THE ECOLOGY OF BISON MOVEMENTS AND DISTRIBUTION IN AND BEYOND YELLOWSTONE NATIONAL PARK

A Critical Review
With Implications for Winter Use and Transboundary Population Management

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The history and enormity of issues leading to this study have touched the professional or personal lives of a broad spectrum of Americans, including federal and state civil servants and citizens who care passionately about the integrity of Yellowstone National Park, bison conservation, or protection of livestock against reinfection with a zoonotic organism nearing eradication in the industry. Given the strong polarization among interests involved in these environmental conflicts, the authors feel privileged to have been welcomed by key informants to engage in exploration of their knowledge and insights, and in many cases to have been provided with unpublished data contributing to our assessment and recommendations. Foremost among those we wish to acknowledge as contributing to the assessment is Dr. Mary Meagher, whose passionate concerns for the conservation of Yellowstone bison and the integrity of the Yellowstone Park ecosystem have been uncompromising. We encourage her to continue analyzing the as yet unrealized potential of a data set spanning more than 30 years, complimented by experience in the Yellowstone ecosystem exceeding the duration of most professional careers in wildlife management. In contrast, Rick Wallen, the current bison biologist with the National Park Service, is just beginning to develop a research and management program. We thank Rick for contributing information and his insights to the assessment and hope in return that the report contributes to the development of his program. We are grateful to both Rick Wallen and Dr. Doug Smith for the experience and insights we gained while riding the Mary Mountain Trail with them in October 2004. Finally, we wish to acknowledge the enormous contribution to the project by Traci Weller of Bozeman, Montana. Traci organized and scheduled the interviews and workshops, recorded the dialogue and prepared transcripts. Her competency and humor sustained us through the arduous interview schedule.

CONTENTS

1

INTRODUCTION

Prehistorically, Yellowstone National Park (YNP) bison ranges were probably linked by migration to expansive grasslands surrounding the Yellowstone Plateau, particularly the Northern Range. Historical accounts indicate that interior ranges also supported resident bison. Market and subsistence hunting extirpated bison from the Greater Yellowstone Area by the late 1800s, except for a small remnant population in the remote interior of the park. Eventually, legislation and enforcement provided protection allowing the population to increase slowly. Bison from Montana and Texas were imported to restore the species to the Northern Range of the park in 1902, which together with the wild herd formed the foundation stock for the present day population. Intensive management limited the size of the population until the mid-1960s when a policy change of 'ecological management'[1] allowed large mammal populations in the park to self regulate in relation to ecological conditions. This form of management has been popularly referred to by the confusing term 'natural regulation'.

As the bison population increased, their range expanded, resulting in increasing numbers moving to contiguous habitat on the western and northern boundaries of the park. The YNP bison population carries the pathogenic bacterium *Brucella abortus*, which is infectious to cattle and people causing the disease brucellosis. Originating with cattle, the organism has been the subject of a national eradication program spanning 70 years and costing an estimated $3.5 billion in public and private funds. Fearful of the risk of transmission of brucellosis from wild bison to cattle, federal and state agencies negotiated the management of bison moving from the park into Montana at West Yellowstone and near Gardiner. Management actions have included hunting, culling by government personnel, capture and slaughter and hazing bison back into the Park. All have been controversial, especially when the combination of a large population and severe winter conditions induce migration of significant numbers of animals to the Montana boundaries where large removals have occurred. In one particularly harsh winter in 1996-1997, more than 1,000 bison were removed from the boundary ranges.

Since the early 1990s, concern has been expressed that grooming of roads in the park for oversnow vehicle (OSV) use has facilitated bison movements within and between ranges, including boundary areas, and that energy saved by bison travelling on packed snow in combination with better access to foraging habitat, results in enhanced population growth. Opponents of road grooming have sought to eliminate the practice, arguing impairment of the park. Protection of the park environment represents one set of interests in the debate over winter use; recreation and business interests are another. Since 1949, the public has had the opportunity to visit the park during winter using OSVs. A

[1] 'Ecological management' was the original term used in the document *Administrative Policies for Natural Areas, 1968*, which defined the new policy for management of plant and animal resources in national parks.

substantial winter recreation industry has developed around winter access to the park, contributing significantly to the regional economy. Proposals to restrict this activity are met with vigorous opposition from this sector.

