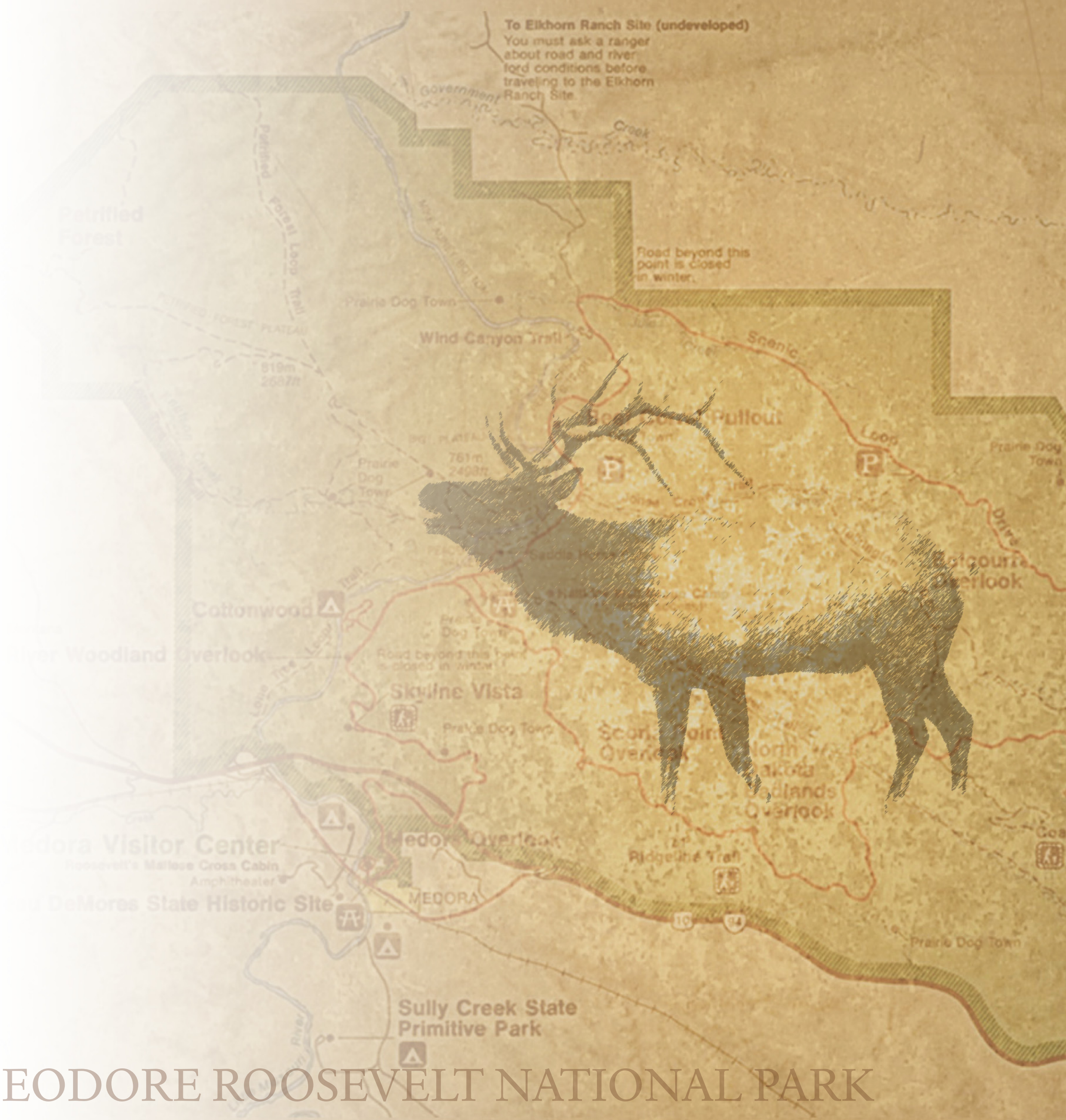
APPENDIX A



THEODORE ROOSEVELT NATIONAL PARK

APPENDIX A. CHRONOLOGY OF ELK MANAGEMENT AND MEMORANDUMS OF UNDERSTANDING

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CHRONOLOGY OF THE REINTRODUCTION AND MANAGEMENT OF THEODORE ROOSEVELT NATIONAL PARK'S ELK POPULATION

1843: John James Audubon reflecting on a trip down the Little Missouri writes: *"We saw 3 elk swimming across it and the number of this fine species of deer that are about us now is almost inconceivable."*

1888: Theodore Roosevelt writes about the decline of elk: *"This stately and splendid deer, the lordiest of its kind throughout the world, is now fast vanishing. In our own neighborhood it is already almost a thing of the past."*

Late 1800s: Elk extirpated from the Badlands (Byran and Maser 1982).

April 25, 1947: Theodore Roosevelt National Park established.

Dec. 20, 1982: Park officials at Wind Cave National Park study the effects of elk and bison grazing and trampling on park vegetation. Elk reduction is considered an option to try and preserve the prairie plant communities at Wind Cave National Park.

June 6, 1983: Theodore Roosevelt National Park Superintendent Harvey Wickware submits the idea of elk reintroduction to the North Dakota Game and Fish Department (NDGF).

August 1983: Park officials consider reintroducing elk into Theodore Roosevelt National Park in an effort to restore the historical Badlands ecosystem that Roosevelt and other visitors once wrote about.

August 16, 1983: First formal meeting between park and NDGF on possibility of elk reintroduction.

August 22, 1983: The elk reintroduction idea is presented to the United States Forest Service (USFS).

December 7, 1983: Superintendent met with Medora Grazing Association (MGA). MGA supported idea with some identified concerns.

October 11, 1983: The three involved agencies Theodore Roosevelt National Park, USFS, and NDGF meet informally to discuss the Elk reintroduction.

All three agree that a Memorandum of Understanding (MOU) should be written for this project to outline each agency's responsibilities.

January 6, 1984: Letter to NDGF formally inviting them to participate in the elk reintroduction process.

March 5, 1984: Acting Regional Director of the National Park Service (NPS) Rocky Mountain Region expresses his support for the elk reintroduction at Theodore Roosevelt National Park writing: *"Theodore Roosevelt already has a well-deserved reputation as a wildlife resource area. Your proposal to re-establish elk in the South Unit should add a major new segment to your resources management program."*

August 13, 1984: Theodore Roosevelt National Park's Elk Management Plan and Environmental Assessment (EA) for the elk reintroduction released for Public Comment.

August 22 - September 17, 1984: Letters received from public and agencies both in support and against the. MGA letter of September 10, 1984 supported plan if there was no substantial damage to private lands from elk and if the NDGF agreed to compensate for damage that did occur.

September 5, 1984: Public Hearing on the EA is held in Medora, North Dakota at MGA's monthly meeting.

September 10, 1984: Chief Ranger met with MGA representative and NDGF to discuss compensation issue.

September 13, 1984: Public Hearing on the EA is held at Dickinson State University in Dickinson, North Dakota.

September 26, 1984: NDGF responded with letter to MGA regarding the reference about compensation for damage.

October 31, 1984: USFS Decision Notice signed by forest Supervisor.

December 21, 1984: Plans confirmed by the Superintendent of Wind Cave National Park for a transfer of surplus elk to Theodore Roosevelt National Park.

January 8, 1985: At Wind Cave National Park, elk are driven from Boland Ridge to the handling facility 3.5 miles away. Eighty-seven elk are trapped and park officials implement the testing/quarantine requirements needed for transport to North Dakota.

January 9, 1985: The Finding of No Significant Impact (FONSI) for the reintroduction project was issued by Theodore Roosevelt National Park and approved by the Regional Director.

January 21, 1985: It is confirmed by the Rocky Mountain Regional Director of NPS, Lorraine Mintzmeyer, that the elk reintroduction project will have no significant impact on the human environment. Press release on FONSI and plans for elk reintroduction.

January 28, 1985: Memorandum of Understanding (MOU) signed between NDGF, USFS, and Theodore Roosevelt National Park.

March 13, 1985: Forty-seven elk (eight males, 39 females) from the January roundup at Wind Cave National Park are released into South Unit of Theodore Roosevelt National Park at 3 PM. By 11 PM a large group of elk are seen gathered near Buck Hill.

June 1985: Montana State University begins a study in Theodore Roosevelt National Park of elk behavior, habitat use, and food habits.

September 28, 1987: Contact is established with the Rocky Mountain Elk Foundation (RMEF) by requesting information on elk for the park library.

October 7, 1987: RMEF responds with a complementary subscription to *Bugle* magazine and information on how the park can ask for funding for other elk and resource management projects.

September 1988: Population census indicates 148 elk.

September 1989: Population census indicates 176 elk.
October 1989: Jerry Westfall of Montana State University finishes study "Elk Movements, Habitat Use and Population Dynamics in Theodore Roosevelt National Park."

September 24, 1990: Regional letter to NDGF stating reintroduction a success, noting depredation problems outside park and the development of a regional elk management plan by the NDGF.

November 15, 1991: The elk herd continues to grow and many leave the park to forage. Complaints from nearby residents of damage to property spark the question from North Dakota State Representative Kenneth Thompson, "Is the Park Service liable for these damages?"

December 30, 1991: North Dakota Attorney General Nicholas Spaeth replies to Representative Thompson stating that because the elk are outside the park they are under the proprietorship of the state yet still considered wild and the state is not liable for damage done by the elk. He supports this by offering a judgement from *Metier v. Cooper Transport Co., Inc*., 378 N.W.2nd 907 (Iowa 1985): *"To hold the state liable for all the conduct of its wild animals in every situation would pose intractable problems, and intolerable risks to the ultimate ability of the state to administer its trust. The heritage of wildlife beauty and splendor the state seeks to preserve for future generations might well be lost."* Liability for damages is averted, but elk reduction is considered.

March 16, 1992: North Governor George Skinner proposes that Theodore Roosevelt National Park donate their surplus elk to replace the herd of Mitchell Charles which, at the time, was the only herd in North Dakota quarantined for brucellosis contamination.

August 1992: Money for the water well and distribution system is approved at the National level for the new wildlife handling facility at Theodore Roosevelt National Park to be completed by 1993.

January 11 – May 13, 1993: First elk reduction in park with 90 day quarantine.

> **January 11, 1993:** Theodore Roosevelt National Park begins roundup with intentions of transferring the animals to two zoos, the Sully's Hill National Game Preserve in North Dakota, and the Cheyenne River and Pine Ridge Reservations in South Dakota. Pre-roundup census estimated at 400 elk. Captured 278: 44 died, 176 shipped, and 51 returned to park. Cost of roundup: approximately $48,800. Post-roundup census estimated between 110 and 160 (130).
>
> **January 29, 1993:** Returned 51 elk back to park after testing negative for tuberculosis and brucellosis.
>
> **February 20, 1993:** A major effort is put forth to get the herd of Mitchell Charles replaced by Theodore Roosevelt National Park elk. Because the park had already stated they could not directly transfer the elk to Mr. Charles, the North Dakota Board of Animal Health, North Dakota Department of Agriculture, NDGF, North Dakota Elk Growers, North Dakota Stockmen's Association, and the Standing Rock Sioux Tribe of North Dakota devised a plan for a number of elk to be transferred to the Standing Rock Sioux Tribe. These elk could then be given to Mr. Charles in exchange for the meat from the herd that was infected.
>
> **February 24, 1993:** Ten elk were shipped to the Dakota Zoo, two to the Chahinkapa Zoo, three to Sully's Hill Game Preserve, and eight to the Prairie State Park.

> **May 5, 1993:** After the 90 day quarantine, 169 elk were left (44 having died during the whole roundup process). Forty-seven elk were sent to the Standing Rock Sioux Tribe, 51 were shipped to the Cheyenne River Reservation, and 55 to the Pine Ridge Reservation.

October 10, 1993: "Forage Allocation Model for Four Ungulate Species" submitted by Montana State Univserity (Westfall et al. 1989). Elk population numbers set at approximately 360 to 400 using the model as a guide, and depending on numbers of bison and horses.

October 28, 1993: MOU renewed by three parties.

March 11, 1997: Helicopter census estimated at 226 plus**,** (42 bulls and 184 antlerless [cows and calves]).

March 11, 1997: MOU renewed by three parties.

July 28, 1997: NDGF meeting with ranchers on the upcoming August elk Depredation Hunt.

August 15-31, 1997: NDGF authorized the first hunting season for elk outside the park boundaries (a split season in one unit. The depredation hunt issued 36 sportsman permits and 17 landowner permits. Thirty-seven bulls were harvested.

February 11 & March 12, 1998: Two fixed-wing census efforts counted 160 and 120 elk, respectively. There was no snow on the ground for first flight. After a later snow, the second flight was flown. Census in fixed-wing aircraft did not appear to reflect true count.

February 18, 1998: NDGF meeting with ranchers concerning proposed 1998 depredation hunt.

July 10, 1998: RMEF approved park's request for funding a helicopter elk census in winter 1999.

August 1998: NDGF allows another short season for elk hunting outside the park. Forty sportsman and 18 land-owner licenses were issued for this elk unit. Three cows and 34 bulls harvested.

February 25, 1999: Fixed wind survey completed. Counted 273 elk (24 bulls, 237 cows and 12 calves) with 270 in park and 3 bulls outside the park.

March 1, 1999: Helicopter survey completed. Counted 417 elk (74 bulls, 257 cows and 86 calves) with 410 in park and 7 bulls outside the park. Both surveys funded by RMEF, Theodore Roosevelt National Park, NDGF, and USFS. Total cost was $15,185.

August 1999: NDGF establishes two hunting units. The first year there were 14 licenses issued in E3 (two landowner and 12 sportsman – all were "any elk" licenses). Season was from August 13 through August 29. Eight bulls were harvested. For unit E4, there were 58 licenses issued (18 landowner and 40 sportsman). Early season was August 13 through 19, and late was August 20 through 29. Twenty bulls and 16 cows were harvested.

Jan. 18-28, 2000: Second elk reduction in park. The 2000 Roundup lasted 11 days. Initial effort took four days (18^{th}-21^{st}) to process 297 elk (one small calf was not processed). Tuberculosis was checked in 203 elk (21^{st}-24^{th}). On the 25^{th}, 27^{th}, and 28^{th}, 198 elk were shipped: 144 to Kentucky, eight to Dakota Zoo, three to Roosevelt Zoo, three to Sully Hills, 40 to the Three Affiliated Tribes**.** A total of five deaths, four due to injury, and one from Johne's Disease. A total of 94 were released back into the park (50 with radio collars). Roundup was considered a success. Cost of roundup was approximately $40,000. Post roundup census was 200 elk.

2001-2003: NPS, RMEF and University of North Dakota (UND) formed a partnership to finance and implement a 3-year monitoring study (VHF collars) to track and monitor elk habitat and movements. UND dropped out of the project prior to its completion. The U.S. Geological Survey (USGS) Biological Resources Division Northern Prairie Wildlife Research Center also was funded to implement a companion study to research the population ecology of the park herd and develop a survey protocol.

July 2002: Due to concerns about chronic wasting disease (CWD) a memo was issued by the NPS Director restricting movement of cervids (including elk) to or from NPS units without a 99% confidence that the prevalence of CWD was less than 1%.

January 2003: Roundup scheduled to remove approximately 250 elk from South Unit of Theodore Roosevelt National Park (reduce population to approximately 200) is cancelled. The memo described above effectively resulted in this cancellation.

May 25 and 26, 2004: NPS conducts an interagency internal scoping meeting to discuss development of an elk management plan for Theodore Roosevelt National Park. Participants included the NPS, NDGF, USFS, and USGS.

November 29 through December 6, 2004: NPS holds five public scoping meetings for the plan/EIS in Dickinson, Minot, Fargo, Bismarck, and Medora North Dakota. The meetings started a public comment period that ended on December 31, 2004. Comments were solicited to identify potential environmental impacts, issues, concerns, and alternatives.

March through November 2005: The science team for the project was convened and conducted 12 meetings, including conference calls. Smaller working groups have since met informally, primarily through conference calls, to address specific issues as well.

August 17 and 18, 2005: NPS conducts an interagency alternatives development meeting to discuss recommendations of the project science team; describe details of the alternatives; and evaluate how well each alternative meetings project objectives. Participants included the NPS, NDGF, USFS, and USGS.

April 25, 2006: The science team reconvenes in Rapid City, South Dakota to address the direction of the monitoring plan to be incorporated into the elk management program for Theodore Roosevelt.

October 24 through 26, 2006: NPS and USGS staff participate in a roundtable meeting, primarily to review the latest science team recommendations and to further detail the alternatives to be described in the plan.

January 17, 2007: A small science team working group participates in a conference call to further discuss direction of the monitoring plan for the elk management program.

February 17, 2007: The NPS cancels public meetings scheduled for February 21 and 22 due to the withdrawal of the NDGF as a cooperating agency. The intent of the meetings was to allow interested members of the public an opportunity to help refine the draft alternatives being developed for elk management.

August 20 and 21, 2007: NPS hosts an alternatives development roundtable meeting to finalize details of the alternatives to be considered in the plan/EIS, as well as those dismissed from detailed analysis.

A44

FS AGREEMENT #03-MU-110118-033

AGREEMENT No. G1540030001

MEMORANDUM OF UNDERSTANDING
AMONG
NATIONAL PARK SERVICE, THEODORE ROOSEVELT NATIONAL PARK
NORTH DAKOTA GAME AND FISH DEPARTMENT
AND
USDA, FOREST SERVICE, DAKOTA PRAIRIE NATIONAL GRASSLANDS

I. PURPOSE

The purpose of this Memorandum of Understanding (MOU) is to facilitate a cooperative effort among the National Park Service, herein referred to as NPS; the North Dakota Game and Fish Department, herein referred to as NDGF; and the U.S. Forest Service, herein referred to as USFS, to manage elk in and around the South Unit of Theodore Roosevelt National Park (THRO). The successful re-establishment of elk to these areas has provided the basis for the development of elk management programs by the NDGF, the NPS, and the USFS. Concern about the spread of chronic wasting disease (CWD) prompted the Director of the NPS to mandate that NPS restrict translocating deer or elk from areas where CWD is known to occur, or where there is inadequate documentation to confirm absence of the disease (i.e., prevalence<1% with a 99% confidence interval). The NPS has inadequate documentation on the prevalence of CWD in elk in THRO, therefore, until the Director's mandate is rescinded, this requirement must be satisfied before any translocation of live elk from THRO can occur.

The authority for NPS, NDGF, and the USFS to enter into this agreement is contained in the following:

North Dakota Century Code 20.11-02-04 Subsection 7
16 U.S.C. Sections 1 and 3
36 C.F.R. Part 10
36 C.F.R. 241.2

II. STATEMENT OF MUTUAL BENEFITS AND INTERESTS

Elk (*Cervus elaphus)* were common in the North Dakota badlands in historical times, and were extirpated in the late 1800s. National Park Service natural resource management policies encourage the restoration of native wildlife species when there is adequate habitat and the species does not pose a threat to park visitors, park resources, persons or property outside park boundaries. The NDGF has responsibilities for conserving wildlife and for providing recreational opportunities to the public, and will endeavor to maximize responsible use of natural resources within their jurisdictions. The USFS has responsibilities and interests in the management and conservation of wildlife. The parties agree that public wildlife needs to be conserved and managed to meet growing public demand. It is mutually beneficial for all parties to agree as follows:

III. NDGF AGREES TO AND WILL, TO THE EXTENT RESOURCES PERMIT:

A. Manage all elk for any period of time they are not on lands controlled by NPS, as directed by the statutes of the State of North Dakota.

B. Provide, when practical, wildlife management expertise to assist the NPS in collecting data to assess habitat utilization and elk demographics.

C. Provide the NPS and the USFS with the written results of any data generated by radio telemetry, range utilization analysis, census and mortality investigations.

D. Provide, where possible, controlled public harvest of surplus elk outside of THRO.

E. Provide reasonable mitigation measures to alleviate damage if significant elk depredation and/or damage occurs on private lands adjacent to THRO.

IV. THE NPS AGREES TO AND WILL, TO THE EXTENT RESOURCES PERMIT:

A. Manage elk consistent with NPS policies within the boundaries of THRO.

B. Continue to monitor and evaluate vegetation within THRO.

C. Conduct an aerial census of elk in THRO once per year and provide results to NDGF and USFS.

D. Provide reports on elk research conducted on elk in THRO to NDGF and USFS.

E. Notify NDGF of all incidents of elk mortality in which the cause of death is not obvious. NPS and NDGF biologists will determine the need to collect blood, tissue and organ samples for analyses. Laboratory results will be made available to NDGF and the USFS.

F. Allow NDGF and USFS access to the elk and the range they occupy within THRO under regulations governing NPS use and protection.

G. Periodically reduce the herd when the numbers of elk exceed the limits of established THRO objectives.

H. Attempt through herd reduction and fence maintenance to limit the egress of elk from THRO.

I. Provide data from elk research and technical assistance to NDGF and USFS to identify, substantiate, and mitigate confirmed depredation by elk on private lands in areas adjacent to the South Unit of the park

J. Make surplus elk available to NDGF, other Federal agencies, Indian Tribes, and to other states for wildlife management purposes,. Reasonable efforts will be made to ensure that public elk are not transferred to private ownership. Elk translocated within the State of North

Dakota will be certified healthy only by criteria determined and agreed to by the NDGF, NPS, and the North Dakota Board of Animal Health.

V. USFS AGREES TO AND WILL, TO THE EXTENT RESOURCES PERMIT:

A. Strive to achieve and maintain the desired future condition of Grasslands as defined in the Grassland's Plan, while taking into consideration the ecosystem capabilities and natural variability of the area.

VI. NPS (LEAD AGENCY) AND NDGF (COOPERATING AGENCY) AGREE TO BEGIN NEPA COMPLIANCE IN A JOINT EFFORT TO ADDRESS FUTURE REDUCTIONS OF THE PARK HERD. USFS WILL BE A COMMENTING AGENCY.

VII. IT IS MUTUALLY AGREED AND UNDERSTOOD BY AND AMONG THE SAID PARTIES THAT:

A. It is mutually agreed that the details of cooperative work shall be planned and executed jointly by the NPS, NDGF, and the USFS. All three parties to this agreement will meet once annually for the purpose of evaluating the program, evaluating annual accomplishments, and planning future activities.

B. The principal contacts for this instrument are:

North Dakota Game and Fish Department
Randy Kreil, Chief of Wildlife
North Dakota Game and Fish Department
100 North Bismarck Expressway
Bismarck, ND 58501-5095
PH (701) 221-6305, FAX (701) 221-6352

National Park Service
Michael Oehler, Wildlife Biologist
Theodore Roosevelt National Park
PO Box 7
Medora, ND 58645
PH (701) 623-4730 ext. 3567, FAX (701) 623-4840

U.S. Forest Service
Dan Svingen, Grasslands Biologist
U.S. Forest Service
Dakota Prairie Grasslands
Bismarck, ND 58501
PH (701) 250-4443

Changes in coordinators shall be approved by written modification of the MOU.

C. A party to this MOU may terminate their involvement with 30 day written notice to the other parties.

D. This instrument in no way restricts the NPS, NDGF, or USFS from participating in similar activities with other public or private agencies, organizations, and individuals.

E. This instrument is executed as of the last date shown below and expires upon completion of NEPA compliance by NPS and NDGF, at which time it will be subject to review, renewal, or expiration.

F. This instrument is neither a fiscal nor a funds obligation document. Any endeavor involving reimbursement or contribution of funds between the parties to this instrument will be handled in accordance with applicable laws, regulations, and procedures including those for Government procurement and printing. Such endeavors will be outlined in separate agreements that shall be made in writing by representatives of the parties and shall be independently authorized by appropriate statutory authority. This instrument does not provide such authority. Specifically, this instrument does not establish authority for noncompetitive award to the cooperator of any contract or other agreement. Any contract or agreement for training or other services must fully comply with all applicable requirements or competition.

G. Modifications within the scope of this instrument shall be made by the issuance of multilaterally executed modification prior to any changes being performed.

IN WITNESS WHEREOF, The parties hereto have executed this MOU as of the last written date below.

North Dakota Game and Fish Department

By Dean Hildebrand   Date June 19. 03

Dean Hildebrand

Title: *Director*

National Park Service, Theodore Roosevelt National Park

By Valerie J. Naylor   Date July 2, 2003

Valerie Naylor

Title: *Superintendent*

USDA, Forest Service, Dakota Prairie Grasslands

By________________________ Date 6/27/03

DAVID M. PIEPER

Fay

Title: Grasslands Supervisor

United States Department of Agriculture | Forest Service | Dakota Prairie Grasslands | 240 W. Century Ave.
Bismarck, ND 58503

File Code: 1580
Date: June 25, 2003

Theodore Roosevelt National Park
Attn: Valerie Naylor, Superintendent
P.O. Box 7
Medora, ND 58645

Dear Ms. Naylor:

Enclosed you will find the Memorandum of Understanding between the National Park Service, North Dakota Game and Fish and USDA Forest Service regarding elk management programs in North Dakota.

