution of the northern diseased bison issue.

In February 2001, 57 wood bison from Elk Island National Park were transferred to an 80-acre fenced enclosure and fed year round until the facility was expanded and was large enough to allow the herd to graze without supplemental feeding. Funding shortfalls, delays in expanding the enclosure, and on-site management issues with overcrowding and poor animal condition have delayed the transfer of the remaining 43 wood bison until sufficient funding can be generated to continue expanding the enclosure and improve the habitat by prescribed burning and re-seeding of logged areas. A Heart Lake Wood Bison Advisory committee (comprised of First Nation, Alberta Pacific Forest Industries Inc. (ALPAC), Canadian Wildlife Service, and Parks Canada representatives) continues to be committed to developing funding initiatives to maintain the project. The Heart Lake First Nation and the member First Nations of the Tribal Chiefs Association remain firmly committed to the long-term success of the project (Reynolds and Cool 2002, pers. comm.).

Hook Lake Wood Bison Recovery Project, NT (12) *Captive*

The Hook Lake Wood Bison Recovery Project (HLWBRP) seeks to establish a captive, disease-free herd of wood bison from a wild herd infected with bovine tuberculosis and brucellosis, and then reintroduce a disease-free population into the wild (Gates *et al.* 1998; Nishi *et al.* 2002). This project, cooperatively managed by the Deninu Kue' First Nation, Fort Resolution Aboriginal Wildlife Harvesters' Committee, and the Government of Northwest Territories, Canada, endeavours to contribute to the resolution of the northern diseased bison issue (Chapter 7). The long term objectives of the project focus on habitat management, disease eradication, genetic conservation, and wood bison recovery in the Slave River Lowlands (Nishi *et al.* 2001).

After three calf capture operations, followed by extensive disease testing and hand rearing, the captive herd now has 57 founders in three cohorts (Nishi *et al.* 2001; Wilson *et al.* 2002). Conservation genetics studies on the herd reveal that 95% of the original genetic diversity in the wild Hook Lake herd is represented within the captive herd (Wilson 2001), making it more genetically variable than any other captive wood bison herd (Gates *et al.* 2001b; Wilson *et al.* 2002). Although this project represents a successful genetic salvage operation, studies have found that the variability held by the founding animals is not fully represented in the calves born to the population. This discrepancy is likely the result of the high variance in male reproductive success observed in this population (Wilson 2001). If differential reproductive success in males is not managed, over time, genetic drift will erode the diversity salvaged from the wild population (Wilson 2001). Therefore, studies have been underway to assess techniques for managing and maintaining the diversity currently held by the captive herd (Wilson *et al.* 2002), and a genetic management plan has been designed to ensure that genetic diversity within the population is not lost at unacceptable rates (Wilson and Nishi 2003, pers. comm.). A recent risk assessment on the health status herd determined that it is improbable that brucellosis and tuberculosis are present in the herd (Animal Plant and Food Risk Analysis Network (APFRAN) 2003). Once the herd obtains official disease-free status it can be a source of bison for future wood bison reintroductions.

Mackenzie Bison Sanctuary, NT (10) *Free-ranging*

In an effort to salvage the wood bison subspecies, bison from the Nyarling region of WBNP were captured and relocated to establish two new herds at the Mackenzie

Bison Sanctuary and Elk Island National Park. In 1963, wood bison were moved to the Mackenzie Bison Sanctuary north of Great Slave Lake (Gates *et al.* 2001a). The herd of approximately 2,000 bison now ranges over an estimated 13,000 km^2 (Gates *et al.* 2001a). Limited hunting is used to regulate the population (Mitchell and Gates 2002). The Mackenzie herd is the largest free-ranging population of wood bison that is uninfected with bovine tuberculosis and brucellosis (Tessaro *et al.* 1992).

Nahanni, NT (9) *Free-ranging*

The Nahanni herd was established in 1980 with the release of 28 EINP wood bison into the Nahanni butte area in southwestern Northwest Territories. The herd fragmented, with some bison dispersing more than 250 km into British Columbia (Gates *et al.* 2001a). The herd was augmented in 1989 (12 animals) and 1998 (61 animals) with bison of EINP origin. The population is currently estimated at 170 bison. Lack of quality habitat may prevent the population from reaching 400, the number estimated as the MVP for bison (Gates *et al.* 2001a). The Nahanni herd may merge with the Nordquist herd in the future

Nordquist, BC (3) *Free-ranging*

The Nordquist herd was established in 1995 with the reintroduction of 49 wood bison from EINP to Aline Lake in the Nordquist Flats area of the Liard River valley (Harper *et al.* 2000). The bison were held in a temporary on-site enclosure for two months to become habituated to the area prior to release (Harper *et al.* 2000). The current population is estimated at 60 animals. Prescribed fire has been used in the past, and will likely be used again, to improve bison grazing habitat (Gates *et al.* 2001a). The reintroduction site for this herd was only 80 km from the southern edge of the range of the Nahanni herd. Therefore, it is expected that the two herds will eventually merge (Gates *et al.* 2001a).

Slave River Lowlands, NT (11) *Free-ranging*

In 1970, the Slave River Lowlands (SRL) adjacent to WBNP held approximately 2,500 bison. By 1994, there were only 212 bison in the eastern SRL (Hook Lake herd) and 463 in the western SRL (Little Buffalo Herd) (Gates *et al.* 2001a). The decline in population is attributed to poor calf production, infection with tuberculosis and brucellosis, wolf predation, and hunting. The current population of the SRL is estimated at 600 bison. The SRL herds historically played an important role in the culture and economies of aboriginal communities; this role is now limited by the small size and instability of the SRL herds, and the presence of tuberculosis and brucellosis (Gates *et al.* 2001a).

Syncrude, AB (16) *Captive*

The Syncrude herd is a captive breeding population established on 2.6 km^2 of reclaimed oil sands property; EINP provided the bison. In 1993, Alberta Environmental Protection, the Canadian Wildlife Service, Syncrude Canada Ltd., and the Fort McKay First Nation cooperatively established the herd to determine experimentally whether restored soil on reclaimed areas could support forage crops and a productive wood bison herd. Results after five years indicate that the landscape can support a healthy and productive bison herd (Gates *et al.* 2001a). The current population is 322 bison. There is the potential to convert 20 km^2 of reclaimed oil sands into grassland habitat that could support 1,200 bison (Gates *et al.* 2001a). In 1995, the herd became the property of Syncrude Canada Ltd. after the *Alberta Wildlife Act* classified all bison outside the Hay-Zama bison management zone as domestic (Gates *et al.* 2001a; Mitchell and Gates 2002). The contribution of this herd to conservation goals will depend on the Syncrude's long-term bison management objectives; there is great potential for the establishment of a minimally-managed captive conservation herd (Gates *et al.* 2001a). The establishment of a free-ranging herd in this area is limited by the presence of diseases in WBNP (Gates *et al.* 2001a).

