National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

A Comprehensive Review of National Park Service Ungulate Management

Second Century Challenges, Opportunities, and Coherence

Natural Resource Report NPS/NRSS/BRMD/NRR—2014/898

ON THE COVER
A Rocky Mountain bighorn sheep at Badlands National Park
Photography by: Dan Licht

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National Park Service
1201 Oakridge Drive
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Fort Collins, Colorado 80525

December 2014

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

National Park Service. 2014. A comprehensive review of ungulate management by the National Park Service: Second century challenges, opportunities, and coherence. Natural Resource Report NPS/NRSS/BRMD/NRR—2014/898. National Park Service, Fort Collins, Colorado.

NPS 999/127574, December 2014

Contents

Page

Figures v
Tables vii
Executive Summary ix
Authors xi
Acknowledgements xiii
Photo Credits xiii
Introduction 1
Ungulates as a Natural Resource 2
Terminology 2
Investigative Approach 3
Key Findings 5
Recommendations 11
Action Items 13
Appendix A: NPS Ungulate Management Working Group 15
Appendix B: Review of NPS Ungulate Management Plans 17
Objectives and Methodology 17
History of Ungulate Management in the National Park Service 17
Alaska-Specific Considerations 17
Native Ungulates 18
White-Tailed Deer 18
Rocky Mountain Elk 19
Bison 21
Management Techniques 21
Non-Native Ungulates 22
Conservation of Ungulates 23
Summary 24
Appendix C: NPS Ungulate Management Survey 35
Objectives and Methodology 35
Results and Discussion 35
Distribution of Native and Non-Native Ungulates 36
Management Issues of Concern to Parks 36
Concern for Management Issues Relating to Individual Species 37

Contents (continued)

Page

Management Activities Occurring in Parks (2000–2011) 38
Management Plans and Enabling Legislation 38
Summary 38
Appendix D: Interviews with Key NPS Personnel 49
Objectives and Methodology 49
Themes Emerging from Interviews 49
Overview 49
Management Contexts 49
Science 50
Additional Considerations in Decision Making 51
Proactive versus Reactive Management 51
Conclusions 52
Appendix E: Ungulate Management Workshop 53
Objectives and Methodology 53
Key Findings 53
Principles 54
Goals and Objectives 54
Issues and Concerns 55
Management Actions 55
Synthesis Discussion 55
Literature Cited 59

Figures

Page

Figure 1. Caribou at Kobuk Valley National Park. . . . 1
Figure 2. White-tailed deer at Fire Island National Seashore. . . . 2
Figure 3. Endangered Sierra Nevada bighorn sheep at Kings Canyon National Park. . . . 2
Figure 4. Mountain goats at Kenai Fjords National Park. . . . 3
Figure 5. Elk at Rocky Mountain National Park. . . . 3
Figure 6. Bison at Yellowstone National Park. . . . 4
Figure 7. Dall sheep at Denali National Park and Preserve. . . . 5
Figure 8. Bison at Grand Teton National Park. . . . 6
Figure 9. Mule deer at Bighorn Canyon National Recreation Area. . . . 6
Figure 10. Chronic wasting disease research is conducted on elk at Rocky Mountain National Park. . . . 7
Figure 11. Movements of moose are monitored at Voyageurs National Park. . . . 7
Figure 12. A fenced deer exclosure at Valley Forge National Historical Park. . . . 8
Figure 13. White-tailed deer at Valley Forge National Historical Park. . . . 8
Figure 14. Restored elk at Great Smoky Mountains National Park. . . . 9
Figure 15. Endangered Sonoran pronghorn at Organ Pipe Cactus National Monument. . . . 9
Figure 16. Mountain goats at Olympic National Park. . . . 10
Figure 17. Tule elk at Point Reyes National Seashore. . . . 11
Figure 18. Feral hogs at Pinnacles National Park. . . . 12
Figure 19. Pryor Mountain wild horses at Bighorn Canyon National Recreation Area. . . . 12
Figure 20. Recommended paradigm shift for NPS ungulate management wherein short-term management objectives should be accomplished as explicit components of a long-term consevation vision. . . . 13
Figure 21. Muskoxen at Bering Land Bridge National Preserve. . . . 14
Figure 22. A collared peccary at Saguaro National Park. . . . 14
Figure 23. Distribution of National Park Service units responding to the survey and reporting presence of native or non-native ungulates. . . . 40
Figure 24. From a summary presentation during the 2012 workshop “Ungulate Management in the NPS” held in Fort Collins, Colorado . . . 56
Figure 25. From a summary presentation during the workshop “Ungulate Management in the NPS” held February 2012 in Fort Collins, Colorado . . . 57

Tables

Page

Table 1. National Park Service management plans for native ungulates 27

Table 2. Methods evaluated or used by the National Park Service to control or reduce population size or effects of native ungulates. 29

Table 3. Methods rejected and not fully evaluated as an alternative for managing native ungulates under formal National Environmental Policy Act (NEPA) planning 30

Table 4. National Park Service management plans for 'desired' non-native ungulates. 31

Table 5. National Park Service management plans for 'undesired' non-native ungulates 32

Table 6. Number of National Park Service units responding to the survey with native resident or transient ungulate species occurring within unit boundaries. 41

Table 7. Number of National Park Service units responding to the survey that have considered restoring non-extinct native ungulates from 2000 through 2011. 41

Table 8. Number of National Park Service units responding to the survey with non-native resident or transient ungulate species occurring within unit boundaries. 42

Table 9. Average level of concern for management issues relating to non-domesticated ungulates occurring at National Park Service units responding to the survey. 43

Table 10. Level of concern for management issues relating to ungulate species occurring in National Park Service units responding to the survey. 44

Table 11. Management activities related to ungulates on which National Park Service units responding to the survey have spent time or money from 2000 through 2011. 45

Table 12. Ungulate species for which National Park Service units responding to the survey spent resources (i.e., time or money) on management issues from 2000 through 2011. 46

Table 13. Ungulate species for which conservation or management is specifically included in the enabling legislation of a National Park Service unit responding to the survey. 47

Table 14. Ungulate species for which National Park Service units responding to the survey have (currently or in development) a formal management plan. 48

Executive Summary

The National Park Service (NPS) "Call to Action" is forward-thinking as NPS prepares for a second century of resource stewardship (NPS 2011a). This review of NPS ungulate management contributes to several goals articulated in that vision: #20 "Scholarly Pursuits", #21 "Revisit Leopold", #22 "Scaling Up", and #26 "Back Home on the Range." Additionally, in 2011, the Director asked the National Park System Advisory Board Science Committee to answer three questions: What should be the goals of resource management in the National Park Service? What policies for resource management are necessary to achieve these goals? What actions are required to implement these policies? Broad in scope and implication, these questions and their answers are intended to help chart the course of NPS resource stewardship in the 21st century. This dialogue generated a call "to steward NPS resources for continuous change that is not yet fully understood, in order to preserve ecological integrity and cultural and historical authenticity, provide visitors with transformative experiences, and form the core of a national conservation land- and seascape" (National Park System Advisory Board 2012).

Within this overarching context, in 2011 the NPS Associate Director of Natural Resources Stewardship and Science (NRSS) requested the NPS Biological Resources Management Division (BRMD) undertake a comprehensive review of ungulate management by the NPS and allocated resources to support the array of activities described below that have informed this review. The overall goal of this review is to inform a servicewide coherent, effective, and efficient approach to ungulate management that is relevant and consistent with the NPS mission. BRMD convened and led a servicewide working group to conduct this unprecedented review with the objectives to: (1) ascertain the full spectrum of prevailing ungulate management issues and concerns, (2) identify key servicewide ungulate management needs, and (3) formulate recommendations towards addressing these needs. The investigative approach included an in-depth review of all known NPS ungulate management plans, a structured survey of NPS units, and formal structured interviews with key NPS personnel. A multi-day workshop attended by the working group and other NPS representatives also informed this review. Information from these activities provided the basis for the key findings, recommendations, and action items presented in this report. From the outset, this review strived to provide insights and generalized recommendations, rather than solutions for specific ungulate management situations, so as to inform a servicewide approach to ungulate management that is relevant and consistent with the NPS mission.

Protection of wildlife at Yellowstone National Park during the late 19th century represented some of the first formal wildlife protection programs in North America and laid the groundwork for a wide range of management practices within and outside the NPS during the 20th century. Within this history, the NPS has never before conducted a comprehensive review of ungulate management so as to help inform resource stewardship of ungulates and other natural resources across the NPS. As the NPS enters a second century of natural and cultural resource stewardship, the agency faces distinct challenges and opportunities for coherent and effective ungulate management. Findings of this report indicate that native and non-native ungulates now occur across at least 56% of all NPS units, comprising over 98% of NPS lands, with twice as many non-native than native species present. While the ecological, socio-cultural, and political

Banner photo: Muskoxen at Bering Land Bridge National Preserve.

complexities of ungulate management across the full breadth of the National Park System preclude a "one-size solution fits all" approach, contradictions across the agency cause many stakeholders to perceive that NPS ungulate management lacks overall strategic or coherent direction. This can result in undesirable outcomes such as internal and external confusion, strained relationships with partners and stakeholders, and ineffective and inefficient allocation of resources.

Based upon this review, a suite of guiding principles for ungulate management are offered to help NPS decision makers navigate the social and ecological complexities of managing ungulates through collaborations, partnerships, and networks with private, federal, state, and tribal land managers. Foremost amongst these guiding principles is to engage in strategic planning with potential partners to identify opportunities to actively restore, conserve, and manage native ungulates as wildlife at the large-landscape scales consistent with their dynamic ecological and cultural role. Within the scope of respective unit authorities, the NPS should continue to emphasize ecological process conservation amidst emerging broad ecological and social stressors such as climate change, land use changes, and invasive species as the principal management context for native and non-native ungulates on all NPS lands. NPS should move forward from any lingering emphasis on management of ungulates and their habitat to replicate a vignette of pre-European-contact America. Within a world of continuing ecological and social change, the NPS must continue to effectively manage near-term acute conditions while avoiding long-term over-reliance on static solutions to such near-term conditions. In other words, the NPS must strive to embed such near-term acute concerns and solutions into long-term adaptive management frameworks for conservation of native ungulates and their ecosystem processes at the large-landscape scale wherever possible. Renewed emphasis should be placed on deliberately controlling or eliminating non-native ungulates unless they are specifically identified in legislation as a park purpose.

Native and non-native ungulate management at the large-landscape scale will necessitate that the NPS undertake increased collaborative teamwork, strategic planning, and feasibility analysis with adjacent jurisdictions such as tribal, state, and other federal wildlife agencies. Often, this teamwork will challenge the NPS to actively seek innovations to preserve, yet merge, its mission with those of adjacent jurisdictions to identify and achieve mutually-agreed on large-landscape ungulate management objectives. The NPS also needs to emphasize innovative long-term stakeholder engagement and communication, especially where the spatial scales of ungulates transcend the park, and particularly when an ungulate species is managed differently across the National Park System due to different ecological and societal factors, and their relation to park purpose.

The NPS needs to continue its investment in ecological and social science capacity for ungulate management—emphasis should be on rigorous site-specific science through NPS assets and innovative partnerships with federal, state, tribal, and private groups, including the use of deliberate and well-founded citizen science. Integration of best available sound ungulate science into adaptive ungulate management is crucial to meeting the NPS mission. Key policy considerations require clarification regarding native and non-native population control. Additionally, in order to achieve optimal long-term management of ungulates, the NPS must empower its managers and scientists to gain and apply requisite skills for integration of biological and social science, law and policy, communication, critical thinking, and analysis at the large-landscape scale. Indeed, integrated thinking and solutions at large-landscape scales will be needed to address many natural resources challenges to NPS stewardship in the 21st century. After a century of contribution to the conservation of our nation's wildlife, the NPS is now poised to vitalize a second century of science-informed, large-landscape, and cooperative ungulate management.

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Acknowledgements

This report was a collaborative effort between NPS Washington Offices, regions, and parks. The undertaking would not have been possible without the foresight and support of NPS leadership, specifically NRSS Associate Director H. Frost and BRMD Chief E. Leslie. Special thanks to members of the NPS Ungulate Management Working Group for their collaboration and input throughout the project: S. Bates, J. Berger, M. Clarke, D. Decker, K. Faulkner, M. Foley, N. Gates, G. Hilderbrand, T. Hobbs, D. Jacob, T. Johnson, R. Kahn, K. Leong, D. Licht, R. Monello, T. Pinion, G. Plumb, J. Resnik, R. Wallen, P.J. White, and S. Windels.

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Introduction

In 2016, the National Park Service (NPS) will begin its second century of natural and cultural resource stewardship. Historically, ungulate management by the NPS has been carried out under a wide variety of management paradigms, often with considerable controversy (see Porter 1991, Sellars 1997, Olliff et al. 2013). For instance, over the last 100 years native and non-native ungulates in parks have been introduced, reintroduced, fed, hunted, shot by sharpshooters, rounded-up for live transfer or slaughter, herded out of parks, fenced in parks, fenced out of parks, euthanized, or treated with contraceptives. This cumulative history of NPS ungulate management, combined with present levels of variability as described in this report, influences the way in which many formal and informal partners and stakeholders gauge overall NPS wildlife management. Indeed, to many partners and stakeholders, the variability in NPS ungulate management is often perceived to be carried out without strategic direction and, at times, without explicit rationale.

All parks in the NPS system share in the common mission of stewardship of our national heritage. The NPS has authority to manage wildlife populations and habitats under the NPS Organic Act (16 USC 1, 2-4), the General Authorities Act, as amended (16 USC 1a-1 et seq.), and other authorities. NPS policies for wildlife management are set out in section 4.4 and other provisions of NPS Management Policies 2006 (NPS 2006). Within these overarching authorities and policies, there is (and should be) some inherent variability in stewardship amidst an agency that administers over 400 individual units from the South Pacific to the Arctic, New England, and the Caribbean; each unit engendered with unique enabling legislation, empowered with a variety of park-specific management directives, and situated in varied cultural, social and political settings.

Indeed, management of large mammals at national parks inevitably requires consideration of both the larger natural and human built landscapes in which a park is embedded. A challenge now facing the NPS lies in identifying the elements of ungulate management which can be coherent and consistent among all parks while remaining flexible enough to effectively manage individual parks. Currently, sharing and coordination of ungulate best management practices and knowledge between parks and regions is inconsistent, leading towards variable implementation of policies (or justifications for policies). Such perceived lack of coherent direction can affect the overall NPS mission by confusing stakeholders, straining relationships with key partners such as state wildlife agencies, increasing litigation, and fostering ineffective and inefficient use of limited fiscal and personnel resources.

Figure 1. Caribou at Kobuk Valley National Park.

Banner photo: Mule deer at Badlands National Park.

Since the mid-20th century, these considerations have prompted multiple partial reviews of NPS ungulate and wildlife management (see Leopold et al. 1963, Porter 1991, Wright 1992, Sellars 1997, Singer et al. 1998, National Research Council 2002, Demarais et al. 2012, Olliff et al. 2013), yet no previous effort attempted a comprehensive review of native and non-native ungulate management across the entire National Park System. In 2011, the NPS Biological Resources Management Division (BRMD) initiated this unprecedented servicewide review of ungulate management to determine management issues, needs, and recommendations. From the outset, this review strived to provide insights and generalized recommendations rather than solutions for specific ungulate management situations. Overall, the goal of this review is to inform a servicewide coherent, effective, and efficient approach to ungulate management that is relevant and consistent with the NPS mission. To meet this goal, BRMD convened and led a servicewide working group to conduct this review with the objectives to: (1) ascertain the full spectrum of prevailing ungulate management issues and concerns, (2) identify key servicewide ungulate management needs, and (3) formulate recommendations towards addressing these needs.

Figure 2. White-tailed deer at Fire Island National Seashore.

Ungulates as a Natural Resource

In order to understand ungulates within the NPS mission, one must first understand their role as a natural resource. Ungulates are particularly well adapted to large-landscape scale movement and consumption of vegetation, serving as both a core bottom-up trophic driver and focal recipient of top-down trophic pressure. There are approximately 220 species of ungulates globally, 12 species native to North America: bighorn sheep (*Ovis canadensis*), bison (*Bison bison*), caribou (*Rangifer tarandus*), collared peccary (*Tayassu tajacu*), Dall's sheep (*Ovis dalli*), elk (*Cervus elaphus*), moose (*Alces alces*), mountain goat (*Oreamnos americanus*), mule deer (*Odocoileus hemionus*), muskox (*Ovibos moschatus*), pronghorn (*Antilocapra americana*), and white-tailed deer (*Odocoileus virginianus*). For purposes of this report, we did not delve deeply into subspecies; yet recognize that management focus on subspecies may be warranted.

Figure 3. Endangered Sierra Nevada bighorn sheep at Kings Canyon National Park.