I have signed this agreement, Dean Hildebrand, Commissioner of ND Game and Fish Department, has signed and I am forwarding it to you for your review and signature. If you concur with the agreement and sign, I would appreciate it if you would send a copy of the fully executed agreement to me for our records. I am enclosing a self-addressed envelope for your convenience in returning a copy to our office.

If you have any questions regarding this agreement that our office can help answer, please contact Dan Svingen at 701-250-4443.

Sincerely,

for DAVID M. PIEPER
Grasslands Supervisor

Enclosures

United States Department of the Interior

NATIONAL PARK SERVICE

Theodore Roosevelt National Park

Medora, North Dakota 58645

IN REPLY REFER TO:

A44

April 20, 2004

Dave Pieper
Grasslands Supervisor
U.S. Forest Service
Dakota Prairie Grasslands
240 W. Century Avenue
Bismarck, ND 58503

Dear Mr. Pieper:

As you know, the National Park Service is embarking on a major National Environmental Policy Act (NEPA) planning effort concerning the issue of elk population management in Theodore Roosevelt National Park. The North Dakota Game and Fish Department (NDGFD) is working with us as a Cooperating Agency on this effort.

Although the current Memorandum of Understanding among the National Park Service, U.S. Forest Service, and NDGFD for elk management in and around Theodore Roosevelt National Park states that the U.S. Forest Service will be a commenting agency, we invite the USFS to be a Cooperating Agency.

Council on Environmental Quality regulations state that "any other Federal agency which has special expertise with respect to any environmental issue... may be a cooperating agency upon request of the lead agency." Since the USFS has responsibilities and interests in the management and conservation of wildlife, and because much of the available elk habitat outside the park is on the Little Missouri National Grassland, it would be mutually beneficial to have the USFS participate as a Cooperating Agency. We invite you to do so.

Our internal scoping session for the NEPA effort is scheduled in Medora, North Dakota on May 25-26, 2004. In order to have a focused session, we would suggest that one or two USFS representatives attend. At the internal scoping meeting, we will further discuss roles and responsibilities of the agencies involved.

Please let us know as soon as possible in writing so that we will have an official document for the administrative record. In addition, please let us know who will be attending the internal scoping meeting from the USFS.

Thank you very much.

Sincerely,

Valerie J. Naylor

Valerie J. Naylor
Superintendent

United States Department of Agriculture | Forest Service | Dakota Prairie Grasslands | 240 W. Century Ave. Bismarck, ND 58503

File Code: 1950-4
Date: May 5, 2004

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MAY - 6 2004
Theodore Roosevelt National Park

Valerie J. Naylor, Superintendent
Theodore Roosevelt National Park
P. O. Box 7
Medora, ND 58645

Dear Valerie:

Thank you for the invitation for the Dakota Prairie Grasslands of the U.S. Forest Service to work with the National Park Service as a Cooperating Agency in the planning effort concerning the issue of elk management in Theodore Roosevelt National Park. I accept your offer and I am designating Arden Warm to serve as our representative in this National Environmental Policy Act process. Arden can be contacted at our Medora Ranger District Office in Dickinson, North Dakota. I have forwarded your letter with the initial internal scoping dates to Arden and will encourage his participation throughout the process.

Sincerely,

DAVID M. PIEPER
Grasslands Supervisor

cc: Arden Warm, Acting Medora District Ranger

APPENDIX B

THEODORE ROOSEVELT NATIONAL PARK

APPENDIX B. MONITORING METHODS FOR THE ELK POPULATION AND VEGETATION TRENDS

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MONITORING METHODS FOR THE ELK POPULATION AND VEGETATION TRENDS

Elk Population Monitoring Methods

Park staff would continue to conduct aerial surveys for the purposes of estimating the elk population in the South Unit of Theodore Roosevelt National Park. During the first few years after elk were reintroduced, most of the population gathered seasonally in a few easily observable groups (Sullivan 1988). Numbers could be estimated via ground-based counts. At present densities, however, elk remain distributed in many groups that cannot be observed simultaneously, if at all, and group membership is presumably fluid (c.f., Eberhardt et al. 1998). As a result, efforts to count elk during the past decade have probably overlooked many groups and may have counted some elk more than once. Without methods for adjusting counts for these sources of bias, defensible estimates of population size cannot be obtained.

Undercounting of elk is often addressed through the use sightability curves (Samuel et al. 1987, Anderson et al. 1998, Cogan and Diefenbach 1998, Eberhardt et al. 1998) and mark-resight models (Eberhardt et al. 1998). Sightability curves predict probabilities of observing groups of elk, conditional on independent variables that may include, for example, group size, canopy closure, or snow cover. Observed numbers of groups are then divided by probabilities of observation to estimate total numbers of groups present during surveys. Mark-resight models assume marked and unmarked groups are equally likely to be seen during surveys; hence, the total number of elk groups can be estimated by dividing the number of groups seen by the proportion of marked groups seen. Multiplying the total number of marked groups by the mean group size produces an estimate of total population size.

Different landscapes and different types of aircraft require different sightability curves, and most existing curves have been developed for low-altitude helicopter surveys (Anderson et al. 1998). Unfortunately, helicopter surveys are not practical at Theodore Roosevelt National Park because only fixed-wing aircraft are reliably available from area vendors approved by the U.S. Department of Interior Aircraft Management Directorate. Moreover, most vendors of fixed-wing flight services are not certified for low-level flight (less than 500 feet above ground level). This has necessitated the development of correction factors specific to Theodore Roosevelt National Park. In the past, park staff are correcting for group size only, using correction factors derived from a pilot study conducted in 2001. During this study, staff used 66 sighting trials with marked groups of elk to estimate detection rates, conditional on group size (Sargeant and Oehler 2007). Therefore, elk counted during the survey are considered a minimum population, and each group observed is corrected based on its size (sightability for that size group during calibration trials).

Methodologies used in the past would continue to be employed. The logistical constraints described above would limit data collection for elk population monitoring to high altitude surveys (greater than 500 feet above ground level) conducted with a Cessna 172. The park would establish a series of east-west aerial survey transects spaced at 200 meter intervals across the entire South Unit. Over the course of approximately three days, the aircraft would traverse each transect in both directions (from east to west, and from west to east) traveling between 80 and100 miles per hour at 500 feet above ground level. Surveys are only flown when wind speeds are less than 25 miles per hour, and when conditions meet visual flight rules. By combining a dense search pattern with straight, level flight at relatively high altitude, the park would achieve satisfactory detection rates and uniform coverage of the park without compromising the safety of survey crews.

The survey crew would consist of a pilot and a single observer in the right front seat. A global positioning system unit connected to a laptop computer with geographic information system software would be used to monitor the location of the aircraft relative to transect lines during flights. Elk sightings would only be recorded by the observer, to allow the pilot to concentrate on flying and to monitor the computer navigation system used to keep the aircraft on course. This minimizes the number of personnel at risk during surveys.

Based on location data from 137 marked elk recorded since 2001, the majority of collared elk are within the boundaries of the South Unit between December and March. Therefore, elk surveys would be flown between February and March when elk are in the park, and ground conditions are conducive to observing elk from an aircraft (i.e., when trees have no leaves and there is snow cover).

Monitoring Methods for Vegetation Trends

As described in Chapter 2 "Alternatives," it is the park's intent to reestablish and maintain elk use areas in the South Unit to reflect lightly-grazed conditions through elk management, as it had under previous strategies. In order to do so, vegetation would be monitored to determine the current ecological condition (seral stage) and trend, indicating the direction of change. In general, a plant community in a later seral stage would be reflective of a lightly grazed system, while communities in early seral stage would be reflective of heavier use.

The Needle-and-thread – Threadleaf Sedge Herbaceous (STCO-CAFI) plant association, as classified and mapped as part of the NPS-USGS Vegetation Mapping Program, would be monitored in elk use areas to determine the current seral stage. Principal diagnostic species that would be monitored in this association would be needle-and-thread, western wheatgrass, and blue grama.

The general technique for determining the current seral stage would be as follows:

1. Two parallel, permanent 30 meter transects would be established approximately 20 meters apart in an area of at least 800 square meters. The location of the transects would be stratified according to elk location data (heavy, moderate, light, and no use). Specific site selection within each level of use would be conducted randomly.

2. Canopy cover would be recorded using six cover classes for the three major indicators species within a 20 by 50 centimeter quadrat placed at 1 meter intervals along each transect. Cover classes would also be assigned to litter, bare ground, and non-native plants.

3. The midpoint of each cover class would be used to calculate average foliar cover for the three species for each transect. Average cover and percent frequency for each transect would be multiplied, then averaged for the two transects to produce an index value. The index value will be located within seral stage probability tables for that association to determine seral stage (see example figure below).

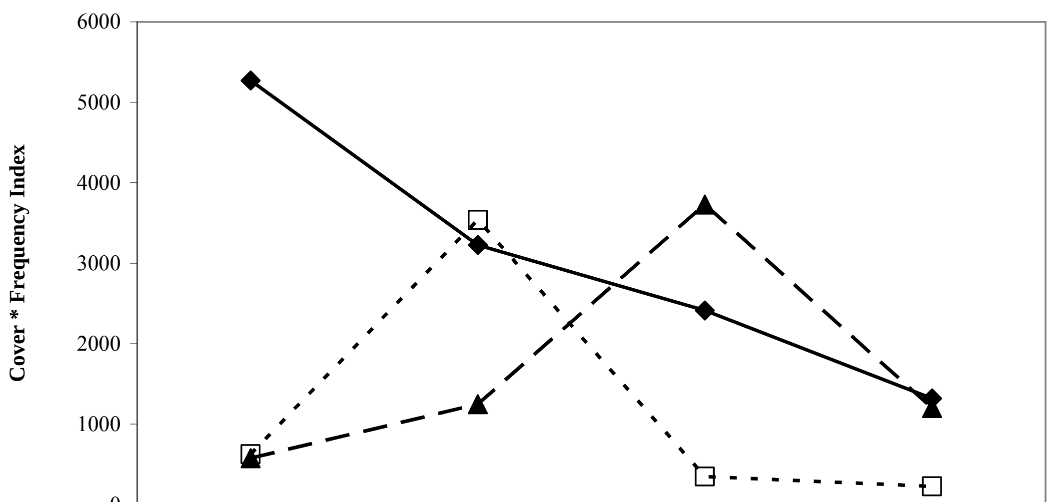
4. Similarity indices using average percent foliar cover would be calculated for each level of use, and compared to historic (pre-1985) data when appropriate.

Shifts in the relative contribution of increaser/decreaser species within the association can be used in an assessment of grazing pressure of a particular site. For example, as shown in the figure on the following page, an early seral stage (heavily grazed system) is characterized by a relatively index value for western wheatgrass when compared to the slightly higher, and relatively equal, index values for needle-and-thread and blue grama. In contrast, a late seral stage (lightly grazed system) in this plant community is characterized by a much higher index value for needle-and-thread when compared to the lower, and relatively equal, index values for western wheatgrass and blue grama.

After current seral stage has been characterized, these species would be monitored for 10 years in the transects placed in areas of high and moderate elk use, and index values would be compared to data from areas of low and no elk use. In order to determine if the reduction in elk is leading toward a condition that reflects a lightly-grazed system (later seral stage), these data would be coupled with information collected on the amount of bare ground and litter present; evidence of over-utilization of key plant species (plant vigor, hedging, browse lines, substantial use of low-preference plants, etc.); and the contribution of non-native plants, especially invasive species. A successful trend would be represented by shifts in the STCO/CAFI association in the high and moderate elk use areas (presumed to be in earlier seral stages) towards the conditions present in the areas of low and no elk use. Exclosures (small areas fenced to keep elk out) could also be used to monitor vegetation in areas of no elk use that would help interpret data.

General Seral Stage Classification Model

Needle-and-Thread Ecological Site



	Late	Late Intermediate	Early Intermediate	Early
Needle and Thread	5271	3226	2413	1319
Western Wheatgrass	626	3538	347	225
Blue Grama	577	1249	3730	1200

Seral Stage

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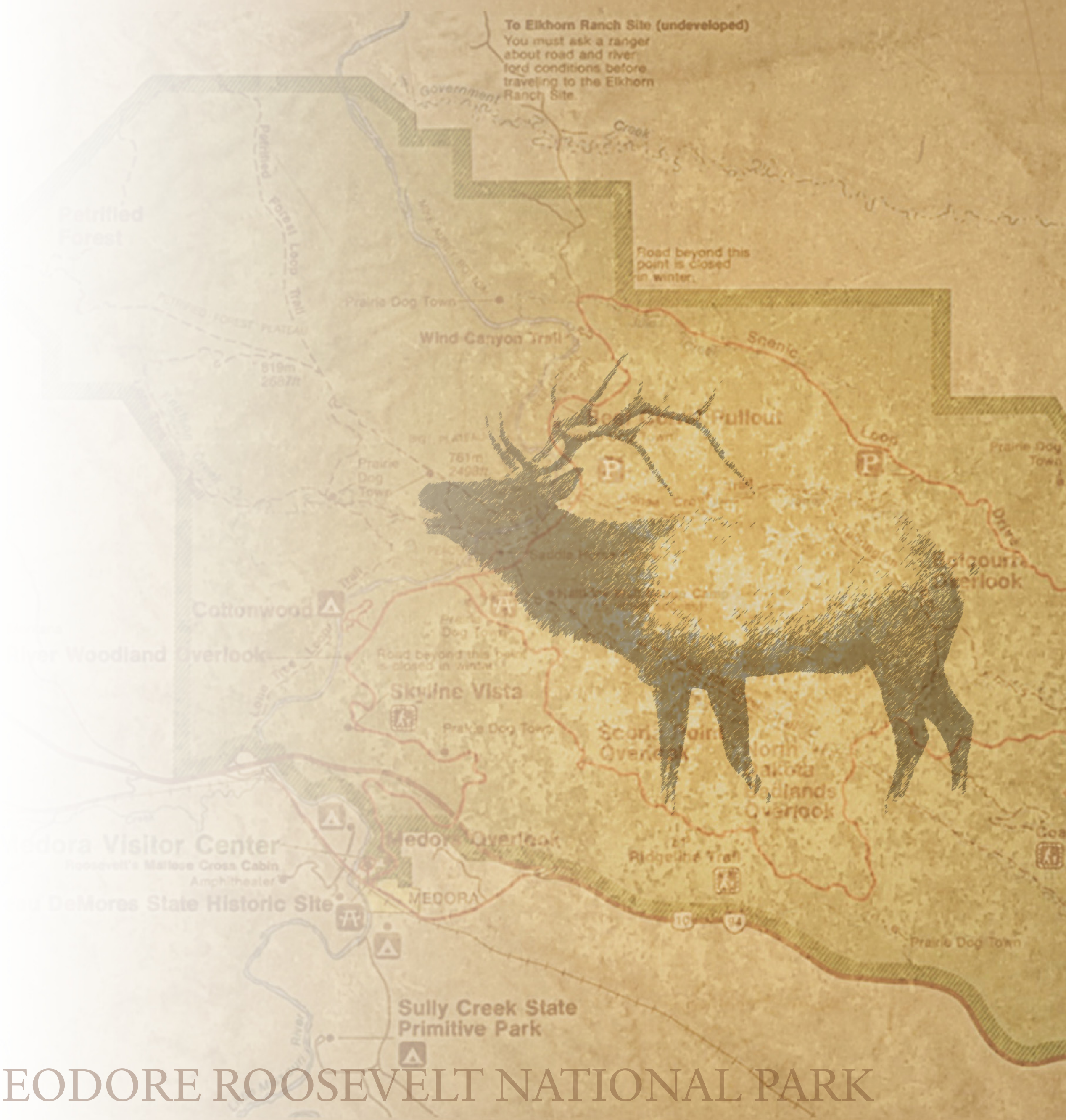
APPENDIX C



THEODORE ROOSEVELT NATIONAL PARK

APPENDIX C. CHRONIC WASTING DISEASE

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CHRONIC WASTING DISEASE

This appendix summarizes guidance provided by the National Park Service (NPS) in response to chronic wasting disease, and it outlines management options available to parks for implementation in the absence of a specific Chronic Wasting Disease (CWD) plan.

As of August 2007, chronic wasting disease has been diagnosed in two national parks — Rocky Mountain and Wind Cave. Several national park system units are at high risk because of their proximity to areas where CWD has been diagnosed in either captive or free-ranging cervids. In addition, there is a high likelihood that the disease would be detected in other areas of the country following spread of the disease and increases in surveillance for the disease. Therefore, chronic wasting disease has become an issue of national importance to wildlife managers and other interested public entities, as well as NPS managers.

NPS Policy and Guidance

Director's CWD Guidance Memorandum (July 26, 2002)

The NPS director provided guidance to regions and parks on the NPS response to chronic wasting disease in a memorandum dated July 26, 2002. Even though the memo pre-dates current CWD distribution in the national park system, the guidance remains pertinent. The guidance addresses surveillance, management, and communication regarding the disease. It also strictly limits the translocation of deer and elk into or out of national park system units. Like any policy, deviation from the guidance memo would require a waiver approved by the director.

A National Park Service Manager's Reference Notebook to Understanding Chronic Wasting Disease (Version 4: July, 2007)

This notebook serves as an informational reference that summarizes some of the most pertinent CWD literature, management options, and policies as they pertain to units of the national park system. It is not meant to be an all-inclusive review of current literature or management options. Chronic wasting disease is an emerging disease, and the knowledge base is continuing to expand. This document is updated as necessary to include information pertinent to the National Park Service.

Elk and Deer Meat from Areas Affected by Chronic Wasting Disease: A Guide to Donation for Human Consumption (June, 2006)

This document provides an overview of the issues surrounding chronic wasting disease as it relates to public health, and includes NPS recommendations for the use of cervid meat for human consumption.

Description and Distribution

Chronic wasting disease is a slowly progressive, infectious, self propagating, neurological disease of captive and free-ranging mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), Rocky Mountain elk (*Cervus elaphus nelsoni*), and moose (*Alces alces*). The disease belongs to the transmissible spongiform encephalopathy (TSE) group of diseases (similar to scrapie and bovine spongiform encephalopathy).

Chronic wasting disease is the only TSE currently found in free-ranging animals. TSEs are characterized by accumulations of abnormal prion (proteinaceous infectious particle) proteins in neural and lymphoid tissues (Prusiner 1982, 1991, 1997).

There is evidence that human-associated movement of cervids has aided in the spread of the disease in captive, and likely free-ranging, deer and elk (Miller and Williams 2003; Salman 2003; Williams and

Miller 2003). Localized artificial concentration of cervids in areas with few natural predators likely aids in disease transmission (Spraker et al. 1997; Samuel et al. 2003; Farnsworth et al. 2005). There is strong evidence to suggest that anthropogenic factors, such as land use, influence CWD prevalence (Farnsworth et al. 2005). Therefore, human influences are likely a substantial component of observed CWD distribution and prevalence.

As of August 2007, chronic wasting disease had been found in captive/farmed cervids in 10 states and 2 Canadian provinces and in free-ranging cervids in 11 states and 2 provinces. The historic area of CWD infection encompasses northeastern Colorado, southeastern Wyoming, and the southwest corner of the Nebraska panhandle (Williams and Miller 2002; Williams et al. 2002). However, with increased surveillance that has occurred since 2001, the disease has been found with increasing frequency in other geographically distinct areas (Joly et al. 2003).

Clinical Signs

The primary clinical signs of chronic wasting disease in deer and elk are changes in behavior and body condition (Williams et al. 2002). Signs of the disease are progressive. Initially only someone who is quite familiar with a particular animal or group of animals would notice a change in behavior. As the clinical disease progresses over the course of weeks to months, animals demonstrate increasingly abnormal behavior and additional clinical signs (Williams and Young 1992). Affected animals can lose their fear of humans, show repetitive movements, and/or appear depressed but quickly become alert if startled. Affected animals rapidly lose body condition, despite having an appetite (Williams et al. 2002b). In the end stages of the disease they become emaciated. Once an animal demonstrates clinical signs the disease is invariably fatal. There is no treatment or preventative vaccine for the disease.

Diagnosis and Testing

Chronic wasting disease was initially diagnosed in deer and elk by testing a portion of the brain (histopathology techniques) (Williams and Young 1993). While this method is effective at diagnosing relatively advanced cases, it is not sensitive enough to detect early disease stages (Spraker et al. 1997; Peters et al. 2000). In contrast, immunohistochemistry (IHC) is a sensitive, specific, and reliable test that can be used to identify relatively early stages of chronic wasting disease. This technique can detect CWD prions in many tissues (brain, retropharyngeal lymph nodes, tonsils, rectal lymphoid tissue, etc.) (O'Rourke et al. 1998, Spraker et al. 2006).

In addition to immunohistochemistry, which takes several days to complete, new rapid tests also employ antibody technology to diagnose chronic wasting disease. Each has various advantages and disadvantages. Only certified laboratories can perform immunohistochemistry or the rapid CWD tests. No available test is 100% sensitive for chronic wasting disease, which means that a negative test result is not a guarantee of a disease-free animal.

Transmission

There is strong evidence that chronic wasting disease is infectious and is spread by direct lateral (animal to animal) or indirect (environment to animal) transmission (Miller et al. 2000; Miller and Williams 2003). Bodily secretions such as feces, urine, and saliva have all been suggested as possible means of transmitting the disease between animals and disseminating infectious prions into the environment (Williams et al. 2002b; Williams and Miller 2003). It has recently been demonstrated in captive laboratory animals that blood and saliva from infected deer can transmit the disease to naïve deer (Mathiason et al. 2006). Maternal transmission cannot be ruled out, but it does not play a large role in continuing the disease cycle in either deer or elk (Miller et al. 1998; Miller et al. 2000; Miller and Williams 2003; Miller and Wild 2004, Miller et al. 2006).

Like other infectious, contagious diseases, CWD transmission increases when animals are concentrated. High animal densities and environmental contamination are important factors in transmission among captive cervids. These factors may also play a role in transmission in free-ranging animals (Miller et al. 2004, Joly et al. 2006, Miller et al. 2006).

Management actions that increase mortality rates in diseased populations may retard disease transmission and reduce prevalence. Increasing mortality slows transmission by two mechanisms:

1. It reduces the average lifetime of infected individuals. Reduced lifespan, in turn, can compress the period of time when animals are infectious, thereby reducing the number of infections produced per infected individual.
2. The effect of reduced intervals of infectivity is amplified by reductions in population density.

Both of these mechanisms may decrease disease transmission. If these mechanisms cause the number of new infections produced per infected individual to fall below one, then the disease would be eliminated from the population (Tompkins et al. 2002).

Disposal of CWD Infected Organic Material

Discarding known or suspect CWD-contaminated organic material, such as whole or partial carcasses, is likely to become an important issue for national park system units in the future. Each state, Environmental Protection Agency region, and refuse disposal area is likely to have different regulations and restrictions for disposal of potentially infected tissues. Currently there is no national standard for disposal. Because infected carcasses serve as a source of environmental contamination (Miller et al. 2004), and once prions bind to soil components their infectivity may be increased (Johnson et al. 2007), it is recommended that known and suspect CWD-positive animals be removed from the environment.

Given the type of infectious agent (prions), there are limited means of effective disposal. In most cases, however, off-site disposal of infected material is recommended in approved locations. The available options for each park would vary and would depend on the facilities present within a reasonable distance from the park. Disposal of animals that are confirmed to be infected should be disposed of in one of the following ways:

- *Alkaline Digestion or Incineration* — Alkaline digestion is a common disposal method used by veterinary diagnostic laboratories. This method uses sodium hydroxide or potassium hydroxide to catalyze the hydrolysis of biological material (protein, nucleic acids, carbohydrates, lipids, etc.) into an aqueous solution consisting of small peptides, amino acids, sugars, and soaps. Incineration is another disposal method used by veterinary diagnostic laboratories. This method burns the carcass at intense temperatures. Alkaline digestion and incineration are two of the most effective ways of destroying contaminated organic material. These are usually available at veterinary diagnostic laboratories or universities. Arrangements can often be made with laboratories to test and then dispose of animals.
- *Landfill* — The availability of this option varies by region, state, and local regulations. Therefore, local landfills must be contacted for more information regarding carcass disposal, to determine if they would accept CWD positive or negative carcasses or parts.

Management

Chronic wasting disease has occurred in a limited geographic area of northeastern Colorado and southeastern Wyoming for over 20 years. More recently, it has been detected in captive and free-ranging deer and elk in several relatively new locations, including Nebraska, South Dakota, New Mexico, Utah, new areas of Wyoming and Colorado, and east of the Mississippi River in Wisconsin, Illinois, West Virginia, and New York.

The National Park Service does not currently have a single plan to manage chronic wasting disease in all parks. However, it has provided guidance to parks in how to monitor for and minimize the potential spread of the disease, as well as remove infected animals from specific areas. Generally, two levels of action have been identified, based on risk of transmission: (1) when chronic wasting disease is not known to occur within a 60-mile radius from the park; and (2) when the disease is known to occur within the park or within a 60-mile radius.

The chance of finding chronic wasting disease in a park is related to two factors: the risk of being exposed to the disease (the likelihood that the disease would be introduced into a given population), and the risk of the disease being amplified once a population of animals has been exposed. The first risk is important for national park system units where no CWD cases have been identified within 60 miles of their border. The second risk applies to units where chronic wasting disease is close to or within their borders, as well as in proactive planning efforts. By evaluating the risk of CWD exposure and amplification, managers can make better decisions regarding how to use their resources to identify the disease.