Waterhen Wood Bison Ranch, MB (15) *Captive*

The Waterhen Wood Bison Ranch herd is a component of the Waterhen Wood Bison Project, which involved the establishment of a wood bison ranch and a free-ranging herd (Chitek Lake) in the northern Interlake region of Manitoba (Stock 1998). The project endeavours to contribute to wood bison conservation while generating economic benefits for the local aboriginal community (Huck 1995). The Ranch was established in 1984 predominately with founding stock from EINP; additional animals came from the Toronto, Edmonton, and Calgary zoos, and animal parks in Banff and near Edmonton (Huck 1995). Initially the Manitoba Department of Natural Resources and the Waterhen First Nation cooperatively managed the herd; now it is managed solely by the Waterhen First Nation. The 2000 population estimate is 185 bison. Manitoba is outside the original range of wood bison.

Wood Buffalo National Park, AB/NT (1) *Free-ranging*

The Wood Buffalo National Park (WBNP) herd is the only population of wood bison in North America that has existed continuously in the wild. When the park was established in 1922, there were approximately 1,500-2,000 wood bison in WBNP (Gates *et al.* 2001a). During 1925-1928, 6,673 plains bison from Wainwright Buffalo Park in Alberta were transferred to WBNP. This action introduced bovine tuberculosis and brucellosis to the wood bison population, and caused varying degrees of hybridization between plains and wood bison. The population of the park increased to approximately 12,000 bison and remained stable for several decades (Gates *et al.* 2001a). After 1970, the population steadily decreased to a low of 2,151 in 1999 (Joly 2001). This decrease is believed to be attributed in part to the effects of the diseases (Fuller 1991; Carbyn *et al.* 1998; Joly and Messier 2001). Infected animals are subject to increased mortality, reduced fecundity, and increased vulnerability to predation (Gates *et al.* 1992; Joly and Messier 2001). Recently, the WBNP population increased to 4,050; the reasons for this increase are unclear (Bradley 2002, pers. comm.). The presence of bovine diseases in and around WBNP limits the potential for re-establishing additional wood bison herds in northern Alberta, northeastern British Columbia, and southwestern Northwest Territories (Gates *et al.* 2001a).

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Personal Communication References

Ed Anderson, Herd Manager, Camp Wainwright, December 9, 2002.

Al Arsenault, Wildlife Population Biologist, Saskatchewan Environment, Fish and Wildlife Branch, October 22, 2002.

Bill Bates, Wildlife Manager, Utah Division of Wildlife Resources, May 20, 2002.

Steven Bates, Wildlife Range Manager, Utah Division of Parks and Recreation, Antelope Island State Park, May 20, 2002.

Rhys Beaulieu, Wildlife Biologist, Saskatchewan Environment, Fish and Wildlife Branch, October 22, 2002.

Toby Boudreau, Wildlife and Area Biologist, Alaska Department of Fish and Game, September 17, 2002.

Mark Bradley, Wildlife Biologist, Wood Buffalo National Park, Parks Canada Agency, December 10, 2002.

Tom Bragg, Ranch Manager, Medano-Zapata Ranch, The Nature Conservancy, May 24, 2002.

Eddie Childers, Wildlife Biologist, Badlands National Park, US National Park Service June 17, 2002.

Juanita Constible, Contract Researcher for study on Santa Catalina Island, University of North Dakota, August 2, 2002.

Norm Cool, Wildlife Biologist, Elk Island National Park, Parks Canada Agency, July 23, 2002 and December 11, 2002. (BSG Member)

Dennis Darr, Arizona Fish and Game Department, March 19, 2002.

James Derr, Associate Professor, Department of Veterinary Pathobiology, Texas A & M University, June 3, 2002. (BSG Member)

Steve DuBois, Wildlife and Area Biologist, Alaska Department of Fish and Game, September 18, 2002.

Richard Egelhoff, Bison Manager, Niobrara Valley Preserve, The Nature Conservancy, June 10, 2002.

Jim Eidson, Preserve Manager, Clymer Meadow Preserve, The Nature Conservancy, December 6, 2002.

John Elliott, Biologist, British Columbia Ministry of Water, Land and Air Protection, October 21, 2002.

Cyndi Evans, Park Naturalist, Prairie State Park, Missouri Department of Natural Resources, March 19, 2002.

Dan Frandsen, Conservation Biologist, Prince Albert National Park, Parks Canada Agency, March 11, 2002 and July 4, 2002.

Robert Hamilton, Assistant Director, Division of Science and Stewardship, The Nature Conservancy, June 5, 2002.

Joe Kimball, Biologist, Wichita Mountains National Wildlife Refuge, US Fish and Wildlife Service, June 4, 2002.

Joe Maxwell, Refuge Manager, Sullys Hill National Game Preserve, US Fish and Wildlife Service, September 27, 2002.

Russ McKeehan, Superintendent, Wildcat Hills State Recreation Area, Nebraska Game and Parks Commission, January 3, 2003.

Kathy McPeak, Wildlife Biologist, Fort Niobrara National Wildlife Refuge, US Fish and Wildlife Service, June 10, 2002.

Mary Miller, Preserve Manager, Ordway Prairie Preserve, The Nature Conservancy, June 18, 2002.

Terry Minter, Park Supervisor, Buffalo Pound Provincial Park, Saskatchewan Environment, July 3, 2002.

Mike Morava, Superintendent, Fort Robinson State Park, Nebraska Game and Parks Commission, June 11, 2002.

Barbara Muenchau, Biological Science Technician, Wind Cave National Park, US National Park Service, June 12, 2002.

John Nishi, Bison Biologist, Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories, March 6, 2003. (BSG Member)

Tom Norman, Wildlife Area Manager, Finney Game Refuge, Kansas Department of Wildlife and Parks, August 6, 2002.

Mike Oehler, Wildlife Biologist, Theodore Roosevelt National Park, US National Park Service, June 21, 2002.

Barry Opekokew, Canoe First Nation, October 23, 2002.

Ruth Palmer, Development and Communications, The Nature Conservancy, January 3, 2003.

Cliff Peterson, Assistant Wildlife Manager, Maxwell Wildlife Refuge, Kansas Department of Wildlife and Parks, June 6, 2002.

Scott Ray, Wildlife Technician, USDA National Forest Service, Land Between the Lakes National Recreation Area, August 26, 2002.

Hal Reynolds, Wildlife Biologist, Canadian Wildlife Service, Environment Canada, December 11, 2002. (BSG Member)

Jon Robaidek, Wildlife Technician, Sandhill Wildlife Area, Wisconsin Department of Natural Resources, August 20, 2002.