The bison/cattle/brucellosis and the winter use/bison movement issues are functionally linked highly charged conflicts with public interests and agencies willing to engage in confrontation to protect their interests. Yellowstone National Park (YNP) was established by an Act of Congress in 1872 setting aside 2 million acres “dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people...” and "for the preservation, from injury or spoilation, of all timber, mineral deposits, natural curiosities, or wonders. . . and their retention in their natural condition.". The current controversy over the effects of winter use of groomed roads by bison reflects the inherent tension between the NPS’ dual mandates to accommodate public recreational enjoyment while protecting park resources. The bison of Yellowstone National Park are ecologically and evolutionarily significant because they are among less than a dozen free-ranging herds exposed to natural regulation and selection and the only free-ranging plains bison population on the continent that exceeds several thousand (Boyd 2002). Conservation of bison and maintenance of its ecological roles within the park system has created difficult relationships with agencies responsible for managing other public interests outside the park, such as disease risk to livestock.

Defining the common interest in a sea of conflicting values is a formidable challenge. To date, research has provided conflicting evidence of how groomed roads affect bison movements, energetics, and population productivity, and no research has provided a clear or convincing answer to the question. The notion that winter road maintenance facilitates bison movement, range expansion and increased population growth, was originally offered for bison on the Northern Range where the road is plowed in winter. The concept was elaborated a short time later for the Central Range where snow on roads is packed in winter.

The underlying ecology of bison movements and the influence of natural and anthropogenic features in the Yellowstone landscape are not well documented in the peer reviewed literature. Much existing knowledge exists in internal agency reports, unpublished manuscripts and data sets held close by researchers, and as expert knowledge gained through observation and experience. The available knowledge has not been systematically compiled or evaluated relative to current theories and concepts of ungulate movements and dispersal, nor have these sources been evaluated for uncertainties and knowledge gaps.

The Task

Winter use of groomed roads by bison in YNP is controversial, in part because bison moving beyond the boundary of the Park are subject to lethal control and other actions to prevent transmission of brucellosis to livestock. Two recent court orders concerning winter use and road maintenance were apparently contradictory. One on December 16, 2003 (Washington, D.C. federal court) directed the National Park Service to phase-out recreational snowmobiling by winter 2004-2005. The other on February 10, 2004 (Wyoming federal court) restrained NPS from doing so, and required a temporary rule for winter use that would be fair and equitable to all parties. The Washington, D.C. federal court noted that conflicting science exists concerning the effects of groomed roads on bison movements, finding the National Park Service (NPS) must “cogently explain why it has exercised its discretion in a given matter”, and when faced with conflicting evidence [disagreement between experts] the decision-maker must “identify the considerations he found persuasive”.

Consequently, the NPS identified a need for this project, the purpose of which was to: 1) produce a thorough,unbiased and independent assessment of the state of knowledge of the ecology of bison movements and distribution within the context of current published concepts and theories; 2) provide recommendations for adaptive management of uncertainties and gaps in reliable knowledge within adaptive environmental assessment and management and systems frameworks, including institutional structures and processes for adaptive and collaborative management planning to link science and management.

Structure of This Study

The principal investigators, Cormack Gates and Brad Stelfox (University of Calgary, Faculty of Environmental Design), were chosen because of their lack of previous association with issues related to YNP bison ecology or winter use management, allowing them to assess the state of knowledge and adaptive management from an unbiased perspective. The project was commissioned by the National Park Service (principal contact Dr. G. Plumb). The research contract was administered by the Rocky Mountains Cooperative Ecosystems Studies Unit (RM-CESU) based at the University of Montana (principal contact Dr. L. Broberg). RM-CESU operates independently and in association with a national network of CESUs.