Actions available to identify chronic wasting disease are linked to the risk factors present in and around the park. When risk factors are moderate, surveillance for chronic wasting disease can be less intense (e.g., opportunistic) than when risk is high (NPS 2007). When the risk is higher, surveillance (e.g., opportunistic and targeted) should be increased. Other management actions that are in place for the host species may limit risk of exposure or transmission by maintaining appropriate population densities. Whether chronic wasting disease is within 60 miles of a unit or not, coordination with state wildlife and agriculture agencies on CWD activities is strongly encouraged.

Opportunistic Surveillance

Opportunistic surveillance involves taking diagnostic samples for testing from cervids found dead or harvested through a management activity within a unit of the national park system. Cause of death may be culling, predation, disease, trauma (hit by car), or undetermined. Opportunistic surveillance has little, if any, negative impact on current populations. Unless elk or deer are culled, relatively small sample sizes may be available for opportunistic testing. Animals killed in collisions with vehicles may be a biased sample that could help detect chronic wasting disease. Research has indicated that CWD-infected mule deer may be more likely to be hit by vehicles than non-CWD infected deer (Krumm et al. 2005).

Opportunistic surveillance is an excellent way to begin surveying for presence of chronic wasting disease without changing management of the deer population. This is a good option for park units where chronic wasting disease is a moderate risk but where it has not yet been encountered within 60 miles of the park.

Targeted Surveillance

Targeted surveillance entails lethal removal of elk and deer that exhibit clinical signs consistent with chronic wasting disease. Targeted surveillance has negligible negative effects on the entire population, removes a potential source of CWD infection, and is an efficient means of detecting new centers of infection (Miller et al. 2000). One limitation to targeted surveillance is that environmental contamination and direct transmission may occur before removal. Additionally, there is no available method to extrapolate disease prevalence when using targeted surveillance because actions are focused only on those individuals thought to be infected. Targeted surveillance is moderately labor intensive and requires educating NPS staff in recognition of clinical signs and training in identifying and removing appropriate samples for testing, as well as vigilance for continued observation and identification of potential CWD suspect animals. Training is available through the NPS Biological Resource Management Division. Targeted surveillance is recommended in all parks and is required in areas with moderate to high CWD risk (within 60 miles of known CWD occurrence) or in park units where chronic wasting disease has already been identified.

Population Reduction

Population reduction involves randomly culling animals within a population in an attempt to reduce animal density, and thus decrease risk of transmission. In captive situations, where animal density is high, the prevalence of chronic wasting disease can be substantially elevated compared to that seen in free-ranging situations. Thus, it is hypothesized that increased animal density and increased animal-to-animal contact, as well as increased environmental contamination, may enhance the spread of chronic wasting disease. Therefore, decreasing animal densities may decrease the transmission and incidence of the disease. However, migration patterns and social behaviors may make this an ineffective strategy if instead of spreading out across the landscape, deer and elk stay in high-density herds in tight home ranges throughout much of the year (Williams et al. 2002b). Population reduction is an aggressive and invasive approach to mitigating the CWD threat. It has immediate and potentially long-term effects on local and regional populations of deer and the associated ecosystem. This may be an appropriate response if animals are above population objectives and/or the need to know CWD prevalence with a high degree of accuracy is vital.

Coordination

Regardless of which surveillance method is used, each park should cooperate with state wildlife and agriculture agencies in monitoring chronic wasting disease in park units, working within the park's management policies. Chronic wasting disease is not contained by political boundaries, thus coordination with other management agencies is important.

Additionally, as stated above, the NPS Biological Resource Management Division provides assistance to parks for staff training (e.g., sample collection, recognizing clinical signs of CWD) and testing (e.g., identifying qualified/approved labs or processing samples).

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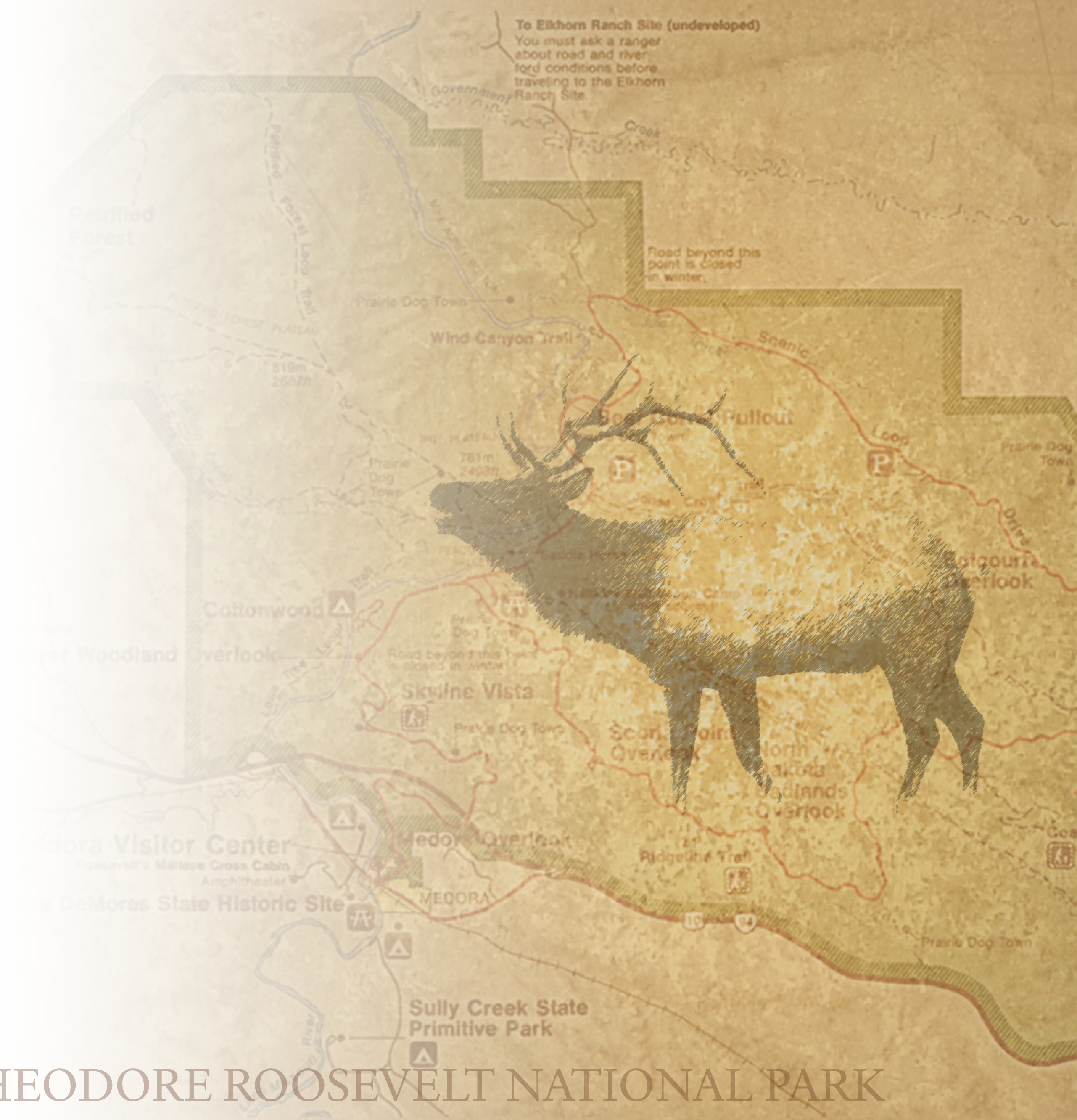
APPENDIX D



THEODORE ROOSEVELT NATIONAL PARK

APPENDIX D. COSTS OF USING SKILLED VOLUNTEERS

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Additional Costs Associated with Using Skilled Volunteers for Elk Management Under Alternative B, Initial Reduction (Years 1-5)
(assumes that initial reduction would last 12 weeks, and 15 skilled volunteers would be used per week)

ACTIVITY	ASSUMPTIONS	ANNUAL COSTS				
		Unit	Rate/hr	Base cost	Benefits @ 45%	Total cost
SELECTION PROCESS						
Development/Coordination	1 GS 11 - 40 hours per year	40	$27.00	$1,080.00	$486.00	$1,566.00
Proficiency Test						
Targets	None	500	$0.50	$250.00		$250.00
Development/Oversight (oversees proficiency test)	1 GS 7 for 12 weeks - 4 hours per week	48	$15.60	$748.80	$336.96	$1,085.76
Communications (e.g., notifications)						
Mailings	500 letters @ $0.42per letter	500	$0.42	$210.00		$210.00
Clerical for mailings	1 GS 5 - 16 hours per year	$16.00	$12.60	$201.60	$90.72	$292.32
REDUCTION ACTIVITIES						
Direct Reduction Coordinator Coordinates overall logistics for teams of NPS staff and skilled volunteers including identifying locations for activities; identifying numbers of animals to be removed; ensuring safety protocols are implemented; communicating with media and other interested parties; evaluating results and determining next steps.	1 GS 11 for 12 weeks - 20 hrs per week during actual reduction efforts	240	$27.00	$6,480.00	$2,916.00	$9,396.00
Public Relations Officer Responsible for communicating with media, public, and other interested parties; developing informational materials regarding the use of skilled volunteers; coordinating with NPS direct reduction team members.	1 GS 12 for 16 weeks - 20 hours per week for 12 weeks during actual reduction efforts, 40 hours per week for 2 weeks before and after (preparation and closeout)	400	$27.65	$11,060.00	$4,977.00	$16,037.00

Direct Reduction Team Leaders Oversees direct reduction teams in the field, identifying which animals are removed, ensuring field safety protocols are implemented, communicating with direct reduction coordinator and primary/secondary volunteer contact(s); Assume 3 NPS staff, one for each team	3 GS 7 for 16 weeks each - 40 hours per week for 12 weeks during actual reduction efforts, and 2 weeks before and after (preparation and closeout)	1920	$15.60	$29,952.00	$13,478.40	$43,430.40
Primary Volunteer Contact Responsible for checking-in volunteers upon arrival at the park and assisting Direct Reduction Coordinator with miscellaneous requests.	1 GS 5 for 16 weeks - 10 hours per week for 12 weeks during actual recution reduction efforts; 40 hours per week for one week before and after for preparation and closeout	200	$12.58	$2,516.00	$1,132.20	$3,648.20
TIDC radio dispatcher						
1 GS 5 (same person as Volunteer contact)	1 GS 5 for 12 weeks - 30 hours per week during actual reduction efforts	360	$12.58	$4,528.80	$2,037.96	$6,566.76
Law enforcement rangers Additional staff required during direct reduction activities to ensure program conducted appropriately and to respond to potential emergencies.	5 GS 5 for 12 weeks - 40 hours per week per staff member during actual reduction efforts.	2400	$12.58	$30,192.00	$2,309.69	$32,501.69
Equipment/supplies						
Additional equipment needs, e.g. binoculars, radios, firearms/ammunition	Average of $1,800 per year (Initial year 1 cost would be $5,000, and $1,000 per year in years 2-5)			$1,800.00		$1,800.00
Fuel/Vehicle costs	Approximately $10,000 per year for the 1st 5 years			$10,000.00		$10,000.00
Annual Subtotal, Staffing Costs						$114,524.13
Annual Subtotal, Equipment and Suppliles						$12,260.00
Annual Total						$126,784.13
Total for Years 1-5 of the Plan						$633,920.64

Additional Costs Associated with Using Skilled Volunteers for Elk Management Under Alternative B, Maintenance (Years 6-15)
(assumes that annual maintenance would last 2 weeks, 5 skilled volunteers would be used per week)

ACTIVITY	ASSUMPTIONS	ANNUAL COSTS				
		Unit	Rate/hr	Base cost	Benefits @ 45%	Total cost
SELECTION PROCESS						
Development/Coordination	1 GS 11 - 40 hours per year	40	$27.00	$1,080.00	$486.00	$1,566.00
Proficiency Test						
Targets	None	500	$0.50	$250.00		$250.00
Development/Oversight (oversees proficiency test)	1 GS 7 for 12 weeks - 4 hours per week	48	$15.60	$748.80	$336.96	$1,085.76
Communications (e.g., notifications)						
Mailings	500 letters @ $0.42 per letter	500	$0.42	$210.00		$210.00
Clerical for mailings	1 GS 5 - 16 hours per year	$16.00	$12.60	$201.60	$90.72	$292.32
REDUCTION ACTIVITIES						
Direct Reduction Coordinator Coordinates overall logistics for teams of NPS staff and skilled volunteers including identifying locations for activities; identifying numbers of animals to be removed; ensuring safety protocols are implemented; communicating with media and other interested parties; evaluating results and determining next steps.	1 GS 11 for 2 weeks - 20 hrs per week during actual reduction efforts	40	$27.00	$1,080.00	$486.00	$1,566.00
Public Relations Officer Responsible for communicating with media, public, and other interested parties; developing informational materials regarding the use of skilled volunteers; coordinating with NPS direct reduction team members.	1 GS 12 for 6 weeks - 20 hours per week for 2 weeks during actual reduction efforts, 40 hours per week for 2 weeks before and after (preparation and closeout)	200	$27.65	$5,530.00	$2,488.50	$8,018.50

Direct Reduction Team Leaders Oversees direct reduction teams in the field, identifying which animals are removed, ensuring field safety protocols are implemented, communicating with direct reduction coordinator and primary/secondary volunteer contact(s); Assume 3 NPS staff, one for each team	3 GS 7 for 6 weeks each - 40 hours per week for 2 weeks during actual reduction efforts, and 2 weeks before and after (preparation and closeout)	720	$15.60	$11,232.00	$5,054.40	$16,286.40
Primary Volunteer Contact Responsible for checking-in volunteers upon arrival at the park and assisting Direct Reduction Coordinator with miscellaneous requests.	1 GS 5 for 6 weeks - 10 hours per week for 2 weeks during actual recution reduction efforts; 40 hours per week for one week before and after for preparation and closeout	100	$12.58	$1,258.00	$566.10	$1,824.10
TIDC radio dispatcher						
1 GS 5 (same person as Volunteer contact)	1 GS 5 for 2 weeks - 30 hours per week during actual reduction efforts	60	$12.58	$754.80	$339.66	$1,094.46
Law enforcement rangers Additional staff required during direct reduction activities to ensure program conducted appropriately and to respond to potential emergencies.	5 GS 5 for 2 weeks - 40 hours per week per staff member during actual reduction efforts.	400	$12.58	$5,032.00	$384.95	$5,416.95
Equipment/supplies						
Additional equipment needs, e.g. binoculars, radios, firearms/ammunition	$1,000 per year in years 6-15			$1,000.00		$1,000.00
Fuel/Vehicle costs	Approximately $1,000 per year in years 6-15			$1,000.00		$1,000.00
Annual Subtotal, Staffing Costs						$37,150.49
Annual Subtotal, Equipment and Suppliles						$2,460.00
Annual Total						$39,610.49
Total for Years 6-15 of the Plan						$396,104.88

APPENDIX E

THEODORE ROOSEVELT NATIONAL PARK

APPENDIX E. REVIEW OF ELK FERTILITY CONTROL

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REVIEW OF ELK FERTILITY CONTROL

INTRODUCTION

Managing the overabundance of certain wildlife species has become a topic of public concern (Rutberg et al., 2004). Species such as Canada geese (*Branta canadensis*), coyotes (*Canis latrans*), white-tailed deer (*Odocoileus virginianus),* and elk *(Cervus elaphus nelsoni)* have become either locally or regionally overabundant throughout the United States (Fagerstone et al., 2002). In addition, traditional wildlife management techniques such as hunting and trapping are infeasible in many parks and suburban areas, forcing wildlife managers to seek alternative management methods.

The use of reproductive control in wildlife management has been assessed for the last several decades. Its use has gained more attention as the public has become more involved in wildlife management decisions. Interest in reproductive control, as an innovative alternative to traditional management methods, has led to the current state of the science (Baker et al., 2004). Often, the use of reproductive control is promoted in urban and suburban areas where traditional management tools, such as hunting, are publicly unacceptable or illegal due to firearm restrictions (Kilpatrick and Walter, 1997, Muller et al., 1997).

The following appendix describes the current state of reproductive control (2007) as it relates to ungulate (hoofed mammals) management with an emphasis on experimental studies in elk. In addition to describing the current technology available, it also covers population management challenges, regulatory issues, logistics, and consumption issues. It should be noted that since technology is changing rapidly in this field of research, this appendix is meant to be a description of the types of technology available and is not all-inclusive. At this time, fertility control agents have not been proven through science to effectively manage wildlife populations; however, ongoing research in other NPS units has indicated that use of such an agent for elk population maintenance at Theodore Roosevelt National Park could be feasible during the life of this plan.

CURRENT TECHNOLOGY

The area of wildlife contraception is constantly evolving as new technologies are developed and tested. For the sake of brevity, this appendix will only discuss reproductive control as it applies to female elk. There is a general understanding in herd based species, such as elk, that managing the female component of the population is more effective than managing the male component. Based on the polygamous breeding behavior of elk, suppressing male fertility would be ineffective if the overall goal is population management.

There are three basic categories of reproductive control technology: (1) immunocontraceptives (vaccines), (2) non-immunological methods (pharmaceuticals), and (3) physical or chemical sterilization.

IMMUNOCONTRACEPTIVES

It is suggested that immunocontraceptive vaccines offer significant promise for future wildlife management (Rutberg et al., 2004). Immunocontraceptive treatment involves injecting an animal with a vaccine that, “stimulates its immune system to produce antibodies against a protein (i.e., antigen) involved in reproduction” (Warren, 2000). In order to provide for sufficient antibody production, an adjuvant is combined with the vaccine. An adjuvant is a product that increases the intensity and duration of the immune system’s reaction to the vaccine. There are two primary types of antigens used in fertility control vaccines tested in elk: porcine zona pellucida (PZP) and gonadotropin releasing hormone (GnRH).

PORCINE ZONA PELLUCIDA (PZP). The majority of immunocontraceptive research in wildlife has been conducted using PZP vaccines, and has been used experimentally in free-ranging Tule elk (Shideler et al., 2002) and captive as well as free-ranging Rocky Mountain elk (Garrott et al., 1998, Heilmann et al., 1998). Due to its mechanism of action, this type of vaccine is only effective in females. Until recently there were only two PZP vaccine products being developed- one is simply called PZP, and the other SpayVac™, however the company producing SpayVac™ has stated that it will no longer begin new research projects involving SpayVac™ in cervids. The other PZP vaccine has been used extensively in a variety of ungulates including white-tailed deer (Kirkpatrick et al., 1997; Turner et al., 1992, 1996; Walter et al., 2002a, 2002b), horses (Kirkpatrick et al., 1990, 1995, 1997; Turner et al., 1997, 2002), exotic species (Kirkpatrick et al., 1996a; Frank et al., 2005), and elk (Shideler et al., 2002; Garrot et al., 1998; Heilmann et al., 1998) in the course of investigating its effectiveness.

The currently available PZP vaccine formulation is effective for one year, though multi-year applications are also being studied. There are several limitations to the PZP based vaccines. First, at this time, PZP vaccines require annual boosters in order to maintain infertility, resulting in the need to mark treated animals and re-treat the same individuals each year. Second, regulatory agencies (e.g. the Food and Drug Administration and the Environmental Protection Agency) have not definitively determined whether vaccine components pose a human health risk. However, adjuvanted PZP does not appear to be a risk to non-target species if consumed orally (Barber and Fayrer-Hosken, 2000). Finally, the PZP based vaccines often cause abnormal out of season breeding behavior in treated populations (Fraker et al., 2002, Heilmann et al., 1998; McShea et al.,1997) as treatment with PZP causes repeated estrous cycling in females, which can result in late pregnancies and behavioral changes.

GONADOTROPIN RELEASING HORMONE (GNRH) VACCINES. GnRH is a small neuropeptide (a protein-like molecule made in the brain) that plays a necessary role in reproduction. It is naturally secreted by the hypothalamus (a region of the brain that regulates hormone production), which directs the pituitary gland to release hormones that control the proper functioning of reproductive organs (Hazum and Conn, 1998). In an attempt to interrupt this process, research has focused on eliminating the ability of GnRH to trigger the release of reproductive hormones. One solution that has been investigated is a vaccine that, when combined with an adjuvant, stimulates the production of antibodies to GnRH. These antibodies attach to GnRH in the hypothalamic region and prevent the hormone from binding to receptors in the pituitary gland, thus suppressing the secretion of downstream reproductive hormones.

GnRH vaccines have been used in a variety of wild and domestic ungulates as well as other wildlife species. One such GnRH vaccine being researched and developed is GonaCon™. In addition to developing an adjuvant with fewer unwanted side effects, researchers are also studying ways to develop a multi-year dose of the vaccine (USDA 2007). Potential benefits of this vaccine include the longer-lasting contraceptive effect and the lack of repeated estrous cycling. There are currently two ongoing studies investigating the safety and efficacy of GonaCon™ in elk (J. Powers personal communication, 2006). However, at this stage there are many uncertainties about this vaccine. First, like PZP vaccines, there is little information regarding the human and non-target species health risks. True health risks are likely to be negligible; however, more research is needed to confirm this hypothesis. Second, there is little information regarding vaccination of pregnant animals. Third, the vaccine can cause antibody development to not only the GnRH antigen but also a component of the adjuvant. This may cause difficulties if attempting to determine the Johne's disease status of a population of treated elk. Finally, there is limited published data using this vaccine in free-ranging animals. More work is necessary to establish population and herd level effects.

NON-IMMUNOLOGICAL REPRODUCTIVE CONTROL METHODS

This group of reproductive control agents includes GnRH agonists, GnRH toxins, steroid hormones, and contragestives.

GNRH AGONISTS. GnRH agonists are similar in structure to GnRH and act by attaching to receptors in the pituitary gland. By attaching to the receptors, GnRH agonists reduce the number of binding sites available and thereby suppress the effect of natural GnRH. As a result of this suppression, reproductive hormones are not released (Aspden et al., 1996; D'Occhio et al., 1996). However, not all agonists have the same effects in all species. In fact, some can have an effect that is the opposite of what is intended. Therefore, it is important to fully understand the effects of a product on a given species. The GnRH agonists have been used experimentally in captive and free-ranging elk (Lincoln, 1987, Baker et al., 2002).

Leuprolide acetate: Leuprolide is one GnRH agonist that is being studied. Tests reveal that when it is administered as a controlled-release formulation it results in 100% pregnancy prevention in treated female elk (Baker et al., 2002; Baker et al., 2005; Conner et al. in press). In addition, the treatment is reversible, and effects last only for a specific period of time (90-120 days; Baker et al., 2002; Trigg et al., 2001). This means that, should a female be treated in one year, before the breeding season, it will not be come pregnant in that year, but if the female is not re-treated the following year, then it has the same chances of becoming pregnant as an animal that was never treated. Treatment using leuprolide differs from GnRH vaccines in that it does not require an adjuvant; however, it does require a slow release implant that remains under the skin or in the muscle for the duration of treatment effectiveness and likely longer.

An added benefit to the use of leuprolide is that it requires only one treatment for the first year of contraception, whereas some immunocontraceptive vaccines require re-treating the same individual several times with additional doses to develop and maintain infertility. Additionally, leuprolide is not likely to pose a threat to the environment or non-target species (including humans; Baker et al., 2004). In contrast with some of the immunocontraceptive vaccines, leuprolide does not appear to have negative physiological side effects, and short term behavioral effects are minimal.

GNRH TOXINS. GnRH toxins consist of a cellular toxin that is combined with a GnRH analog. The toxin is carried to the receptors in the pituitary gland and is internalized. Once absorbed, the toxin disrupts cellular function and can lead to cellular death. When this occurs the production of reproductive hormones is affected. This process has been studied in female mule deer (Baker et al., 1999), and the technology is still being developed. This contraceptive method has not been explored in elk.

STEROID HORMONES. The field of wildlife contraception began with research examining the manipulation of reproductive steroid hormones. Treatments using steroids can include administering high doses of naturally occurring hormones, such as estrogens or progesterone. However, the treatment usually entails the application of synthetic hormones, such as norgestomet, levangesterol, and melangestrol acetate. Most products that are available are used in domestic animal or zoological veterinary medicine, and have not been used widely in free-ranging wildlife. Some issues related to using steroids include: difficulties in treating large numbers of animals for extended periods of time, negative side effects experienced by the treated animals, and concerns over the consumption of treated animals by non-target species, including humans. Therefore reproductive steroids are not recommended for use in free-ranging wildlife.

CONTRAGESTIVES. Contragestives are products that terminate pregnancy. Progesterone is the primary gestational hormone for maintaining pregnancy in mammals. Many contragestives act by preventing progesterone production or blocking its effect, thereby affecting pregnancy. The primary contragestive that has been researched for use in domestic animals and wild ungulates is Prostaglandin $F_{2\alpha}$ analogue (Becker and Katz, 1994; DeNicola et al., 1997; Waddell et al., 2001). $PGF_{2\alpha}$ has been used successfully to disrupt pregnancy in captive elk (Bates et al., 1982; J. Powers personal communication, 2006). Lutalyse® is a commercially available form of Prostaglandin $F_{2\alpha}$ analogue. Unlike many of the other alternatives, there are no issues related to consumption of the meat when it has previously treated with this product. Difficulties with contragestives include: timing of administration, percent efficacy, potential to re-breed if breeding season is not finished, and the potential for aborted fetuses on the landscape.