Most North American ungulates are ruminants, with a multipart stomach that permits effective digestion of both green and senescent vegetation, whose life history is governed by the interaction of herbivory and movement across variable spatial scales (e.g., several km^2 [local] to more than 10,000–100,000 km^2 [migration]). As a consequence of these drivers, ungulates express an array of species-specific ecological characteristics and processes (e.g., population, nutrition, behavior, predator-prey, genetics, disturbance, landscape, and nutrient cycling). The Revisiting Leopold report (National Park System Advisory Board 2012) recently observed that, "While individual parks can be considered distinct units, they are—regardless of size—embedded in larger regional and continental landscapes influenced by adjacent land and water uses… (p. 9)." Native ungulate management that strives for conservation of their evolved ecological processes at large-landscape scales is fundamental to achieving the comprehensive natural resource conservation mission of NPS.

Terminology

Much of the discussion in this document hinges on a common understanding of some important terms in NPS policy (NPS 2006a). Native species are defined as "all species that have occurred, now occur, or may occur as a result of natural processes on lands designated as units of the national park system (p. 43)." Non-native (or exotic) species are "those species that occupy or could occupy park lands directly or

Figure 4. Mountain goats at Kenai Fjords National Park.

indirectly as the result of deliberate or accidental human activities (p. 43)." Non-native species may include species that are native to North America but are not locally native to a particular area where they now occur. Not all ungulates fit neatly into the definition of native or non-native and not all non-native populations may be undesirable. For example, native populations could expand into new areas due to climate-related range shifts or expansions (we suggest such animals should still be considered native); and non-native ungulates may be desired in some NPS units and inhabit specific park lands for a specific park purpose.

Native animal population level is considered in NPS policy (section 4.4.2) but overabundance is not therein explicitly defined. For the purposes of this report, the term "overabundance" represents a high continuous concentration of ungulates that may negatively impact other resources or values at a park; often as a result of human influences such as loss of native habitat and top-level carnivores combined with creation of highly productive habitat surrounding a park (e.g., agriculture or urban landscapes). Ungulates can be perceived as overabundant due to the prevailing social carrying capacity (e.g. see Plumb et al. 2009) even if those populations are below biological carrying capacity in or near parks. In other situations, ungulates may have increased beyond biological carrying capacity due to absence of predators combined with habitat changes at the large-landscape level and restrictions on hunting. Conversely, ungulates can be perceived as underabundant to stakeholders desiring higher levels of wildlife harvest opportunities (Hilderbrand et al. 2013). Lastly, we use the term "park" in the generic sense to include all types of units administered by the National Park Service (e.g., historical sites, monuments, national parks, recreation areas, and preserves).

Investigative Approach

In September 2011, BRMD convened the NPS Ungulate Management Working Group consisting primarily of invited key NPS personnel from parks and regional offices (see Appendix A). Working group members represented all seven NPS regions and included individuals identified by their respective Regional Offices for their knowledge of issues in ungulate management, science, and planning. The working group was augmented by three invited senior academic and research specialists with substantial professional knowledge of ungulate issues in the NPS. A subset of the working group served as primary leads to gather and synthesize source information and prepare this report. The working group first developed the following set of questions to guide a comprehensive examination of ungulate management across the NPS system:

- What is the full spectrum of ungulate management issues/concerns?
- What are the prevailing goals and objectives for ungulate management?
- What core principles, if any, are guiding ungulate management?
- What management actions are being used or considered by the NPS?
- What are key ungulate management and planning needs?

The working group met regularly by conference call and pursued three lines of inquiry to address those questions: An in-depth review of all known NPS ungulate management plans, a detailed structured survey of NPS units, and formal structured interviews with key NPS personnel (see Appendices B–D). Analysis was aided by additional NPS representatives and other specialists convened and hosted by BRMD

Figure 5. Elk at Rocky Mountain National Park.

in February 2012 for a workshop in Fort Collins, Colorado (see Appendix E). Data and information from these lines of inquiry provided the basis for the key findings, recommendations, and action items summarized in this report.

Figure 6. Bison at Yellowstone National Park.

Key Findings

1. **Native and non-native ungulates occur across 98% of NPS lands, and active intervention management is increasing.**

A structured survey of 272 natural resource parks in the NPS indicated native and non-native ungulates now occur in at least 225 NPS units comprising over 98% of all NPS lands. On these lands, there are twice as many species of non-native ungulates than species of native ungulates (Appendix C). Our inquiry revealed that within the NPS there are three primary concerns motivating ungulate management: Population management of native species (which can include over- or under-abundance), non-native invasive species, and native species conservation (e.g., restoration of extirpated species). Each of these concerns likely requires development and application of specific NPS natural resource policies and guidance (see Appendices B and E). While conservation of native ungulates is core to the NPS mission, nearly all recent ungulate management planning by NPS has focused on reducing impacts from overabundant native ungulate populations or eliminating non-native ungulates. The high numbers of native and non-native ungulates in parks is generally attributed to application of the concept of "natural regulation" from the mid-1960s to the mid-1990s, the aim of which was to allow the "natural environment to be maintained essentially by nature" (Sellars 1997, Singer et al. 1998). This philosophy resulted in NPS ending ungulate culling programs in parks that, combined with absence of predators and hunting (in parks), led to ungulate population increases in and around parks. Formal native and non-native ungulate management plans have been developed for more than 25 parks during the last 20 years, though only limited consideration is now being given to larger-scale adaptive management of integrated issues (e.g., disease management, migration).

2. **NPS is progressing from emphasis on preservation of vignettes of pre-European settlement America towards ungulate management within the context of large-scale, emerging, and complex ecological and social issues.**

NPS is increasingly engaging in active ungulate management, both at the individual animal level and the population level, as evidenced by increasing emphasis on intensive ungulate management via formal planning since the 1990s. This transition is a recognizable departure from earlier emphases on reestablishing or maintaining a desired pre-European-contact ecological scene (per Leopold et al. 1963, also see Houston 1982, Sellars 1997). Indeed, the 1963 Leopold Report did not preclude active manipulation of resources, or

Figure 7. Dall sheep at Denali National Park and Preserve.

Banner photo: Non-native elk at Channel Islands National Park.

Figure 8. Bison at Grand Teton National Park.

dismiss the continuous change inherent to nature, but it did emphasize that, "A national park should present a vignette of primitive America (p. 3)." In the 50 years since the Leopold Report, the NPS has recognizably transitioned from this backwards-looking emphasis to development of solutions for near-term, acute ungulate-induced resource impact issues. Presently, only limited consideration is being given to long-term and dynamic ungulate management within the context of conserving large-scale ecological processes and emerging large-scale issues such as wildlife disease, non-native and invasive species, stakeholder values (including harvest demand), land-use change, and climate change. Since few NPS parks are large enough to incorporate landscape-level natural processes, one of the main challenges lies with managing ungulates in the numerous smaller parks that are embedded within these landscape-level processes.

The ecological, socio-cultural, and political variability in ungulate management situations across the NPS, combined with park-specific enabling legislation, precludes a "one-size solution fits all" approach. Yet, considerable contradiction prevails in ungulate management across the NPS that may not be necessary or desirable.

Both perceived and actual contradictions exist and contribute to internal and external confusion, strained relationships, lack of trust with partners and stakeholders, conflict and litigation, and ineffective/inefficient allocation of resources. Perceived contradictions exist primarily when external stakeholders have difficulty understanding and reconciling that broad NPS policies with wide latitude for discretion at the park level, combined with the wide range of management priorities between parks, may result in different management actions for the same species.

However, actual contradictions can be confounded with perceived contradictions to exacerbate this confusion. Actual contradictions prevalent across parks include: (a) inconsistent use of terminology, (b) recognizably different management techniques being used to address similar species-specific management issues, and (c) varying interpretation or application of law and policy. Further actual contradictions also arise from how the agency variably engages stakeholders, frames issues, and formulates decisions (Appendix E).

Broad agency policies with wide latitude for discretion at the park level, combined with a wide range of specific park purposes and local stakeholder groups, necessarily results in varied management situations and potential for recognizably different on-the-ground management for the same species. Some variation is inherent in an agency which manages hundreds of individual parks each with unique enabling legislation and varied management directives. These variations can be perceived by internal and external stakeholders as inconsistent management approaches, even if there may be some internal rationale behind the management direction. Perceived lack of transparency in decision-making processes also further confuses stakeholders about the basis for different management approaches across the NPS system. These contradictions help account for park managers' reporting that it can be very difficult to explain their park-specific ungulate management direction compared to other parks' approaches when they are perceived both internally and externally to NPS as similar situations (see Appendices D and E).

Figure 9. Mule deer at Bighorn Canyon National Recreation Area.

3. **For many parks, there is little or no in-depth or long-term site-specific ecological or social science available about ungulates or their management.**

Lack of science-based information to help address critical uncertainties about park-specific ungulate ecosystem processes and dynamics has posed and will continue to pose challenges to ungulate management decisions (see Appendices B and D). Most parks lack the fiscal and personnel resources or science partnerships to undertake and consider in-depth or long-term ecological and social science of ungulate management such as studies that address multiple trophic levels, incorporate local or traditional ecological knowledge, or systematically assess stakeholder interests and desires. This means that managers must often rely on the best available sound science from other geographic areas and often have to extrapolate from general scientific principles or use data from other geographic areas to frame local ungulate management issues and alternatives.

Figure 10. Chronic wasting disease research is conducted on elk at Rocky Mountain National Park.

Scientific information from multiple studies can be legitimately used for meta-analyses across studies towards robust understanding of ungulate ecology and habitat relations at scales larger than local measurements. However, there are limitations to this approach and inappropriately extrapolated science can lead to multiple complications, including difficulty explaining decisions to ungulate management partners (e.g., state wildlife agencies) and stakeholders. Failure to properly extrapolate across temporal and spatial scales can lead to improper framing of ecological processes and outcomes, contributing to the risk of accepting a working hypothesis that does not have adequate evidence to support it—a serious misstep for science-informed stewardship. Over-reliance on extrapolated science can also contribute to a mindset that additional site-specific science is unnecessary for effective stewardship. The NPS Inventory and Monitoring program has certainly made progress in providing helpful information about components of natural systems. Yet, information gaps and research needs persist and are important to address and disclose internally and externally to NPS.

4. **Most recent, formal NPS ungulate management plans have focused on reductions in ungulate population densities to protect key vegetation resources.**

Motivated by concern for ungulate over-browsing or overgrazing of vegetation, the NPS has recently focused on limiting the range of population densities at which some ungulate species can exist in a park. For example, most plans completed during the last 20 years on white-tailed deer and forest regeneration have prescriptive goals for an initial, targeted range of population densities (e.g., 6–8 or <10 deer/km^2; Appendix B, Table 1). These goals are typically established based on densities needed to promote deciduous forest regeneration, and are informed by scientists convened to participate in the planning process. This may be appropriate in the short-term to allow recovery of heavily grazed ranges or browsed forests.

Figure 11. Movements of moose are monitored at Voyageurs National Park.

For the longer term, it is preferable to allow variability in ungulate population dynamics by considering such things as forage quantity and quality, migration, and causes of mortality. A few management plans already incorporate this type of landscape-scale ecosystem approach. Allowing for long-term ecosystem variability and heterogeneity could be accomplished by tolerating greater variation in ungulate densities; pole-sized tree recruitment in some but not necessarily all time periods; and range conditions that are considered on average good, but variable, and not always maximized. Although adaptive plans that incorporate long-term variability may be more complicated and costly to plan for and implement than the currently emphasized planning framework, such plans would provide higher probability of long-term conservation of larger-scale ungulate ecological processes.

Figure 12. A fenced deer exclosure at Valley Forge National Historical Park.

The need for robust large-scale adaptive management strategies is further highlighted in that initially static density goals can address short-term issues such as over-browsing but long-term application of static densities could prevent a full evaluation of ecosystem influences and interactions, and thus ultimately hamper adaptive management abilities. For example, if a park is successful in keeping native ungulate density at or below the prescribed static target, the park may sacrifice its adaptive management capacity to understand how the system might respond to variability in long-term ungulate density. Opportunities exist to examine such issues in a broader adaptive management framework across multiple parks with similar issues.

5. Relatively few NPS ungulate restoration or conservation efforts have occurred over the last 20 years.

Servicewide, managers indicate that negative impacts of ungulates on vegetation and other park resources are a much larger concern than ungulate species conservation or restoration (Appendix C). Managers and staff also indicate challenges in acquiring and directing resources towards proactive ungulate conservation efforts. This situation is likely exacerbated through orientation of servicewide project funding towards mitigation of acute "severity of threat" topics. To our knowledge, there have only been a few efforts by NPS in the last two decades to re-establish a native ungulate within its historic range (e.g., elk in Great Smoky Mountains National Park). We recognize that such restoration opportunities may no longer exist for elk or deer due to disease concerns and the fact that many NPS units that historically had deer or elk currently have them. Yet, the few examples of proactive NPS ungulate conservation efforts within the last 20 years have largely been led by individual parks and do not reflect servicewide priorities.

Ungulate restoration and conservation needs persist in and around NPS units. Of note, the 2011 NPS Call to Action Item #26 "Back Home on the Range," coupled with the Department of Interior (DOI) Bison Conservation Initiative, recently elevated restoration of wild and free-ranging bison. Emerging science indicates there are significant opportunities to increase desert bighorn sheep meta-population connectivity and long-term viability in the southwestern U.S. via non-controversial efforts on NPS and adjacent lands. Several parks have the potential to become essential contributors to the long-term persistence of pronghorn populations. Aside from species restorations, the comprehensive approach used by a select few NPS native ungulate management plans can

Figure 13. White-tailed deer at Valley Forge National Historical Park.

serve as useful examples for how to integrate conservation of both ungulates and vegetation into a landscape-scale ecosystems context (see Appendix B).

Figure 14. Restored elk at Great Smoky Mountains National Park.

6. Interpretation and application of NPS natural resource policy to non-native ungulate management is highly variable.

There is need for clarification and guidance about policies regarding non-native ungulates (see Appendices B and E). Currently, non-native ungulates are essentially organized by three broad categories of management emphasis on NPS lands: (1) non-native species considered a cultural resource, whose presence is desired as a positive contribution to the purpose of a park; (2) non-native species whose presence is not aligned with park cultural or natural resource values, and may or may not be actively managed to minimize population or impacts; and (3) non-native species whose correlation with park purpose has not been resolved, and they are thus not being actively managed for various reasons.

NPS policy explicitly identifies conditions that must be fulfilled to manage a non-native species, up to and including eradication: control must be prudent and feasible; and the non-native species must interfere with, disrupt, or damage park resources, or significantly hamper their management, and/or pose a public health or safety hazard. However, NPS policy also suggests that non-native species may be removed even when they have not yet interfered with, disrupted, or damaged park resources, e.g.: "Lower priority will be given to exotic species that have almost no impact on park resources or that probably cannot be successfully controlled" (NPS 2006a, section 4.4.4.2).

7. Stakeholder engagement and potential development of partner relationships are not a consistent high-priority for NPS ungulate management, despite the recognized need for improved agency capacity for ungulate management through stronger stakeholder support and partnerships.

Locally, ungulates using NPS units often move across jurisdictions (e.g., state, federal, tribal, and private lands). Park managers recognize that stakeholder perspectives and values affect ungulate management issues, concerns, problems, and solutions. However, aside from National Environmental Policy Act (NEPA) public scoping processes, there are underutilized opportunities for seeking and integrating in-depth stakeholder engagement so as to best understand stakeholder beliefs, attitudes, preferences, and motivations regarding ungulate management. Rather than logically simple problems, a majority of NPS ungulate management falls within what are called "wicked" problems, whereby problems are not only complex but are interpreted differently by stakeholders with varying beliefs and values (Rittel and Webber 1973, Allen and Gould 1986, Balint et al. 2010). This often leads to disagreement about what the focus of management should be and what science is relevant.

Ungulate movement across multiple jurisdictions and the nesting of parks within large-landscape ecological processes inherently means interdependence with local and regional stakeholders (e.g., state agencies, non-governmental organizations, communities, landowners) and thus the inevitable need for more collaborative approaches within a coupled natural-human systems framework (see Machlis et al. 1997). This ultimately brings about the type of shared- or co-management promoted in the Revisiting Leopold report (National Park System Advisory Board 2012), where agencies working within their own missions and mandates are collectively contributing to larger goals. Of note, parks may

Figure 15. Endangered Sonoran pronghorn at Organ Pipe Cactus National Monument.

serve as a source ungulate population for both undesirable (e.g., vehicle collisions, browsing) and desirable (e.g., hunting, non-game viewing) outcomes on adjacent lands and jurisdictions. Thus, multiple and varied stakeholders are certain to hold strong and emphatic beliefs and attitudes about ungulates associated with parks.