Todd Stevenson, Park Superintendent, Hot Springs State Park, Wyoming State Parks and Historic Sites, July 8, 2002

Tom Sawtelle, Assistant Park Manager, Blue Mounds State Park, March 19, 2002.

Jerry Tripp-Addison, Superintendent, Denver Parks and Recreation, Mountain Parks Department, July 8, 2002.

Bradley Scotton, Wildlife Biologist, Alaska Department of Fish and Game, May 10, 2002.

Tom van Slyke, Site Manager, Konza Prairie Biological Station, Division of Biology, K-State University, June 7, 2002.

Christy Smith, Refuge Operations Specialist, Neal Smith National Wildlife Refuge, US Fish and Wildlife Service, July 8, 2002.

Doug Walker, Park Warden, Riding Mountain National Park, Parks Canada Agency, October 29, 2002.

Ron Walker, Resource Program Manager, Custer State Park, June 13, 2003. (BSG Member)

Rick Wallen, Wildlife Biologist, Yellowstone National Park, US National Park Service, September 3, 2002

Rob Watt, Senior Park Warden, Waterton Lakes National Park, Parks Canada Agency, September 9, 2002.

Greg Wilson, Post-doctoral Fellow, Department of Medical Genetics, University of Alberta, February 11, 2002. (BSG Member)

David Wiseman, Refuge Manager, National Bison Range, US Fish and Wildlife Service, November 15, 2002

Appendix 3: Contact Information for Members of the Bison Specialist Group (North America)

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Appendix 4: Bison Specialist Group Briefing Notes

BRIEFING NOTE
IUCN/SSC Bison Specialist Group - North America

October 10, 2001

Membership changes

Joel Berger of University of Nevada has decided to step down from the BSG. The BSG welcomes new members Glenn Plumb of the US National Park Service operating out of Yellowstone National Park, and Joe Templeton of Texas A&M University. Cormack Gates (BSG Co-chair) will be formalizing the IUCN appointment with these individuals shortly. Please refer to the revised membership list sent with this briefing note for contact information and other details.

Recent Meeting

At the recent conference of The Wildlife Society in Reno, Nevada (Sept 25-29, 2001) several members of the BSG met, including James Derr, Pete Gogan, Glenn Plumb, Joe Templeton, and Cormack Gates, to discuss status survey development with BSG Officer Delaney Boyd. They reviewed the process for survey development and the role of the BSG (as per the draft process flowchart and table of contents distributed to the BSG on June 18, 2001). Ms. Boyd suggested that the timeline for developing the survey should be one year (i.e. by next October). The BSG could then proceed with Action Plan development over the next year, allowing for completion of the North American Status Survey and Action Plan within two years.

Status Survey Collaboration Process

Through discussion, the group determined it would be most efficient for members to review the sections related to their respective specialties first and work with Delaney Boyd to produce draft sections of the survey that will then be forwarded to the rest of the BSG for comment.

Website

Delaney Boyd is currently creating a BSG website that will function both as an information point for the interested public, and as a dissemination vehicle for survey comments and drafts. The survey dissemination section of the website will have a login screen, and will only be accessible to BSG members. When new drafts are available for comment, Delaney Boyd will email the BSG, at which time members can log in to the site, download the sections, and provide comments through an on-line feedback form. Ms. Boyd will then post the comments for other BSG members to review.

Example Status Report

Some members indicated it would be helpful to view another IUCN/SSC status report for comparative purposes. For those interested, the African Rhino Action Plan is available on the web as a pdf file at http://www.rhinos-irf.org/specialists/AfRSG/AfRSG.html.

IUCN
The World Conservation Union

SPECIES SURVIVAL COMMISSION

BRIEFING NOTE
IUCN/SSC Bison Specialist Group - North America

February 26, 2002

Membership Changes
Welcome to Gerardo Ceballos of Instituto de Ecologia, UNAM in Mexico. Cormack Gates (BSG Co-chair) has formalized the IUCN appointment with Dr. Ceballos. Please refer to the revised membership list sent with this briefing note for contact information and other details.

Website
The BSG website is now posted at www.notitia.com/bison. It is a work in progress, so please email Delaney Boyd (dpboyd@ucalgary.ca) with suggestions. Very shortly, each BSG member will receive via email a unique User ID and password for accessing the Member Forum. The Member Forum is the primary mechanism for facilitating collaboration on the Bison Status Survey project. The website is also a forum for BSG members to share information related to bison with other members and the general public. BSG members are encouraged to submit material for the site such as photos, documents for the virtual library, suggested links, or descriptions of bison conservation research and initiatives.

Drafts
Delaney Boyd has commenced drafting of the status survey document. She will be contacting topic-specific experts on the BSG for initial comment on the drafts, and then posting the material on the website Status Survey page for open review by all BSG members and other collaborators. Ms. Boyd will send email notification to all members when new material is posted on the website.

Process for Determining Conservation Significance
Delaney Boyd is currently developing a decision support process for assessing the conservation significance of the public herds in North America. As part of the process, she will be asking the BSG members to assign rankings to criteria, which will be used to weight questionnaire responses received from public herd managers. Ultimately, this process will add a quantitative aspect to the survey to enhance the analysis of conservation priorities. Further information will be supplied as the process develops.

USA Research Trip
Delaney Boyd is currently planning a travel itinerary for visiting the major public herds in the USA (Lower 48). Information regarding this trip will be posted shortly under the Member Forum of the BSG website.

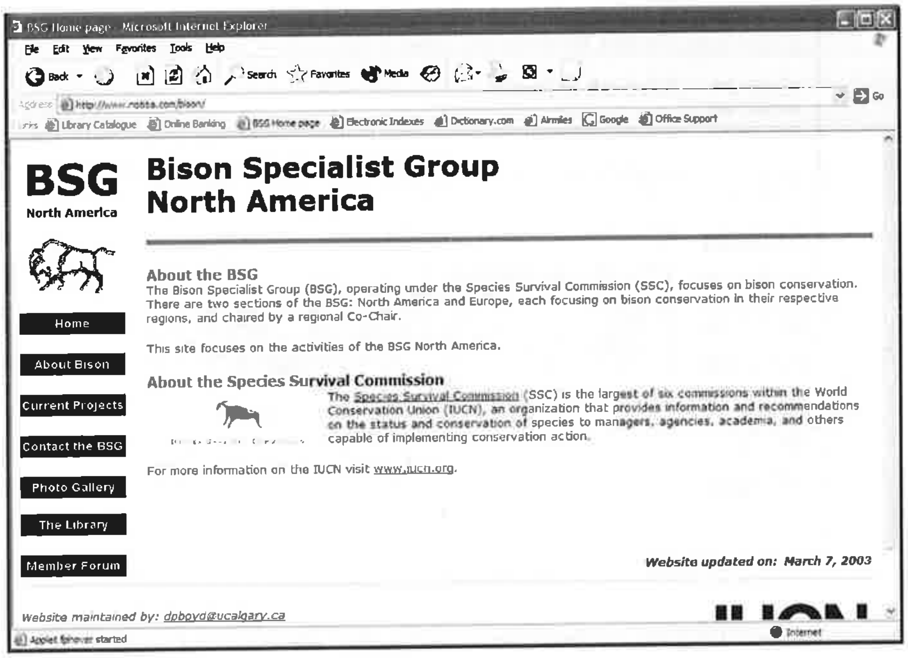
SSC Newsletter
Check out the latest issue of Species, the newsletter of the Species Survival Commission, for the latest BSG report (Species No. 36, July-December 2001).