STERILIZATION. Sterilization can be either a surgical or chemical treatment process. Surgical sterilization is an intensive and invasive procedure that requires a veterinarian and is common in managing domestic animal fertility. Physical sterilization has not been used for population management in free-ranging elk populations. Chemical sterilization using sclerosing agents to initiate scar tissue development and physical damage to the reproductive tract is typically performed on males as a contraceptive measure. Both types of sterilization are generally permanent.

REGULATORY ISSUES

The application of reproductive control agents in free-ranging wildlife is fairly new and is currently (August 2007) regulated by both the United States Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA). None of the agents discussed here are currently licensed or labeled for use as reproductive control agents in wildlife species. However, some can be used in a research setting under an Investigational New Animal Drug (INAD) exemption through FDA, as an experimental application of a pesticide through EPA, or in either a management application or experimental setting with veterinary prescription if the drug is approved for use in other species (Extralabel drug use – ELDU).

INAD exemptions and experimental use permits are granted by the FDA or the EPA respectively for the purpose of allowing research to facilitate the gathering of information pertaining to the agent prior to granting full approval for its use. Some of the agents discussed above, specifically several of the pharmaceuticals, have FDA approval for therapeutic use in humans (e.g., leuprolide) or other non-wildlife species (e.g. prostaglandin $F_{2\alpha}$). As a safety precaution, each approved agent is labeled indicating how it is to be used. To use the drug in a manner other than that indicated on the label, a licensed veterinarian must prescribe the agent and it must be used in accordance with the Animal Medicinal Drug Use Clarification Act of 1994. The prescribing veterinarian is accountable for prescribing and labeling a product when it is to be used in an extra-label manner. However, the owner (in this case, the NPS unit manager) is responsible for using the agent in the prescribed manner. In addition, the veterinarian must establish a meat residue withdrawal period - the time it takes for the animal to fully metabolize and clear the drug from its tissue - for any animals that may enter the human food chain. A treated animal may not be killed and enter the human food chain before the meat residue withdrawal period is over. Treated animals need to be marked to prevent this from occurring.

POPULATION MANAGEMENT CHALLENGES

Managing local populations of wildlife using reproductive control can be difficult. The level of difficulty relates to the number of animals that need to be treated, their behavior (i.e., solitary, herd, diurnal, nocturnal, habituation, etc.), the topography of the habitat in which they are found, as well as treatment protocol logistics. In order for reproductive control agents to effectively reduce population size, treatment with an agent must decrease the reproductive rate to less than the mortality rate. In many protected environments, where human alteration of the landscape and a lack of a full suite of large predators, mortality rates are generally very low. Regarding elk in and around Theodore Roosevelt National Park, the average survival rates – with hunting – for females and males are 96% and 52%, respectively (Sargeant and Oehler, 2004). Additionally, a significant amount of population data is necessary to successfully monitor the effects of long-term population changes due to the use of contraceptives (Rudolph et al. 2000, Hobbs et al., 2000, Porter et al., 2004).

Reproductive control agents generally decrease population levels slowly, and over time, may not result in a sustained reduction of population growth. Modeling conducted by the science team for this plan/EIS showed treating 75% of the female elk population in the park annually resulted in a brief suspension of population growth. However, within the first five years, the population resumed growing at a rate of 6.5% annually. Even when the model was run assuming 90% of female elk are treated annually, the initial reduction in population growth was not sustained, and the population resumed growing at 1.5% within the first 10 years. Hobbs et al. described a model that suggests white-tailed deer density will remain constant if 90% of the initial females are treated with a long term reproductive control agent. Subsequently, 90%

of female fawns would require treatment. This would stabilize the population if the average mortality rate is 10 percent. However, this result does not hold for short-duration agents (1 year duration). In this case, the 90% of reproductively mature females would require treatment each year in order to maintain constant herd numbers (Hobbs et. al., 2000). Reproductive control techniques are best suited to localized populations where the number of breeding females to be treated is small (e.g., less than 100 animals) and managers are trying to maintain the population between 30% and 70% of carrying capacity (Rudolph et al., 2000).

ADMINISTERING THE TREATMENT

There are two basic approaches to administering reproductive control agents: capture and treat and remotely treat. Capture and treat requires physically and/or chemically restraining the animal and using a syringe or other delivery device to treat the animal. One benefit of this approach is that it allows for marking the elk which facilitates subsequent treatments. This method also is helpful in collecting valuable biological data, and it provides notice of meat residue withdrawal times. Depending on the method of capturing the animal (round-up versus ground darting versus net gunning or darting from a helicopter), this approach may be more time intensive and can be more expensive than using a remote delivery system, especially as treated animals tend to be more difficult to recapture. In addition, capture-related mortality may also be a concern.

A remote delivery system uses an adapted firearm (i.e., dart gun) and some form of projectile that contains the reproductive control agent. These projectiles can be darts or another form of delivery system (e.g., biobullet) that can be used at a distance without needing to capture the animal first. One shortcoming of remote treatment is that it does not allow for permanently marking the treated animals. In addition, previously treated animals can be more difficult to re-treat.

POTENTIAL IMPACTS TO ELK BEHAVIOR AND HEALTH

There have been few studies designed to intensively assess the effects of reproductive control on elk behavior and health. For many agents, additional research is needed to fully understand the behavioral, social, and physiological consequences of reproductive control. However, some research has been conducted on the effects of reproductive control on deer, and although the effects are unknown for elk, they may be similar. Because each group of reproductive control agents operates differently, studies show that the effects to the individual elk or population could vary widely. Porcine zona pellucida (PZP) immunocontraceptive agents have been documented to cause the continued cycling of females, which can extend the breeding season or rut (Fraker et al., 2002; Heilmann et al., 1998; McShea et al., 1997). This may lead to an extended period for herding behaviors in males. In addition, if the female gets pregnant later in the year, there are changes to fawning dates and survival rates, as they are born later in the season, similar to what has been seen in white-tailed deer (DeNicola et al., 1997). Other immunocontraceptives such as the gonadotropin releasing hormone (GnRH) vaccine, when applied in male deer, have resulted in depressed antler development and lack of interest in breeding (Killian et al, 2005). When this vaccine is applied to female deer, they display decreased estrous behavior during the breeding season (Miller et al., 2000). If enough females in the population are treated, it may result in a disruption to natural male/female social as well as reproductive interactions. An ongoing study is investigating the effects of GnRH vaccination on reproductive behavior in captive female elk (J. Powers personal communication, 2006).

The group of reproductive control agents categorized as non-immunocontraceptive methods can also have varying effects on behavior and health. For example, GnRH agonists have not been documented as causing behavioral changes when applied to female elk (Baker et al., 2002). GnRH agonists have had variable behavioral effects when applied to male elk (Lincoln, 1987). Contragestives pose a different kind of problem depending on when the treatment is applied. If applied too early in the breeding season, then the female could potentially breed again later in the year extending the rut and resulting fawn-related health issues such as those described for some immunocontraceptive agents above. If applied too late in the season contragestives can result in health implications for the female, as described for deer (DeNicola et al., 1997).

Depending on the method of sterilization this procedure may have behavioral effects on both male and female elk. If gonads are removed, the source of several important reproductive hormones will be removed. This may change elk social interactions. If gonads are not removed, females will continue to ovulate and show behavioral signs of estrus and consequently may extend the breeding season similar to the phenomenon seen with PZP immunocontraception.

As described above, any effect that could extend the rut has the potential for secondary effects to the individual elk. Increased attempts to breed, especially if unwelcomed, can result in increased aggression and movements. This can be problematic in areas with high vehicle use, as there could be increases in elk/vehicle collisions or other negative interactions with the public. However, as stated above, the effects of reproductive control agents still need more research in order to better understand the variations in elk behavior and health.

POTENTIAL IMPACTS TO CONSUMPTION

As described above, some of the reproductive control agents can result in issues related to human consumption of meat. These issues can be avoided by: 1) using an agent that does not pose any risk to humans, 2) marking treated animals and providing meat residue withdrawal times (if established), 3) providing educational materials to the local public that may consume hunted animals in the general area of treated animals, and 4) increasing research efforts to determine true human consumption risks.

TABLE E-1. A SUMMARY OF THE PERCEIVED ADVANTAGES AND DISADVANTAGES OF DIFFERENT REPRODUCTIVE CONTROL AGENTS FOR ELK

Reproductive Control Agent	Mechanism	Advantages	Disadvantages
PZP Vaccine	Immunization – antibodies directed at the ovum (egg).	• No hormonal residues. • Effective for at least 1 year. • Antibodies not harmful to humans. • Apply any time of year. • No apparent adverse health effects. • Generally reversible. • Currently available for use as an INAD (may change in the future).	• Requires booster vaccinations. • Only useful in females. • Females continue to cycle out of natural breeding season. • Not 100% effective. • Animals must be permanently marked. • No meat residue withdrawal time established.
GnRH Vaccine	Immunization – antibodies directed at a protein hormone that is needed for reproduction.	• Same as above plus: • Stops hormonal cycling. • Applicable to both males and females. • Is likely to be EPA approved for use as a pesticide in 2007-2008.	• May remove primary and secondary sexual characteristics. • May affect behaviors. • Currently animals must be permanently marked. • Incompletely tested in free-ranging populations. • No meat residue withdrawal time established.
GnRH Agonists Leuprolide Buserelin	Overwhelming GnRH receptors on anterior pituitary suppressing release of reproductive hormones.	• No hormonal meat residues. • No affect on reproductive behaviors. • FDA approved for therapeutic use in humans. • Slow-release formula available. • Remote delivery possible.	• Annual treatment prior to breeding season. • Meat residue withdrawal period not well established.
GnRH Toxin	Linking a GnRH analog to a cellular toxin which targets and kills GnRH receptors preventing release of reproductive hormones.	• May cause permanent sterility.	• More research is needed before using this product in elk.
Steroid Hormones Progestins Estrogens	Controlling the reproductive cycle by administering steroid hormones or their analogues.	• Variable efficacy. • Variable duration.	• Some formulations can accumulate in tissues and may pose a health risk to scavengers or humans. • Some steroids can be harmful to the target species. • Animals must be marked. • Administered by slow release implants or repeated feeding.
Contragestion $PGF_{2\alpha}$	Pre-term pregnancy termination.	• Administered by biobullet or hand injection. • FDA approved for use in domestic large animals. • No meat withdrawal period in domestic cattle.	• Administered when the animal is pregnant. • Re-breeding may occur if given early. • Increased health complications if given late.

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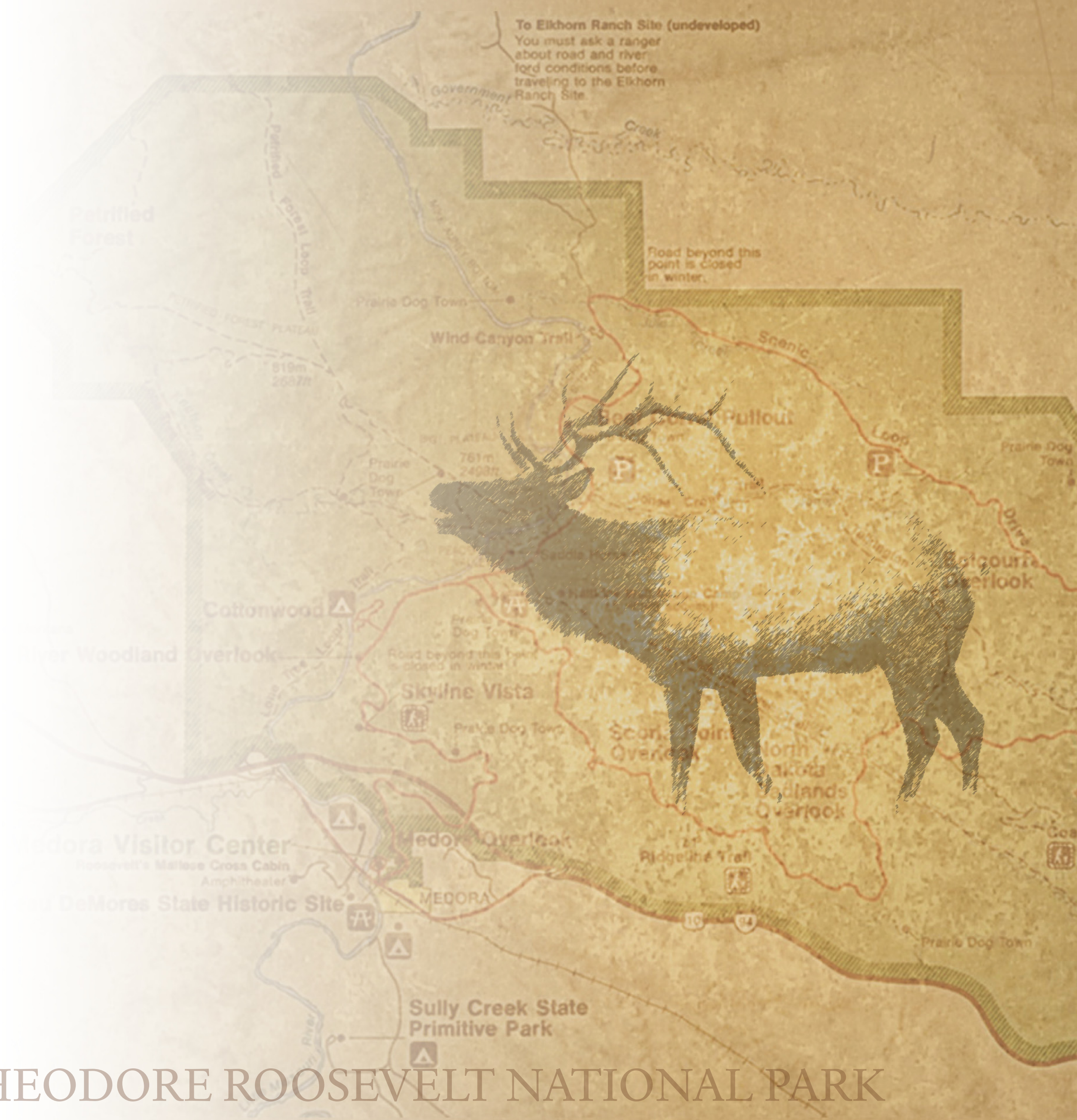
APPENDIX F



THEODORE ROOSEVELT NATIONAL PARK

APPENDIX F. PLANTS IN THEODORE ROOSEVELT NATIONAL PARK

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NATIVE PLANT SPECIES OF THEODORE ROOSEVELT NATIONAL PARK

Common Name	Scientific Name
Common twinpod	*Physaria didymocarpa* var*. didymocarpa*
Painted milkvetch	*Astragalus ceramicus* var*. filifolius*
Missouri milkvetch	*Astragalus missouriensis*
Box elder	*Acer negundo*
Soapweed	*Yucca glauca*
Narrowleaf water plantain	*Alisma gramineum*
American water plantain	*Alisma subcordatum*
Northern water plantain	*Alisma triviale*
Arum-leaf arrowhead	*Sagittaria cuneata*
Broadleaf arrowhead	*Sagittaria latifolia*
Fragrant sumac	*Rhus aromatica*
Skunkbrush sumac	*Rhus trilobata*
Poison ivy	*Toxicodendron rydbergii*
Water hemlock	*Cicuta maculata*
Plains spring parsley	*Cymopterus acaulis*
Carrot-leaf desert-parsley	*Lomatium foeniculaceum*
Biscuit root	*Lomatium orientale*
Wild parsley	*Musineon divaricatum*
Aniseroot	*Osmorhiza longistylis*
Snakeroot	*Sanicula marilandica*
Spreading dogbane	*Apocynum androsaemifolium*
Indian hemp	*Apocynum cannabinum*

Common Name	Scientific Name
Wild sarsaparilla	*Aralia nudicaulis*
Sidecluster milkweed	*Asclepias lanuginosa*
Plains milkweed	*Asclepias pumila*
Showy milkweed	*Asclepias speciosa*
Whorled milkweed	*Asclepias verticillata*
Green milkweed	*Asclepias viridiflora*
Western yarrow	*Achillea millefolium*
Prairie dandelion	*Agoseris glauca*
Common ragweed	*Ambrosia artemisiifolia*
Western ragweed	*Ambrosia psilostachya*
Giant ragweed	*Ambrosia trifida*
Howell's pussytoes	*Antennaria howellii* ssp*. neodioica*
Littleleaf pussytoes	*Antennaria microphylla*
Field pussytoes	*Antennaria neglecta*
Parlin's pussytoes	*Antennaria parlinii*
Small-leaf pussytoes	*Antennaria parvifolia*
Woman's tobacco	*Antennaria plantaginifolia*
Rosy pussytoes	*Antennaria rosea*
Arnica	*Arnica fulgens*
Field sagewort	*Artemisia campestris*
Silver sagebrush	*Artemisia cana*
Green sagebrush/ false tarragon	*Artemisia dracunculus*
Fringed sage	*Artemisia frigida*
Long-leaved sage	*Artemisia longifolia*
Cudweed sagewort	*Artemisia ludoviciana*

Common Name	Scientific Name
Mountain big sagebrush	*Artemisia tridentata*
Nodding beggarstick	*Bidens cernua*
Bur beggartick	*Bidens frondosa*
Nodding beggarstick	*Bidens vulgata*
False boneset	*Brickellia eupatorioides*
Flodman's thistle	*Cirsium flodmanii*
Wavy-leaf thistle	*Cirsium undulatum*
Horseweed	*Conyza canadensis*
Spreading fleabane	*Conyza ramosissima*
Hawk's beard	*Crepis occidentalis*
Hawk's beard	*Crepis runcinata*
Fetid marigold	*Dyssodia papposa*
Purple cone flower	*Echinacea angustifolia*
Rubber rabbitbrush	*Ericameria nauseosa* var. *glabrata*
Rubber rabbitbush	*Ericameria nauseosa* var. *nauseosa*
Rough fleabane	*Erigeron asper*
Hoary fleabane	*Erigeron canus*
Smooth fleabane	*Erigeron glabellus*
Low-meadow fleabane	*Erigeron lonchophyllus*
Philadelphia daisy	*Erigeron philadelphicus*
Low fleabane	*Erigeron pumilus*
Prairie fleabane	*Erigeron strigosus*
Three-nerve fleabane	*Erigeron subtrinervis*
Blanketflower	*Gaillardia aristata*

Common Name	Scientific Name
Curlycup gumweed	*Grindelia squarrosa*
Broom snakeweed	*Gutierrezia sarothrae*
Common sunflower	*Helianthus annuus*
Maximilian sunflower	*Helianthus maximiliani*
Stiff sunflower	*Helianthus pauciflorus*
Plains sunflower	*Helianthus petiolaris*
Hairy goldaster	*Heterotheca villosa*
Finleaf hymenoppas	*Hymenopappus filifolius*
Chalk Hill hymenopappus	*Hymenopappus tenuifolius*
Pingue rubberweed	*Hymenoxys richardsonii*
Poverty weed	*Iva axillaris*
Marsh elder	*Iva xanthifolia*
Wild lettuce	*Lactuca ludoviciana*
Blue lettuce	*Lactuca tatarica* var. *pulchella*
Dotted gay feather	*Liatris punctata*
Rush skeleton plant	*Lygodesmia juncea*
Hoary aster	*Machaeranthera canescens*
Goldenweed	*Machaeranthera grindelioides*
Cutleaf goldenweed	*Machaeranthera pinnatifida* var. *pinnatifida*
Prairie false dandelion	*Nothocalais cuspidata*
Prairie goldenrod	*Oligoneuron album*
Stiff goldenrod	*Oligoneuron rigidum*
Woolly groundsel	*Packera cana*
Prairie grounsel	*Packera plattensis*
Plains bahia	*Picradeniopsis oppositifolia*

Common Name	Scientific Name
Lanceleaf goldenweed	*Pyrrocoma lanceolata* var. *lanceolata*
Prairie coneflower	*Ratibida columnifera*
Green prairie coneflower	*Ratibida tagetes*
Blackeyed susan	*Rudbeckia hirta*
Ragwort	*Senecio integerrimus*
Canada goldenrod	*Solidago canadensis*
Giant goldenrod	*Solidago gigantea*
Missouri goldenrod	*Solidago missouriensis*
Soft goldenrod	*Solidago mollis*
Gray goldenrod	*Solidago nemoralis*
Thrift mock goldenweed	*Stenotus armerioides* var. *armerioides*
Wire lettuce	*Stephanomeria runcinata*
White heath aster	*Symphyotrichum ericoides*
White prairie aster	*Symphyotrichum falcatum* var. *falcatum*
Smooth blue aster	*Symphyotrichum laeve*
White panicle aster	*Symphyotrichum lanceolatum* var. *lanceolatum*
Aromatic aster	*Symphyotrichum oblongifolium*
Stemless hymenoxys	*Tetraneuris acaulis*
Stemless townsendia	*Townsendia exscapa*
Cockleburr	*Xanthium strumarium*
Mountain birch	*Betula occidentalis*
Paper birch	*Betula papyrifera*
Beaked hazelnut	*Corylus cornuta*
Butte candle	*Cryptantha celosioides*

Common Name	Scientific Name
Nodding stickseed	*Hackelia deflexa*
Many flower stickseed	*Hackelia floribunda*
Stickseed	*Lappula occidentalis*
Hoary puccoon	*Lithospermum canescens*
Narrowleaf puccoon	*Lithospermum incisum*
Prairie bluebells	*Mertensia lanceolata*
False gromwell	*Onosmodium molle* ssp. *occidentale*
Hairy rockcress	*Arabis hirsuta*
Rockcress	*Arabis holboellii*
Spreadingpod rockcress	*Arabis X divaricarpa*
Western tansymustard	*Descurainia pinnata*
Yellow whitlowort	*Draba nemorosa*
White whitlowort	*Draba reptans*
Western wallflower	*Erysimum asperum*
Smallflower wallflower	*Erysimum inconspicuum*
Pepperweed	*Lepidium densiflorum*
Pepperweed	*Lepidium virginicum*
Alpine bladderpod	*Lesquerella alpina*
Bladderpod	*Lesquerella arenosa*
Foothill bladderpod	*Lesquerella ludoviciana*
Mustard twinpod	*Physaria brassicoides*
Yellowrocket	*Rorippa palustris*
Prince's plume	*Stanleya pinnata*
Missouri foxtail cactus	*Escobaria missouriensis* var. *missouriensis*
Pincushion cacti	*Escobaria vivipara*

Common Name	Scientific Name
	var. *vivipara*
Brittle prickly pear	*Opuntia fragilis*
Twistspine pricklypear	*Opuntia macrorhiza*
Plains prickly pear	*Opuntia polyacantha*
Water starwort	*Callitriche hermaphroditica*
Little pod flax	*Campanula rotundifolia*
Looking glass	*Triodanis leptocarpa*
Common hops	*Humulus lupulus*
Rocky mtn bee plant	*Cleome serrulata*
Clammy weed	*Polanisia dodecandra*
Common snowberry	*Symphoricarpos albus*
Buckbrush	*Symphoricarpos occidentalis*
Nannyberry	*Viburnum lentago*
Prairie chickweed	*Cerastium arvense*
Shortstalk chickweed	*Cerastium brachypodum*
Nodding chickweed	*Cerastium nutans*
Grove-sandwort	*Moehringia lateriflora*
Creeping nailwort	*Paronychia sessiliflora*
Sleepy catchfly	*Silene antirrhina*
Bittersweet	*Celastrus scandens*
Silverscale saltbush	*Atriplex argentea*
Four-wing saltbush	*Atriplex canescens*
Shadscale saltbush	*Atriplex confertifolia*
Nuttall's saltbush	*Atriplex nuttallii*
Saline saltbush	*Atriplex subspicata*
Pitseed goosefoot	*Chenopodium berlandieri*

Common Name	Scientific Name
Arid goosefoot	*Chenopodium desiccatum*
Fremont's goosefoot	*Chenopodium fremontii*
Smooth goosefoot	*Chenopodium leptophyllum*
Desert goosefoot	*Chenopodium pratericola*
Giant seed goosefoot	*Chenopodium simplex*
Standley's goosefoot	*Chenopodium standleyanum*
Smooth goosefoot	*Chenopodium subglabrum*
Suckley's saltbush	*Endolepis dioica*
Winterfat	*Krascheninnikovia lanata*
Poverty weed	*Monolepis nuttalliana*
Red swampfire	*Salicornia rubra*
Greasewood	*Sarcobatus vermiculatus*
Seepweed	*Suaeda calceoliformis*
Alkali seepweed	*Suaeda moquinii*
Bracted spiderwort	*Tradescantia bracteata*
Prairie spiderwort	*Tradescantia occidentalis* var. *occidentalis*
False bindweed	*Calystegia macounii*
Hedge bindweed	*Calystegia sepium*
Redosier dogwood	*Cornus sericea*
Ditch stonecrop	*Penthorum sedoides*
Common juniper	*Juniperus communis*
Creeping juniper	*Juniperus horizontalis*
Rocky mountain juniper	*Juniperus scopulorum*
Dodder	*Cuscuta gronovii*
Dodder	*Cuscuta pentagona*