Direct communication and social science can be used to build better NPS understanding of multiple stakeholder beliefs and attitudes, and incorporate different types of knowledge into ecological models. Coupling of social and ecological considerations can help NPS more comprehensively address the drivers and stressors of ungulate management challenges and opportunities. Yet, NPS seldom couples insight from social sciences with ecological sciences to understand the broader ungulate management system. Currently, the NEPA process for public participation in ungulate management planning relies on a "public input" approach to governance (Leong et al. 2009, 2011) whereby agencies seek input from individual stakeholders or groups, and the focus is typically limited to the agency learning about and categorizing stakeholder interests.

Exclusive reliance on this approach may discourage "public engagement" typified by identifying common interests, broadening decision space, and developing partnerships for

Figure 16. Mountain goats at Olympic National Park.

sustainable alternatives via dialogue-based processes, including strategic planning and feasibility analysis. When addressing "wicked" ungulate management situations, "public input" without "public engagement" is unlikely to result in satisfactory long-term outcomes. This may cause parks to miss opportunities for developing stakeholder understanding and collaborative support for ungulate management (see Appendices D and E). There are additional opportunities to the formal NEPA process that NPS could pursue in order to engage the public in a more robust manner.

Recommendations

1. Regarding management of ungulates and associated ecosystem processes, NPS should continue to move beyond any lingering emphasis that, "A national park should present a vignette of primitive America" (p. 3; Leopold et al. 1963). Rather, NPS should emphasize the increasing role of ecological and social stressors such as habitat impacts, safety, land-use change, invasive species, wildlife disease, stakeholder values, harvest demand, and climate change (see Cole and Yung 2010, Hildebrand et al. 2013, National Park System Advisory Board 2012, White et al. 2013) as the principal management context for native and non-native ungulates on all NPS lands
2. NPS decision makers should look for opportunities to undertake ungulate management at the large-landscape scale through collaborations, partnerships, and networks with private, federal, state, and tribal land managers. Where large-landscape shared goals and approaches exist, NPS should actively contribute. When landscape-level planning is not in place, NPS should undertake a leadership role.
3. NPS should develop improved guidance and tools to help parks and regions work with a wide array of stakeholders to address the social and ecological complexities of ungulate management decision making.
4. NPS should strive for more balance amongst priorities for ungulate management where there is currently a large focus on mitigating impacts to specific resources—a perspective that may be too narrow for most management situations. Although planning and management at a larger scale may result in more extensive planning and NEPA reviews, this can be achieved by identifying and implementing priorities for long-term, overarching landscape-scale native ungulate ecosystem conservation. In situations where near-term resource values (e.g., habitat condition, property damage, harvest management) are deemed highly important, the NPS should strive to embed such near-term concerns and solutions into long-term adaptive management frameworks. Indeed, such "scaling up" by the NPS should be expected to entail more inclusive and complex stakeholder engagement and formal planning towards conservation of native ungulates and their inherently dynamic ecosystem processes at the large-landscape scale wherever possible (see also National Park System Advisory Board 2012).
5. NPS must continue to invest in ecological and social science capacity for ungulate management. Emphasis should be on rigorous science that can be applicable to parks by leveraging NPS resources through innovative science partnerships with federal and state agencies,

Figure 17. Tule elk at Point Reyes National Seashore.

Banner photo: White-tailed deer at Valley Forge National Historical Park.

tribes, non-governmental organizations, universities, and private groups, including the use of deliberate and well-founded citizen science. Additionally, NPS should empower its managers and scientists by providing opportunities for them to gain and apply requisite skills for integration of communication, critical thinking, analysis, and landscape-scale ungulate science, accompanied by inclusion of such skills into personnel performance management systems.

Figure 18. Feral hogs at Pinnacles National Park.

6. Criteria used to award servicewide project funding should be re-oriented so that ungulate conservation projects can effectively compete with mitigation projects. It is likely that important ungulate restoration opportunities still exist in and around NPS units and they are not being fully recognized and supported.
7. NPS should clarify policy guidance specifically for ungulate applications to (a) clearly state that non-native ungulates do not need to have a demonstrable effect on NPS lands in order to be removed, and (b) reconcile approaches for controlling native and non-native ungulate population abundance and distribution (e.g., live transfer, public hunting, volunteer and agency sharpshooters, fertility control).
8. NPS needs to undertake innovative communication and engagement with stakeholders to clarify that, within the overall conservation mandate of the NPS, some native and non-native ungulate species will be managed differently across the National Park System based on park purpose and a combination of ecological, societal, and cultural factors, such as the distinctive relationship between Tribes and select ungulate species and populations.

Figure 19. Pryor Mountain wild horses at Bighorn Canyon National Recreation Area.

Action Items

The above findings and recommendations can be summarized as a paradigm shift wherein the current emphasis on short-term, relatively focused ungulate impact concerns should be more comprehensively embedded into forward-looking, long-term, landscape-level, stakeholder-informed, adaptive approaches as discussed in the NPS Call to Action, Revisiting Leopold report (National Park System Advisory Board 2012), DOI Landscape Conservation Cooperatives, and America's Great Outdoors Initiative. This paradigm shift would seek to accommodate short-term management goals by deliberately nesting them within landscape-scale frameworks that address long-term ungulate management through adaptive management and a cooperative, regional approach towards shared stewardship (Figure 25).

The following action items are intended to build capacity for this paradigm shift. To achieve these action items, NRSS would continue to lead a servicewide Ungulate Management Working Group that could be expanded to include key non-NPS representatives (e.g., federal, state, tribal, private) to develop detailed implementation plans and initiate the following Action Items.

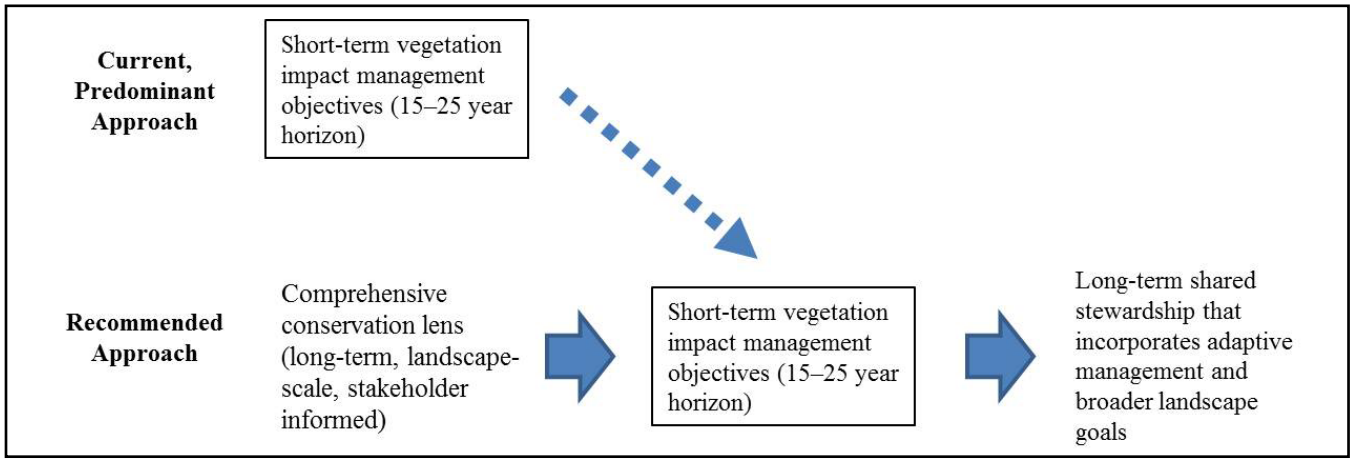

Figure 20. Recommended paradigm shift for NPS ungulate management wherein short-term management objectives should be accomplished as explicit components of a long-term conservation vision.

Banner photo: An American pronghorn at Wind Cave National Park.

Figure 21. Muskoxen at Bering Land Bridge National Preserve.

Action Item—1. Adopt the following servicewide guiding principles for NPS ungulate management as a consistent basis for stakeholder engagement and decision making. Ungulate management solutions may indeed be variable due to unique park circumstances, yet overarching guiding principles would remain consistent.

Guiding Principles of NPS Ungulate Management

- NPS will strive to restore, conserve, and manage native ungulates as wildlife at the large-landscape scale consistent with their dynamic ecological and cultural role within the scope of respective unit authorities.
- NPS will seek innovative collaborative partnerships with federal, tribal, state, local governments, non-government organizations, and private landowners for native and non-native ungulate management.
- NPS will promote native ungulate conservation and management that is responsive to ever-changing conditions and is based on the ecological and cultural role(s) of ungulates, based on sound biological and social science, fidelity to law and policy, and long-term public interest.
- NPS will control or eliminate non-native ungulates in a manner consistent with the scope of NPS servicewide and unit-specific purpose and authorities.
- NPS will apply best available sound science and adaptive management principles to management of both native and non-native ungulates.
- NPS will monitor and manage appropriate native and non-native ungulate health issues that may impact other wildlife, livestock, or human health and safety.

Action Item—2. Develop a Director's policy memo for native and non-native ungulate population control.

Action Item—3. Develop a strategic planning process that allows stakeholders to collaborate and identify priorities for ungulate management prior to initiation of formal planning through NEPA. Such planning should allow NPS and stakeholders an opportunity to identify common ungulate management issues and goals on a given landscape and consider the numerous variables associated with planning at this level, including but not limited to issues such as land ownership, willingness of partners, availability of habitat, and data gaps and availability. Examples of internal and external stakeholder engagement and communication tools that should be developed include new ungulate management training modules, an internal ungulate management web portal for NPS communication that provides access to an ungulate resource library, case studies, best management practices, web-based external outreach accessible to stakeholders (for example, the Yellowstone bison public website <www.IBMP.info>), and dialogue-based approaches towards gaining better understanding of stakeholders. Activities identified through such strategic planning and tools will ideally help inform stakeholders towards mutually agreed upon objectives that are then carried forward into formal planning processes.

Action Item—4. Prioritize key servicewide conservation and science needs for ungulates, identify opportunities to meet those needs, and implement and invest in those top priorities in an inclusive fashion with appropriate partners.

Figure 22. A collared peccary at Saguaro National Park.

Action Item—5. Develop and invest in servicewide or regional guidelines for population monitoring and estimation techniques for key ungulate species such as white-tailed deer, bighorn sheep, pronghorn, and elk.

Action Item—6. Develop a NPS Ungulate Management Handbook as a resource to consolidate and formalize the above products as a "toolkit" for NPS ungulate management.

Appendix A: NPS Ungulate Management Working Group

Chair
Glenn Plumb, Chief Wildlife Biologist, BRMD

Alaska Region
Grant Hilderbrand, Regional Wildlife Biologist

Intermountain Region
Therese Johnson, Wildlife Biologist, Rocky Mountain NP

Rick Wallen, Wildlife Biologist, Yellowstone NP

PJ White, Chief Wildlife Biologist, Yellowstone NP

Midwest Region
Dan Licht, Regional Wildlife Biologist

Steve Windels, Wildlife Biologist, Voyageurs NP

National Capital Region
Scott Bates, Regional Wildlife Biologist

Northeast Region
Mary Foley, Regional Chief Scientist

Pacific West Region
Kate Faulkner, Natural Resource Chief, Channel Islands NP

Natalie Gates, Superintendent, Haleakalā NP

Southeast Region
Tim Pinion, Regional Wildlife Biologist

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Joel Berger, Professor, University of Montana

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Appendix B: Review of NPS Ungulate Management Plans

Objectives and Methodology

The objective of this section is to describe the purpose, methods, and supporting science of existing or draft National Park Service (NPS) ungulate management plans. We used the NPS Planning, Environment, and Public Comment website (https://pepc.nps.gov/), the NPS Technical Information Center (http://www.nps.gov/dsc/technicalinfocenter.htm), and internal NPS knowledge (e.g., members of the working group) to identify and collect all known NPS formal management plans for native and non-native ungulates, with a focus on those that have been created in the last 20 years. All supporting information that forms the basis for this section was taken directly from these management plans. We recognize this may not be a total summary of every plan, but we do think this represents where the NPS has placed the majority of their ungulate management efforts and resources in the last 20 years.

History of Ungulate Management in the National Park Service

The NPS is directed to manage NPS units in a manner that will leave them 'unimpaired for future generations' (NPS 2006a). Ungulates have been managed under a variety of paradigms since the inception of the NPS and this history still influences on-the-ground conditions and the culture of management. Past NPS management practices can be summarized as three distinct time periods: early efforts (~1900–1930) that stressed increases in ungulate abundance and visibility via protection from human harvest, feeding, or predator reduction or elimination; control programs (1940–1968) that used shooting of ungulates, primarily by NPS employees or other resource professionals, and translocation to regulate ungulate population sizes due to concerns about their effects on range conditions; and the post-1970 era that has become known as 'natural regulation' (post-1970, Huff and Varley 1999) which relied on natural processes (i.e., range conditions, weather, predation, density-dependent responses etc.) to control ungulate population size, but recognized management intervention may be necessary to supplement such processes in systems altered by humans (Wright 1998). In reality, only a couple of well-known parks closely paralleled this entire management history (e.g., elk and deer management in Yellowstone and Rocky Mountain national parks; Olliff et al. 2013). The majority of parks only participated in early protection efforts or had sporadic control programs (Wright 1999).

The concept of natural regulation has always been controversial and significant discussions on this topic have taken place within the science literature (e.g., see Soukup et al. 1999 and associated journal feature). Most of these discussions have focused on Yellowstone National Park and whether or not the effects of elk on willow, aspen, and grassland communities were outside their natural or historic range of variation on the northern range (e.g., Singer et al. 1994, Singer and Cates 1995, Wagner et al. 1995). Following the introduction of gray wolves (Canis lupus) in 1995 and their subsequent population increase, primary focus of this discussion shifted to documenting the effects of a restored predator community on elk demographics, movements, and associated vegetation conditions (e.g., White and Garrott 2005, Beyer et al. 2007). Implicit in the discussion of natural regulation was the implication that NPS managed all native ungulates in a similar, passive manner. This was largely true until the mid to late 1990s, with the exception of units that had population removals specified in legislation (e.g., elk in Grand Teton National Park).

Since 1995 the NPS has increasingly recognized that management options for ungulates (particularly elk and white-tailed deer) and their effects on vegetation should be re-evaluated to ensure that permanent impairment of park resources does not occur. This has resulted in an array of formal ungulate management plans that call for decreasing and maintaining ungulate numbers at 10–50% of the population size or density present at the start of the planning process (i.e., a 50–90% reduction). Considered in a historical sense, these management plans represent a new period of wildlife management for the NPS, as there are now more parks engaged in active ungulate and vegetation management than ever before.

Alaska-Specific Considerations

Per Hilderbrand et al. (2013), wildlife stewardship on NPS Areas in Alaska is guided by the Organic Act, the General Authorities Act, the Alaska National Interest Lands Conservation Act (ANILCA), Federal regulations, and NPS Management Policies. Hilderbrand et al. (2013) consolidated this collective guidance to serve as a focused reference for NPS staff in Alaska as they evaluate the myriad issues and decisions facing the agency and the wildlife held in its trust; and to inform members of the public, fellow agencies, and partners about the considerations and constraints used by NPS when implementing mandates relative to wildlife. In

contrast to the variability across the rest of the NPS, wildlife stewardship is practiced on all Alaska NPS units uniformly. Through ANILCA, harvest of wildlife within Parks, Monuments, and Preserves is managed so that wildlife resources and wildlife values are unimpaired as defined in NPS Management Policies. The application of recognized scientific principles of wildlife population health and viability is the lens of whether the activities of humans are compatible with applicable federal laws and NPS regulations and policies. Methods and means of wildlife harvests, within NPS Preserves in Alaska, promulgated by the State of Alaska are evaluated for compliance with applicable federal laws and NPS regulations and policy by the same standards applied to Parks and Monuments. The standard for wildlife stewardship on all NPS lands in Alaska is ensuring that these resources are unimpaired. The terms "healthy" and "natural and healthy" as they appear in ANILCA apply to determining the appropriate level of wildlife populations and subsistence use. These terms are relevant to the broader NPS role as wildlife steward at the nexus of subsistence management and wildlife management. NPS adopts non-conflicting State regulations for harvest in Preserves; and where State of Alaska laws and wildlife harvest regulations are conflicting, Federal mandates are pre-emptive.

Native Ungulates

Many NPS units and equivalent protected areas in North America have experienced substantial increases in the numbers of several species of grazing and browsing native ungulates in the past several decades—numbers that are now considered by many managers and scientists to exceed levels that have existed at any time since the arrival of European colonists (Wright 1992). Reasons for increases in species such as Rocky Mountain elk, white-tailed deer, and to a lesser extent bison within the NPS system are varied but largely come down to three causes: the almost complete elimination of major ungulate predators (e.g., gray wolf), prohibition of harvest of wildlife in parks and adjacent protected areas, and anthropogenic alterations to habitat that provide additional refugia from human hunters or have increased food resources in or near parks. Concerns in NPS units about increased numbers of ungulates have primarily focused on the potential adverse effects on native vegetation, other animal species, and ecosystem properties in general (Huff and Varley 1999, Porter and Underwood 1999, Wright 1999). More recently, work has focused on complex interactions within places such as Yellowstone, where the reintroduction of wolves has allowed scientists to assess evidence of trophic cascades among wolves, elk, and willow habitat (e.g., Ripple and Beschta 2006, Marshall et al. 2014).