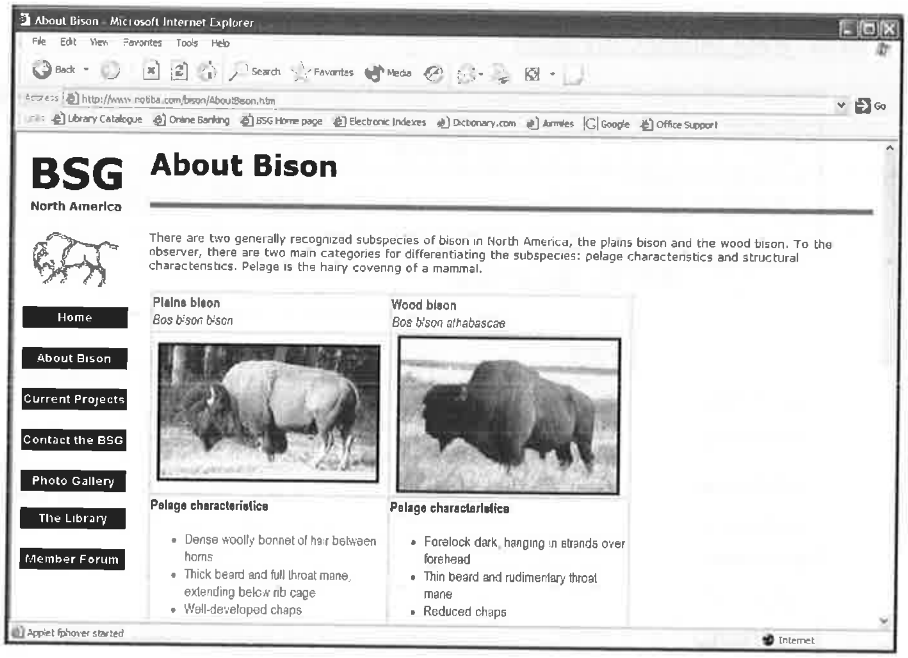
IUCN
The World Conservation Union

Species Survival Commission

Appendix 5: Bison Specialist Group Website Examples

Posted at: www.notitia.com/bison





About Bison - Microsoft Internet Explorer

http://www.notiba.com/bison/AboutBison.htm

BSG
North America

Home
About Bison
Current Projects
Contact the BSG
Photo Gallery
The Library
Member Forum

About Bison

There are two generally recognized subspecies of bison in North America, the plains bison and the wood bison. To the observer, there are two main categories for differentiating the subspecies: pelage characteristics and structural characteristics. Pelage is the hairy covering of a mammal.

Plains bison
Bos bison bison

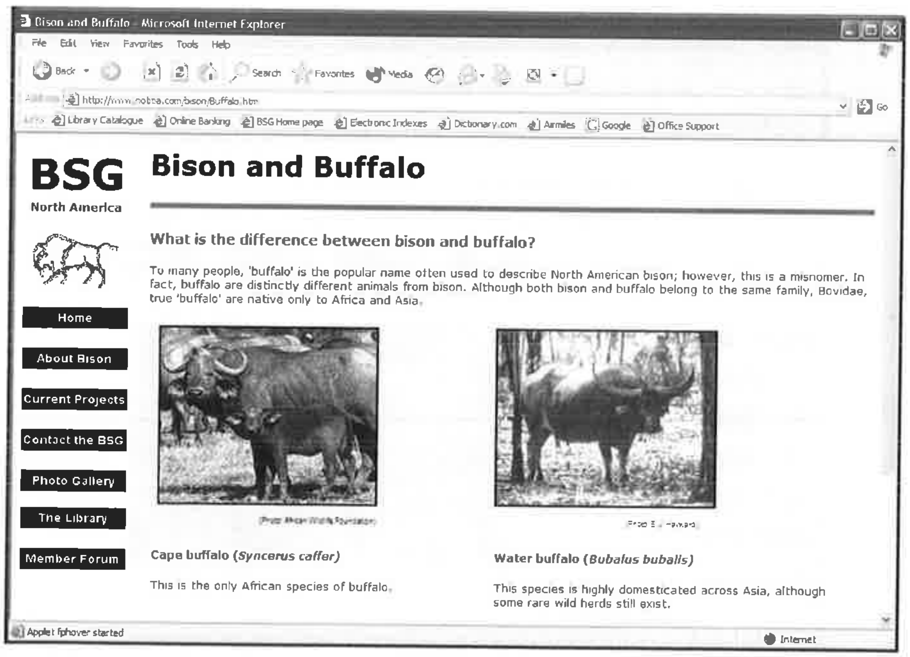
Pelage characteristics

- Dense woolly bonnet of hair between horns
- Thick beard and full throat mane, extending below rib cage
- Well-developed chaps

Wood bison
Bos bison athabascae

Pelage characteristics

- Forelock dark, hanging in strands over forehead
- Thin beard and rudimentary throat mane
- Reduced chaps



Bison and Buffalo - Microsoft Internet Explorer

http://www.notiba.com/bison/Buffalo.htm

BSG
North America

Home
About Bison
Current Projects
Contact the BSG
Photo Gallery
The Library
Member Forum

Bison and Buffalo

What is the difference between bison and buffalo?