The ecological, social, legal, and political complexities underlying the linked winter use/bison ecology and bison movements/brucellosis risk management issues required an interdisciplinary approach involving the integration of social and natural sciences concepts and methods. Interdisciplinary approaches are distinguished from multidisciplinary and monodisciplinary approaches by the manner in which complex problems are addressed. By interdisciplinary, we mean involving several unrelated academic disciplines in a way that forces them to cross subject boundaries to solve a common research goal. To develop the approach, we drew on concepts and methods from spatial and population ecology, systems dynamics modeling, adaptive environmental assessment and management, collaborative resource management, alternative environmental dispute settlement, and natural resource policy science.

We began by orienting to the problem through a review of documents and interviews of key informants to seek rapid understanding about what was known about the system, what the issues were, and the nature of people’s interests in the issues. We used a broad range of methods to acquire and organize available knowledge, and then integrated results using a dynamic systems model. It was understood from the outset that one of the central causes of ongoing conflict was not a lack of knowledge but a lack of policy process by which people and institutions can be constructively engaged in integrative decision making using the best available science.

For this project, we adopted an Adaptive Environmental Assessment and Management (AEAM) and a systems framework approach, recognizing the need as well for integration of principles and practices from other disciplines noted above. We addressed the issue in a broad sense, defining the ecological and management settings within which the issues are occurring. AEAM can be defined as the process of organizing people and their decisions around systems modeling and iterative hypothesis testing (Holling 1978, Blumenthal and Jannink 2000). Adaptive Management (AM) is the systems-modeling/hypothesis-testing aspect of AEAM that provides for use of the scientific method to test the outcome of management actions against objectives (McLain and Lee 1996). Its most effective form, "active" adaptive management, employs management programs designed to compare selected policies or practices, by evaluating alternative hypotheses about the system being managed (Nyberg and Taylor 1995). Adaptive management also refers to a process in which uncertainty is acknowledged, learning is an integral component of management, and the scientific method forms the basis for management experiments (Lee 2001, Lancia et al. 1996). Adaptive management provides for monitoring and evaluation of resource outcomes relative to objectives at specified intervals (Ringold et al. 1996, McMullin 1999).

Systems modeling emphasizes broad viewpoints, or the "big picture" view, so that interrelationships and interconnectivity are the focus rather than statistical precision, collection of complex data and empiricism. AEAM rejects the notion that all elements and interactions must be fully defined and understood to effectively manage a natural system. Systems modeling is employed to reduce complexity by identifying important components and interactions, thereby limiting the number of possible management options (Walters 1986). As stated by Holling (2000) "There is a requisite level of simplicity/complexity behind complex, evolving systems that, if identified, can lead to understanding that is rigorously developed but can also be lucidly communicated."

The state of knowledge of bison movement ecology was compiled by reviewing published and grey literature and conducting interviews with key informants including past and present agency personnel involved in research and/or management, university researchers, and others with local knowledge of the issues. We searched electronic databases and asked key informants for relevant documents. Literature was accumulated on ungulate movement, relevant research in YNP, pre-historical and historical information on bison in YNP, and legal and management documents relevant to bison management. We conducted semi-structured interviews with key informants to obtain information not available in published or unpublished documents (Robson 1993, Babbie 2001). Initially key informants were identified *a priori* based on their expertise. Additional key informants were identified during the interviews (the snowball method, Babbie 2001). Key informant interviews are considered an efficient method for rapidly learning and integrating local and scientific knowledge (Kloppenberg 1991, Stromquist et al. 1999). Some interviews were conducted with groups when key informants were compatible, e.g. part of the same research group/agency. A list of interviewees is provided in Appendix I.