Historical ungulate management in the NPS (defined here as >20 years ago) varied from complete protection to large-scale reduction programs, as summarized above. Contemporary ungulate management in NPS units (<20 years ago) is conducted on a park-by-park basis and is influenced variably by multiple factors, including park-specific mandates, NPS Management Policies (NPS 2006a), research findings, stakeholder involvement, available personnel, and funding resources. We identified 14 final or draft management plans for native ungulates in the NPS related to overabundance (Table 1). The following discussion describes the purpose, science, and management decisions of these contemporary NPS plans, and summarizes the management techniques they employ. Discussion is organized around the three species that these plans have addressed to date: white-tailed deer, elk, and bison.

White-Tailed Deer

The increase of white-tailed deer populations in the eastern and mid-western United States is not limited to parks (e.g., McShea et al. 2003). However, NPS units have often been at the center of the debate on how to locally manage white-tailed deer because their concentrations and ecological effects are amongst the most visible (Porter and Underwood 1999). Seven parks have drafted or finalized plans to control white-tailed deer populations (Table 1), and at least six additional parks have formal National Environmental Policy Act (NEPA) planning processes underway for white-tailed deer and vegetation management purposes (Cuyahoga Valley National Park; Fire Island National Seashore; Morristown National Historic Park; and a joint plan by Antietam, Monocacy, and Manassas national battlefields). Examples of other concerns about white-tailed deer include vehicle collision safety and damage concerns, the role of deer populations in maintaining larger tick populations, and effects on threatened and endangered species.

The stated purpose of plans completed to date is similar; they aim to reduce the effects of deer browsing in order to allow for forest regeneration and/or native plant maintenance. However, there are different motivations behind each plan and these often depend on the enabling legislation of each park. For example, Gettysburg National Military Park decided to manage deer densities to be compatible with the maintenance of cultural landscapes that reflect the conditions during the battle (e.g., row crops and specific patches of forest; Frost et al. 1997); Catoctin Mountain Park sought to enable natural processes such as native forest regeneration (NPS 2008a); and Apostle Islands National Lakeshore decided to completely remove deer from islands where they

did not historically occur in order to maintain Canada yew (*Taxus canadensis*), a conifer shrub that is considered incompatible with deer browsing (Table 1; NPS 2007a).

The range of desired densities that were identified in these plans as compatible with native forest or plant regeneration varies from 0–4 deer/km2 at Apostle Islands National Lakeshore (NPS 2007a) to 12–13 deer/km2 at Valley Forge National Historical Park (NPS 2009a). In each case, the density selected was determined by park-specific or regional research. For example, Indiana Dunes National Lakeshore specified 4–8 deer/km^2 because that is the predicted range at which large-flowered trillium (*Trillium grandiflorum*) can be maintained (Anderson 1994), while Valley Forge National Historical Park selected 12–13 deer/km^2 because these densities had been found to allow sustained forest regeneration in the mid-Atlantic region (Horsley and Marquis 1983, Tilghman 1989, Marquis et al. 1992, deCalesta 1994, Sage et al. 2003). These density goals represent significant reductions in population densities of white-tailed deer, as most of the goals are 50% to 90% below deer densities that existed at the time of the plan. Although a wide range of methods for achieving deer reductions is evaluated in each plan, the primary method actually used is culling by federal employees; other methods were found to generally be insufficient. For example, large-scale fencing (>100 acres) is considered in many of the plans, but was not selected due to the limited area of effectiveness and/or incompatibility with park management goals (e.g., maintenance of cultural landscapes). Several of the plans allow for the possibility of maintaining desired population levels in the future via fertility control, pending development of an acceptable agent.

Three NPS units have also recently developed contingency plans for chronic wasting disease (Table 1) and Shenandoah National Park is in the NEPA planning stage. Although the impetus of these plans is disease, there are overlapping issues associated with overabundance. For example, plans to date allow for rapid reduction of deer densities to levels similar to areas adjacent to parks. The one-time reduction may occur over several years and deer density goals may be even lower than those used for vegetation and cultural resource management reasons (e.g., see Valley Forge National Historical Park in Table 1). The logic behind this approach is that state wildlife agencies, which manage deer outside of NPS boundaries, may decide to significantly reduce deer in areas where chronic wasting disease occurs in order to create a containment zone. Subsequently, parks want to conduct similar efforts to ensure they do not maintain higher deer densities than surrounding areas, as higher densities may amplify and facilitate disease transmission. Having a rapid, short-term response plan in place allows the parks to act immediately, but also gives them more time to identify and develop long-term disease management objectives.

Rocky Mountain Elk

Elk management has been consistently at the center of controversy over natural regulation. This can be attributed to three reasons: (1) elk can exhibit dramatic population growth in the absence of hunting and predation, and learn to concentrate their activity in areas without such pressures; (2) the herding and migratory nature of elk exacerbates actual and perceived impacts on public and private lands; and (3) high levels of park visitor interest in viewing elk. A central focus of this debate has been the effects of elk on aspen (*Populus tremuloides*) and willow (*Salix* spp.) persistence on the northern range in Yellowstone National Park (e.g., Huff and Varley 1999) and winter range in Rocky Mountain National Park (e.g., Hess 1993, Baker et al. 1997, Peinetti et al. 2002, Cooper et al. 2003). On the surface, ecological conditions and management trajectories of these two parks were similar until the mid-1990s, when neither park had wolves and both parks supported elk populations that were deemed larger than at any other time in the past 100+ years. Elk management in these parks has diverged significantly since that time. Yellowstone National Park introduced wolves in 1995 and has not since actively managed elk in the park (although significant habitat alterations and relatively large harvest have occurred outside park), whereas Rocky Mountain National Park implemented an elk management plan that included extensive population and range management actions. In retrospect, these recent differences in management should not be all that surprising, as Yellowstone National Park has an intact ungulate predator community, more severe winters, high hunting pressure adjacent to the park, and is more than eight times larger than Rocky Mountain National Park.

Of particular interest is why the basis for a new management direction adopted in Rocky Mountain National Park and what did it entail? In the early 1990s, the park recognized that the elk population and its effects on park resources were increasing. Research on this topic was thus initiated in 1994 (Singer et al. 2002) and management planning in 2003 (NPS 2007b). The research and ensuing plan concluded that: (1) the elk population was larger and more concentrated than it would have been in the presence of an intact predator base, and (2) this resulted in altered plant communities on the winter range that could lead to substantial declines of biodiversity in aspen and willow communities (NPS 2007b). These conclusions were based on all available research (e.g., Singer

et al. 2002) and an ecosystem simulation model that examined the effects of elk and an intact predator base (Coughenour 2002). The primary objective of the plan was to reduce the impacts of elk on vegetation and to restore the natural range of variability in the elk population and effected plant and animal communities. To do this, in addition to other conservation tools, the management plan called for reducing the number of elk from the winter range (which included areas in and adjacent to the park) from a high of approximately 3,500 elk (in 1999) to 1,600–2,100 elk. A variety of methods for adaptively restoring ecological conditions were incorporated into the plan, including: sharpshooters to reduce the populations size, >400 acres of fencing to restore aspen and willow communities on the winter range, aversive conditioning to periodically disperse elk that concentrate on core winter range areas, and the option to use fertility control to maintain elk population sizes (contingent on development of an acceptable agent; see Management Techniques section below for more detail). To date, only culling and fencing have been implemented.

The elk plan for Rocky Mountain National Park is notable for at least two reasons. First, it represents a clear break from the concept of 'natural regulation' in a western park that is relatively large compared to the majority of NPS units. Although the NPS has always retained the option to control ungulate numbers when populations are unnaturally high due to human influence (e.g., NPS 1988, 2001, 2006a), this was the first time that controls were instituted in a park where natural regulation had been the dominant paradigm for over 35 years. Second, it set a new precedent for controlling ungulates with 'skilled volunteers' to assist with herd reduction and maintenance activities (i.e., sharpshooting, removal of carcasses). This has had servicewide implications, as other NPS units have considered using volunteers in their ungulate planning efforts (see Theodore Roosevelt National Park discussed below).

Wind Cave and Theodore Roosevelt national parks have also prepared elk management plans (NPS 2009b, 2010; Table 1). Both parks are fenced and have actively managed their resident elk since the populations were restored, primarily through periodic round-ups and translocations. However, these efforts came to an end at Wind Cave National Park when in 1997 chronic wasting disease was found in a captive elk herd adjacent to the park. The most recent translocation had occurred in 1994 and future translocations were discontinued. Although the disease was not found in Theodore Roosevelt National Park, or in the surrounding area, the NPS decided in 2000 to also cease elk translocations out of this park due to lower demand for elk and national concerns about the spread of chronic wasting disease (NPS 2002a).

The purpose of the management plans at Wind Cave and Theodore Roosevelt national parks was to re-assess appropriate elk population levels and their effects on vegetation, and to determine which management approach would best accomplish these goals (since translocation was no longer considered a short-term option). Population goals in both parks were established with forage allocation models that incorporated variable weather patterns and associated vegetation growth. Wind Cave National Park set their elk population objectives at levels that are compatible with 25% of the total forage for bison and elk (Hanselka et al. 2001) and a minimum of 400 bison (NPS 2006b), which resulted in a population goal of 232–475 elk (NPS 2006c, 2009b). Theodore Roosevelt National Park took a different approach and allocated a maximum of 35% consumption for any single forage item, regardless of which ungulate species consumes it. This resulted in a population range of 100–400 elk (Westfall et al. 1993).

The primary methods proposed to reduce elk populations differ between these parks. Wind Cave National Park primarily relies on hunting outside the park. Hunter success on lands adjacent to the park is increased by NPS periodically lowering fences to allow elk to leave the park and raising them so they cannot return (NPS 2009b). In contrast, Theodore Roosevelt National Park relies on culling within the park to reduce and maintain herd size, and includes the use of skilled volunteers during these actions (NPS 2010).

Grand Teton National Park prepared an elk and bison management plan (USFWS and NPS 2007) in conjunction with the U.S. Fish and Wildlife Service, which manages the nearby National Elk Refuge. The planning process was initiated in response to a 1998 lawsuit that sought to end bison hunts outside the park, but was also undertaken to address concerns about feeding and high densities of animals on the elk refuge that could increase transmission of brucellosis in the region. The resulting management plan seeks to reduce the number of elk that summer in the park from ~2,500 to a range of 1,300–1,600 in the park. The number of bison in Grand Teton National Park and the National Elk Refuge would be reduced from 800–1,000 animals to ~500, with the stipulation that the bison population should not fall below 400 individuals in order to maintain genetic viability. Both elk and bison would be reduced using a combination of public hunting on the National Elk Refuge and adjacent U. S. Forest Service lands, and reductions in feeding at the

National Elk Refuge. Public Law 81-787 expanded Grand Teton National Park in 1950 (by including the Jackson Hole National Monument in the park) and, when necessary for conservation purposes, allowed for hunters to participate in the controlled reduction of elk when licensed by the state and deputized as volunteer park rangers. As such, elk have been hunted in eastern portions of the park since 1950.

Bison

In addition to Grand Teton National Park, both Yellowstone and Wind Cave national parks have recently developed bison management plans (Table 1). Theodore Roosevelt and Badlands national parks also control bison numbers through roundup removal to tribes but there are no formal plans for these actions. The purpose of the interagency *Bison Management Plan for the State of Montana and Yellowstone National Park* (NPS and USFS 2000) is to maintain a wild, free ranging bison population while reducing the risk of transmission of the non-native disease brucellosis from bison to domestic cattle. Because brucellosis transmission to cattle is only an issue when bison leave the park, a central emphasis of the plan is to clarify if, where, and when bison can occur outside the park. Specific boundaries and allowable use limits on lands adjacent to the park are defined using a risk management approach. The plan established a guideline limiting the population to 3,000 bison at the end of winter because migrations out of the park tend to increase numbers above this level, depending on snowpack and forage availability. A variety of methods are considered for managing brucellosis risk, including capture/removal and hazing. The plan specifies an adaptive management approach using stakeholder involvement and intense monitoring and research initiatives to continue efforts for reducing brucellosis in the bison population (NPS and USFS 2000, White et al. 2011).

Bison have been actively managed at Wind Cave National Park since 1923. Bison are fenced in at the park because management was initially considered necessary to prevent them from degrading range conditions and starving. The current plan (NPS 2006b) formalized the management of bison based on recent research, but did not institute new management actions. Since 1987, the park has sought to maintain 350–400 bison using round-ups and relocation (e.g., in 2009 some bison were translocated to re-establish an extirpated herd in Mexico). These numbers were adjusted upward in the new management plan, which states that a minimum of 400 bison should be maintained to ensure the genetic integrity of the herd (Gross and Wang 2005). This was subsequently incorporated into the forage allocation model that determined the number of elk (NPS 2006c, 2009b; see previous section on elk).

Management Techniques

Contemporary NPS deer and elk management plans vary little in the range and selection of methods used to reduce overabundant ungulate populations and their effects on park resources. This is due to the fact that few effective and proven options exist for altering ungulate population sizes, mitigating ungulate impacts on park resources, and modifying ungulate behavior. To date, all plans rely primarily on lethal controls, whether culling by federal agents or skilled volunteers or hunting in or adjacent to parks (Table 2). Culling operations occur under a variety of conditions, ranging from sharpshooters working alone to those that use bait stations, silencers, and night vision equipment (NPS 1995a, 2007a, 2007b, 2007c, 2009a, 2010). Skilled volunteers are defined as different from hunting in two primary ways: (1) volunteers work in a team to identify appropriate targets within specific areas, and (2) volunteers do not get to keep the meat from animals they cull. These distinctions are clear in Rocky Mountain National Park, where the meat is donated to charitable organizations (e.g., a food pantry) or distributed via a lottery (which volunteers can apply for, but get no special treatment). However, the distinction in Theodore Roosevelt National Park is less clear, wherein meat is given to charities, tribes, and the state wildlife agency which subsequently gives meat to the volunteer sharpshooters (among other entities). Parks also retain the ability to capture and euthanize animals, but with the exception of research activities in Rocky Mountain National Park that needed to euthanize and evaluate elk for chronic wasting disease, it has not occurred to any appreciable extent in the NPS. The only other method of directly manipulating ungulate numbers is translocation. It remains the primary management tool for transferring bison to tribes (Tables 2, 3) but has been discarded entirely for deer and elk due to disease concerns and the fact that most NPS units that historically had deer or elk already have them.

Fertility control of females via immuno-contraceptives (gonadotropin-releasing hormone (GnRH) vaccine) or pharmaceuticals (e.g., leuprolide) have been proposed and included as an option in many management plans. However, fertility control has not been implemented because park-specific stipulations for its use have not been met. Although there are differences between plans, parks to date generally specify an acceptable fertility control agent as one that is federally approved, has multi-year efficacy, can be delivered remotely, would not prevent human consumption or affect non-target animals that consume the carcass, would not have

long-term or permanent effects on reproductive behavior, and would not have unintended effects on animal behavior. Despite extensive research efforts, no fertility control drug meets all of these requirements. In addition, studies should be conducted on both captive and free-ranging ungulates prior to approval in parks. For example, the GnRH vaccine GonaConTM has been federally approved and has multi-year effectiveness in captivity (Miller et al. 2008), but is only partially effective in free-ranging white-tailed deer after the first year (>50% of treated deer were pregnant in second year following treatment; Gionfriddo et al. 2011).

Specific reasons for the inclusion of a fertility control option (such as costs, logistics, or ethics) are not provided in management plans (e.g., NPS 2007b, 2009a). Research indicates population reduction via fertility control is unproven, will often take longer than the life of a 15–25 year plan (Hobbs et al. 2000), and is only applicable to closed populations (Rudolph et al. 2000) or an intensively managed small segment of a larger population (Rutberg and Naugle 2008). For these reasons, parks have concluded that fertility control agents are most suitable to keep ungulate population numbers stable after a target level has been reached.

There are no other widespread, consistent techniques used by NPS units to manage ungulate populations and their effects on park resources (Table 3). Other methods currently used on a park-by-park basis include fencing, translocation or removal to slaughter (bison only), permanent sterilization via surgery, aversive conditioning/hazing, habitat restoration efforts, and reducing supplemental feed (outside park boundaries). Of these, only Rocky Mountain National Park has implemented large-scale fencing operations (defined here as >50 hectares) to restore vegetation conditions. No plans, other than Yellowstone National Park's, have restored or used native predators to control ungulate populations. Rocky Mountain National Park fully evaluated the possibility of restoring and intensively managing wolves to reduce elk numbers, but concluded it would not be appropriate to do so without support from the state of Colorado (as wolves would inevitably leave the park).