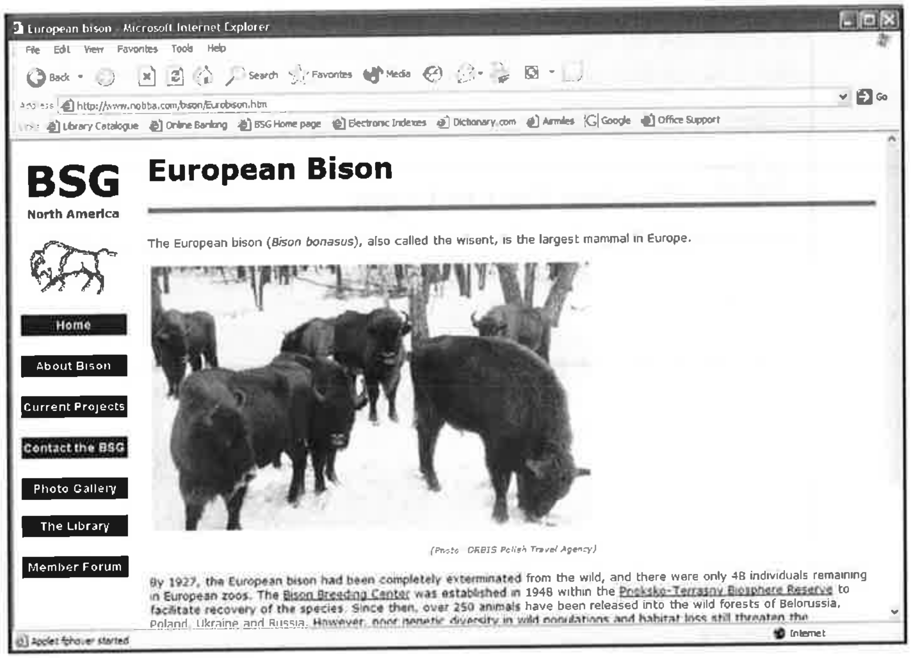
To many people, 'buffalo' is the popular name often used to describe North American bison; however, this is a misnomer. In fact, buffalo are distinctly different animals from bison. Although both bison and buffalo belong to the same family, Bovidae, true 'buffalo' are native only to Africa and Asia.

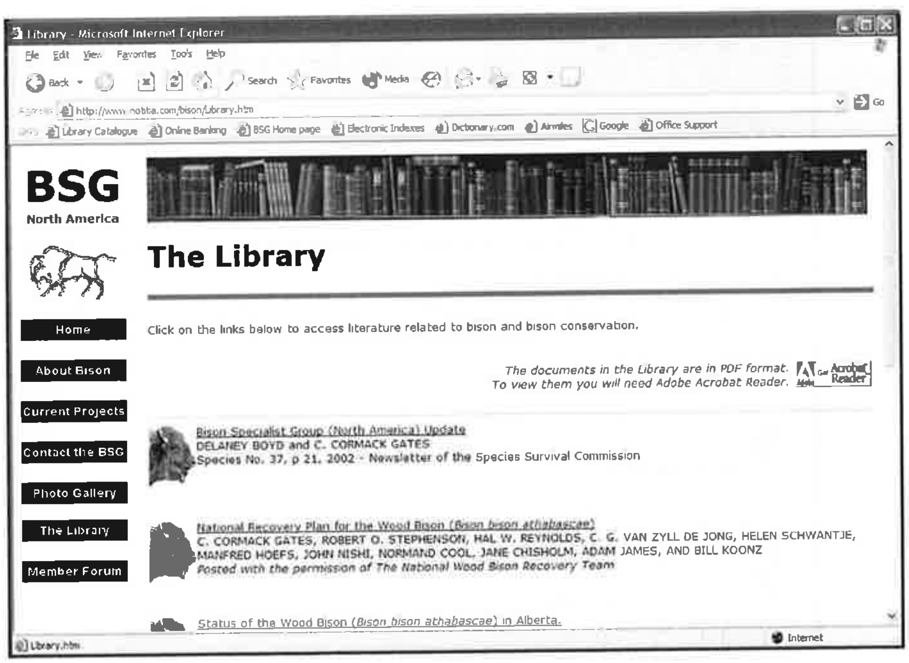
Cape buffalo (*Syncerus caffer*)

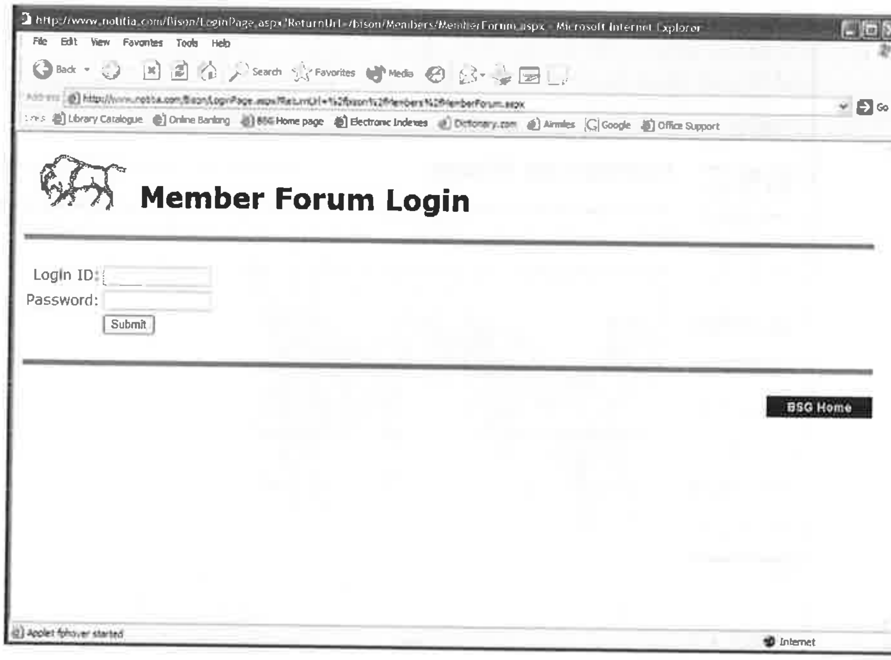
This is the only African species of buffalo.

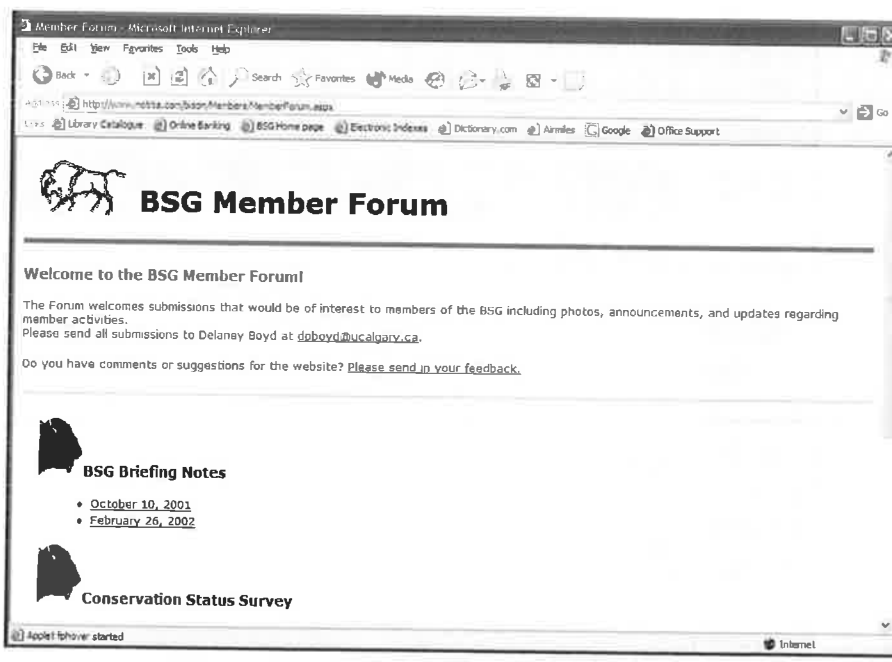
Water buffalo (*Bubalus bubalis*)

This species is highly domesticated across Asia, although some rare wild herds still exist.