Common Name	Scientific Name
Wheat sedge	*Carex atherodes*
Shortbeak sedge	*Carex brevior*
Crested sedge	*Carex cristatella*
Needleleaf sedge	*Carex duriuscula*
Bristleleaf sedge	*Carex eburnea*
Emory's sedge	*Carex emoryi*
Threadleaf sedge	*Carex filifolia*
Heavy sedge	*Carex gravida*
Deer sedge	*Carex hallii*
Sun sedge	*Carex inops* ssp*. heliophila*
Smoothcone sedge	*Carex laeviconica*
Woolly sedge	*Carex pellita*
Penn sedge	*Carex pensylvanica*
Rocky mtn sedge	*Carex saximontana*
Sprengel sedge	*Carex sprengelii*
Upright sedge	*Carex stricta*
Torrey's sedge	*Carex torreyi*
Fox sedge	*Carex vulpinoidea*
Needle spikerush	*Eleocharis acicularis*
Flatstem spikerush	*Eleocharis compressa*
Bald spike-rush	*Eleocharis erythropoda*
Hardstem bulrush	*Schoenoplectus acutus* var*. acutus*
Three square	*Schoenoplectus americanus*
River bulrush	*Schoenoplectus fluviatilis*
Cosmopolitan bulrush	*Schoenoplectus maritimus*

Common Name	Scientific Name
Three square	*Schoenoplectus pungens* var*. pungens*
Softstem bulrush	*Schoenoplectus tabernaemontani*
Torrey's bulrush	*Schoenoplectus torreyi*
Green bulrush	*Scirpus atrovirens*
Brittle bladder fern	*Cystopteris fragilis*
Cliff fern	*Woodsia oregana*
Silverberry	*Elaeagnus commutata*
Silver buffaloberry	*Shepherdia argentea*
Field horsetail	*Equisetum arvense*
Scouring horsetail	*Equisetum hyemale*
Smooth horsetail	*Equisetum laevigatum*
Bear berry	*Arctostaphylos uva-ursi*
Geyer's sandmat	*Chamaesyce geyeri*
Ribseed sandmat	*Chamaesyce glyptosperma*
Spotted sandmat	*Chamaesyce maculata*
Prairie sandmat	*Chamaesyce missurica*
Matted sandmat	*Chamaesyce serpens*
Thyme-leaved sandmat	*Chamaesyce serpyllifolia*
Horned spurge	*Euphorbia brachycera*
Warty spurge	*Euphorbia spathulata*
Leadplant	*Amorpha canescens*
Purple milkvetch	*Astragalus agrestis*
Two grooved milkvetch	*Astragalus bisulcatus*
Ground plum	*Astragalus crassicarpus*

Common Name	Scientific Name
Pliant milkvetch	*Astragalus flexuosus*
Plains milkvetch	*Astragalus gilviflorus*
Prairie milkvetch	*Astragalus laxmannii* var. *robustior*
Lotus milkvetch	*Astragalus lotiflorus*
Narrowleaf milkvetch	*Astragalus pectinatus*
Woollypod milkvetch	*Astragalus purshii*
Cream milkvetch	*Astragalus racemosus*
Tufted milkvetch	*Astragalus spatulatus*
Loose flower milkvetch	*Astragalus tenellus*
White prairie clover	*Dalea candida*
Nine-anther prairie clover	*Dalea enneandra*
Purple prairie clover	*Dalea purpurea*
Wild licorice	*Glycyrrhiza lepidota*
Sweet broom	*Hedysarum boreale*
American bird's foot trefoil	*Lotus unifoliolatus*
Silvery lupine	*Lupinus argenteus*
Low lupine	*Lupinus pusillus*
Field locoweed	*Oxytropis campestris*
Lambert crazyweed	*Oxytropis lambertii*
Yellow-flower locoweed	*Oxytropis monticola*
White locoweed	*Oxytropis sericea*
Silverleaf scurfpea	*Pediomelum argophyllum*
Indian breadroot	*Pediomelum esculentum*
Lemon scurfpea	*Psoralidium lanceolatum*

Common Name	Scientific Name
Slimflower scurfpea	*Psoralidium tenuiflorum*
Goldenpea	*Thermopsis rhombifolia*
American vetch	*Vicia americana*
Bur oak	*Quercus macrocarpa*
Northern gentian	*Gentiana affinis*
Annual gentian	*Gentianella amarella*
Bicknell's cranesbill	*Geranium bicknellii*
Arolina cranesbill	*Geranium carolinianum*
Black current	*Ribes americanum*
Golden current	*Ribes aureum* var. *villosum*
Missouri gooseberry	*Ribes missouriense*
Canadian gooseberry	*Ribes oxyacanthoides*
American watermilfoil	*Myriophyllum sibiricum*
Silverleaf phacelia	*Phacelia hastata*
Blue-eyed grass	*Sisyrinchium angustifolium*
Mountain blue-eyed grass	*Sisyrinchium montanum*
Arctic rush	*Juncus arcticus*
Baltic rush	*Juncus balticus*
Toad rush	*Juncus bufonius*
Bog rush	*Juncus effusus*
Inland rush	*Juncus interior*
Knotted rush	*Juncus nodosus*
Torrey's rush	*Juncus torreyi*
Arrowgrass	*Triglochin maritimum*
Blue giant hyssop	*Agastache foeniculum*
False pennyroyal	*Hedeoma drummondii*

Common Name	Scientific Name
False pennyroyal	*Hedeoma hispida*
American bugleweed	*Lycopus americanus*
Rough bugleweed	*Lycopus asper*
Field mint	*Mentha arvensis*
Wild bergamot	*Monarda bradburiana*
Wild bergamot	*Monarda fistulosa*
Lanceleaved sage	*Salvia reflexa*
American germander	*Teucrium canadense*
White wild onion	*Allium textile*
Sego lily	*Calochortus nuttallii*
Fairy bells	*Disporum trachycarpum*
Leopard lily	*Fritillaria atropurpurea*
Yellow bell	*Fritillaria pudica*
Wood lily	*Lilium philadelphicum*
False solomon's seal	*Maianthemum racemosum*
Starry false solomon's seal	*Maianthemum stellatum*
Smooth solomon's seal	*Polygonatum biflorum*
Death camus	*Zigadenus venenosus*
Blue flax	*Linum lewisii*
Stiff flax	*Linum rigidum*
Tenpetal blazingstar	*Mentzelia decapetala*
Bushy blazingstar	*Mentzelia dispersa*
Purple ammannia	*Ammannia coccinea*
Scarlet globemallow	*Sphaeralcea coccinea*
Sand verbena	*Abronia fragrans*

Common Name	Scientific Name
White four o'clock	*Mirabilis albida*
Hairy four o'clock	*Mirabilis hirsuta*
Narrow-leaf 4-o'clock	*Mirabilis linearis*
Heart-leaf 4-o'clock	*Mirabilis nyctaginea*
Sandpuffs	*Tripterocalyx micranthus*
Green ash	*Fraxinus pennsylvanica*
Cutleaf primrose	*Calylophus serrulatus*
Autumn willowherb	*Epilobium brachycarpum*
Fringed willowherb	*Epilobium ciliatum*
Scarlet gaura	*Gaura coccinea*
White-stem evening-primrose	*Oenothera albicaulis*
Common evening primrose	*Oenothera biennis*
Gumbo lily	*Oenothera caespitosa*
Cut-leaved evening primrose	*Oenothera laciniata*
Pale evening primrose	*Oenothera latifolia*
Gumbo lily	*Oenothera nuttallii*
Hairy evening primrose	*Oenothera villosa*
Clustered broomrape	*Orobanche fasciculata*
Broom-rape	*Orobanche ludoviciana*
Yellow wood sorrel	*Oxalis stricta*
Ponderosa pine	*Pinus ponderosa*
Indianwheat	*Plantago elongata*
Broadleaf plantain	*Plantago major*
Woolly plantain	*Plantago patagonica*

Common Name	Scientific Name
Indian ricegrass	*Achnatherum hymenoides*
Ticklegrass	*Agrostis scabra*
Shortawn foxtail	*Alopecurus aequalis*
Big bluestem	*Andropogon gerardii*
Sand bluestem	*Andropogon hallii*
Red threeawn	*Aristida purpurea*
American sloughgrass	*Beckmannia syzigachne*
Sideoats grama	*Bouteloua curtipendula*
Blue grama	*Bouteloua gracilis*
Hairy grama	*Bouteloua hirsuta*
Fringed brome	*Bromus ciliatus*
Buffalo grass	*Buchloe dactyloides*
Plains reedgrass	*Calamagrostis montanensis*
Reedgrass`	*Calamagrostis stricta*
Prairie sandreed	*Calamovilfa longifolia*
Drooping woodreed	*Cinna latifolia*
Poverty oatgrass	*Danthonia spicata*
Tapered rosette grass	*Dichanthelium acuminatum*
Scribner dichanthelium	*Dichanthelium oligosanthes* var. *scribnerianum*
Fall panicum	*Dichanthelium wilcoxianum*
Saltgrass	*Distichlis spicata*
Rough barnyard grass	*Echinochloa muricata*
Canada wildrye	*Elymus canadensis*
Bottlebrush squirreltail	*Elymus elymoides* ssp. *elymoides*
Streambank wheatgrass	*Elymus lanceolatus* ssp. *lanceolatus*

Common Name	Scientific Name
Wildrye	*Elymus trachycaulus* ssp. *trachycaulus*
Hairy wildrye	*Elymus villosus*
Virginia wildrye	*Elymus virginicus*
Sheep fescue	*Festuca saximontana* var. *saximontana*
American mannagrass	*Glyceria grandis*
Fowl mannagrass	*Glyceria striata*
Needle-and-thread	*Hesperostipa comata*
Porcupine grass	*Hesperostipa spartea*
Foxtail barley	*Hordeum jubatum*
Little barley	*Hordeum pusillum*
Junegrass	*Koeleria macrantha*
False buffalograss	*Monroa squarrosa*
Scratchgrass	*Muhlenbergia asperifolia*
Plains muhly	*Muhlenbergia cuspidata*
Wirestem muhly	*Muhlenbergia mexicana*
Marsh muhly	*Muhlenbergia racemosa*
Mat muhly	*Muhlenbergia richardsonis*
Green needlegrass	*Nassella viridula*
Rough-leaved ricegrass	*Oryzopsis asperifolia*
Witchgrass	*Panicum capillare*
Switchgrass	*Panicum virgatum*
Western wheatgrass	*Pascopyrum smithii*
Common reed	*Phragmites australis*
Littleseed ricegrass	*Piptatherum micranthum*
Plains bluegrass	*Poa arida*

Common Name	Scientific Name
Cusick's bluegrass	*Poa cusickii*
Inland bluegrass	*Poa nemoralis* ssp. *interior*
Fowl bluegrass	*Poa palustris*
Sandberg bluegrass	*Poa secunda*
Bluebunch wheatgrass	*Pseudoroegneria spicata* ssp. *spicata*
Alkali grass	*Puccinellia nuttalliana*
Tumble grass	*Schedonnardus paniculatus*
False melic	*Schizachne purpurascens*
Little bluestem	*Schizachyrium scoparium*
Common rivergrass	*Scolochloa festucacea*
Alkali cordgrass	*Spartina gracilis*
Prairie cordgrass	*Spartina pectinata*
Prairie wedgegrass	*Sphenopholis obtusata*
Alkali grass	*Sporobolus airoides*
Sand dropseed	*Sporobolus cryptandrus*
Sixweeks fescue	*Vulpia octoflora*
Agrohordeum	*xElyhordeum macounii*
Collomia	*Collomia linearis*
Ballhead gilia	*Ipomopsis congesta*
Needle-leaf pincushion-plant	*Navarretia intertexta* ssp. *propinqua*
Hood's phlox	*Phlox hoodii*
White milkwort	*Polygala alba*
Senega snakeroot	*Polygala senega*
Whorled milkwort	*Polygala verticillata*
Yellow eriogonum	*Eriogonum flavum*

Common Name	Scientific Name
Few-flower wild buckwheat	*Eriogonum pauciflorum*
Water knotweed	*Polygonum achoreum*
Water knotweed	*Polygonum amphibium*
Knotweed	*Polygonum douglasii*
Erect knotweed	*Polygonum erectum*
Pale smartweed	*Polygonum lapathifolium*
Pennsylvania smartweed	*Polygonum pensylvanicum*
Lady's thumb	*Polygonum persicaria*
Western dock	*Rumex aquaticus* var. *fenestratus*
Willow dock	*Rumex salicifolius* var. *mexicanus*
Wild begonia	*Rumex venosus*
Western polypody	*Polypodium hesperium*
Baby pondweed	*Potamogeton pusillus*
Clasping leaf pondweed	*Potamogeton richardsonii*
Sago pondweed	*Stuckenia pectinatus*
Rock jasmine	*Androsace occidentalis*
Sea milkwort	*Glaux maritima*
Fringed loosestrife	*Lysimachia ciliata*
Baneberry	*Actaea rubra*
Canada anemone	*Anemone canadensis*
Candle anemone	*Anemone cylindrica*
	Anemone patens
Tall thimbleweed	*Anemone virginiana*
Red columbine	*Aquilegia canadensis*

Common Name	Scientific Name
Western virgin's bower	*Clematis ligusticifolia*
Virgin's bower	*Clematis virginiana*
Little larkspur	*Delphinium bicolor*
Pasque flower	*Pulsatilla patens*
Early wood buttercup	*Ranunculus abortivus*
Alkali buttercup	*Ranunculus cymbalaria*
Sagebrush buttercup	*Ranunculus glaberrimus*
Long-beak water-crowfoot	*Ranunculus longirostris*
Macoun's buttercup	*Ranunculus macounii*
Labrador buttercup	*Ranunculus rhomboideus*
Cursed buttercup	*Ranunculus sceleratus*
Purple meadow rue	*Thalictrum dasycarpum*
Veiny meadow rue	*Thalictrum venulosum*
Woodland grooveburr	*Agrimonia striata*
Saskatoon serviceberry	*Amelanchier alnifolia*
Silverweed	*Argentina anserina*
Little ground rose	*Chamaerhodos erecta*
Fineberry hawthorn	*Crataegus chrysocarpa*
Shrubby cinquefoil	*Dasiphora floribunda*
Woodland strawberry	*Fragaria vesca*
Wild strawberry	*Fragaria virginiana*
Yellow avens	*Geum aleppicum*
White avens	*Geum canadense*
Prairie smoke	*Geum triflorum*
Tall cinquefoil	*Potentilla arguta*

Common Name	Scientific Name
Elegant cinquefoil	*Potentilla concinna*
Woolly cinquefoil	*Potentilla hippiana*
Norwegian cinquefoil	*Potentilla norvegica*
Bushy cinquefoil	*Potentilla paradoxa*
Pennsylvania cinquefoil	*Potentilla pensylvanica*
Wild plum	*Prunus americana*
Pin cherry	*Prunus pensylvanica*
Sand cherry	*Prunus pumila* var. *besseyi*
Chokecherry	*Prunus virginiana*
Prairie rose	*Rosa arkansana*
Wood's rose	*Rosa woodsii*
Red raspberry	*Rubus idaeus*
Catchweed bedstraw	*Galium aparine*
Northern bedstraw	*Galium boreale*
Balsam poplar	*Populus balsamifera*
Plains cottonwood	*Populus deltoides*
Quaking aspen	*Populus tremuloides*
Lanceleaf cottonwood	*Populus X acuminata*
Peachleaf willow	*Salix amygdaloides*
Bebb's willow	*Salix bebbiana*
Diamond willow	*Salix eriocephala*
Narrowleaf willow	*Salix exigua*
Prairie willow	*Salix humilis*
Sandbar willow	*Salix interior*
Shining willow	*Salix lucida*
Yellow willow	*Salix lutea*

Common Name	Scientific Name
Toadflax	*Comandra umbellata*
Alumroot	*Heuchera richardsonii*
Indian paintbrush	*Castilleja sessiliflora*
Clammy hedge-hyssop	*Gratiola neglecta*
Oldfield toadflax	*Nuttallanthus canadensis*
Owl clover	*Orthocarpus luteus*
White penstemon	*Penstemon albidus*
Narrowleaf penstemon	*Penstemon angustifolius*
Fuzzytongue penstemon	*Penstemon eriantherus*
Narrow leaf beardtongue	*Penstemon gracilis*
Waxleaf penstemon	*Penstemon nitidus*
Small clubmoss	*Selaginella densa*
Smooth carrion flower	*Smilax herbacea*
Blue ridge carrion flower	*Smilax lasioneura*
Clammy groundcherry	*Physalis heterophylla*
Virginiana groundcherry	*Physalis virginiana*
Common twinpod	*Physaria didymocarpa*
Buffalobur nightshade	*Solanum rostratum*
Cutleaf nightshade	*Solanum triflorum*
Broad-fruit bur-reed	*Sparganium eurycarpum*
Broadleaf cattail	*Typha latifolia*
American elm	*Ulmus americana*
Pennsylvania pellitory	*Parietaria pensylvanica*

Common Name	Scientific Name
Stinging nettle	*Urtica dioica*
Prostrate vervain	*Verbena bracteata*
Western vervain	*Verbena lasiostachys*
Hoary vervain	*Verbena stricta*
Blue violet	*Viola adunca*
Canadian white violet	*Viola canadensis*
Northern bog violet	*Viola nephrophylla*
Nuttall's violet	*Viola nuttallii*
Prairie violet	*Viola pedatifida*
Virginia creeper	*Parthenocissus quinquefolia*
Woodbine	*Parthenocissus vitacea*
Riverbank grape	*Vitis riparia*
Winter grape	*Vitis vulpina*
Horned pondweed	*Zannichellia palustris*

Source: NPS 2007a

Exotic Plant Species of Theodore Roosevelt National Park

Common Name	Scientific Name
Prostrate pigweed	*Amaranthus albus*
Rough pigweed	*Amaranthus retroflexus*
Poison hemlock	*Conium maculatum*
Russian knapweed	*Acroptilon repens*
Burdock	*Arctium minus*
Absinth wormwood	*Artemisia absinthium*
Biennial wormwood	*Artemisia biennis*
Plumeless thistle	*Carduus acanthoides*
Musk thistle	*Carduus nutans*
Spotted knapweed	*Centaurea biebersteinii*
Canada thistle	*Cirsium arvense*
Bull thistle	*Cirsium vulgare*
Prickly lettuce	*Lactuca serriola*
Sow thistle	*Sonchus arvensis*
Dandelion	*Taraxacum officinale*
Goats beard	*Tragopogon dubius*
Golden crownbeard	*Verbesina encelioides*
German madwort	*Asperugo procumbens*
Gypsyflower	*Cynoglossum officinale*
European stickseed	*Lappula squarrosa*
Alyssum	*Alyssum desertorum*
India mustard	*Brassica juncea*
Littlepod false flax	*Camelina microcarpa*
Shepherd's purse	*Capsella bursa-pastoris*
Blue mustard	*Chorispora tenella*

Common Name	Scientific Name
Hare's-ear-mustard	*Conringia orientalis*
Flixweed	*Descurainia sophia*
Wormseed wallflower	*Erysimum cheiranthoides*
Clasping pepperweed	*Lepidium perfoliatum*
Radish	*Raphanus sativus*
Tumbling mustard	*Sisymbrium altissimum*
Small tumbleweed mustard	*Sisymbrium loeselii*
Field pennycress	*Thlaspi arvense*
Tartarian honeysuckle	*Lonicera tatarica*
Smooth catchfly	*Silene cserei*
Bladder campion	*Silene latifolia* ssp. *alba*
Burningbush	*Bassia scoparia*
Lambsquarters	*Chenopodium album*
Oak-leaved goosefoot	*Chenopodium glaucum*
Russian thistle	*Salsola kali*
Prickly russian thistle	*Salsola tragus*
Field bindweed, creeping jenny	*Convolvulus arvensis*
Russian olive	*Elaeagnus angustifolia*
Urban spurge	*Euphorbia agraria*
Leafy spurge	*Euphorbia esula*
Black medic	*Medicago lupulina*
Alfalfa	*Medicago sativa*
White sweetclover	*Melilotus alba*
Yellow sweetclover	*Melilotus officinalis*
Red clover	*Trifolium pratense*

Common Name	Scientific Name
White clover	*Trifolium repens*
Common vetch	*Vicia sativa*
Catnip	*Nepeta cataria*
Asparagus	*Asparagus officinalis*
Blue flax	*Linum perenne*
Small fruited mallow	*Malva parviflora*
Common mallow	*Malva rotundifolia*
Crested wheatgrass	*Agropyron cristatum*
Desert wheatgrass	*Agropyron desertorum*
Smooth brome	*Bromus inermis*
Japanese brome	*Bromus japonicus*
Cheat grass	*Bromus tectorum*
Orchard grass	*Dactylis glomerata*
Barnyard grass	*Echinochloa crus-galli*
Bearded wheatgrass	*Elymus caninus*
Quackgrass	*Elymus repens*
Stinkgrass	*Eragrostis cilianensis*
Meadow fescue	*Lolium pratense*
Pearl millet	*Pennisetum glaucum*
Bulbous blue grass	*Poa bulbosa*
Canada bluegrass	*Poa compressa*
Kentucky bluegrass	*Poa pratensis*
Green bristlegrass	*Setaria viridis*
Intermediate wheatgrass	*Thinopyrum intermedium*
Common knotweed	*Polygonum arenastrum*
Prostrate knotweed	*Polygonum aviculare*
Climbing knotweed	*Polygonum convolvulus*
Curly dock	*Rumex crispus*
Narrow-leaf dock	*Rumex stenophyllus*
Common purslane	*Portulaca oleracea*
Annual buttercup	*Ceratocephala testiculata*
Dalmatian toadflax	*Linaria dalmatica*
Butter and eggs	*Linaria vulgaris*
Purslane speedwell	*Veronica peregrina*
Black henbane	*Hyoscyamus niger*
Hoe nightshade	*Solanum sarrachoides*
Saltcedar	*Tamarix ramosissima*
Narrowleaf cattail	*Typha angustifolia*
Siberian elm	*Ulmus pumila*

Source: NPS 2007a

Noxious Weeds of North Dakota

Common Name	Scientific Name
Russian knapweed	*Acroptilon repens*
Absinth wormwood	*Artemisia absinthium*
Musk thistle	*Carduus nutans*
Diffuse knapweed	*Centaurea diffusa*
Yellow starthistle	*Centaurea solstitialis*
Spotted knapweed	*Centaurea stoebe ssp. Micranthos*
Canada thistle	*Cirsium arvense*
Field bindweed	*Convolvulus arvensis*
Leafy spurge	*Euphorbia esula*
Dalmatian toadflax	*Linaria dalmatica ssp. Dalmatica*
Spotted knapweed	*Centaurea stoebe ssp. Micranthos*
Purple loosestrife	*Lythrum salicaria*
purple loosestrife	*Lythrum vigatum*
Saltcedar	*Tamarix chinensis*
Saltcedar	*Tamarix parviflora*
Saltcedar	*Tamarix ramosissima*

Source: USDA-NRCS 2007

ATTACHMENT 1

THEODORE ROOSEVELT NATIONAL PARK

RECOMMENDATIONS FOR MANAGEMENT OF ELK AT THEODORE ROOSEVELT NATIONAL PARK

ELK MANAGEMENT PLAN/ENVIRONMENTAL IMPACT STATEMENT, THEODORE ROOSEVELT NATIONAL PARK (THRO), NORTH DAKOTA

FINAL RECOMMENDATIONS OF THE SCIENTIFIC ADVISORY TEAM, 30 AUGUST 2007

SCIENCE TEAM MEMBERS

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EXECUTIVE SUMMARY

In this document, the Science Team provides recommendations for park managers to consider relative to management goals for elk in the South Unit of Theodore Roosevelt National Park. Specifically, we provide background information and recommendations on the following topics related to elk and vegetation management at the park: 1) considerations for population estimation and determining population objectives; 2) recommended maximum population size; 3) recommended minimum population size (considering genetics and population viability); 4) implications for management of population dynamics; and 5) our recommendations for monitoring to determine the success of management strategies.

As the park progressed through the early stages of the Environmental Impact Statement (EIS) process (internal and public scoping, development of alternatives, etc.), it became readily apparent to the Science Team that there were several reoccurring science-related questions and concerns frequently raised by NPS staff, cooperating agencies, and the general public. For that reason, we developed very specific "white papers" to address those reoccurring issues, and have attached them as appendices to this document. These papers serve(d) several critical functions, and in particular: 1) they serve as repository for our collective conclusions; 2) they provided a mechanism for a review and collective approval by the Science Team; 3) they provide an administrative record of our conclusions; and 4) they are the foundation for our recommendations. In an additional appendix we present park managers with various treatment scenarios to consider relative to their management goals for this elk population.