Non-Native Ungulates

Non-native species are referred to as exotic species by NPS Management Policies (NPS 2006a, section 4.4.1.3) and defined as those that occupy park lands directly or indirectly as the result of deliberate or accidental human activities. There are three broad categories of non-native ungulates in the NPS[1] : (1) non-native species that are considered critical to the cultural resources and purpose of a park (hereafter referred to as "desired"), (2) non-native species that exist at parks and are being actively managed, and (3) non-native species that exist at parks but are not being actively managed for various reasons. In many cases, and for the purposes of this report, the latter two categories are considered "undesired" within park units.

Examples of desired non-native species include free-ranging horses (*Equus ferus caballus*) at Assateague Island National Seashore, longhorn cattle at Theodore Roosevelt National Park, and cattle at Grant-Kohrs Ranch National Historic Site that are maintained for park-specific cultural resource purposes. To our knowledge, there are no desired non-native ungulates that are maintained for natural resource purposes. Undesired non-native ungulates include a variety of species, such as: pigs (*Sus scrofa*) and axis deer (*Axis axis*) at Kalaupapa National Historic Park, mountain goats at Rocky Mountain and Grand Teton national parks, and fallow deer (*Dama dama*) at Point Reyes National Seashore. The distinction between a desired and undesired non-native ungulate frequently depends on enabling legislation of the park; the same type of animal may be desired in one NPS unit (e.g., horses at Assateague) and undesired in another unit (e.g., horses and burros in Death Valley National Park).

Management plans for desired non-native ungulates in the last 20 years have only been developed for horses (Table 4). The general goal of these plans was to maintain the genetic diversity and sustainability of horse populations, while at the same time preventing unacceptable adverse impacts to NPS lands. To date, this has only required slight reductions in the size of horse populations (e.g., the largest proposed reduction was from 195 to 90–120 horses in Bighorn Canyon National Recreation Area), and all of these plans used fertility control or round-up and adoption programs instead of lethal methods (Table 4). Although management plans have not been created for other desirable non-native species, NPS units do work to promote their long-term persistence. For example, Theodore Roosevelt National Park has replenished their longhorn cattle (castrated steers) with new animals from Grant-Kohrs Ranch National Historic Site.

The majority of non-native ungulates are considered undesirable on NPS lands and have direct or indirect negative impacts on park vegetation, soil, water quality, and/or native wildlife species. To date, every NEPA plan developed for undesired non-native ungulates calls for their eradication via culling, fertility control, fencing, and/or round-ups (Table 5). All of these plans include the option to lethally remove ungulates by shooting them. Some parks are able to manage

such species without management plans, in part because they are not firmly established within NPS lands. For example, Rocky Mountain National Park removes occasional, non-native mountain goats that are considered a disease threat to native bighorn sheep.

It is notable that one plan, the Draft Environmental Impact Statement (EIS) for mountain goat management in Olympic National Park (NPS 1995b), was never completed due to public controversy. An interesting aspect of this effort is that the park was challenged about whether or not mountain goats were (a) non-native and (b) having negative effects on park lands. A review by non-NPS scientists (Noss et al. 2000) concluded: "Available evidence suggests the mountain goat has never been native to the Olympic Peninsula… On the other hand, available data are insufficient to establish that mountain goats are causing significant damage to vegetation, harming rare plant populations, or are otherwise having deleterious impacts on the natural system (p. iv)." Our review considered these aspects because NPS policy identifies the conditions that must be fulfilled to remove non-native species—up to and including eradication: control must be prudent and feasible; and the non-native species must interfere with, disrupt, or damage park resources, or significantly hamper their management, and/or pose a public health or safety hazard (NPS 2006a, section 4.4.2). However, the same section of the NPS Management Policies document also seems to suggest that non-native species don't necessarily need to cause damage in order to merit actions for removing them: "Lower priority will be given to exotic species that have almost no impact on park resources or that probably cannot be successfully controlled." There is need for clarification on this point.

Conservation of Ungulates

Conservation of ungulates within the NPS is multi-faceted and has changed dramatically during the past 100 years. For the purposes of this report, conservation means undertaking specific actions to conserve a native ungulate species within the habitat and ecological processes that sustain them. Activities such as species restoration (both in and outside of NPS units), habitat improvement, disease surveillance, census, and monitoring are key components of ungulate management and are relatively easy to quantify. Conserving species ecologies is also important, particularly internally in the NPS, but is more difficult to document and quantify. Specific ungulate ecologies such as migration, dispersal, and the role of ungulates as prey can be documented for some species such as elk, bison, and caribou but other ecological processes such as competition, feeding behaviors, disease, and the role of ungulates as part of larger ecosystems are much more difficult to document and measure.

From the time the NPS was established in 1916 until the midpoint of the 20th century, ungulate populations in the United States were at historically low levels due to unregulated hunting and habitat degradation occurring since colonial times. The establishment of key parks in the National Park System like Yellowstone, Yosemite, Grand Canyon, and Glacier provided ungulates with habitat protected from timber harvest and livestock grazing as well as sanctuaries from legal and illegal hunting. Populations of mule deer, pronghorn, bison, and elk were thus able to recover. From 1912 through the 1960s more than 13,500 elk were translocated from Yellowstone National Park to establish populations in 38 states, Canada, and Mexico (Robbins et al. 1982). In addition, elk from Yellowstone National Park have been used to supplement native populations in most of the Rocky Mountain west (e.g., Rocky Mountain National Park) and restore or augment populations in many other national parks (e.g., Wind Cave, Theodore Roosevelt, Crater Lake, Mount Rainier, and Guadalupe Mountains). The wholesale restocking of elk from Yellowstone National Park was key to the reestablishment of the Rocky Mountain subspecies of elk (*C. e. nelsoni*) in North America. However, restoration of elk on non-NPS lands has occasionally led to increased levels on NPS lands, as well as the introduction of Rocky Mountain elk in places where they formerly did not exist (e.g., Mount Rainier National Park, which probably supported the Roosevelt subspecies (*C. e. roosevelti*; Wright et al. 1933).

The efforts of the NPS to maintain and expand the ranges of ungulate species such as mule deer, pronghorn, and elk were critically important during the first half of the 20th century when these species were in relatively low numbers. In the case of mule deer, it soon became apparent that protection from illegal and legal harvest and elimination of livestock grazing on NPS lands quickly resulted in recovered populations, and mule deer damage to ranges was noted as early as the 1920s in Yosemite, Zion, Bryce Canyon, and Grand Canyon national parks. By the mid-1920s, the NPS was trapping mule deer in areas of Yosemite National Park and moving them to other areas within or adjacent the park in an attempt to reduce populations and minimize damage to vegetation (Wright et al. 1933). As white-tailed deer and elk populations expanded inside NPS units, and more importantly outside NPS boundaries, it became clear by the late 1960s that extensive trap and transplant operations were not going to be a viable tool for managing populations on NPS lands. Following the time period known as "natural regulation",

conflicts with managing vegetation and attempts to manage white-tailed deer and elk have increased throughout the NPS system (Table 1). Two exceptions to such trends are bighorn sheep and pronghorn, which have continued to be trapped and transplanted both to and from NPS lands for conservation purposes in the past 50 years (Singer et al. 2001, Scott 2004).

In 1963, two reports on NPS natural resource management were developed: the *National Academy Report* (Robbins et al. 1963) and the *Leopold Report* (Leopold et al. 1963). Both reports called upon the NPS to use science as the basis for natural resource management and became long-term influences on the way the NPS managed ungulates. In particular, the *Leopold Report* became the basis for almost 30 years of ungulate management in the NPS that was characterized by less intensive management (i.e. "natural regulation") than in the 30 years prior. It is interesting to note that what was stated in the *Leopold Report* and what subsequently took place on the ground were not entirely congruent. The report stated: "Insofar as possible, animal populations should be regulated by predation and other natural means. However, predation cannot be relied upon to control the populations of larger ungulates, which sometimes must be reduced artificially (p. 13)." The report goes on to state, "Trapping and transplanting has not proven to be a practical method of control… Direct removal by killing is the most economical and effective way of regulating ungulates within a park (pp. 13–14)." The NPS appears to have been somewhat selective in its use of these recommendations from the mid-1960s through the early 1990s. During that time most NPS units took a "hands-off" approach to ungulate management and populations of mule deer, white-tailed deer, and elk generally increased throughout the National Park System. Culling activities, which had existed in a few parks, were phased out during the 1960s and natural regulation coupled with state-level harvest adjacent to parks ultimately became the operative approach for ungulate management (Cole 1971, Leopold et al. 1963, NPS 1988, Soukup et al. 1999).

Natural regulation assumed that ecological processes such as predation, migration, and density-dependent responses to food resources such as dispersal and lower survival rates would combine to maintain ungulate populations within a natural range of expected densities and overall populations. While in theory this could work, most NPS units did not have either enough land to ensure all these processes were still functioning or the suite of predators available to exert enough pressure on these populations to mimic historical levels of take. As a result, deer and elk densities continued to rise and increasing conflicts were noted both in NPS units and on adjacent lands managed by other federal agencies, states, or private individuals.

Recent conservation efforts have focused primarily on supplying other areas with ungulates (e.g., elk from Theodore Roosevelt National Park to tribal lands; and bison from Wind Cave National Park to tribes, private land, and Mexico), re-establishing elk in Great Smoky Mountains National Park (Table 1), or supporting conservation efforts through research or cooperative agreements. NPS has also been involved with restoration efforts of declining or federally listed ungulate species. For example, efforts by the U.S. Fish and Wildlife Service and National Park Service are ongoing in Organ Pipe Cactus National Monument to restore the Sonoran pronghorn, and in Yosemite National Park and Sequoia and Kings Canyon National Parks to restore Sierra Nevada bighorn sheep. However, with the exception of restoring elk to Great Smoky Mountains National Park, the NPS has not been the lead on ungulate restoration efforts.

Inventory and monitoring of ungulates is a key conservation tool used in the development, evaluation, and implementation of ungulate plans. Survey information suggests that almost 50% of park units with ungulates have used some form of population monitoring and inventory (see Appendix C). The NPS does not have overarching standards for ungulate inventory and monitoring, as conditions and species vary greatly from park to park. Inventory of white-tailed deer populations is highly variable and primarily designed to be indicative of trends and indices and not to infer scientifically sound population information (e.g., with confidence intervals). In some cases, such as elk monitoring in Yellowstone and Rocky Mountain national parks, the NPS uses state-of-the-art techniques and shares and pools information with cooperators. Most parks and preserves in Alaska use sophisticated aerial inventory techniques to survey caribou and moose, then pool information with state and other agencies to get a more holistic view of trends across large landscapes.

Summary

There is currently more active management of ungulate populations by the NPS than at any other time in its history. Almost all recent actions have focused on reducing overabundant native populations or suppressing or eliminating non-native ungulates. This trend can be attributed to: (1) the concept of natural regulation, which allowed ungulates to increase to maximum population numbers in the absence of large predators and human harvest; (2) a greater understanding of the impacts that ungulates can have on park

resources, primarily vegetation; and (3) a lack of social tolerance for large numbers of certain ungulate species. There has also been an increase in disease-related plans over the last 15 years to address the management of brucellosis and chronic wasting disease. Overall, this has resulted in ungulate management plans (native and non-native) for more than 25 parks during the last 20 years and more plans are in progress.

Although research is more sophisticated and planning processes are more in depth, there are some striking similarities between past and current population control efforts enacted for vegetation or habitat reasons. Most notably, contemporary reduction and control programs are essentially based on the same central tenet as they were in the 1940s: ungulates are over-browsing or over-grazing vegetation. In many cases, the current-day response has been to severely limit the range of population densities at which an ungulate population can exist in a park. For example, every NEPA plan completed during the last 15–20 years on white-tailed deer and forest regeneration places relatively strict limits on the range of densities (e.g., 6–8 or <10 deer/km2, Table 1). This is not necessarily inappropriate for management plans that cover 15–25 years into the future and are a response to heavily browsed or grazed habitats that have been inhabited by increasingly expanding ungulate populations in the last 30 years. However, we suggest that future management plans consider increased long-term variability for reasons discussed below.

First, if the limited range of ungulate densities and management actions used in some current NPS plans were successfully achieved and maintained, they would likely prevent a full evaluation of ecosystem influences and interactions, and could hamper adaptive management abilities. For example, if a park is successful in keeping an ungulate population at or below a target density, the park will sacrifice its adaptive management capacity to understand how the system might respond to variability in long-term ungulate density. Opportunities exist to examine such issues in a broader framework across multiple parks with similar ungulate issues and different management strategies, but such an approach should be a *priori* adaptive management not *post hoc*. There may also be opportunities to compare management strategies between parks within a region; these should be similarly designed as part of a formal, multi-part monitoring framework.

Second, ungulates are known to affect different ecosystem components in different ways depending on whether their abundance is near the capacity of resources to sustain them (Kie et al. 2003). For example, some plant and animal species are negatively affected by moderate to high ungulate grazing or browsing while others benefit from it (Rooney and Waller 2003). We suggest the next phase of management (e.g., >25 years from now) consider the merits of a middle ground that would allow for greater ecosystem heterogeneity that would include: (1) ungulate densities exhibiting greater variation with occasional or variable park control efforts; (2) successful tree or plant recruitment in some but not necessarily all years; (3) range conditions that are considered on average good, but variable and not always maximized; and (4) implementation of adaptive management (see guidelines provided by the Department of the Interior (Williams et al. 2009, Williams and Brown 2012)) and NPS policies (NPS 2006a).

We are not suggesting all parks can feasibly adopt all of these measures, but their benefits and challenges should be considered during planning efforts. Although adaptive plans that incorporate more variability may be more complicated than the current planning framework, such plans have been successfully implemented within the NEPA framework (e.g., the Interagency Bison Management Plan, NPS and USFS 2000, White et al. 2011). There may also be opportunities to manage adaptively within the existing framework of plans. For example, if many parks in an area have a diversity of ungulate densities and management strategies, comparison between parks could provide valuable insight into deer-vegetation relationships. However, to ensure the use of "best available sound science" as defined by *Revisiting Leopold* (National Park System Advisory Board 2012), NPS would need to establish research objectives a *priori* in a peer-reviewed document that describes the goals and management strategies for such a program. Finally, though ecosystem responses are important and vital to the management of healthy ecosystems, NPS also needs to acknowledge that wildlife viewing and wildlife harvesting (and their relationship to visitor satisfaction) are an important element in managing ungulate populations.

One plan that takes a slightly different approach to ungulate and vegetation interactions is the elk plan for Rocky Mountain National Park. This plan based population goals on elk and vegetation conditions that would be expected in the presence of wolves (versus an alternative that focused solely on vegetation thresholds). However, one of the reasons they were able to do this is because they also included large-scale fencing that excludes elk and allows for some key vegetation types to fully recover even in the presence of high elk concentrations (NPS 2007b). Contrasting this with other NPS management plans that minimize ungulate densities and do not fence sensitive resources demonstrates the dilemma

that faces modern-day NPS managers when dealing with an overabundant ungulate population. Managers have limited options and can either choose to limit ungulates to low levels without fencing, or allow higher ungulate populations with large-scale fencing. A park such as Rocky Mountain is better poised to use fencing than small cultural parks, as large-scale fencing on a historic battlefield would prevent the park from meeting federal mandates instructing managers to preserve cultural landscapes that were present during the Civil War (e.g., NPS 1995a).

There are significant fiscal and personnel resources being expended across the NPS system on monitoring. A rigorous evaluation needs to take place in order to allow NPS units to obtain the information they need to manage populations and implement management plans, and yet still be efficient in terms of dollars and time spent by employees. In some instances, partnerships could be developed and formalized with state wildlife agencies that are currently inventorying and monitoring ungulates up to park boundaries (e.g., Fort Pulaski National Monument and Olympic National Park recently did this). However, managers should be careful to ensure that inventory and monitoring systems are scientifically rigorous and statistically sound. In some situations, they generate key data that may trigger certain actions in management plans. NPS should also continue to develop standardized monitoring and modeling techniques that could be used by NPS units with similar ungulate management issues. Data sharing, as already occurs for white-tailed deer, should be encouraged between parks and with other state and federal wildlife management agencies.

There are a variety of needs that the NPS should further explore or seek to further clarify with respect to ungulate management. On a policy level, NPS should: (1) determine if non-native ungulates need to have a demonstrable effect on NPS lands prior to a decision that they should be removed, and (2) establish an unambiguous, servicewide definition of "volunteer sharpshooters" and recommendations for when they should be used. With regard to the latter, NPS should clarify its terminology in terms of how it differentiates volunteer sharpshooting from hunting. Efforts are currently underway to define limitations and requirements for fertility control agents; this could be used as a basis for making a decision on culling strategies.