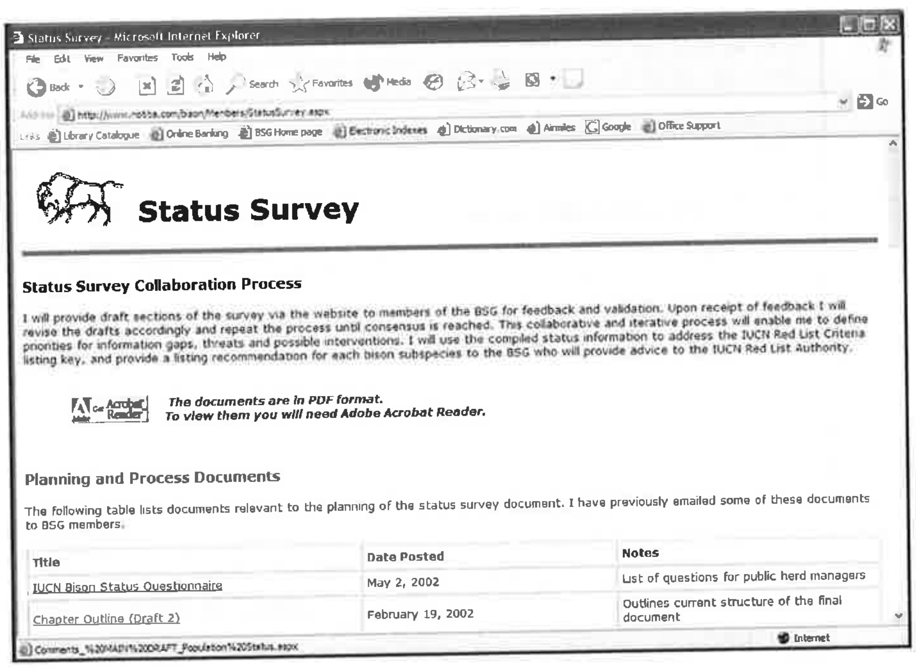

European bison - Microsoft Internet Explorer
File Edit View Favorites Tools Help
http://www.nobba.com/bison/Eurobison.htm
BSG
North America
Home
About Bison
Current Projects
Contact the BSG
Photo Gallery
The Library
Member Forum
European Bison
The European bison (Bison bonasus), also called the wisent, is the largest mammal in Europe.
(Photo ORBIS Polish Travel Agency)
By 1927, the European bison had been completely exterminated from the wild, and there were only 48 individuals remaining in European zoos. The Bison Breeding Center was established in 1948 within the Poleskie-Terrasny Biosphere Reserve to facilitate recovery of the species. Since then, over 250 animals have been released into the wild forests of Belorussia, Poland, Ukraine and Russia.
Internet

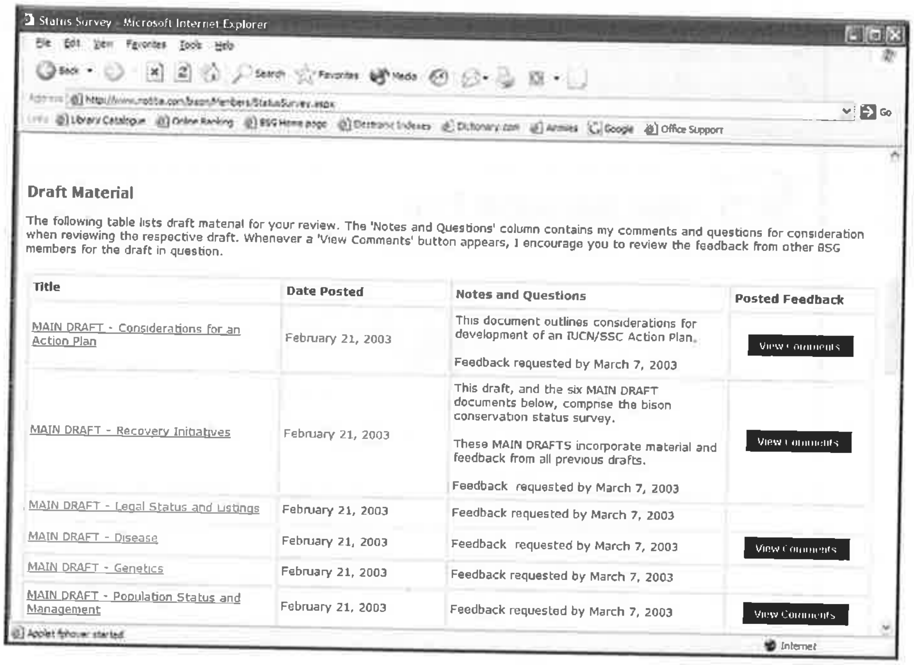

Library - Microsoft Internet Explorer
File Edit View Favorites Tools Help
http://www.nobba.com/bison/Library.htm
BSG
North America
Home
About Bison
Current Projects
Contact the BSG
Photo Gallery
The Library
Member Forum
The Library
Click on the links below to access literature related to bison and bison conservation.
The documents in the Library are in PDF format.
To view them you will need Adobe Acrobat Reader.
Bison Specialist Group (North America) Update
DELANEY BOYD and C. CORMACK GATES
Species No. 37, p 21, 2002 - Newsletter of the Species Survival Commission
National Recovery Plan for the Wood Bison (Bison bison athabascae)
C. CORMACK GATES, ROBERT O. STEPHENSON, HAL W. REYNOLDS, C. G. VAN ZYLL DE JONG, HELEN SCHWANTJE, MANFRED HOEFS, JOHN NISHI, NORMAND COOL, JANE CHISHOLM, ADAM JAMES, AND BILL KOONZ
Posted with the permission of The National Wood Bison Recovery Team
Status of the Wood Bison (Bison bison athabascae) in Alberta.
Internet