The interview protocol received approval from the University of Calgary Conjoint Faculties Research Ethics Board. Before release of the final report, key informants had the opportunity to review information or statements attributed to them. They were asked to confirm that we correctly represented the information they provided, and were given an opportunity to modify inaccurate statements to their satisfaction. During interviews, we discussed background to the issues and key elements and processes influencing bison movements in YNP. We used a conceptual system diagram (Impact Hypothesis Diagram or IHD) to aid deliberative dialogue. The IHD identified system variables and interactions (e.g. forage distribution and quality, patch metrics, forage competition, predation), key system indicator variables (e.g. bison density distribution in the park and in relation to the park boundary), and extrinsic drivers (e.g. snow pack, geothermal patterns, and anthropogenic influences). We used the diagram to focus discussion on additional information and insights on feedback loops and interaction behaviors between system components. Maps were used to record spatial information (e.g. location of bison winter ranges and movement corridors) offered by interviewees using a technique known as 'interviewing the map' (Catley 1999). Spatial information was drawn by the interviewee on an acetate sheet overlaying a base map. Spatial data were digitized using ArcView Geographic Information Systems (ESRI 1999).

Information from the interviews was compiled and used as the basis for building a spatially stratified strategic level systems dynamics model representing bison ecology and management relevant to road grooming effects and bison management at the boundaries of the park. Technical validation workshops were held in October 2004 with five groups of key informants, two to three months after individual interviews were completed. A list of key informants invited to and participating in each workshop is listed in Appendix II. Technical Workshop Groups were assigned a unique number, which is not crossreferenced to a specific Group in the report to protect the confidentiality of individual participants in compliance with the policy of the University of Calgary on the Ethical Conduct of Research on Human Subjects.

A draft operating systems model was presented at workshops to seek further input and explore participant's understanding of the system. We used the Analytical Hierarchical Procedure (AHP; Berry 2003) to "weight" some of the key components of the model based on expert opinion. These were the parameters influencing the permeability of winter movement corridors (snow, thermal areas and forage) determined to be important during initial interviews. AHP allows key informants to rank the importance of each component against each other component; a weight defining the relative influence of each parameter is calculated from the ranking matrix. An average weight for a workshop group was calculated and used to attribute a group model. Additionally, key relationships and response surfaces were defined during the workshops. We created individual systems dynamic models that represented how each workshop group perceived the system. Separate models were constructed representing input from each workshop group. Some models were similar, thus an averaged model was produced. We used a standard set of scenarios and compared outcomes between models. Simulations enabled us to identify sensitive and uncertain components of the system and assess their potential influence on bison movement patterns and population dynamics. We identified system key drivers and relationships that require further research. A final technical workshop was held with Yellowstone Center for Resources personnel in late February 2005 to identify any technical inconsistencies or factual errors.

A facilitated workshop was held in Livingston Montana in late October 2004 for representatives of Environmental Non-Government Organizations (ENGO); 13 organizations were represented and 18 people attended (Appendix II). At this workshop, we sought further information on bison movements and ecology in YNP. The nature of the system was discussed using an IHD refined through previous technical workshops, and the graphical user interface from the model. In addition, there was general discussion of stakeholder issues.

Organization of the Report

A comprehensive review of the worldwide literature on the ecology of ungulate movements and distribution is provided in Chapter 2. It is important to consider environmental and historical contexts of bison in YNP to understand the current situation and identify potential future directions. Chapter 3 provides a review of the environmental setting and history of road and other infrastructure development and levels of use in YNP. Data on baseline conditions presented in Chapter 3 were used in building the systems dynamics model. Pre-historical and historical contexts of the issues, highlighting the history of bison the YNP area and their management, is provided in Chapter 4. Chapter 5 provides an assessment of available knowledge on bison distribution, movements and population ecology in YNP. Results of system dynamics simulations are presented in Chapter 6. In Chapter 7, we provide a synthesis of key findings of the assessment and offer recommendations for adaptive environmental assessment and management, monitoring and basic research needs. Recommendations are offered to improve the process of creating broadly supported management policy and actions, drawing on the theories and practices of environmental problem solving (Endter-Wada et al. 1998, Clark 1999), shared learning (Daniels and Walker 1996), collaborative decision making (Wondolleck and Yaffee 2000, Conley and Moote 2003) and policy process (Clark 2002). Recommendations are offered in recognition of a lack of clarity on the common interest of society, the historical power struggle and remaining deep divisions between agencies, and conflicting world views bearing on the issues of winter use management in YNP and containment of bison to mitigate risk of brucellosis transmission to livestock.