Finally, on a servicewide level, NPS needs to identify ungulate conservation priorities. To our knowledge, the NPS has led only one effort in the last decade to restore a native ungulate (elk in Great Smoky Mountains National Park). Such opportunities may no longer exist for elk or deer, but it is likely that significant ungulate restoration opportunities exist for other species in and around NPS units but are not being fully realized.

Table 1. National Park Service management plans for native ungulates. All planning processes recognize the need to re-evaluate such goals over time using the principles of adaptive management. Only plans created in the last 20 years are included.

Park (Plan Reference)[a]	Species[b]	Stated Reason for Plan	Density or Population Size at Time of Plan	Desired Density or Population Size	Supporting Data Cited in Plan
Gettysburg NMP and Eisenhower NHS (NPS 1995a, Frost et al. 1997)	WT deer	High levels of deer browsing prevent the maintenance of cultural landscapes.	138 deer/km^2 of forested land (~1150 deer total)	10 deer/km^2 of forested land (~80 deer total)	Forest regeneration in Pennsylvania occurs with 6–8 deer/km^2 (Bramble and English 1948, Behrend et al. 1970, Drake and Palmer 1991). NPS used 10 deer/km^2 of forested land as an initial goal because the study areas also included park croplands.
Catoctin Mountain Park (NPS 2008a)	WT deer	High levels of deer browsing prevent forest regeneration and adversely affect forest structure, composition, and wildlife habitat.	29–75 deer/km^2	6–8 deer/km^2	Regeneration of maple, beech, and birch forests in Pennsylvania occurs at 5–8 deer/km^2 (Stout 1999, Sage et al. 2003); negative impacts of deer browsing occur at 8 deer/km^2 (Horsley et al. 2003).
Rock Creek Park (NPS 2011a)	WT deer	High levels of browsing cause unacceptable changes in species composition, structure, abundance, and distribution of native plants and associated wildlife; and there is an increased risk of chronic wasting disease.	74–93 deer/km^2	ulla 12–13 deer/km^2 (also allows for one-time reduction to 4 deer/km^2 to respond to chronic wasting disease)	Natural forest regeneration in the mid-Atlantic Region occurs at 4–15 deer/km^2 (Horsley and Marquis 1983, Tilghman 1989, Marquis et al. 1992, deCalesta 1994, Sage et al. 2003).
zApostle Islands NL (NPS 2007a)	WT deer, emphasis on harvest species	Control of native wildlife populations expanding their range to islands that historically did not have deer populations and are threatening rare vegetation communities.	0–57 deer/km^2 depending on island and habitat under study	4 deer/km^2 on 12 islands that historically had deer, and complete removal on 8 islands that have no record of deer	Prior to 1800, deer populations in northwestern Wisconsin were the lowest in the state (<3.9/km^2; Dahlberg and Guettinger 1956). Canada yew (Taxus canadensis) is highly palatable, not resistant to browsing, and considered incompatible with deer on the islands (Beals et al. 1960).
Indiana Dunes NL (NPS 2009c)[c]	WT deer	To prevent deer from becoming a dominant force that negatively influences ecosystem components, including sensitive and rare plant species and ground-nesting birds.	38 deer/km^2	4–8 deer/km^2	Large-flowered trillium (Trillium grandiflorum) stem heights and flowering plants can be maintained in northeastern Illinois at 4–6 deer/km^2 (Anderson 1994).
Antietam NB and Monocacy NB (NPS 2009d)	WT deer	Chronic wasting disease is found within 160 km (~60 miles) of these park units.	35–63 deer/km^2	10–17 deer/km^2	As deer populations increase, risks relating to the transmission of contagious diseases, including chronic wasting disease, within these higher density populations are a concern (Samuel et al. 2003, Joly et al. 2006, NPS 2007c). Desired densities are designed to be compatible with surrounding areas.
Rocky Mountain NP (NPS 2007b)	Elk	The elk population is larger, less migratory, and more concentrated than it would be under natural conditions. This has altered plant communities on the winter range and may cause declines of biodiversity in aspen and willow communities.	1,700–2,200 on winter range (2,800–3,500 from 1997–2001)	1,600–2,100 on winter range; plan also includes fencing to facilitate restoration of aspen and willow riparian communities	If wolves existed with the current amount of habitat, ecosystem modeling and empirical work indicates the elk population would be 1,200–2,100 elk (Coughenour 2002). Elk are having adverse effects on winter range aspen (Baker et al. 1997, Olmsted 1979, Suzuki et al. 1999, Weisberg and Coughenour 2003) and willow communities (Peinetti et al. 2002, Zeigenfuss et al. 2002, Cooper et al. 2003).

Table 1 (continued). National Park Service management plans for native ungulates. All planning processes recognize the need to re-evaluate such goals over time using the principles of adaptive management. Only plans created in the last 20 years are included.

Park (Plan Reference)[a]	Species[b]	Stated Reason for Plan	Density or Population Size at Time of Plan	Desired Density or Population Size	Supporting Data Cited in Plan
Wind Cave NP (NPS 2009b)	Elk	The elk population is not regulated by natural processes. Left unchecked, this will lead to adverse effects on native vegetation, wildlife, and neighboring land.	525–800 elk in the park during winter	232–475 elk in the park during winter	A forage allocation model indicated a target range of 232–475 elk (NPS 2006c), based on forage allocation as follows: 25% consumption by major herbivores, 25% other, 50% left over.
Theodore Roosevelt NP (NPS 2010)	Elk	Elk population size is expected to continue to increase, which could affect plant communities and other resources.	~900 elk	100–400 elk	A forage allocation model indicated a target range of 100–400 elk based on forage allocation levels no greater than 35% of any one plant species (Westfall et al. 1993).
Great Smoky Mountains NP (NPS 2000a, 2011b)	Elk	To re-establish elk (NPS 2000a) and to guide future management, monitoring, and research on re-established elk.	0 elk prior to year 2000; 93 elk in 2009	A viable population of elk	Elk were abundant prior to extirpation by hunting (Van Doren 1998, Wathen et al. 1997). Research found re-establishment was feasible (e.g., Long 1996, Nettles and Corn 1998).
Grand Teton NP (USFWS and NPS 2007)	Elk and bison	Reasons for this plan include a 1998 lawsuit to stop bison hunting, issues related to ungulate concentration (including disease), and the use of supplemental feed on National Elk Refuge.	2,500 elk in the park (summer), and >1000 bison in park region (region includes National Elk Refuge).	1,600 elk in the park (summer), 500 bison in park region (plan will also reduce feeding on refuge, and thus may change population size)	Numerous sources; for example, within Grand Teton NP the combined effects of fire suppression, ungulate browsing, and climate change are preventing aspen stands from regenerating (McCloskey and Sexton 2002). Ultimately, ungulate population goals were not based on specific browsing or disease transmission levels, but a variety of issues.
Yellowstone NP (NPS and USFS 2000)	Bison	To manage the risk of brucellosis transmission from bison to cattle, while allowing some bison to occupy winter ranges on public lands in Montana.	~3000 bison	~3000 bison (plan also includes provisions to continue efforts to eradicate brucellosis)	Yellowstone bison comprise the largest and one of the most imporatant conservation populations of plains bison. The risk of brucellosis transmission from bison to cattle is low but tangible, and increases as population numbers increase and more bison migrate out of park (National Research Council 1998).
Wind Cave NP (NPS 2006b)	Bison	The park is surrounded by a woven wire fence and there is a finite amount of forage available for bison and other wildlife species. The plan defines desired vegetation conditions, the number of the bison the park would maintain, and alternatives to manage the bison population.	350–500 bison	>400 bison	Bison herds with more than 400 animals have a high probability of retaining genetic heterozygosity for 200 years (Gross and Wang 2005).

[a] NMP = National Military Park, NHP = National Historic Park, NP = National Park, NL = National Lakeshore, NB = National Battlefield
[b] WT deer = white-tailed deer
[c] Draft Environmental Impact Statement or Environmental Assessment (all documents summarized in this table are publicly available)

Table 2. Methods evaluated or used by the National Park Service to control or reduce population size or effects of native ungulates.

Method	Parks That Use the Method or Have Proposed It to Control Ungulates or Their Effects[a]	Parks That Evaluated the Method but Selected Different Methods
Culling[b] by federal agency	Gettysburg NMP/Eisenhower NHS, Catoctin Mountain Park, Valley Forge NHP, Indiana Dunes NL, Rock Creek Park, Rocky Mountain NP, Yellowstone NP	Apostle Islands NL, Wind Cave NP
Culling[b] by skilled volunteers	Rocky Mountain NP	None
Capture and euthanasia	Catoctin Mountain Park, Valley Forge NHP, Indiana Dunes NL, Rock Creek Park, Rocky Mountain NP, Yellowstone NP (following disease testing)	Wind Cave NP (round-up followed by capture/euthanasia evaluated)
Hunting[c] (as a primary means of population control or reduction)	Grand Teton NP, Apostle Islands NL, Wind Cave NP (elk only hunted on areas adjacent to Wind Cave), Yellowstone NP (bison only hunted outside the park)[d]	Gettysburg NMP/Eisenhower NHS (outside parks)
Large-scale fencing (>100 acres) that exclude ungulates (e.g., to restore vegetation)	Rocky Mountain NP, Wind Cave NP	Valley Forge NHP, Indiana Dunes NL, Rock Creek Park
Fertility control (e.g., pZP, GonaCon®, etc.) of females for population control (i.e., not reduction) if an agent meets criteria	Valley Forge NHP, Indiana Dunes NL, Rock Creek Park, Rocky Mountain NP	Gettysburg NMP/Eisenhower NHS, Catoctin Mountain Park, Valley Forge NHP, Rock Creek Park, Wind Cave NP, Grand Teton NP (bison only)
Aversive conditioning (hazing) to reduce concentrations or move to desired area	Rocky Mountain NP, Yellowstone NP	Gettysburg NMP/Eisenhower NHS
Reduce or increase supplemental feed (outside park boundary)	Grand Teton NP (reduce outside park boundary)	None
Translocation	Wind Cave NP (bison), Yellowstone NP (bison, elk, pronghorn)	Gettysburg NMP/Eisenhower NHS
Surgical reproductive control	None	Gettysburg NMP/Eisenhower NHS, Rock Creek Park, Wind Cave NP (elk)
Reintroduction of predators	Yellowstone NP (wolves used to reduce elk population)	Rocky Mountain NP
Repellents	None	Catoctin Mountain Park

[a] See Table 1 for species, description of issues, and references; several parks have not made final management decisions and are not included in this table.
[b] Culling refers to lethal removal by sharpshooters (i.e., not capture and euthanasia).
[c] The enabling legislation of Apostle Islands National Lakeshore and Grand Teton National Park allow hunting within all or some of the park, respectively.
[d] In their bison management plan, Yellowstone NP rejected the alternative which relied on hunting outside the park to regulate population numbers. However, it is still used to manage the population.

Table 3. Methods rejected and not fully evaluated as an alternative for managing native ungulates under formal National Environmental Policy Act (NEPA) planning[a].

Method	Reason Why It Was Not Evaluated Further	Parks That Rejected It as an Alternative
Public hunting in the park	Inconsistent with existing laws, policies, regulations, and case law regarding public hunts in the National Park System. It is also inconsistent with long-standing basic policy objectives of the National Park Service. Other alternatives (such as agency culling) raise fewer safety concerns, would impact other visitors to a lesser degree, would have similar environmental effects, and are more efficient (Doerr et al. 2001).	Gettysburg NMP/Eisenhower NHS, Catoctin Mountain Park, Valley Forge NHP, Indiana Dunes NL, Rock Creek Park, Rocky Mountain NP, Wind Cave NP, Theodore Roosevelt NP, Yellowstone NP
Fertility control to reduce population size	Logistically and economically infeasible at this time (due to number of animals required or no multi-year control agent) or would not reach population goals within the time of the plan (e.g., 15 years).	Rocky Mountain NP, Theodore Roosevelt NP, Grand Teton NP, Yellowstone NP
Fence the entire park to keep animals in or out	It does not address the core issue (ungulate population size and their effects) and has unintended negative consequences for a number of other wildlife species and visitor use.	Gettysburg NMP/Eisenhower NHS, Catoctin Mountain Park, Valley Forge NHP, Indiana Dunes NL, Rock Creek Park, Wind Cave NP, Yellowstone NP
Surgical sterilization to reduce or control ungulate population size	The feasibility of this method to attain population reductions or control is uncertain. Research indicates it may only be effective on populations that are largely closed (Merrill et al. 2006). Further, it causes stress to the animals via surgery and, because it is irreversible, may have unintended long-term effects on population genetics and behavior.	Catoctin Mountain Park, Valley Forge NHP, Indiana Dunes NL, Rock Creek Park (for bucks), Grand Teton NP, Yellowstone NP
Reintroduce predators to reduce or control ungulate population size	Wolves are efficient predators of deer and elk, but they have been eliminated from much of the United States. Reintroducing these predators would not be feasible in many locations due to lack of suitable habitat and lack of support from state agencies.	Gettysburg NMP/Eisenhower NHS, Catoctin Mountain Park, Valley Forge NHP, Indiana Dunes NL, Rock Creek Park, Rocky Mountain NP (without active management), Wind Cave NP, Theodore Roosevelt NP
Translocation	Violates NPS policy on translocation (NPS 2002a) for units with chronic wasting disease, could be a potential hazard to other wildlife.	Catoctin Mountain Park, Valley Forge NHP, Indiana Dunes NL, Rock Creek Park, Rocky Mountain NP, Wind Cave NP, Theodore Roosevelt NP, Yellowstone NP
Providing supplemental feed	Increasing food sources would increase animal health, reproduction, and population size. In the long term this would compound problems associated with high ungulate numbers and could lead to unintended negative behavior.	Catoctin Mountain Park, Valley Forge NHP, Indiana Dunes NL, Rock Creek Park, Grand Teton NP (additional areas), Yellowstone NP
Poison	Death from poisoning is not immediate, and health concerns resulting from people potentially hunting and eating poisoned animals is a concern. In addition, non-target native wildlife or roaming pets could potentially eat a tainted carcass or the poison itself.	Gettysburg NMP/Eisenhower NHS, Catoctin Mountain Park, Valley Forge NHP, Indiana Dunes NL
Complete depopulation	Removal of a native species is contrary to NPS Management Policies 2006 (NPS 2006a). In addition, this alternative would eliminate an important aspect of the visitor experience.	Theodore Roosevelt NP, Grand Teton NP (bison only), Yellowstone NP

[a] See Table 1 for species, description of issues, and references; several parks have not made final management decisions and are not included in this table.

Table 4. National Park Service management plans for 'desired' non-native ungulates.

Park (Plan Reference)[a]	Species[b]	Stated Reason for Plan	Population Size at Time of Plan	Desired Population Size	Supporting Data Cited in Plan
Assateague Island NS (NPS 2008b)	Horse	Horse grazing levels as of 2008 were negatively affecting vegetation.	140 horses (175 at peak in 2001)	80–100	Feral horse grazing decreases the distribution, abundance and reproduction of American beachgrass, the primary dune-building species on Assateague (Seliskar 1997).
Bighorn Canyon NRA (BLM 2009)	Horse	To… [maintain] healthy wild horses in a thriving natural ecological balance…and protect the range from deterioration associated with an over-population of wild horses.	195 horses (~25% of the horses range is in Bighorn Canyon NRA; prior to this 2009 plan, management goals were to maintain a population of 85–105 horses (BLM 2009))	90–120 horses (note this is a higher range than the current management targets; there are specific age and sex considerations)	Over-utilization of key forage species has occurred and is resulting in a reduction of the forage base and range conditions. The site index in relation to range condition is 18–47% range-wide. This indicates rangelands are not healthy, have poor species diversity, and are not functioning properly. Population goals were based on levels that allow 45% utilization and prevent range deterioration (BLM et al. 2008).
Cape Lookout NS (NPS 2005)[b]	Horse	Herd size is re-evaluated every five years with the goal of maintaining at least 100 horses (a federal law) and minimizing grazing effects.	110–130 horses	110–130 horses	The Shackleford Banks horses have existed for centuries; there is no known date of arrival. As of 2009 there were 116 horses on the island and their nutrient requirements are being met in spring and summer (Stuska et al. 2009).

[a] NRA = National Recreation Area, NS = National Seashore

[b] The Shackleford Banks horses are jointly managed by Cape Lookout National Seashore and the Foundation for Shackleford Horses, Inc. (Foundation) under a General Agreement. All management decisions are considered, planned, and executed cooperatively.

Table 5. National Park Service management plans for 'undesired' non-native ungulates. Plans created in the last 20 years are included.