Member Forum Login
Login ID:
Password:
Submit
BSG Home


Member Forum - Microsoft Internet Explorer
BSG Member Forum
Welcome to the BSG Member Forum!
The Forum welcomes submissions that would be of interest to members of the BSG including photos, announcements, and updates regarding member activities.
Please send all submissions to Delaney Boyd at dpboyd@ucalgary.ca.
Do you have comments or suggestions for the website? Please send in your feedback.
BSG Briefing Notes
October 10, 2001
February 26, 2002
Conservation Status Survey


USA Research Trip - Microsoft Internet Explorer
USA Research Trip
Visit www.notitia.com/roadtrip for trip details and accounts of day-to-day activities!
BSG Home
Forum Home


Status Survey - Microsoft Internet Explorer
Status Survey
Status Survey Collaboration Process
I will provide draft sections of the survey via the website to members of the BSG for feedback and validation. Upon receipt of feedback I will revise the drafts accordingly and repeat the process until consensus is reached. This collaborative and iterative process will enable me to define priorities for information gaps, threats and possible interventions. I will use the compiled status information to address the IUCN Red List Criteria listing key, and provide a listing recommendation for each bison subspecies to the BSG who will provide advice to the IUCN Red List Authority.
The documents are in PDF format.
To view them you will need Adobe Acrobat Reader.
Planning and Process Documents
The following table lists documents relevant to the planning of the status survey document. I have previously emailed some of these documents to BSG members.
Title
Date Posted
Notes
IUCN Bison Status Questionnaire
May 2, 2002
List of questions for public herd managers
Chapter Outline (Draft 2)
February 19, 2002
Outlines current structure of the final document



Status Survey - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://www.notitia.com/bison/Members/StatusSurvey.aspx

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Draft Material

The following table lists draft material for your review. The 'Notes and Questions' column contains my comments and questions for consideration when reviewing the respective draft. Whenever a 'View Comments' button appears, I encourage you to review the feedback from other BSG members for the draft in question.

Title	Date Posted	Notes and Questions	Posted Feedback
MAIN DRAFT - Considerations for an Action Plan	February 21, 2003	This document outlines considerations for development of an IUCN/SSC Action Plan. Feedback requested by March 7, 2003	View Comments
MAIN DRAFT - Recovery Initiatives	February 21, 2003	This draft, and the six MAIN DRAFT documents below, comprise the bison conservation status survey. These MAIN DRAFTS incorporate material and feedback from all previous drafts. Feedback requested by March 7, 2003	View Comments
MAIN DRAFT - Legal Status and Listings	February 21, 2003	Feedback requested by March 7, 2003	
MAIN DRAFT - Disease	February 21, 2003	Feedback requested by March 7, 2003	View Comments
MAIN DRAFT - Genetics	February 21, 2003	Feedback requested by March 7, 2003	
MAIN DRAFT - Population Status and Management	February 21, 2003	Feedback requested by March 7, 2003	View Comments

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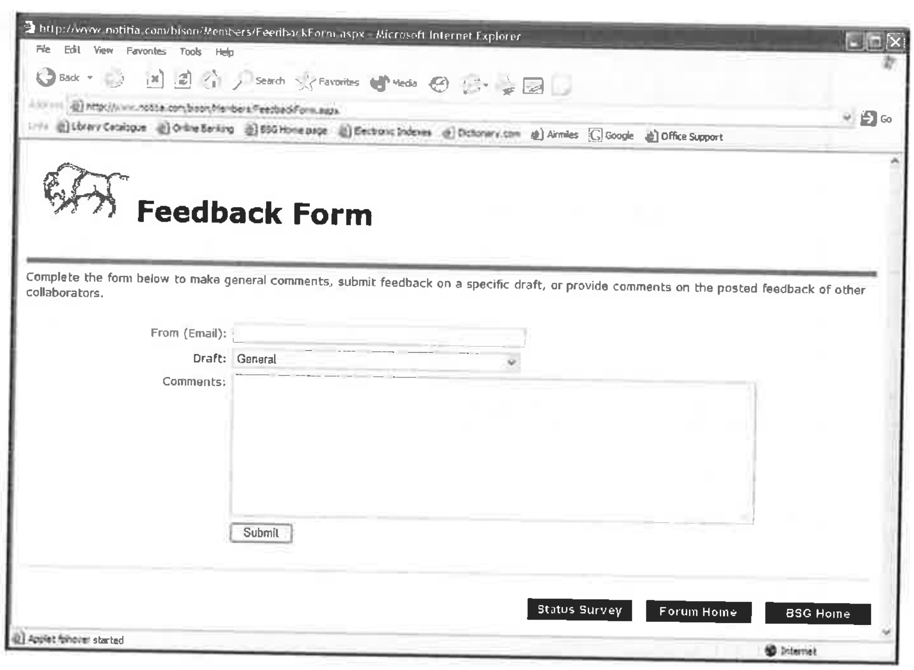

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Feedback Form

Complete the form below to make general comments, submit feedback on a specific draft, or provide comments on the posted feedback of other collaborators.

From (Email):

Draft: General

Comments:

Submit

Status Survey | Forum Home | BSG Home

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Appendix 6: Plains Bison Status Questionnaire

IUCN/SSC Bison Specialist Group
BISON STATUS QUESTIONNAIRE

Conducted by
Delaney Boyd,
Officer, Bison Specialist Group
Faculty of Environmental Design
University of Calgary
Calgary, Alberta T2N 1N4
CANADA
(403) 283-3642
dpboyd@ucalgary.ca
www.notitia.com/bison

IUCN
The World Conservation Union

SPECIES SURVIVAL COMMISSION

Name:

Organization:

Position:

Contact information Phone:

Email:

Name/Location of Herd:

Bison Subspecies: ☐ Plains ☐ Wood

GENERAL QUESTIONS

Who manages the herd?

Is there a bison management plan in place for the herd?
Is it available online or could it be mailed to me?

The following table contains questions relating to various status categories. As you type in the form fields, the table will expand to fit your text. Please feel free to attach documents that elaborate further on your responses.

Questions	Responses
Numerical Status	
What is the management objective for population size range (min and max)? Why this target range?	
What is the current population size of the herd?	
Is the current population trend increasing, decreasing, or stable? What is the management objective for population growth (increasing, decreasing, or stable)?	
Demographic Status	
What is the male-female ratio?	
What are the current numbers in the following age-sex classes?: Female: calves, yearlings, 2 yr olds, 3-13 yr olds, 13+ Male: calves, yearlings, 2-4 yr olds, 5-7 yr olds, 8+	(Please indicate if you are attaching a spreadsheet or other document with this information.)
Geographical Status	
Is the herd located within the original range of the subspecies?	
What do you know about the historical use of this area by bison? (e.g., seasonal range? Annual range?)	
Habitat Status : Range	
What is the current size of the herd's range?	