Briefly, the Science Team recommends that Theodore Roosevelt National Park continues to manage its ungulates at or below historical population levels. Given the unpredictable nature of precipitation in this region (hence forage production) and uncertainty inherent in the estimation of population size, forage production, and effects of herbivory on park vegetation, we believe that this conservative approach will continue to protect the range from overuse, and ensure that plant communities in the park continues to contribute to the diversity of the broader regional landscape. If ungulate populations are maintained at levels greater than historical objectives, then impacts of elk and other herbivores on plant communities should be the primary concern for park managers, and thus, extensive monitoring of vegetation will be critical. If on the other hand, ungulate populations are maintained at or below historical levels, as recommended by the Science Team, then monitoring of the ungulate population should become the primary concern.

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POPULATION OBJECTIVES AND POPULATION ESTIMATION

Population estimates for elk at THRO require aerial surveys; however, a proportion of elk are not seen during surveys. Estimates must thus be based on numbers of elk seen and on correction factors that compensate for uncertainties in elk detection. Because correction factors are estimates and proportions of elk seen during surveys are random variables, overestimates and underestimates of population size are inevitable. As a result, impacts of population manipulations cannot be predicted with certainty *a priori*. The following hypothetical example helps to illustrate that point:

Consider a post-removal population target of 200 elk and a pre-removal population estimate of 1,000 ± 250 elk. Assume the population estimate is based on the observation of 500 elk and an estimated detection rate of 50%. Removing 800 elk would result in a projected population size of 200 ± 250 elk. In such a case, the treatment could jeopardize the future of the elk population, and yet could not predictably be expected to reduce the population below the maximum desired population level.

For reasons that are evident from the preceding example, the Science Team has reached 3 conclusions:

1) Expressing population goals in terms of minimum numbers, rather than estimated numbers, would reduce the risk that uncertainty accompanying population estimates will lead to greater-than-desired reductions. Detection rates for elk surveys can be taken into account when minimum numbers are specified.
2) If the population is surveyed at least once annually so population estimates can be updated and projections can be calibrated, the risk of failing to accomplish population objectives will be greatly reduced.
3) Refining estimates of detection rates could substantially reduce uncertainty regarding elk numbers and management decisions.

MAXIMUM POPULATION SIZE AND CONSIDERATIONS FOR PREVENTING UNDESIRABLE IMPACTS TO PLANT COMMUNITIES

Plant communities exist in a state of dynamic equilibrium characterized by natural fluctuations in composition, which can be caused by such factors as grazing, drought, or fire acting singly and in combination. When influences on community composition change—for example, when the intensity of grazing or frequency of fire increases—communities can be driven from one state to another.

Transitions from late-successional states to earlier states can occur very rapidly, especially when disturbance factors interact: in contrast, restoration to desired conditions may require sweeping changes in management and a much longer period of time because of the need to accommodate the range of natural variation in environmental conditions typical of the region. Consequently, monitoring that includes both an evaluation of current ecological condition (seral stage) and trend, indicating the direction of change from a desired future condition (DFC), are extremely important. Unfortunately, the park does not have a current vegetation management plan for the park from which to identify DFCs for park vegetation. Given the rate at which the elk population in the park is growing, and the undesirable consequences it will have for plant communities in the park, the Science Team recommends that the park should not delay active management of the elk population until a vegetation plan is completed.

If we consider the park's management of elk and other ungulates since elk were reintroduced in 1985, and our conclusion that there has been no overt degradation of the range when managed at historical levels, we believe it is reasonable to conclude that past management has succeeded in achieving the objective of protecting vegetation from overuse. We acknowledge that although more or less ungulates (i.e., elk, bison, and feral horses) might have been maintained in the park during any given year—depending on precipitation and subsequent forage production—the conservative science-based approach adopted by the park was a responsible strategy for maintaining long-term health of the plant community, and viability of ungulate populations.

Therefore, after extensive discussion (Appendix B; Principles of Ecological Modeling with Implications for Elk Management at Theodore Roosevelt National Park), the Science Team concurred with the use of the forage allocation model developed by Westfall et al. (1993) to establish an upper population limit of approximately 400 elk. This limit, however, should not be misconstrued as a population objective. The Science Team does not anticipate adverse consequences for park vegetation or other wildlife if considerations other than forage production and effects of elk on plant succession lead to population objectives substantially below the upper limit. Science Team perspectives on relations between this upper limit and management objectives are summarized in Appendix C (The Concept of Carrying Capacity: Implications for Elk Management at Theodore Roosevelt National Park, North Dakota).

MINIMUM POPULATION SIZE

POPULATION VIABILITY

Elk at THRO have demonstrated rates of reproduction and survival that are among the highest recorded for any population (Sargeant and Oehler 2007). As a result, the Science Team believes the population could be reduced to <100 individuals without substantial risk to population persistence. The greatest risk to population viability at low numbers would likely result from uncertainty inherent in population estimates, which could lead to errors in the implementation of management prescriptions. Using minimum elk numbers, rather than population estimates, to track population status could help alleviate this risk.

POPULATION GENETICS

Although elk are presently abundant and widely distributed in North America, the species was extirpated from much of its historic range by 1900. Most restored populations, including the population at THRO, originated with stock that can ultimately be traced to Yellowstone National Park. Indeed, Hicks et al. (2007) recently reported that the genetic diversity of elk at THRO does not differ significantly from that of the Yellowstone population. Because elk derived from the same parent population are distributed throughout North America and some metapopulations number in the tens-of-thousands, the Science Team does not believe the THRO population contributes in a meaningful way to the conservation of genetic material.

The Science Team also considered the potential for deleterious effects resulting from inbreeding, but concluded that risks are minimal because the THRO population is not genetically isolated from other populations in the region. For example, tag returns from hunter-killed elk and movement records for elk marked with radio collars have documented the exchange of individuals from THRO with metapopulations inhabiting the Killdeer Mountains of North Dakota and Missouri Breaks of Montana. Moreover, the Science Team expects regional elk populations to gradually expand in numbers and distribution, leading to more frequent contacts with elk from THRO, as land management priorities and public tolerance evolve.

Hicks, J. F, J. L. Rachlow, O. E. Rhodes, Jr., C. L. Williams, and L. P. Waits. 2007. Reintroduction and genetic structure: Rocky Mountain elk in Yellowstone and the western states. Journal of Mammalogy 88(1): 129-138.

IMPLICATIONS OF MANAGEMENT FOR POPULATION DYNAMICS

Regardless of the method used, effects of elk management are manifested through changes in survival and recruitment. The Science Team used a deterministic population model to: 1) gain insights about potential consequences of changes in survival and recruitment rates; and 2) evaluate and refine preliminary conclusions reached via discussions. Simulations and Science Team conclusions are summarized in Appendix D.

MONITORING

A monitoring plan essentially describes a set course of action to observe and document how a management action is affecting a particular resource. The information gained through monitoring allows decision-makers to better understand whether or not the federal actions chosen provide the route best suited to mitigate any and all negative effects on the environment. Code of Federal Regulations section 1505.2 requires that after an EIS is finished pursuant with NEPA, a Record of Decision (ROD) must "state whether all practicable means to avoid or minimize environmental harm from the alternative selected have been adopted, and if not, why they were not. A monitoring and enforcement program shall be adopted and summarized where applicable for any mitigation." Therefore a monitoring plan must be developed as part of the NEPA process.

Further, under Section (1500.2)(c), agencies are required to "integrate the requirements of NEPA with other planning and environmental review procedures required by law or by agency practice so that all such procedures run concurrently rather than consecutively" (NEPA Overview and NPS Mandates pg 78). With this statute in mind, the Department of the Interior (DOI) also requires the National Park Service (NPS) to include “adaptive management” as an agency function. Adaptive management is a systematic approach for improving resource management by learning from management outcomes (Adaptive Management Guide pg. 1). This learning is based on taking an action, monitoring the effects of that action, and allowing the information gained in monitoring to inform subsequent management decisions and make adjustments as needed. The achievements and failures of certain actions in the management plan cannot be properly evaluated if the resources being managed are not monitored. Further, “an adaptive approach involves exploring alternative ways to meet management objectives” and “monitoring to learn about the impacts of management actions”, which essentially describes how NEPA is to be implemented at the practical level (Adaptive Management pg 1).

Also, a monitoring plan would help ensure compliance with the National Parks Omnibus Management Act of 1998 (NPOMA). Under Section 201, NPOMA states, “the purpose of this title…” is “to ensure appropriate documentation of resource conditions in the National Park System”. Monitoring for the Elk Management Plan would provide a useful tool for documentation of resource conditions. With the high level of variability in the affects of adjusting/managing the elk population on the grassland habitat, a monitoring plan is necessary to ensure proper management.

In the instance of the Elk Management Plan at Theodore Roosevelt National Park, a monitoring plan would not only benefit the park goals, but it provides the information necessary to meet the requirements of adaptive management and NEPA. It would supply data to ensure the chosen plan develops, meets expectations, and whether the plan needs adjustment or should continue as implemented.

Recognizing the previous requirements of NEPA and other NPS policies for monitoring, the Science Team envisioned two possible monitoring strategies that could be implemented by the park, depending on their final decision. First, if it is decided that ungulate populations should be maintained at levels greater than historical objectives, then the impacts of elk and other herbivores on plant communities should be the primary concern for park managers, and thus, extensive monitoring of vegetation would be critical. If on the other hand, ungulate populations are maintained at or below historical levels, as recommended by the Science Team, then monitoring of the ungulate populations becomes the primary concern, and extensive monitoring of vegetation at these conservative numbers would not be necessary.

Literature Cited

USDA Forest Service. 2002. Land and resource management plan, Dakota Prairie Grasslands: Final environmental impact statement. USDA Forest Service, Northern and Rocky Mountain Regions, Bismarck, North Dakota.

Sargeant, G. A., and M. L.O. Oehler, Sr. 2007. Dynamics of newly established elk populations. Journal of Wildlife Management, 71:1141-1148.

Westfall, J. A. Jr., L. R. Irby, and J. E. Norland. 1993. A forage allocation model for four ungulate species in Theodore Roosevelt National Park. Montana State University, Bozeman, Montana, USA.

APPENDIX A - JUSTIFICATION FOR PARK-BASED MANAGEMENT GOALS

The prevailing legal authority and guidance for management of natural resources on National Park Service lands is the National Park Service Organic Act of 1916. The Organic Act states that the NPS:

> *"shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified… by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."*

The "fundamental purpose" for a park is typically codified in the park's enabling legislation. Theodore Roosevelt National Memorial Park was established in 1947 as a memorial to its namesake. However, the legislation does not call for management of conditions present at the time of Roosevelt's residence at the site nor does the legislation prescribe other detailed management goals. Therefore, in the absence of clear guidance in the Organic Act or the park's enabling legislation, the next level of natural resource guidance for the park is the National Park Service Management Policies (National Park Service 2000).

NPS Management Policies state that parks will manage their lands for "natural conditions" (unless otherwise directed by enabling legislation or statute). Natural conditions are defined by the policies as "*the condition of resources that would occur in the absence of human dominance over the landscape*" (4.0).

The policies further state that the NPS:

> *"will try to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems. Just as all components of a natural system will be recognized as important, natural change will also be recognized as an integral part of the functioning of natural systems"* (4.1).

NPS policies do not dictate what the natural conditions are for a specific park unit, but rather, leave it up for the individual parks to determine. The policies do recognize that complete restoration of "natural conditions" may be unattainable and that human intervention may be necessary under certain circumstances (4.1). Parks are directed to prepare long-range management strategies that clearly identify the "desired future conditions" for a park using the "best available science" (4.1.1.).

NPS Management Policies also acknowledge that park units are parts of much larger ecosystems, and that parks can contribute to the conservation of regional biodiversity. Conversely, many parks cannot meet their natural resource preservation goals without the assistance and collaboration of neighboring landowners and resources. Therefore, the NPS Management Policies state that the agency:

> *"will pursue opportunities to improve natural resource management within parks and across administrative boundaries by cooperating with public agencies, appropriate Native American representatives, and private landowners. The Service recognizes that cooperation with other land managers can accomplish ecosystem stability and other resource management objectives … Such cooperation also may involve … providing essential habitats adjacent to, or across, park boundaries."* (4.1.4)

Using an ecosystem or landscape perspective is also consistent with the spirit and intent of the National Environmental Policy Act and with conservation biology principles and concepts. Collaboration allows for the conservation of resources that would otherwise not be possible.

Lower level guidance documents such as Director's Orders and NPS handbooks can sometimes expound or clarify on the Management Policies and statutes. However, there is no lower level guidance that clearly and directly instructs Theodore Roosevelt NP as to how to address the issue of elk overabundance and population targets. Existing park-developed management plans such as the General Management Plan, the Resource Management Plan, and other plans are also lacking in regards to specific guidance for management of elk at the park.

Therefore, it is incumbent on this EIS to develop detailed management goals and objectives that are consistent with the guidance and bounds set by the NPS Management Policies and other authorities. The emphasis of such goals shall be on the conservation of natural conditions and processes in the park while at the same time taking an ecosystem perspective.

Although empirical data are lacking, it is fairly well accepted by the scientific community that the pre-Columbian Great Plains was a temporally and spatially dynamic mosaic of grassland seral stages, a consequence of fire, grazing, weather, soil, and other factors (Collins and Glenn 1995, Knapp et al. 1999, Fuhlendorf and Engle 2001). This conclusion is based on the reports and journals of early explorers, on ecological theory and models, and on existing natural areas. Therefore, managing Theodore Roosevelt NP for a spatially and temporally dynamic system with a diversity of habitat types would be consistent with NPS policies. As long as the park was conserving a mosaic of grassland stages it could be generally inferred that it was conserving most or all of the native species and processes associated with the site.

The National Grasslands surrounding the park are currently managed for livestock grazing among other uses. The Forest Service has identified seral stage (specifically, for “grass and grass like life forms, as well as sagebrush”) as a means to meet compositional and structural vegetation objectives (USDA Forest Service 2002). Although monitoring of seral stage has been problematic and contentious, workable models have been developed (see Benkobi and Uresk 1996). The Forest Service defines seral stage as “the sequence of a plant community’s successional stages to potential natural vegetation” (USDA Forest Service 2002). The majority of the Forest Service lands are currently in early to mid-seral stages (likely the result of livestock grazing), with comparatively little in late seral stages. To better conserve biological diversity, the Forest Service has recently established the following seral stage goals for lands near Theodore Roosevelt National Park (USDA Forest Service 2002):

Early	Mid	Late
10-15%	65-75%	15-20%

Samson et al. (2003) recommended that the Little Missouri National Grasslands maintain 29-46% in “high” structural categories, analogous to late seral stages. They stated that species of conservation concern in the Northern Great Plains could most efficiently be conserved by “emphasizing low- and high-seral habitats.”

Since most rangelands in western North Dakota are generally heavily grazed it behooves the NPS to manage their lands for a lightly grazed condition. Some might argue that lightly grazed or ungrazed lands are not “natural” in the Northern Great Plains; however, Kay (1998) suggested that much of the Great Plains was lightly grazed, due in large part to the harvest of ungulates by aboriginal people. We acknowledge that providing specific recommendations for seral conditions is outside the scope of the current Science Team; however, we do recommend that the park maintain its efforts to develop a protocol for measuring and monitoring seral condition of selected grassland communities. This information will greatly facilitate the development and implementation of a vegetation management plan in the future, which in turn will help guide ungulate management.

We believe that once the park develops a protocol for monitoring of seral condition, and determines the status and trends of selected communities, managers will be better able to consider the park in a regional context with other adjacent lands, and to better evaluate its contributions to biodiversity, and evaluate efficacy of its management actions relative to DFCs identified by a vegetation management plan. The Science Team contends that various DFCs could be achieved by utilizing a scientifically established culling program of ungulates, by implementing an ambitious prescribed fire program, and by conducting a rigorous and timely vegetation monitoring program that feeds back into management decisions. However, we acknowledge that seral stage goals established for the park in the future may be less precise than those set by the Forest Service for the neighboring Grassland. Whereas the latter agency can set more specific targets because their land management program, which includes fenced pastures, tightly controlled stocking rates managed via a permit system, and the use of artificial water sources and supplemental feeding, the NPS generally limits management intervention to those actions that mimic natural processes. For those reasons, if it is ultimately determined that future seral stage objectives are not the desired targets, or that they are not achievable, or it cannot be determined that they are being achieved, we recommend that the park re-evaluate its vegetation objectives.

In summary, some of the advantages/justification for monitoring seral stage include:

- Seral stage can be reasonably linked to the NPS policies of conserving natural conditions and processes.
- Ecological heterogeneity at multiple scales, including diversity of seral stages, is the ultimate source of biodiversity and is the basis for ecosystem resilience.
- Seral stage measurements and sampling protocols can be information rich (they are typically comprised of floral species composition, relative abundance, and structural measurements).
- Seral stage is widely recognized as a critical component of ecosystems and therefore is monitored in some form by many entities including land management agencies near the park.
- Conservation of seral stages allows park management to best contribute to the conservation of regional biological diversity.

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APPENDIX B - PRINCIPLES OF ECOLOGICAL MODELING WITH IMPLICATIONS FOR ELK MANAGEMENT AT THEODORE ROOSEVELT NATIONAL PARK

PROBLEM STATEMENT

The forage allocation model developed by Westfall et al. (1993) has been central to discussions of population management objectives for elk at Theodore Roosevelt National Park. Discussions of that model have highlighted several common misconceptions about models and the role of modeling in wildlife management. Because it is likely that decisions about elk management will be based in part on the Westfall et al. (1993) model projections, decision makers must be well-informed about relevant aspects of the utility and limitations of ecological models. In this document, we review principles underlying the construction and use of ecological models, with an emphasis on issues with implications for elk management at Theodore Roosevelt National Park. We conclude by discussing an evaluation of the Westfall et al. (1993) model conducted by Irby et al. (2002) in the context of the modeling concepts we present.

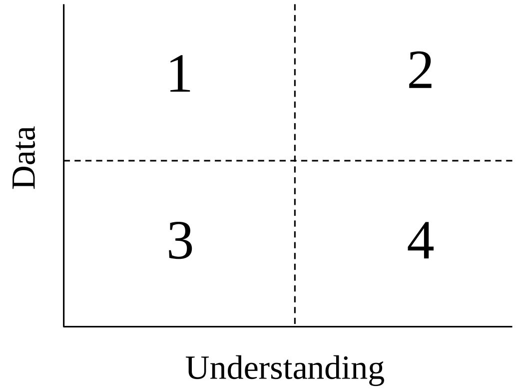
PRINCIPLES OF ECOLOGICAL MODELING

What is an Ecological Model?

Models are often perceived to be complex and mysterious. However, models are actually nothing more than abstract descriptions of systems or processes (Starfield and Bleloch 1986:1). In other words, a model is a formal framework for organizing and synthesizing existing knowledge of an ecological system. Model output is conditional on model structure, parameterization, underlying assumptions, and data quality. Consequently, models facilitate insights and decision-making, but do not produce new information.

The Principle of Parsimony

In wildlife management we often build models with limited data and an incomplete understanding of the system. A useful presentation of modeling was presented by Holling (1978) and is illustrated in the following figure.



In Hollings classification diagram, the x-axis represents understanding of a system (from limited to complete) and the y-axis (from incomplete to adequate) represents the quality and quantity of data that are available for use in model-building (Figure 1). Ecological models typically are based on limited data and incomplete understanding of systems, and thus fall in region 3 (Starfield and Bleloch 1991). Because of uncertainty surrounding our knowledge of the system and limited data, the use of complex models may not improve one's understanding of a system. Occam's razor is a logical guiding principle in ecological modeling: the simplest model that is consistent with existing knowledge is likely to be most appropriate and is most likely to produce reliable insights. Models should be no more complex than necessary to capture the key features of the system.

Uses of Models

In the context of resource management, a "good" model is one that promotes a better decision than could be made without it (Starfield 1997, Johnson 2001). Consequently, models may be very useful tools for decision-making even when they are based on imperfect data and incomplete understanding. The very process of model building helps us evaluate the relative importance of various influences on a system and identify data that should be collected.

Models can serve a number of useful purposes that Johnson (2001) assigned to the following categories: explanation, prediction, and decision-making.

- *Explanatory models* are used to describe or decipher the workings of systems.

- *Predictive models* are used to forecast future states of systems or results of management actions.

- *Decision support models* are used to identify management strategies that will produce desired results.

A given model may be used for more than one purpose. For example, models of elk population dynamics at Theodore Roosevelt National Park are being used to 1) investigate the relative importance of various population processes and 2) predict future elk numbers. The forage allocation model that Westfall et al. (1993) developed for Theodore Roosevelt National Park is a decision-making model that allows managers to estimate numbers of ungulates that will result in various levels of forage utilization. As a result, the Westfall et al. (1993) model allows managers to evaluate trade-offs with resource management objectives.

Characteristics of Ineffective Models

As frameworks for the organization and synthesis of existing information, "all models are wrong, but some are useful" (Box 1979). Ineffective or unreliable models maintain the following characteristics (Starfield 1997):

- Explicit accounting for processes that are not well understood.
- Explicit accounting for processes that are not relevant.
- Dependence on parameters that cannot be estimated precisely.
- Dependence on too many parameters (uncertainty is compounded).

Using Models Developed from Other Systems

Models are developed to meet specific objectives and are influenced by available data, knowledge of the system, and assumptions. Although many models are structurally similar (e.g., matrix models for demographic analyses), many models are uniquely suited for specific regions and applications.

When applying a model developed for another region and purpose, several important assumptions must be made. For example, you must assume that specified relationships are appropriate and relevant to your system, and that parameters in the model can be estimated precisely. Moreover, the model must have been developed for the same intended purpose. For these reasons, applying models from one system to another should be done judiciously.

USE OF THE WESTFALL MODEL FOR ELK MANAGEMENT AT THEODORE ROOSEVELT NP

Review of the Westfall et al. (1993) model by Irby et al. (2002)

Irby et al. (2002) evaluated a forage allocation model developed by Westfall et al. (1993) for Theodore Roosevelt National Park. Here we summarize their key findings.

- Maintenance of ungulates near optimal numbers identified in the model was associated with minimal negative changes in plant communities they monitored over a 12-15 year period. Some categories expected to decline under over-use, increased (e.g., climax graminoids). Some variables expected to decline under moderate, sustainable grazing did decline (e.g., bare ground).

- The model was not generally sensitive to low precipitation or to animal numbers close to maxima. Changes in vegetation that they interpreted as probable if animal numbers exceeded estimated carrying capacity under high or low precipitation conditions did not occur consistently.

- The model results were not overly sensitive to unpredictable events. During their monitoring period, portions of the Park burned (not portions with sample sites, however), two multi-year droughts occurred, prairie dog towns increased by > 100% reducing forage available for ungulates in some preferred habitat types (and destroying three sampling sites), and land impacted by leafy spurge increased from 280 to 730 hectares.

- The model optima were not developed based on the most sensitive plant species or communities. Their subjective observations as they walked to their monitoring sites indicated ungulates were using plant species and/or communities that were not captured by their model.

- When all attributes they measured were considered, the Westfall et al. (1993) model produced conservative estimates of maximum sustainable numbers for elk, mule deer, bison, and horses. At the same time, it did not predict that overuse would occur where animals were concentrated.

- The model was useful as a tool for planning future monitoring; it allowed managers to assess the feasibility of some ungulate population scenarios proposed by the public (more of everything) without risking plant community health.

The limitations of the Westfall et al. (1993) model discussed by Irby et al. (2002) are not uncommon or unique in ecological modeling. Because model output is conditional on model structure, parameterization, underlying assumptions, and data quality we should not expect any model to predict unpredictable events not considered in the model (#3 above). Moreover, the Westfall et al. (1993) model was parsimonious; it was no more complex than necessary to capture the *key* features of the system. Therefore, one should not expect the model to detect all subtle changes in vegetation (#1, #2, and #4 above). The model was built without complete understanding of the system; therefore, some estimates and features of the model might provide imperfect estimates for all features of the system (#1 and #5 above). Despite these inherent drawbacks of modeling, the Westfall et al. (1993) model was useful and maintained properties of a “good” model (#6 above); the model improved the management decision process. In other words, as with all models, there were drawbacks, but the Westfall et al. (1993) model proved extremely useful to managers at Theodore Roosevelt National Park.

Use of Other Models

With regard to elk management at Theodore Roosevelt National Park, it has been suggested that use of other forage models might help facilitate management decisions. In considering the utility of other models, the applicability of a model must be evaluated in terms of modeling objectives, the appropriateness of assumed relationships in the model, and the relevancy of those relationships.

Several modeling attempts to estimate carrying capacity or forage allocation of herbivores are available in the published literature (e.g., Hobbs and Swift 1985, Hanley and Rogers 1989) and some have been used in the Environmental Impact Statement process. For example, the model used by Grand Teton National Park is described on the internet as "supporting the development of the environmental impact statement for the National Elk Refuge in Jackson, Wyoming." The Grand Teton model is parsimonious and maintains a similar accounting type approach used by Westfall et al. (1993) to assess the number of ungulates that might be supported at 50% forage utilization (NREL 2005). It also considers how snow accumulation modifies the accessibility of forage. However, the Grand Teton model might be too simplistic given available data for elk in Theodore Roosevelt National Park. Data are available that would support use of a more sophisticated model. For example, the Grand Teton model does not consider plant species separately in ungulate diets: more detailed information is available for Theodore Roosevelt National Park and should not be ignored.