Park (Plan Reference)[a]	Species[b]	Stated Reason for Plan	Population Size at Time of Plan	Desired Population Size	Supporting Data Cited in Plan
Great Smoky Mountains NP (NPS 1993)	Pig	Protect native species and park ecosystem, improve visitor experience by reducing effects of pigs on aesthetic and wilderness values of park, protect public health, and minimize impacts of control methods on resources adjacent to park.	Unknown (thought to be less than 1,000)	Eradicate or control population size to extent possible (shooting, trapping within fenced areas)	Feral pigs can reduce understory cover by 95% (Bratton 1975, Huff 1977), cause local extinction of some plants (Bratton 1974, Bratton et al. 1982), and have negative effects (predation, habitat alternation, competition, disease) on native fauna (Ackerman et al. 1978, Singer et al. 1982, Wood and Barrett 1979, Davidson and Nettles 1988).
Bandelier NM (NPS 1994)	Cattle	Feral and trespass cattle severely degrade park resources.	20–30 cattle	Eradication (shooting)	Cattle negatively affect soil and vegetation (Earth Environmental Consultants 1974, Allen 1989).
Lake Mead NRA (NPS 1995c)	Burro	Expanding burro populations are changing the ecological composition of large areas within Lake Mead NRA.	>1600 burros over 2000 km^2	Eradication in select areas; maintain as on adjacent BLM land in other areas (live capture, fencing, fertility control)	Burros can affect the distribution, abundance, and composition of plant species (Woodward 1976, BLM 1989; see also Yancey and Douglas 1983).
Olympic NP (NPS 1995b)[c]	Mountain goat	Mountain goats are not native to Olympic NP and cause significant impacts to the native ecosystems.	~290 goats in 1994 (from a high of >1100 goats in 1983, when removals began)	Eradication (shoot the remaining goats that could not be captured and moved elsewhere)	Mountain goats are non-native (Schalk 1993, Schultz 1993, Houston and Schreiner 1993; but see Lyman 1988) and adversely affect rare plant species, native plant communities, and soils (Houston et al. 1994; but see Noss et al. 2000, published after this plan).
Channel Islands NP – Santa Rosa Island (NPS 1998)	Cattle, horses, deer, elk	Improve water quality/riparian habitat (to address Cleanup or Abatement Order by Central Coast Regional Water Quality Control Board), and conserve rare species (proposed for USFWS listing) and habitats by removing effects of non-native ungulates	~1,600 cattle, ~900 elk, ~1400 deer, at least 150 horses	Complete removal of all non-native ungulates within ~15 years (move cattle, horses off-island; hunt deer and elk, sharpshoot if necessary)	Fecal coliform measures (Sellgren 1995) exceeded allowable level due to road/ range management practices; USFWS (1995) proposed 10 plans on Santa Rosa for listing due to habitat alteration and grazing; grazing and browsing decreased plant species diversity and production; and increased disturbance and non-native plants (Clark et al. 1990).
Channel Islands NP – Santa Cruz Island (NPS 2002b)	Pig	Protect natural and cultural resources and initiate ecosystem recovery by eradicating feral pigs and controlling fennel.	~1,500–5,000 pigs (15–24 pigs/km^2; large annual fluctuations)	Eradication of pigs (shooting, fencing)	Feral pigs contribute to reproductive failure of island oaks (Barrett 1990) and cause extensive ground disturbance (Peart et al. 1994). A variety of other pig-related impacts from other areas are also documented in NPS (2002b).

[a] NP = National Park, NRA = National Recreation Area, NM = National Monument, NS = National Seashore, NHP = National Historic Park, USFWS = U.S. Fish and Wildlife Service
[b] Note: National Park of American Samoa has a feral pig eradication plan (~1998), but no copy is available; methods included fencing and snaring pigs.
[c] Draft EIS only; Final EIS and mountain goat eradication did not occur.

Table 5 (continued). National Park Service management plans for 'undesired' non-native ungulates. Plans created in the last 20 years are included.

Park (Plan Reference)[a]	Species[b]	Stated Reason for Plan	Population Size at Time of Plan	Desired Population Size	Supporting Data Cited in Plan
Kalaupapa NHP (NPS 2000b)	Pig, goat, deer	Pigs, goats, and deer are not native and need to be eradicated in Special Ecological Areas (SEAs) to protect sensitive resources (e.g., endangered plant species), native ecosystems, and archeological sites.	Unknown	Eradication within Special Ecological Areas via fencing and ungulate removal (methods not specified)	Ungulates destroyed large areas of native forest and damaged damp forests in north-facing drainages of park (NPS 2000b); no citations in the management plan, but well documented elsewhere in Hawaii (e.g., Spatz and Mueller-Dombois 1973, Scowcroft and Sakai 1983, Aplet et al. 1991)
Mojave National Preserve (NPS 2002c)	Burro	Burros are not native to Mojave Preserve.	915 burros	Eradication (live capture/ adoption, shooting, and fencing)	Included as part of the park general management plan (NPS 2002c); no specific science cited.
Death Valley NP (NPS 2002d)	Burro and horse	Natural resources are negatively impacted by burros.	250–300 burros, ~10–15 horses	Eradication (live capture/ adoption or shooting)	Ecological niches of Pleistocene equids no longer exist; no species in North American fauna today would have the same niche relationships as modern equids (National Research Council 1982).
Point Reyes NS (NPS 2006d)	Axis and fallow deer	Restore native ecosystems, prevent negative impacts and spread of non-native deer, eliminate impacts to agricultural permittees within Point Reyes NS, and reduce long-term staff needs that require frequent response to issues associated with non-native deer.	250 axis deer, 860 fallow deer	Eradication (shooting, fertility control)	Axis and fallow deer have negative impacts on native wildlife species and habitats (Putman et al. 1989), reduce forage availability and pose a disease threat to native black-tailed deer and Tule elk (Riemann et al. 1979, Fellers and Osbourn 2006), and negatively impact ranchers by depredating pastures and feed and increasing risk of disease transmission.

[a] NP = National Park, NRA = National Recreation Area, NM = National Monument, NS = National Seashore, NHP = National Historic Park, USFWS = U.S. Fish and Wildlife Service
[b] Note: National Park of American Samoa has a feral pig eradication plan (~1998), but no copy is available; methods included fencing and snaring pigs.
[c] Draft EIS only; Final EIS and mountain goat eradication did not occur.

Appendix C: NPS Ungulate Management Survey

Objectives and Methodology

The primary objective of the survey was to conduct a comprehensive inventory of current ungulate management issues and practices for non-domesticated ungulates throughout the National Park Service (NPS). The only prior survey of ungulate management in the NPS focused on natural versus artificial regulation of ungulate populations in 29 predominantly western parks (Robisch and Wright 1995). The working group developed an interactive web-based survey containing 23 closed-ended questions, the majority being pre-populated lists from which respondents selected answers (NPS 2012a), that built upon questions used in the Robisch and Wright (1995) survey. An ordinal Likert scale (Likert 1932, Dillman et al. 2009) was used for questions asking respondents to indicate level of concern. The survey instrument was intended for an individual park unit, regardless of whether multiple units were managed by a single administrator, and was designed for completion within 5–10 minutes.

The survey targeted 272 NPS units identified as 'natural resource' parks by the NPS Inventory and Monitoring program, or parks self-identified to that program as having significant natural resources. The survey relied on voluntary participation, was informally distributed to individual parks through NPS Regional Offices. Prior to distribution, the survey instrument was piloted by the working group in order to minimize inconsistency in interpretation of questions. Since eliminating all ambiguity in wording is often impossible, respondents were provided an opportunity to supplement responses with open-ended comments. A minimum 70% response rate was targeted, both servicewide and within each region, to ensure the survey's findings were representative.

Non-domesticated ungulates were the focus of this survey. A handful of questions regarding domesticated species were included to allow consideration of issues related to both domesticated and wild ungulates (e.g., disease transmission). A total of 38 species or subspecies were denoted in the survey. Data analysis primarily focused on comparing species distribution with contextual questions such as level of management concern, inclusion of species in park enabling legislation, species for which resources have been spent on management, presence of a management plan, and consideration of species restoration. Measures of central tendency (mean, median, and mode) were calculated for responses rating level of concern.

Caution should be exercised when interpreting survey results. Different metrics can be used to summarize the data and elicit different interpretations of survey results (e.g., % of NPS units represented versus % of NPS acreage represented). The summary presented in this Appendix is intended to be demonstrative, not comprehensive, and does not endeavor to include all interpretations. Different time horizons between questions and the subjective nature of responses can all also make comparisons subjective. The Working Group also conducted targeted interviews to better understand the dynamics that link management issues to management actions (see Appendix D).

Results and Discussion

The web-based survey was implemented with 272 NPS units from November 2011 to January 2012. A total of 227 parks responded (83%) with response rates ranging from 78–100% between the seven NPS regions. These response rates indicate the survey was highly representative regionally and servicewide. Fifty-seven percent of all units of the entire National Park System (covering over 83 million acres, or 98.6% of total acres administered by NPS) were represented by the survey respondents, including most parks with significant natural resources. Survey respondents were primarily park biologists or ecologists (62%) and natural resource managers or chiefs (26%) but included park rangers (5%), park superintendents (4%), or other park staff (e.g., cultural resource specialists, curators, or operations personnel; 3%).

Of 227 parks that responded to the survey (Figure 29), 225 (99%) reported having ungulates within their boundaries at some point during the year. Based on park acreages, this translates to 98.4% of NPS' land base reporting presence of ungulates. Of these 225 parks, native ungulates were present in 215 parks (96%), non-native ungulates including domesticated animals were present in 150 parks (67%), and non-native ungulates excluding domesticated animals were present in 75 parks (33%). The survey focused on presence or absence of ungulates that cross an individual park's boundaries within a given year; it did not inquire about relative abundance or degree of transiency (i.e., duration of time within park boundaries).

Distribution of Native and Non-Native Ungulates

Twelve species of ungulates are native to North America and occur in at least one NPS unit (Table 6): bighorn sheep (*Ovis canadensis*), bison (*Bison bison*), caribou (*Rangifer tarandus*), collared peccary (*Tayassu tajacu*), Dall's sheep (*Ovis dalli*), elk (*Cervus elaphus*), moose (*Alces alces*), mountain goat (Oreamnos americanus), mule deer (*Odocoileus hemionus*), muskox (*Ovibos moschatus*), pronghorn (*Antilocapra americana*), and white-tailed deer (*Odocoileus virginianus)*. Survey results indicate the most ubiquitous native species among all NPS units is white-tailed deer. Occurring in over 60% of parks surveyed, white-tailed deer are present in all regions except Alaska. It is also one of only 1–2 native species in all three regions along the eastern seaboard. The remaining four NPS regions each have 6–9 native species. Three species occur in only one region: collared peccaries in the Intermountain Region, and muskoxen and Dall's sheep in the Alaska Region. Except for one park in the Pacific West Region, caribou also exist exclusively in Alaska. Since 2000, few parks have considered restoring native ungulates to NPS lands where they historically were present (Table 7).

In terms of species diversity, there are roughly twice as many non-native ungulate species as there are native ungulate species on NPS lands. The presence of 23 non-native species were reported in the survey: Axis deer (*Axis axis*), Barbary sheep (*Ammotragus lervia*), bison, blackbuck antelope (*Antelope cervicapra*), burro/donkey (*Equus africanus asinus*), cattle (*Bos taurus*), elk, fallow deer (*Dama dama*), goat (*Capra aegagrus*), horse (*Equus caballus*), llama (*Lama glama*), Mouflon sheep (*Ovis aries orientalis*), mountain goat, mule deer, nilgai antelope (*Bosetaphus tragocamelus*), oryx antelope (*Oryx gazella*), Philippine deer (*Rusa marianna*), pig/hog/boar (*Sus scrofa*), reindeer (*Rangifer tarandus tarandus*), sheep (*Ovis aries*), sika deer (*Cervus nippon*), water buffalo (*Bubalus bubalis*), and white-tailed deer.

This includes several species endemic to the United States (U.S.) but not native to land occupied by individual NPS units (Table 8). It also includes some non-native species authorized to occur on NPS lands due to livestock grazing agreements (e.g., cattle), cultural or historic value (e.g., Ossabaw Island Hog), use for law enforcement (e.g., domesticated horse), use as pack animals by visitors (e.g., domesticated horse, llama, donkey, mule), or special legislation (e.g., feral/wild horse). Wild, non-native ungulates currently occur in all but the National Capital Region; domesticated ungulates occur in all regions. The most common wild non-native ungulate is the feral hog (Table 8). Currently documented in parks in five NPS regions, feral hogs are encroaching on parks in the National Capital Region and are known to occur in southeast Alaska.

Management Issues of Concern to Parks

The survey asked respondents to rate their park's level of concern with a pre-populated list of potential management issues as they relate to non-domesticated ungulates occurring at their park. While it is likely that some management issues are interrelated, and a preliminary cluster analysis suggested as much, identifying individual management issues was the focus of the survey. Concern for management issues varied regionally (Table 9).

The issue of highest concern among parks was the adverse effects of ungulates on plants; this was most evident in the National Capital and Northeast regions. White-tailed deer are the only native species in parks in those regions (Table 6) and they contain no wild, non-native ungulates (Table 8). White-tailed deer are known to be overabundant in the northeast (see Appendix B). According to the survey, "Too many ungulates for the habitat to support" was the top or second highest management issue of concern in the National Capital and Northeast regions (and fourth highest servicewide). In other regions, "Vegetation being adversely affected by ungulates" could be related to overabundant, native ungulates or it could be related to non-native ungulates (Table 9). Connecting which species are associated with salient management issue(s) emerging from this survey could be a follow-up inquiry.

Disease in ungulate population(s) was the second highest issue of concern servicewide; again, highest concern occurred in the National Capital and Northeast regions. Stakeholder views on both NPS ungulate management policies and ungulate behavior were of particular concern in two very different regions (Alaska, National Capital). The nature of these stakeholder views could be pursued in a follow-up inquiry. Three other regions (Intermountain, Pacific West, Southeast) had elevated concern for encroachment of non-native or feral ungulates from outside park boundaries. The Pacific West and Southeast regions also had concern for the (current) presence of non-native species within their boundaries. Damage to cultural/historical resources by ungulates was of concern in the Southeast and National Capital regions. Issues of elevated concern to a single region included: (a) vehicle collisions with ungulates (National Capital), (b) movement of ungulates across park boundaries (Alaska), (c) other wildlife adversely affected by ungulates (National Capital), and (d) management actions incompatible between NPS and other agency (Alaska; Table 9).

Concern for Management Issues Relating to Individual Species

More than 80% of parks with native ungulates had some level of concern for issues related to their management (Table 10). Species of highest management concern to parks where they occur were some of the least prevalent species (muskoxen, bison, Dall's sheep, and mountain goats). Bighorn sheep are the single species that both occur in a large number of parks and have a high percentage of parks with at least moderate concern for their management. While being the most common species, and of concern to the greatest number of parks, management issues associated with white-tailed deer are of moderate or greater concern to only half of the parks where they occur.

Caribou occur in half as many parks as do moose, but level of concern for the two species is roughly similar. Management issues associated with elk, pronghorn, and mule deer are of less concern than those associated with other species; management issues associated with collared peccaries and pronghorn are of least concern. Concern for management issues related to individual species was more or less similar between regions, except for moose and pronghorn—concern was noticeably lower in the Northeast for moose and lower in the Midwest for pronghorn.

In contrast to native ungulates, management issues associated with wild, non-native ungulates are of management concern to all NPS units where they occur. Excluding one NPS unit in Guam with water buffalo, management issues for about two-thirds of all non-native ungulate species are of moderate or greater concern to parks (Table 10). Management issues associated with Barbary or Mouflon sheep, feral/wild horses, and feral hogs are of highest concern. Several parks commented that their management concern for non-native sheep was associated with potential impacts to native bighorn sheep. Feral/wild hogs are the single non-native species that both occurs in a large number of parks and has a high percentage of parks with at least moderate concern for issues related to their management. Among species native to the U.S. but not native to some NPS units, management issues related to wild bison, mule deer, and white-tailed deer were of concern to all parks where they are considered non-native. A large majority of parks with non-native mountain goats or elk have moderate or greater concern for issues related to their management.

The survey was designed to capture concern for management issues related to ungulates occurring within park boundaries. Several parks added commentary regarding ungulates occurring on adjacent lands or potentially occurring on NPS lands in the future. This was the case for bison, where five parks expressed concern over the possibility that populations would be restored in or near their park. Five parks also expressed concern for management issues related to elk. Among the three parks that added comments, one park indicated concern for their absence from the park's ecosystem, one park indicated concern only because confirmation of their elimination from the park (as a non-native) had not yet been confirmed, and one park's concern was relatively neutral: elk had been reintroduced by a state agency five miles outside the park boundary and there is simply a level of 'awareness' at this point. Concern for management issues related to collared peccaries was expressed by four parks, two of which specifically mentioned potential damage to cultural resources due to their digging behavior. One park considering restoring pronghorn indicated concern for potential management issues in the future.