What is the maximum desirable stocking level of bison for your system to maintain long term range health?	
What is the potential to increase the size of the herd's range? If possible, by how much? If not, what are the barriers to range expansion?	
GENETIC STATUS: GENETIC DIVERSITY AND MANAGEMENT	
How many founders is the herd based upon?	
What is the origin of the herd's source stock?	
Is there a genetics management program or plan in place?	
Do you selectively breed within the herd for certain traits? If so, what are the criteria for selection? If not, why not?	
Do you accept bison from other locations for introduction to the herd? If so, where have the animals come from? (Please list all herds from where animals have been transferred.) What age and sex of animals?	
Has any DNA testing been conducted on the herd? If so, what type of testing?	
Are there cattle x bison hybrids in the herd? Is there known introgression of cattle DNA?	
Are there any indications of inbreeding depression in the herd?	

Are there any known genetic defects?	
Are there any known special genetic characteristics, such as rare alleles, present in the herd? If so, please describe them.	
ECOLOGICAL STATUS/LEVEL OF MANAGEMENT	
How is the habitat managed? Open range? Rotational/seasonal management? How is stock distributed throughout the range?	
Is the herd subject to any predation pressures? If so, what are the predators?	
Is the herd fenced? If so, Do you use perimeter fencing? Cross fencing?	
Do you cull the herd? If so, what are the criteria for which animals are culled? (i.e., how do you determine which sex and age classes and the number of animals in each class that are surplus?) How often do you cull? Which sex and age classes and how many in each class are culled?	
Do you provide supplemental feed? If so, when and how much? Winter? Year-round?	
Do you conduct round-ups? Seasonal? Annual?	
How do you dispose of surplus animals? Hunting? Live sales to commercial market?	

Do you provide bison from the herd for reintroductions to other locations? If so, where have animals been reintroduced?	
DISEASE STATUS	
Does the herd have any diseases? If so, which ones?	
Do you conduct disease testing? If so, how often?	
Do you conduct a test-and-slaughter program?	
Are vaccinations conducted on the herd? If so, what vaccinations are administered?	
Do you treat the herd for parasites? If so, what treatment do you use? How often do you administer treatment?	
LEGAL STATUS	
Under what legislation is the herd protected? (e.g., park, protected area, other?)	
How does the state classify bison – wildlife or livestock?	
What is the legal status of the property?	

SUMMARY QUESTIONS

What role do you feel this herd fulfills in the conservation of bison?

- Ecological maintenance of species and ecosystem
- Educational and historical display
- Source of genetic material, breeding stock
- Other?

Do you wish to offer any additional comments about the status of this herd?

Would you like to continue being part of the review process for North American bison conservation in the future?

Do you wish to receive a copy of the final report and analysis of this questionnaire?

If you have further questions or would like to discuss any of the topics in more detail, please do not hesitate to contact me.

Thank you. The information you have provided is valuable and very much appreciated.

Please return to Delaney Boyd at dpboyd@ucalgary.ca or mail to the address indicated at the beginning of the questionnaire.

Appendix 7: University of Calgary Research Ethics Certificate

UNIVERSITY OF CALGARY

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CERTIFICATION OF INSTITUTIONAL ETHICS REVIEW

This is to certify that the Conjoint Faculties Research Ethics Board at the University of Calgary has examined the following research proposal and found the proposed research involving human subjects to be in accordance with University of Calgary Guidelines and the Tri-Council Policy Statement on *Ethical Conduct in Research Using Human Subjects*:

Applicant(s): Delaney Boyd

Department/Faculty: Faculty of Environmental Design

Project Title: Conservation of North American Bison: Status and Recommendations

Sponsor (if applicable):

Restrictions:

This Certification is subject to the following conditions:

1. **Approval is granted only for the project and purposes described in the application.**
2. **Any modifications to the authorized protocol must be submitted to the Chair, Conjoint Faculties Research Ethics Board for approval**
3. **A progress report must be submitted 12 months from the date of this Certification, and should provide the expected completion date for the project.**
4. **Written notification must be sent to the Board when the project is complete or terminated**

Chair
Conjoint Faculties Research Ethics Board

Date: 12 April 2002

Distribution: (1) Applicant, (2) Supervisor (if applicable), (3) Chair, Department/Faculty Research Ethics Committee, (4) Sponsor, (5) Conjoint Faculties Research Ethics Board (6) Research Services

09/00

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Appendix 8: Letter of Consent

UNIVERSITY OF
CALGARY

Faculty of Environmental Design
INFORMED CONSENT AGREEMENT

Research Project Title: Conservation of North American Bison: Status and Recommendations

Investigator: Delaney Boyd

I am a Master's student in the Faculty of Environmental Design at the University of Calgary. I am carrying out a study to review the conservation status of bison in North American, and recommend interventions for enhancing bison conservation to the Bison Specialist Group operating under the IUCN Species Survival Commission (SSC), an organization that provides information and recommendations on the status and conservation of species to managers, agencies, academia, and others capable of implementing conservation action. This project will address four questions: (1) What is the status of both bison subspecies in North America?; (2) What are the threats to bison conservation?; (3) What opportunities exist to improve bison conservation status?; and (4) What measures should a bison conservation action plan include? This project will assemble and synthesize currently disjointed information on bison conservation, to form a succinct reference on the status of bison in North America. My management and listing recommendations based on the status survey information will assist the BSG in developing a conservation action plan.

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

I wish to interview you because of your professional knowledge as bison herd manager, or person otherwise experienced with bison conservation issues. I do not anticipate any risk to you in participating in this study. Your participation would involve an interview, which would require about 1 to 1-1/2 hours. Your participation is voluntary and you may withdraw from the study at any time, in which case your responses would not be used.

All responses to the interview questions will be considered public and may be cited in the Master's Degree Project report. Please let me know if there are any responses that you do not want to be cited.

During the study, I will keep all interview materials on my personal computer. After the study is finished, my supervisor will keep them for two years, as is required by our Faculty ethics guidelines. After that, the materials will be destroyed.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as an informant. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. If you have further questions concerning matters related to this research, please contact:

Investigator:	Delaney Boyd	283-3642	dpboyd@ucalgary.ca
Supervisor:	Dr. C. Cormack Gates	220-3027	ccgates@nucleus.com

If you have any questions or issues concerning this project that are not related to the specifics of the research, you may also contact the Research Services Office at 220-3782 and ask for Mrs. Patricia Evans.

----------------------------**Provide for Signatures as Required** -----------------------------------

____

Participant's Signature Date

____

Investigator and/or Delegate's Signature Date

____

Witness' Signature Date

A copy of this consent form has been given to you to keep for your records and reference.