Other models to estimate carrying capacity of herbivores might be overly complicated for elk management objectives at Theodore Roosevelt National Park. The model of Hanley and Rogers (1989) considers nutritional constraints and restrictions in biomass consumption, which may or not be appropriate for elk at Theodore Roosevelt National Park. For example, the Hanley and Rogers (1989) model assumes that no one plant species may comprise more than 40% of the total dietary biomass and that only biomass greater than 25 kilograms per hectare is available for consumption. Their approach considers the availability of specific plants, but assumes that foraging dynamics will be largely dictated by nutritional constraints. The validity of these assumptions remains untested for elk at THRO. Therefore, use of a nutritional constraints model might unnecessarily include irrelevant parameters and assumptions.

Recommended Use of the Westfall et al. (1993) Model

As related to elk management at Theodore Roosevelt National Park, the forage allocation model by Westfall et al. (1993) represents the best available tool to establish the initial maximum elk population size for the following reasons:

- *The model was developed for Theodore Roosevelt National Park.* Consequently, specified relationships are appropriate and relevant to the system. The model appropriately considers forage species separately at Theodore Roosevelt National Park and forage selection (based on diet analyses conducted at the park) by elk and other ungulates.

- *The model is parsimonious*. The model considers only those parameters that are relevant. There is not an over reliance on parameters that cannot be estimated precisely. Instead, the Westfall et al. (1993) model captures the key features of forage allocation for elk and other ungulates at Theodore Roosevelt National Park. The use of more complex models would not necessarily improve our understanding of forage allocation at Theodore Roosevelt National Park.

- *The model promotes better management decisions than could be made without it*. Despite the difficulty in modeling complex systems, the Westfall et al. (1993) model is useful in making management personnel aware of the biological constraints they face when making management decisions (Irby et al. 2002). The model also provides a formal framework for organizing and synthesizing existing knowledge of Theodore Roosevelt National Park. It also allows for managers to consider appropriate trade-offs when implementing various management strategies.

Conclusions

For reasons discussed above, the Science Team views the Westfall et al. (1993) model as the best-available resource for the setting the maximum population limit of approximately 400 elk at Theodore Roosevelt National Park; however, this limit should not be viewed as the default population objective. Indeed, depending on other resource goals and objectives, the park may choose to manage below this limit. Moreover, the Science Team does not view model refinement as a necessary step in effective application of the model at the park. Furthermore, the model should not be used to establish new population objectives on a regular basis. Instead, after implementation of a management action, the effects of the treatment are directly observable through monitoring of the appropriate resource**.**

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APPENDIX C - THE CONCEPT OF CARRYING CAPACITY: IMPLICATIONS FOR ELK MANAGEMENT AT THEODORE ROOSEVELT NATIONAL PARK, NORTH DAKOTA

PROBLEM STATEMENT

The concept of carrying capacity is central to the topic of herbivore population regulation. However, inconsistent interpretations and terminology led MacNab (1985) to remark that “rarely in the field of resource management has a term been so frequently misused to the confusion of so many.” That confusion is evident in disparate definitions implied by the use of terminology in discussions of elk management at Theodore Roosevelt National Park.

WHAT IS “CARRYING CAPACITY?”

Use of the term “carrying capacity,” especially in the popular lexicon, often implies management objectives extrinsic to herbivores themselves. For example, plant associations have finite capacities for forage production. This constraint limits the number of herbivores a landscape can sustain over the short term. Over the long term, the removal of plant material by herbivores can influence plant succession and the landscape capacity for forage production. Consequently, carrying capacity is often defined with respect to the number of herbivores that can be sustained over the long term without incurring undesirable effects on plant communities. This range-management perspective can readily be generalized to other management objectives. For example, a species might be managed at a level consistent with public tolerance, or social carrying capacity.

In contrast, carrying capacity has also been defined with respect to demographic processes of animals. When forage is limited, herbivores may experience an increase in mortality rates or a decrease in birth rates. Consequently, the number of individuals added to the population annually (the annual increment) may decline at a progressively increasing rate as numbers grow. Ultimately, density-dependent changes in growth rates imply regulation of the population at a level where the average annual increment is equal to zero. In principle, this equilibrium population level represents demographic carrying capacity.

These disparate definitions have profoundly different implications for elk management at Theodore Roosevelt National Park. They describe different population levels, with dramatically different implications for park resources other than elk. To prevent further confusion, we will dispense with the term “carrying capacity” and instead discuss the implications of management strategies that are commonly associated with these definitions: “natural regulation” and “objective-driven” models for elk management. We conclude with a review of issues with ramifications for the selection of population objectives: these include the uncertainty associated with estimates of sustainable use, implications of population objectives for risk management, and implications of management objectives and strategies for animal welfare.

NATURAL REGULATION OF ELK NUMBERS

"Natural" regulation sometimes connotes regulation, mediated by nutritional restriction, at demographic carrying capacity. However, a clearer understanding of natural regulation requires the consideration of population processes and population states.

Historically, densities of native ungulates on the northern plains were spatially and temporally variable (Bailey 1926, Roe 1970, Hart 2001). Population processes were subject to the influences of aboriginal hunting and predation as well as nutrition, and animal movement profoundly influenced local herbivore densities (Laliberte and Ripple 2003). Modern-day circumstances at Theodore Roosevelt National Park are much different. The park is situated in a matrix of public and private lands managed for livestock ranching, mineral extraction, and agriculture, which likely contribute to disproportionate use of the park by elk. Elk are no longer subject to the influence of aboriginal hunting. Recruitment rates and survival rates are among the highest observed in elk and predation has not been documented (Sargeant and Oehler 2007).

Past experience supports informed speculation about the likely consequences for elk, vegetation, and other wildlife of Theodore Roosevelt National Park. Ungulate populations relieved of limitation by nutrition, predation, or hunting typically undergo an irruptive sequence that was described by Caughley (1970). In a stereotypical case, numbers increase rapidly and exceed the range capacity for sustainable use. Persistent effects of herbivory on plant communities lead to resource limitation, causing a marked population decline.

Most newly established elk populations exhibit high initial rates of population growth consistent with the irruptive sequence Caughley described (Murphy 1963, Burris and McKnight 1973, Gogan and Barrett 1987, McCorquodale et al. 1988, Eberhardt et al. 1996). Few examples exist, however, of elk populations that have experienced stereotypical population declines. Even the examples cited by Caughley (Banfield 1949) were precipitated by periodic severe winters, not by persistent changes in the plant community *per se*, and were succeeded by periods of population growth.

Elk are generalists with flexible dietary requirements (Cook 2002). Consequently, elk inhabiting relatively mild environments may be able to defer the demographic consequences of nutritional restriction by broadening diets. This flexibility exacerbates effects on vegetation by enabling elk to reach very high densities before nutritional restriction leads to a significant decline in survival or recruitment rates. In Missouri, for example, captive elk that reached a density of 0.043 ha^{-1} (11 mi^{-2}) were removed to alleviate "very heavy" utilization of available forage. Tule elk at Pt. Reyes National Seashore nevertheless sustained a high rate of increase ($r = 0.19$) at densities ranging from 0.733 ha^{-1} (190 mi^{-2}) to 1.043 ha^{-1} (270 mi^{-2}) (Howell 2002).

Elk populations may also continue to grow, and densities may remain high indefinitely, if such influences as range expansion, emigration, or hunting prevent nutritional restriction from occurring. For example, elk colonized the Fitzner-Eberhardt Arid Lands Ecology Reserve (ALE), which encompasses ca. 330 km^2 of arid shrubsteppe in south-central Washington, in 1972 (Rickard et al. 1977). Although the ALE remained the focus of elk activity, numbers of elk using adjacent lands increased with population size (Washington Department of Wildlife 2000). Rapid population growth continued until elk numbers ($\geq$838 in 1999) were reduced by hunting and live removals in 2000 (McCorquodale et al. 1988, Eberhardt et al. 1996, Washington Department of Wildlife 2000). Hunting removals in 2000 were facilitated by a range fire that destroyed much of the forage within ALE.

Based on the preceding examples, we believe elk densities will continue to increase rapidly in the short term and remain high indefinitely if the NPS does not regulate elk numbers at Theodore Roosevelt National Park. Through effects on forage availability and plant succession, high elk densities are likely to have repercussions for the welfare of bison and feral horses, which are confined to the park by a boundary fence. Population processes, elk densities, and the state of vegetation resulting from a "hands-off" approach to elk management will not be analogous to historical manifestations of "natural regulation."

OBJECTIVE-DRIVEN ELK MANAGEMENT

The elk population at Theodore Roosevelt National Park originated in 1985 with the translocation of 47 animals from Wind Cave National Park. In 1993, in response to rapidly increasing elk numbers, the National Park Service agreed to "periodically reduce the [elk] herd when numbers exceeded carrying capacity." Elk were subsequently captured and translocated from the park to reduce numbers when population estimates exceeded 360 animals.

This population objective was derived from a model developed by Westfall et al. (1993) and was intended to prevent undesirable effects on park vegetation. Clearly, the Service envisioned a "carrying capacity" driven by objectives for the management of park resources other than elk, and not by demographic responses of the elk themselves. Although vital rates of elk can be measured and related to elk densities relatively easily (given time and an adequately broad range of observed elk densities), they are not a suitable metric for measuring the effects of elk on other park resources. For example, demographic responses of elk may not precede undesirable consequences for park vegetation or other wildlife.

Although population objectives for elk at Theodore Roosevelt National Park have been based on a forage allocation model in the past, population objectives can be based on considerations other than the condition of vegetation. For example, elk population objectives have implications for visitor experiences, elk depredations, and the number of elk subjected to management actions.

POPULATION OBJECTIVES

In discussions of objective-driven elk management, the Scientific Advisory Team has identified 3 key considerations for the development of population objectives. These include uncertainty accompanying estimates of sustainable use, management of risks associated with various population objectives, and the implications of population objectives and management prescriptions for animal welfare.

Estimating sustainable use

Translating management objectives into population objectives is the principal challenge of objective-driven ungulate management. Difficulties associated with the estimation of sustainable use are seldom fully appreciated. However, predictions are difficult even for comparatively simple systems. For example, considerable uncertainty exists regarding numbers of cattle that should be sustained on the National Grasslands outside Theodore Roosevelt National Park (Report of the Scientific Review Team, Dakota Prairie Grasslands, 2005).

Sustainable use is much more difficult to predict for wild herbivores than for cattle, and will be especially difficult to predict precisely for Theodore Roosevelt National Park. In general, difficulties result because plant associations do not respond immediately to herbivory, forage production is subject to considerable environmental variation, short-term natural variation in the density of large herbivores is typically modest, and achievable sample sizes (replicate applications of grazing treatments) for studies of large herbivores are typically small. Additional complications will arise at Theodore Roosevelt National Park because 1) the herbivore community includes not only elk, but also bison, feral horses, prairie dogs, and a number of other species with diverse and flexible dietary requirements; 2) numbers of wild herbivores will vary annually and will not be known with certainty; 3) the landscape is complex and heterogeneous, the plant community is diverse, and the distribution of herbivore activity is uneven; and 4) annual environmental variation (e.g., in rainfall, hence forage production) is substantial.

Risk management

Pervasive use of the term “carrying capacity” is unfortunate because it introduces the anthropocentric ideal of managing for the maximum level of production consistent with some external goal. From a more objective point of view, managing a highly variable system at the margin of acceptable limits that are not known precisely poses a substantial risk of failure. Managers should therefore weigh the consequences of failure before choosing to manage for maximum production. Ranchers, for example, mitigate the risk of failure by monitoring range conditions continually and removing cattle or providing supplemental feed as needed to ameliorate emerging problems. In contrast, bison, feral horses, elk, and other free-ranging herbivores are not as tractable as cattle. Manipulating free-ranging populations on short notice may not be feasible.

Animal welfare

Implications of managing for maximum sustainable population size are paradoxical. If a population is to be reduced, a gradual, minimal reduction might seem desirable from an animal welfare standpoint. However, this strategy also maximizes animal production over the long term, hence the number of animals that must ultimately be treated to reduce and maintain the population at a desired level. This result occurs because the annual increment produced by a population well below demographic carrying capacity is proportional to population size. Over the long term, the strategy that reduces the population to the minimum acceptable level, as rapidly as possible, will minimize the number of animals treated or removed.

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APPENDIX D - SUMMARY OF SCIENCE TEAM DISCUSSIONS AND SIMULATIONS OF ELK POPULATION DYNAMICS

Sargeant and Oehler (2007) developed and parameterized a parsimonious density-independent deterministic model that described growth of the THRO elk population from 1987-2005. The Science Team used that model to explore the possible consequences of management prescriptions that could increase mortality rates or reduce fecundity. This document summarizes results of those simulations and conclusions that have been reached by the Science Team in discussions to date. The simulations summarized in this document have been reviewed only by members of the Science Team. Our objectives in conducting simulations were to gain insights about implications of vital rates and logistic constraints for population sizes and treatment intervals that might result under various management scenarios.

METHODS

The Science Team noted that it is possible to imagine an endless variety of management scenarios based on various tools that have been discussed (e.g., translocation, shooting, fertility control) and various treatment schedules. However, effects of various methods are all manifested through increased mortality or reduced fecundity. Simulations can thus provide general insights that transcend differences between management tools. The Science Team conceived and implemented a series of scenarios that were analogous to potential management strategies in some respects, but which can be viewed more generally as attempts to achieve a balance of 5 objectives by manipulating survival and/or fecundity of a model population:

1. Rapidly reduce elk numbers to <400.
2. Minimize the number of animals treated.
3. Minimize the frequency of treatments.
4. Minimize the maximum number of animals treated.
5. Sustain a population that includes approximately 100 cows, calves, and associated yearling bulls.

This list of objectives reflects the recommendations/suggestions made by the Science Team through various documents, as well as other concerns that have been expressed during Science Team discussions. Those included potential impacts of high elk numbers on park vegetation and other wildlife (1), animal welfare (2), logistic constraints associated with implementation (3 & 4), and persistence of the elk population (5).

Scenarios simulated by the Science Team included the following:

Scenario A-1 Survival rates of cows, calves, and associated yearling bulls temporarily reduced by 50% whenever the simulated population size exceeded 400.

Scenario A-2 Survival rates reduced by 63% for cows, calves, associated subadult bulls, and adult bulls during the first year; thereafter, survival rates reduced by 50% for cows, calves, and associated yearling bulls whenever the simulated population size exceeded 400.

Scenario B-1 Pregnancy rates reduced by 75%.

Scenario B-2 Pregnancy rates reduced by 90%.

Scenario C Survival rates reduced by 63% for cows, calves, associated subadult bulls and adult bulls during the first year; thereafter, survival rates reduced by 50% for cows, calves, and associated yearling bulls whenever the simulated population size exceeded 400 individuals. Pregnancy rates temporarily reduced by 50% whenever the simulated population size exceeded 400.

Scenario D Scenario A-1 implemented for initial population sizes ranging from 1000 to 1800.

Scenario E Similar to Scenario A-1 but with survival rates reduced by 10-50%.

Scenario F Annual survival rates reduced by 25% for cows only.

Scenario G Exponential population growth at rates of 20-30% annually.

We considered the following results and reported the most relevant comparisons:

1. Number of years required to achieve a population objective of <400 elk
2. Largest single annual removal
3. Total number of elk removed
4. Number of elk treated but not removed
5. Minimum numbers of cows, calves, and subadult bulls observed
6. Bull:cow ratios (included subadult and adult males)
7. Sex ratios (included all males)

The following features were common to all simulations:

- We specified a starting population size of 1000 and an initial population composition of 14% juvenile females, 11% subadult females, 38% adult females, 14% juvenile males, 11% subadult males, and 11% adult males. This composition was derived from a working draft of the projected herd composition for 2005 (Sargeant and Oehler 2007).

- Social groups of elk captured by the NPS in 1993 and 2000 included 0.66 subadult male per subadult female (n = 161 subadults). We thus assigned 66% of subadult males to social groups that consisted primarily of cows and calves (cow/calf groups). This issue plays a role in the feasibility of managing sex ratios because subadult males associated with cow/calf groups can be readily captured.

- In practice, some elk are overlooked during surveys used to plan management actions. We incorporated a "detection rate" of 0.75 and used it to compute numbers of elk observed in cow/calf groups. Our detection rate was based on estimated detection rates for elk surveys conducted at THRO in 2001 and 2004, but should be considered approximate.

- Unless otherwise specified, we treated sex and age classes in proportion to their representation in groups of cows, calves, and associated subadult bulls.

- Model projections represented counts obtained in January, prior to treatment. Treatments preceded reproduction.

- We used cause-specific mortality rates that did not include deaths due to hunting (i.e., mortalities due to hunting would have counted as removals in our simulations).

RESULTS AND DISCUSSION

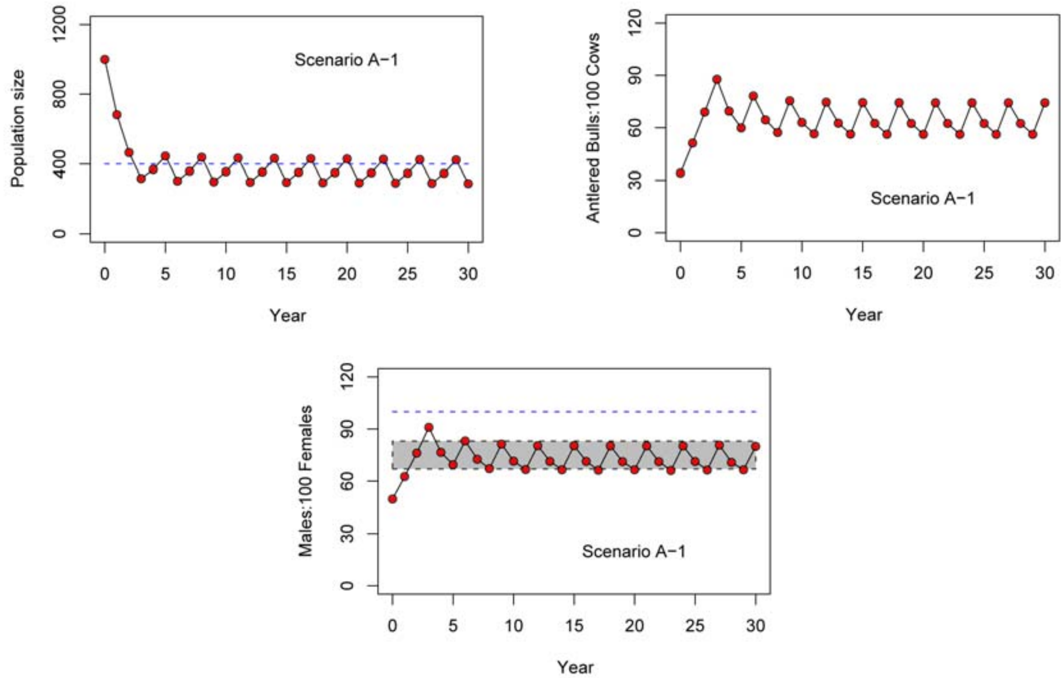
Scenario A-1: 50% reduction in survival

Scenario A-1 was analogous to removing cows, calves, and associated subadult males when elk numbers approached or exceeded 400. Scenario A-1 reduced our model elk population from 1000 in year 1 to 316 in year 4 by removing 860 elk. Thereafter, <200 elk were removed every third year. The minimum number of cows, calves, and associated yearling bulls observed annually was $\geq$84.

Because Scenario A-1 did not reduce survival rates for adult males, bull:cow ratios increased abruptly from 45:100 in year 1 to 100:100 in year 4. Despite high bull:cow ratios, sex ratios did not exceed parity. After elk numbers declined to <400, comparatively high mortality rates of bulls caused bull:cow ratios to decline and range from approximately 55:100 to 75:100.

Consequences of Scenario A depended on the composition (i.e., a representative sample of cows, calves and associated subadult bulls) but not the method of removal.

Figure A-1. Projected population sizes, bull:cow ratios, and sex ratios for Scenario A-1. In the plot of sex ratios, the dashed blue line corresponds with a population size of 400. In the plot of sex ratios, the dashed blue line indicates parity and the shaded region delineates a range of 67-83 males per 100 females.



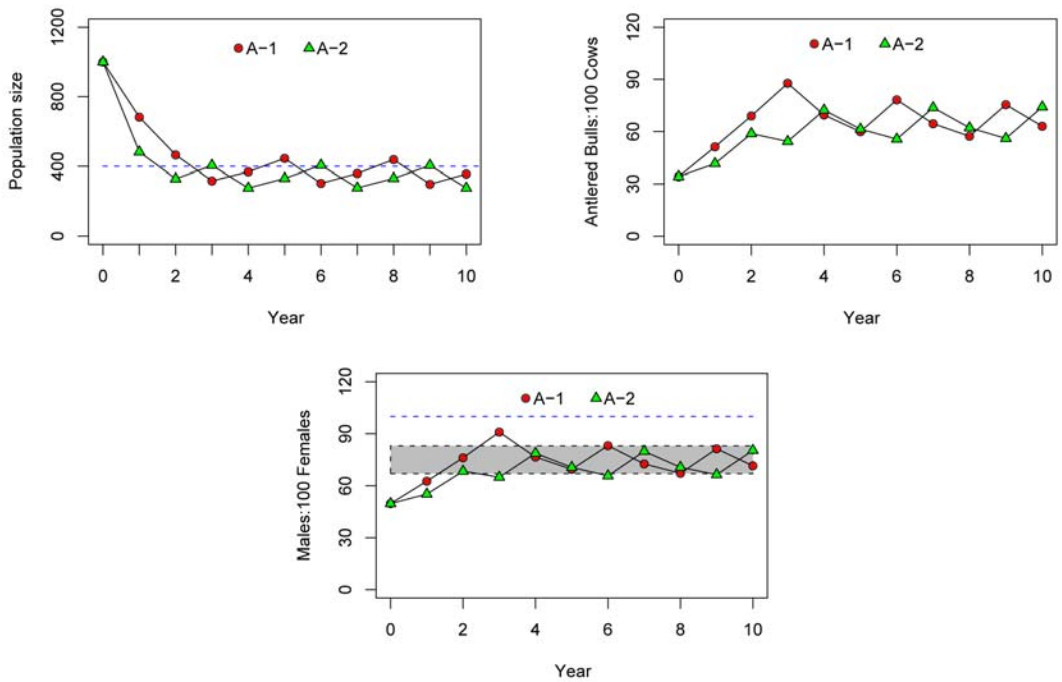
Scenario A-2: 63% reduction in survival

The Science Team noted that the number of cows, calves, and yearling bulls remaining after the first-year reduction in Scenario A-1 (213) could have been reduced further without jeopardizing population persistence. The Science Team also noted that reducing survival rates of adult bulls during the first year could have moderated the initial increase in bull:cow ratios observed under Scenario A-1. Scenario A-2 implemented these changes.

Scenario A-2 reduced elk numbers to <400 within 2 years (1 year less than for Scenario A-1) by removing 734 elk. Bull:cow ratios peaked at 83:100 in year 4. Sex ratios also peaked in year 4 at 87m:100f. These ratios are relatively high: for example, Bubenik reported that elk herds should have 67-83 males per 100 females (Raedeke et al. 2002). Opportunities to observe very high bull:cow ratios have been limited and consequences, if any, are uncertain.

Management prescriptions implemented in Scenario A-1 and A-2 were identical after year 1 and would have produced identical results, given the same starting values for the maintenance phase.

Figure A-2. Comparisons of projected population sizes, bull:cow ratios, and sex ratios for Scenarios A-1 and A-2. In the plot of sex ratios, the dashed blue line corresponds with a population size of 400. In the plot of sex ratios, the dashed blue line indicates parity and the shaded region delineates a range of 67-83 males per 100 females.



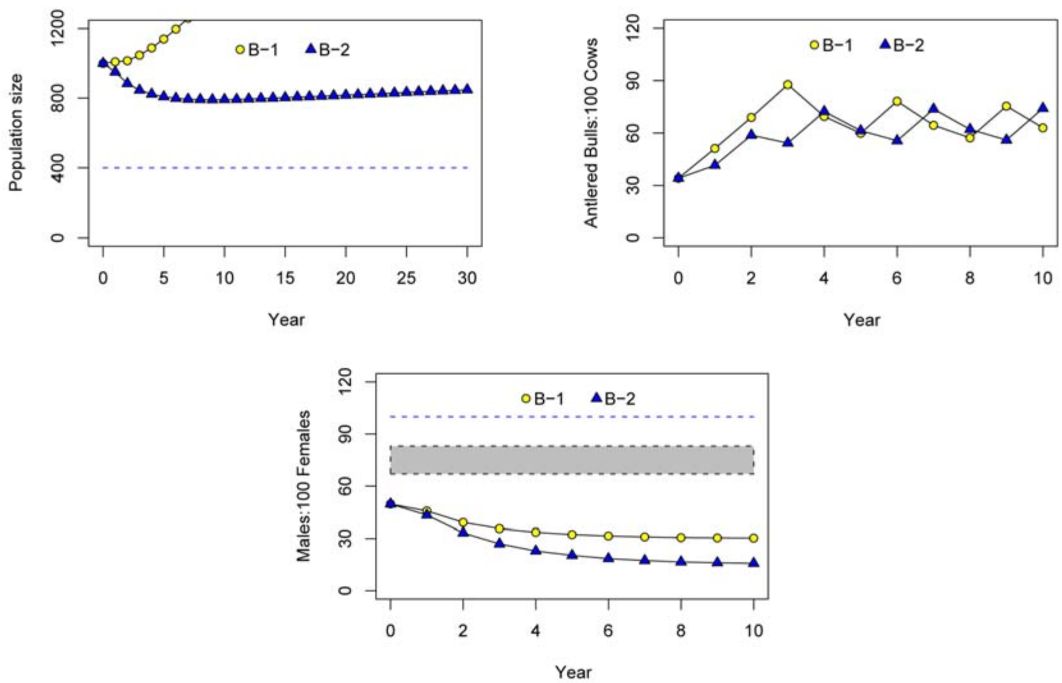
Scenarios B-1 and B-2: pregnancy rates reduced by 50 and 75%

Scenarios B-1 and B-2 were analogous to administering a contragestive (an agent that causes abortion) to pregnant female elk on an annual basis. Administering a contraceptive (an agent that prevents pregnancy) to an equal number of elk after parturition would have a lesser effect on population growth rates.

Terminating 75% of pregnancies annually led to a brief suspension of population growth. However, that result reflected a decline in the representation of adult males, which was caused by reduced recruitment acting in concert with higher mortality rates of males. Population growth resumed at a rate of 6.5% annually after bull:cow ratios and sex ratios declined.

Terminating 90% of pregnancies annually caused an initial reduction that resulted from declining sex ratios, but ultimately resulted in very slow population growth at a rate of 1.5% annually.

Figure B-1/2. Projected population sizes, bull:cow ratios, and sex ratios for Scenarios B-1 and B-2. In the plot of population sizes, the dashed blue line corresponds with a population size of 400. In the plot of sex ratios, the dashed blue line indicates untreated parity and the shaded region delineates a range of 67-83 males per 100 females.

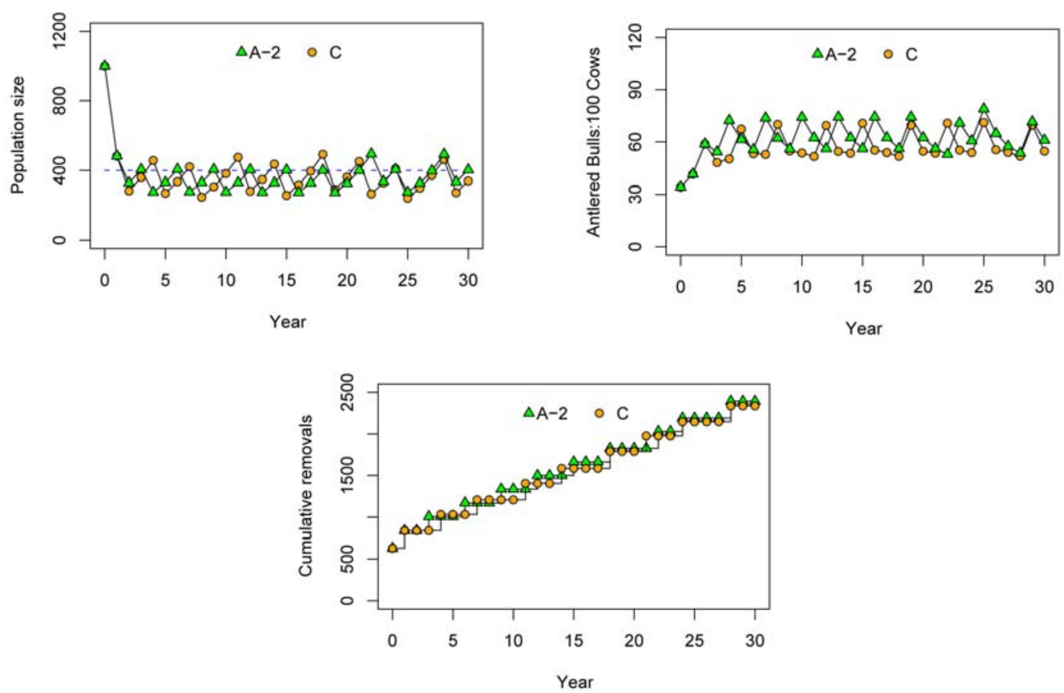


Scenario C: variable reduction in survival combined with 50% reduction in pregnancy rates

Scenario C was analogous to removing elk as described for Scenario A-2, then terminating pregnancies for 50% of remaining cows (i.e., 75% of cow elk were removed or treated). Treatment intervals, bull:cow ratios, and total numbers of elk removed for Scenario C were similar to results for Scenario A-2.

The Science Team expects that untreated animals would likely become progressively more difficult to locate, identify, and treat or capture as they dwindle in number; more so because an uncertain number of elk would be distributed across a large area typified by rugged terrain and patches of dense vegetation, and because elk may leave the park to evade capture. These considerations were the basis for capping the number of elk affected at75% for this scenario.

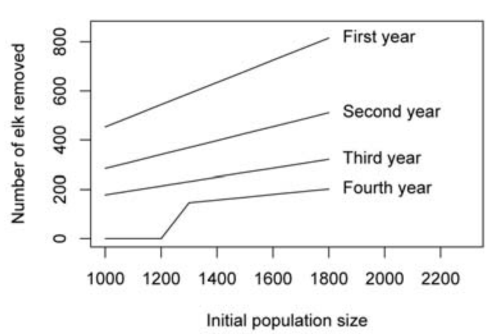
Figure C. Projected population sizes, bull:cow ratios, and cumulative numbers of elk removed for Scenarios A-2 and C. In the plot of population sizes, the dashed blue line corresponds with a population size of 400.



Scenario D: A1 with different initial population size

The Science Team implemented Scenario D to illustrate consequences of varying starting population sizes. Under the prescription implemented in Scenario A-1, the number of elk removed the first year was proportional to population size. Variable initial population sizes had a progressively smaller effect on numbers of elk removed annually after the first removal.

Figure D. Numbers of elk removed during the first, second, and third years of Scenario A-2 for initial population sizes ranging from 1000 to 1800.



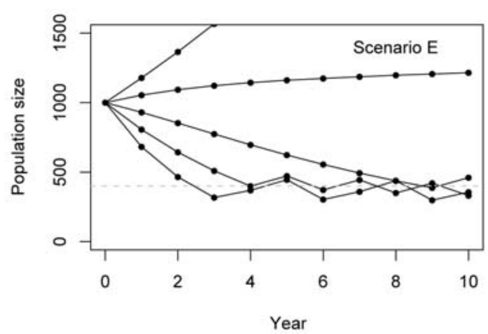
Scenario E: reduction in survival from 10 to 50%

In practice, logistic constraints might limit the maximum number of elk, hence the proportion of elk that could feasibly be removed in 1 year. For example, it might be feasible to remove 60% of 500 elk but only 30% of 1000 elk. In addition, uncertainty associated with estimates of elk numbers could cause the proportion of elk removed to vary substantially from expectations. For example, a manager attempting a 50% reduction might remove 200 elk from an estimated population of 400: however, the population might actually number 500 elk, resulting in an achieved reduction of 40%.

Scenario E emphasizes the sensitivity of population trajectories to proportions of animals removed. In other words, a modest change in the proportion of animals removed for management could have a substantial effect on the rate of population decline, hence the magnitude, duration, and frequency of population reductions.

Such sensitivity dramatically limits the ability of managers to predict the consequences of management actions that must be planned without access to perfect knowledge (e.g., based on population estimates rather than known elk numbers).

Figure E. Projected elk numbers for projections with survival reduced by 10% (top line) to 50% (bottom line) for cows, calves, and associated subadult bulls when elk numbers exceeded 400.



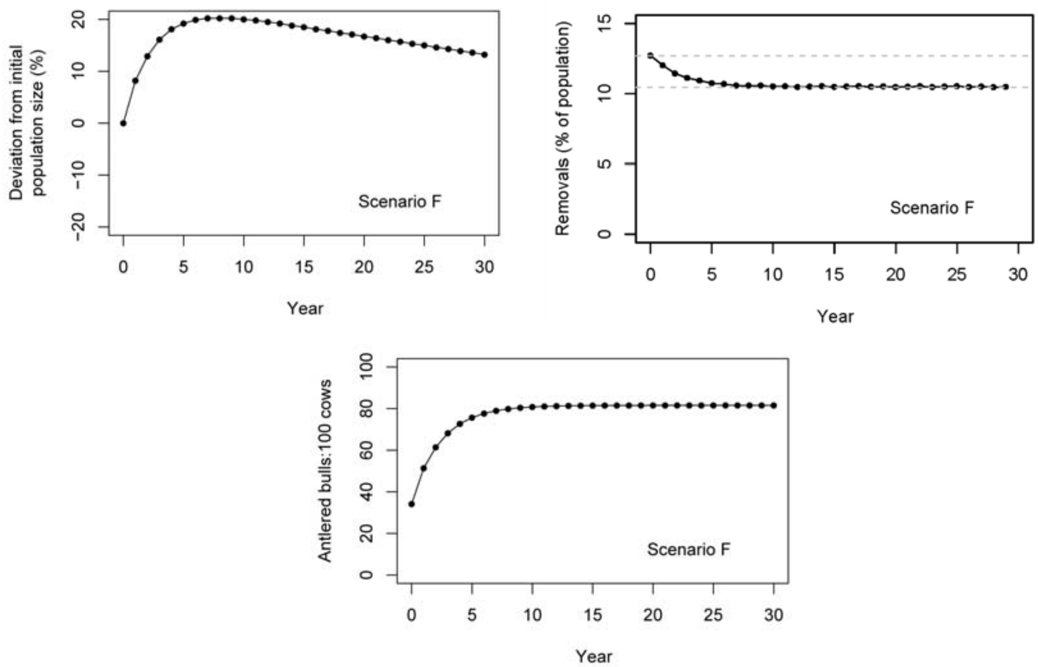
Scenario F: survival reduced to 25% for cows only

Scenario F was analogous to removing 25% of cow elk annually (10-12% of the simulated elk population) to stabilize elk numbers. Reducing survival rates of cow elk resulted in a temporary population increase (reflecting an increase in the representation of males), followed by a gradual decline.

Scenario F permitted a larger minimum population size (up to 400) than strategies that imposed population fluctuations. Total numbers of elk removed were a function of population size and could be either greater than or substantially less than for maintenance phases of scenarios that imposed population fluctuations (i.e., A-1 and A-2).

The initial growth and high bull:cow ratios observed under this strategy could have been mitigated by including calves in removals. In practice, preferential harvesting of males by hunters outside the park would also moderate changes in sex ratios that would result from preferential removals of females.

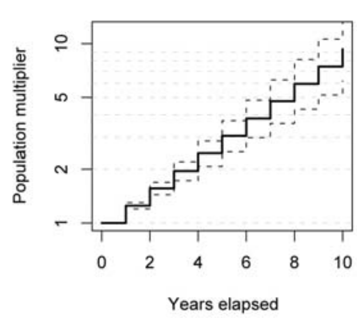
Figure F. Projected deviations of elk numbers from initial population size, proportions of population removed annually, and bull:cow ratios for Scenario F.



Scenario G; exponential population growth (20-30% annually)

For comparative purposes, the Science Team plotted exponential population growth at 20% (lower dashed line), 25% (solid center line), and 30% (upper dashed line) annually over a period of 10 years. Results represent population sizes as multiples of initial population size. For example, a population growing at 25% annually would double in approximately 3 years and triple in approximately 5 years. This result may be useful to the EIS team as they discuss strategies that vary with respect to the frequency or magnitude of treatments.

Fig. E. Exponential population growth at rates of 20% (bottom red dashed line), 25% (solid line), and 30% (top red dashed line). Population size (y axis) is presented as a multiple of initial population size for time spans of 0 to 10 years.



MANAGEMENT IMPLICATIONS

Model projections produced by the Science Team should be interpreted with caution and an awareness of limitations inherent in the use of models for prediction. Some of these have been addressed elsewhere in the Science Team white paper on ecological modeling. Others are addressed here.

Projections were based on a deterministic model that very accurately described growth of the THRO elk population from 1987-2005. However, a deterministic model developed to describe a particular realization of population growth cannot be expected to predict future population growth with equal accuracy because data used to construct models are subject to sampling variation, parameters themselves are subject to environmental influences (e.g., higher elk densities), and realizations of population growth are subject to demographic stochasticity.

In addition, real management prescriptions are not implemented with perfect knowledge. In our simulations, vital rates were manipulated exactly as prescribed and manipulations were triggered by actual population sizes. In contrast, management decisions will be guided by population estimates that will be subject to sampling variation and bias. Logistic constraints may also affect the implementation of prescriptions.

For these reasons, the Science Team viewed simulation as a learning tool, of greatest value for comparing the consequences of manipulating some factors while holding others constant. We used discussion and results of simulations to reach general conclusions about population dynamics. We have not prescribed or endorsed any management strategy: rather, we have tried to gain insights about the potential consequences of various strategies. Our conclusions include the following:

1. To succeed, management strategies must provide the flexibility and information needed to adapt prescriptions on an annual basis and thus compensate for such factors as environmental variation, consequences of uncertainty in the estimation of demographic parameters, logistic difficulties, and unforeseen events. Minimum information needs will include reliable population estimates.

2. In simulations, the Science Team was able to reduce and regulate elk numbers by removing animals when numbers exceeded population objectives (Scenarios A-1 and A-2).

    a. Simulations did not specify a method of removal or even require that removals be conducted by the NPS. For example, elk removed by hunting outside the park would have been counted among removals in simulations.

b. The number of animals handled annually during the reduction phase of simulated removals was approximately proportional to population size.

c. For fixed rates of removal, numbers of elk removed during the first year of reduction were proportional to initial population sizes. Initial population sizes had a lesser impact on numbers of elk removed in subsequent years (Scenario D).

d. Durations of reduction phases and treatment intervals during maintenance phases were quite sensitive to the removal rate (see Scenario E).

e. During maintenance phases, numbers of elk removed were similar to numbers removed from THRO by the NPS in 1993 and 2000 (Scenarios A-1 and A-2).

3. In simulations, the Science Team was able to reduce elk numbers initially and then prevent population growth by removing a relatively small proportion of the population each year (Scenario F).

   a. Science Team simulations did not specify a method of removal or even require that removals be conducted by the NPS. For example, elk removed by hunting outside the park would have been counted among removals in simulations.

   b. Simulated annual removals permitted a relatively large minimum population size and substantially reduced the maximum number of elk removed in a single year.

   c. The total number of elk removed depended on the population objective specified by the Science Team. For the same minimum population size, removals were less for this strategy than for periodic removals (Scenarios A-1 and A-2).

   d. Relatively large minimum population sizes pose less risk to population persistence and help to preserve genetic diversity.

   e. In practice, risks of substantial error (i.e., large departures from objectives) are likely to be least for relatively large population sizes and relatively modest manipulations.

4. Population estimates are subject to substantial sampling error. Resulting uncertainty raises the possibility that an overestimate of population size could lead to a larger population reduction than desired. After considering high rates of recruitment and survival that have been observed at THRO, the Science Team has concluded that the population could be reduced to approximately 100

cows, calves, and associated sub-adult bulls (and possibly further) without jeopardizing population persistence.

5. The Science Team could not accomplish timely reductions in the size of simulated populations by reducing pregnancy rates 75-90%.

6. Reducing pregnancy rates reduced the total number of elk removed to reduce and regulate simulated elk numbers (Scenario C). However, relatively large numbers of elk had to be treated to achieve relatively small reductions in numbers of removals.

7. In practice, decreased recruitment would cause the average age of adult female elk to increase. Mortality rates would increase as a result. We did not incorporate this behavior in Scenarios B-1, B-2, or C because we used a model that was developed without age-specific estimates of survival rates for very old elk. However, elk are long-lived and our simulated population was dominated by young animals. Consequently, we would expect effects of changing age structure to be manifested gradually and would not expect them to substantially change the nature of our results in the short term.

8. Fertility control in ungulates is an area of active research. Improvements in effectiveness or administration may warrant reconsideration of this management tool.

9. The Science Team noted that large-scale manipulations of ungulate populations may have unforeseeable consequences (e.g., disturbance associated with manipulations could result in emigration).

10. The model used by the Science Team shows promise for improving the precision of population estimates and for short-term (3-4 year) management planning. An extended version of the model, incorporating stochastic processes and uncertainty, would likely be a valuable tool for risk assessment. However, additional data collection will be required to assure the continued relevance of parameter estimates based on historic data. Key parameters include pregnancy rates (estimable from blood samples, rectal palpation, or necropsies), survival rates for adult females (estimable via mark-recapture or radio telemetry), and calf survival rates (estimable from age ratios, pregnancy rates, and adult survival rates).

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APPENDIX E - PRINCIPLES OF SERAL STAGE CLASSIFICATION AND MONITORING

PART I. BASIC PRINCIPLES

Numerous vegetation studies have been conducted in Theodore Roosevelt National Park and the adjacent Forest Service lands over the last 40 or so years. These studies include phytosociological classification of the major vegetation types and autecological evaluation of selected species. The vast majority of these studies were conducted prior to the introduction of elk in the Park in 1985 (Nelson 1961, Sanford 1970, Hladek 1971, Williams 1976, Aipperspach 1980, Hansen et al. 1980, Wali et al. 1980, Mastel 1982, Butler and Goetz 1984, Girard 1985, Hirsch 1985, Butler et al. 1986). Several of these studies used the Park as a reference for non-grazed or lightly grazed conditions (see Butler and Goetz 1984 for example). More recently, the vegetation of the Park was classified and digitally mapped following the procedures outlined by the National Vegetation Classification System (NVCS) as part of the National Vegetation Mapping Program (Von Loh et al. 2000). For this effort, detailed sampling plots were subjectively placed in vegetation that was representative of an area, relatively homogenous for that particular vegetation type, and covered more than 0.5 ha (the minimum mapping unit). The vegetation type was then hierarchically classified based upon the NVCS (www.natureserve.org). Although descriptions of plant alliances and associations (the two finest level of the NVCS) included discussions on select aspects of disturbance drivers and ecological conditions, no attempt was made during the classification and mapping process to assign seral stages to individual sample plots. Consequently, quantitative data on seral stage classification (ecological condition) is very limited for the Park.

Fluctuations in community composition can be caused by grazing, drought, fire or absence of fire acting singly and in combination. Such fluctuations are within the range of natural variation and are often used to define the dynamic equilibrium boundaries or state for a particular plant community (Herrick et al. 2000, USDA-NRCS 2003). Resistance and resilience are important community level characteristics of a state. Resistance describes the ability of the community to absorb disturbances and not change appreciably while resilience describes the ability of the community to endure disturbances and return its original condition once the disturbance is removed. However, plant communities are often subjected to disturbances outside the range of natural range of variation, which alters the ecological condition of the community and transitions it into another relatively stable state. Frequent and intensive grazing or droughts greater than historic levels can drive the community across the dynamic equilibrium threshold into a new state. Heavy grazing combined with a severe drought can greatly accelerate the transition process. Intensive inputs are often necessary to return a community to its original state. Consequently, monitoring that includes both an evaluation of current ecological condition (seral stage) and trend, indicating the direction of change, are extremely important.

A single, universally accepted method of assessing ecological condition through seral stage classification and evaluating trend in a heterogeneous landscape such as Theodore

Roosevelt National Park is not readily available. However, the classical approach to such questions usually involves identifying which specific abiotic and biotic factors at small spatial and temporal scales contribute the most to large scale patterns. In the process, the relevant community level attributes that may influence patterns and processes are identified and explored, and, when appropriate, extrapolated to scales suitable for long-term, sustainable management.

PART II: GOALS

1. Provide a preliminary evaluation of the ecological condition through seral stage classification and determine trend of select plant communities at the stand level using a combination of biological and edaphic characteristics.
2. Provide a mechanism for identifying areas that are potentially at risk of degradation (accelerated soil erosion, rapid shifts in plant composition, increase in non-native plants, especially invasives).
3. Help select monitoring sites as part of an overall landscape level monitoring program.
4. Provide a mechanism to communicate basic ecological concepts to a wide audience.

The approach is not designed to identify the cause(s) of any changes in the plant community at the stand level (see # 2 above). Achieving those goals will require more detailed analysis over relatively long periods of time.

PART III: GENERAL APPROACH

Seral Stage Classification

Plant associations suggested for possible evaluation include the Needle-and-Thread / Threadleaf Sedge Herbaceous Vegetation (STCO/CAFI) and the Western Wheatgrass – Green Needlegrass Herbaceous Vegetation (PASM/NAVI). The two associations respectively account for 51% and 8% of the total vegetated land area of the South Unit (Von Loh 2000). Both associations are characterized by major species that respond differentially to drought and grazing by large ungulates.

Needle-and-thread, western wheatgrass, and blue grama are the principal diagnostic species for the STCO/CAFI association. Green needlegrass, western wheatgrass, buffalo grass (or blue grama) are used to assess the PASM/NAVI association. Each species differs in their respective ability to tolerate or avoid grazing that conveys a relative degree of grazing resistance. Grazing tolerance consists of mechanisms that facilitate regrowth following grazing while grazing avoidance include those plant characteristics that reduce the probability and severity of grazing. Avoidance includes low growth form, spines or hairs on the plant, or secondary chemical compounds that reduce palatability. Plants that are more grazing resistant tend to increase in abundance and frequency under heavy grazing pressure (increasers) while plants that lack such characteristics tend to decrease (decreasers). Shifts in the relative contribution of increaser/decreaser species within the association can be used as assessment of change in the ecological condition, usually described by a successional sere, of a particular site

(Uresk 1990). Furthermore, similarity indices that compare current composition to historic climax condition are also valuable in concurrently assessing the ecological condition of a site (USDA-NRCS 2003).

The general technique is as follows:

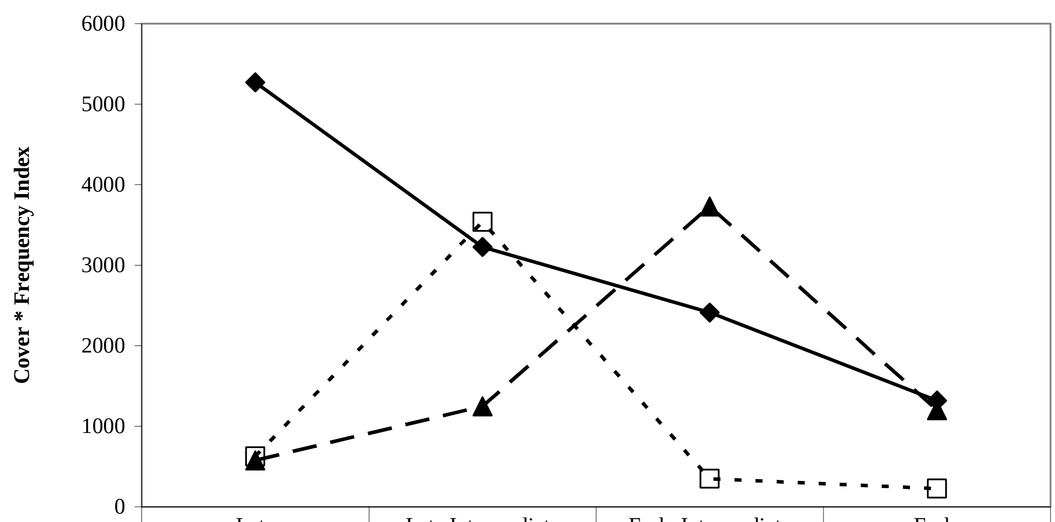
1. Establish 2 parallel permanent 30 meter transects 20 meters apart in an area of at least 800 square meters. Location of transects will be stratified according to elk location data (heavy, moderate, light, and no use). Specific site selection within each level of use will be conducted randomly.

2. Record canopy cover, using 6 cover classes, for the 3 major indicators species for each association within a 20 X 50 cm quadrat placed at 1 m intervals along each transect. Cover classes will also be assigned to litter, bare ground, and non-native plants.

3. The midpoint of each cover class will used to calculate average foliar cover for the 3 species for each transect. Multiply average cover and percent frequency for each transect, and average the two transects to produce an index value. The index value will be located within seral stage probability tables for that association to determine seral stage (see figure below).

General Seral Stage Classification Model

Needle-and-Thread Ecological Site



	Late	Late Intermediate	Early Intermediate	Early
Needle and Thread	5271	3226	2413	1319
Western Wheatgrass	626	3538	347	225
Blue Grama	577	1249	3730	1200

Seral Stage

4. Similarity indices using average percent foliar cover will be calculated for each level of use, and compared to historic (pre-1985) data when appropriate.

Determining Trend

Factors included in the evaluating the direction of change for each site include:

1. Amount of bare ground
2. Amount of litter.
3. Evidence of over-utilization of key plant species (plant vigor, hedging, browse lines, significant use of low-preference plants, etc.).
4. Contribution by non-native plants, especially invasive species.

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