Concern for potential management issues was most pronounced with non-native ungulates. At least 132 parks (59%) expressed concern for encroachment of wild non-native ungulates and subsequent management issues if they eventually occur in parks. This included 74 parks expressing concern for feral hogs, notable because it indicates almost twice as many parks with concern for management issues than currently have the species. Parks also expressed concern for feral goats (n = 6 parks), feral sheep (n = 7 parks), feral horses (n = 6 parks), feral cattle (n = 6 parks), and feral burros (n = 3 parks). Parks reflected that concern for non-natives related to potential impacts to vegetation, cultural resources, and native ungulate species both directly (e.g., disease) and indirectly (e.g., competition for resources). Due to actions on adjacent hunting ranches, one park in Hawaii indicated the presence of blackbuck antelope and/or axis deer was imminent both for their park and all parks (six total) in Hawaii. Additionally, parks expressed concern for potential issues related to some domesticated, non-native ungulates: sheep (n = 11 parks); cattle (n = 19 parks); goats (n = 12 parks); and donkeys, horses, llamas or mules (n = 14 parks).

It is important to note that the survey asked parks to indicate their current, general concern for management issues related to individual species. Concern for some species may be lower (or higher) depending on: (a) the subjective time frame used by the respondent when answering the question, (b) whether or not the park has a management plan for the species and if so, when it was implemented, and (c) whether activities to manage the species were recently implemented (including type, extent, and duration of the activity).

Management Activities Occurring in Parks (2000–2011)

Over 82% of parks spent time or money during 2000 to 2011conducting an activity intended to address an ungulate management issue. Population monitoring was the single most common management activity, occurring in 49% of parks surveyed. Monitoring and mitigation fence enclosures or exclosures (40%), education programming (33%), and protecting vegetation to reduce impacts of grazing (28%) were also common management activities (Table 11). The survey did not capture differences between management activities in terms of their design, how they were implemented, extent and intensity of implementation, and duration(s) of time conducted. Responses inherently reflect a park's subjective determination of management activities, may thus overestimate true occurrence, and would be a topic for follow-up inquiry. Additionally, open-ended comments for this survey question suggest that more management activities are being conducted on NPS lands than responses indicate. Activities can be conducted by outside entities (e.g., state agencies), in cooperation with parks, without requiring the parks to expend resources.

White-tailed deer were by far the native species for which the most parks spent time or money on management activities (Table 12). However, activities took place at only half of the parks where they occur. Approximately equal numbers of parks spent resources managing native mule deer, elk, and bighorn sheep; corresponding to 33%, 50%, and 76%, respectively, of parks where these species occur. All parks where muskoxen and native bison occur spent resources on management issues for these ungulates; one park where bison don't (yet) occur also spent resources in preparation for their restoration on adjacent state lands. Among species endemic to the U.S. but not native to some NPS lands, all or almost all parks spent resources on issues related to their management. Seventy-two to 86% of parks with wild species non-native to the U.S. or its territories spent resources on issues related to their management. Management activities related to feral hogs incurred resource expenditures at the most parks.

The survey was intended to provide initial insight into resource expenditures targeting specific species. The survey did not capture whether concern for the species was higher or lower as a result of resource expenditures, thus it is not appropriate to compare resource expenditures to levels of concern for individual species. A follow-up inquiry could address the specific type(s) of actions that were implemented, the management issue(s) it was intended to address, the species it was directed towards, whether the action was successful, and how success was determined.

Management Plans and Enabling Legislation

Prioritization of resource expenditures may be influenced by an NPS unit's enabling legislation. Among parks responding to the survey, 17 have enabling legislation that specifically mentions conservation or management of at least one ungulate species (Table 13). Nine of these parks occur in Alaska due to the genesis of most parks in that state in conjunction with passage of the Alaska National Interest Lands Conservation Act. The Intermountain and Pacific West are the only other regions with ungulate species mentioned in a park's enabling legislation. One park each in the Northeast and Southeast regions indicated that management of feral horses is mandated in subsequent, but not enabling, park legislation. Conservation or management of four native species is not explicitly mentioned in the enabling legislation of any NPS park surveyed: bison, collared peccary, mountain goat, and muskox.

Presence of a management plan also influences the management activities used at a park. Sixty-two parks reported having (currently or in development) a formal management plan for one or more ungulate species (Table 14). Native and non-native ungulates have approximately the same number of management plans. The Intermountain, Pacific West, and Southeast regions have the most parks (11–12 each) with management plans for one or more ungulate species. The National Capital, Northeast, and Alaska regions have about half as many parks with plans (6–8 parks each). Survey responses indicated that more formal management plans may exist than the NPS Biological Resource Management Division is aware of. As there may be differences in what is considered a formal management plan, clarifying the types of management plans that exist (and acquiring these plans) could be an appropriate follow-up activity.

Summary

Surveys are a means of self-reporting and rely on the knowledge of individual respondents. Although the majority of park staff responding to this survey had natural resource backgrounds, specialties vary immensely in the natural resource field. Additionally, some questions related to managing ungulate *issues* rather than managing ungulates themselves and required types of knowledge which may have been outside some respondents' scope of experience at their park. These limitations were recognized during development of the survey and respondents were instructed to answer questions as best they could. Because parks vary in size and

specific purpose, the specialties and management foci differ among NPS personnel at parks. This inherent subjectivity adds a level of complexity whereby individual contexts need to be considered, and should be noted when reading the conclusions presented below.

Parks responding to the survey represent over 98% of the total land area administered by NPS. High response rates balanced across all regions indicate that survey results are representative of the National Park System. Twelve native ungulate species and roughly twice as many non-native ungulate species exist on NPS lands in the U.S. or its territories. The survey indicated that concern for management issues varies regionally and no single issue was of high concern across NPS. Nonetheless, the issue receiving the highest concern across the most regions was the adverse effects of ungulates on vegetation. Details on the types of effects, the specific ungulate species involved, or whether the majority of effects are caused by native overabundant ungulates or non-native ungulates could be investigated in a follow-up inquiry. Exemplifying the importance of context, stakeholder views on ungulate management policies and ungulate behavior was an important management issue.

High level of concern exists for management issues relating to ungulates, whether native or non-native, in all regions of the National Park System. Assuming all management issues are equally important, those relating to non-native species appeared to be more pervasive and of greater concern than those relating to native species. Relative importance of management issues to parks (and the associated species, if relevant) could be investigated in a follow-up inquiry. As demonstrated by how results are presented in the summary tables accompanying this appendix, one can either choose to focus on the outright number of parks having a management concern (i.e., frequency) or the number of parks with management concern relative to the number of parks having the species (i.e., potency). For example, muskoxen are of at least moderate concern to 100% parks with the species, but they occur in only four parks (e.g., high potency but low frequency). On the other hand, although only 50% of parks with white-tailed deer have at least moderate concern for their management it is still the species of concern to the greatest number of parks simply because it is the most ubiquitous (e.g., high frequency but relatively low potency). This suggests that priorities for comprehensive management of native ungulates should address both the overabundance of some species and the conservation needs of others.

High concern for ungulates, both native and non-native, across the NPS was also reflected in the large percentage of parks that have spent resources on activities to manage ungulate issues. The actions being used to address a particular management issue (or species) was not included in the scope of this survey but could subsequently be investigated. What is clear is that management activities are occurring at most parks and across every region. Whether actions are consistent in addressing similar issues and/or species, and whether actions are successful, were not investigated in this survey. Some of these topics were addressed in subsequent, targeted interviews and are discussed in Appendix D.

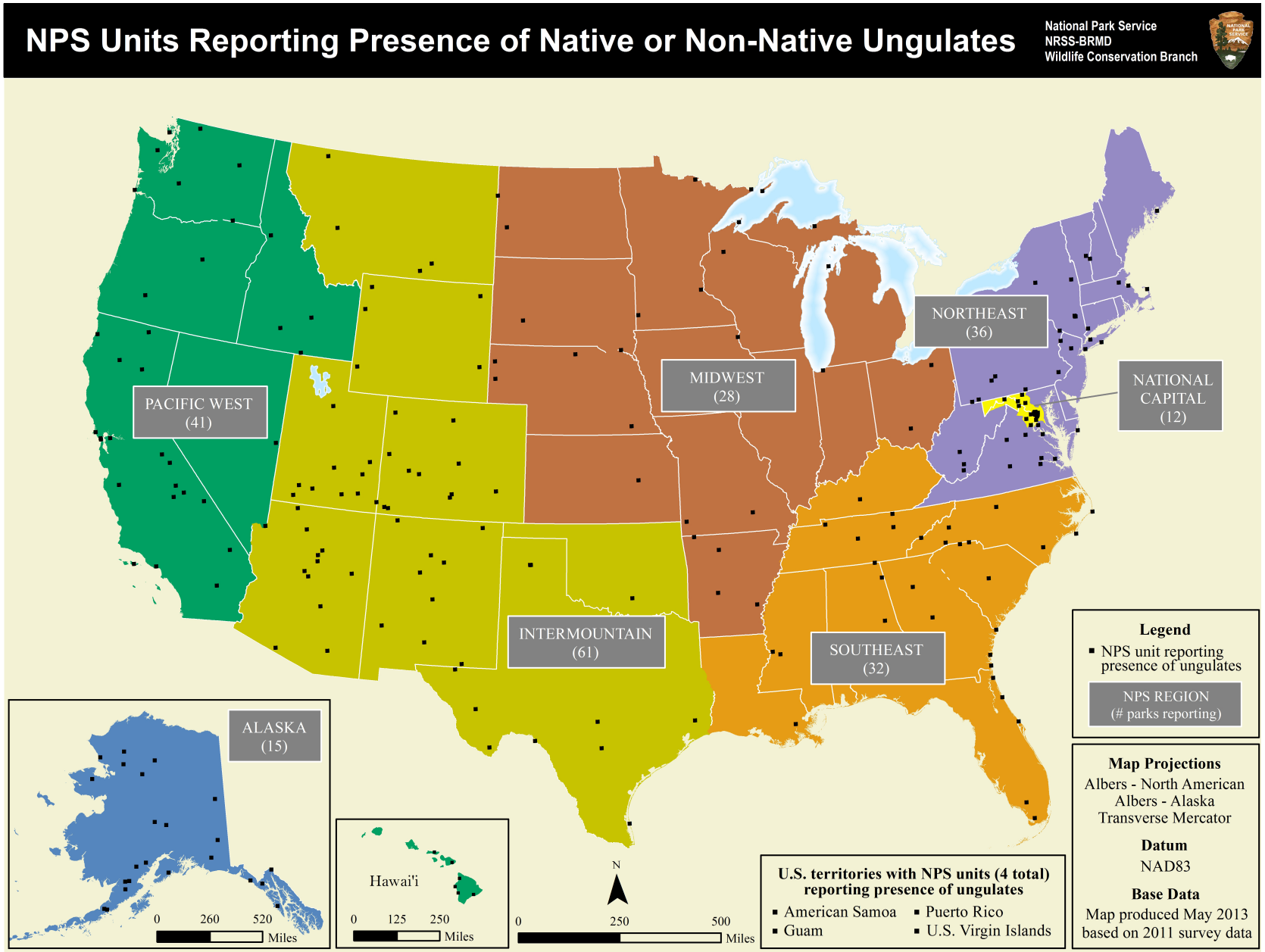

Figure 23. Distribution of National Park Service units responding to the survey and reporting presence of native or non-native ungulates.

Table 6. Number of National Park Service units responding to the survey with native resident or transient ungulate species occurring within unit boundaries.

		Region						
Species	**All Regions**	**Alaska**	**Intermountain**	**Midwest**	**National Capital**	**Northeast**	**Pacific West**	**Southeast**
White-tailed deer	136		24	27	12	36	6	31
Mule deer	90	1	54	5			30	
Elk	58		34	6			15	3
Pronghorn	41		27	5			9	
Moose	38	15	10	5		2	6	
Bighorn sheep	34		24	2			8	
Collared peccary	16		16					
Caribou	15	14					1	
Bison	8		4	4				
Dall's sheep	7	7						
Mountain goat	7	4	1				2	
Muskox	4	4						

Table 7. Number of National Park Service units responding to the survey that have considered restoring non-extinct native ungulates from 2000 through 2011.

Native Species	**Number of Parks with Species Absent**	**Number of Parks That Considered Restoring Species**
Bison	37	3
Elk	34	1
Bighorn Sheep	15	9
Pronghorn	15	4
Caribou	7	1
Moose	4	0
Mule deer	3	0
Dall's Sheep	1	0
Mountain Goat	1	0
White-tailed deer	1	0
Collared peccary	0	0
Muskox	0	0

Table 8. Number of National Park Service units responding to the survey with non-native resident or transient ungulate species occurring within unit boundaries.

		Region						
Species	**All Regions**	**Alaska**	**Intermountain**	**Midwest**	**National Capital**	**Northeast**	**Pacific West**	**Southeast**
Wild species not native to the United States or its territories								
Pig/hog/boar (feral)	43		11	3		1	9	19
Cattle (feral)	16		10				6	
Horse (feral)	17		7	3		1	3	3
Burro/donkey (feral)	11		7				3	1
Goat (feral)	9		2				6	1
Barbary sheep	5		5					
Sheep (feral)	5		2				2	1
Axis deer	3						3	
Fallow deer	3		1				2	
Blackbuck antelope	2		2					
Mouflon sheep	2		1				1	
Nilgai antelope	1		1					
Oryx antelope	1		1					
Philippine deer	1						1	
Sika deer	1					1		
Water buffalo	1						1	
Wild species native to the United States or its territories but not native to NPS unit[a]								
Mountain goat	7		6				1	
Elk	5		4				1	
White-tailed deer	4		2	1				1
Bison	3	1	2					
Mule deer	2	1					1	
Domesticated (non-native) species[b]								
Cattle	81		36	10	4	7	19	5
Donkey, horse, llama, or mule	74	5	23	9	5	9	15	8
Goat	31		11	3	2	9	3	3
Sheep	22		13	1	2	3	3	
Pig/hog	2					1	1	
Bison[c]	1		1					
Reindeer	1	1						

[a] Determination of whether some species are native or not native to individual parks may be under debate.
[b] Includes authorized and trespass animals.
[c] For purposes of this report, domesticated bison are considered non-native.

Table 9. Average level of concern[a] for management issues relating to non-domesticated ungulates occurring at National Park Service units responding to the survey.

Management Issues	All Regions	Region						
		Alaska	Intermountain	Midwest	National Capital	Northeast	Pacific West	Southeast
Vegetation resources adversely affected by ungulates	2.5	1.3	2.0	2.8	4.0	3.2	2.6	2.6
Disease in ungulate population(s)	2.2	1.9	2.2	2.4	3.5	2.6	1.9	1.8
Stakeholder views on ungulate management policies	2.2	3.0	2.0	1.9	3.5	2.2	2.3	2.1
Too many ungulates for habitat to support	2.1	1.6	1.5	2.6	4.1	2.9	1.6	2.1
Vehicle collisions with ungulates	2.1	0.6	2.0	2.1	3.6	2.3	2.0	2.3
Movement of ungulates across park boundaries	2.0	2.9	2.3	1.6	1.9	1.3	2.4	1.6
Encroachment of non-native or feral ungulates from outside park boundaries	1.9	0.4	2.5	1.2	0.7	0.4	2.4	2.7
Presence of non-native ungulates, excluding domesticated species but including feral species, within park boundaries	1.8	0.3	2.0	1.5	0.6	0.4	2.4	2.9
Damage to cultural/historical resources by ungulates	1.8	0.3	1.6	1.1	2.7	2.2	2.0	2.5
Other wildlife adversely affected by ungulates	1.8	0.4	1.7	1.9	3.3	1.9	1.8	2.1
Stakeholder views on ungulate behavior	1.8	2.7	1.5	1.1	3.1	1.9	2.1	1.6
Habituation to people	1.8	0.7	1.7	1.5	1.7	2.0	2.0	2.0
Roads or developed sites within or adjacent to park interfere with ungulate behavior	1.6	2.4	2.0	0.9	1.8	1.1	1.9	1.3
Management actions incompatible between your park and other agency	1.5	3.7	1.4	1.2	1.6	1.3	1.5	0.9
Food or water conditioning (within park)	1.4	0.9	1.7	0.8	1.1	1.5	1.7	1.3
Food or water conditioning (adjacent to park)	1.4	1.0	1.6	0.9	1.0	1.3	1.8	1.3
Genetics of ungulate population(s)	1.3	1.5	1.7	1.2	1.2	0.7	1.3	1.1
Presence of domesticated ungulates authorized to occur within park boundaries	1.3	1.1	1.3	1.7	0.8	1.0	1.7	1.0
Restoring native ungulate species/subspecies	1.2	0.4	1.7	1.3	0.5	0.4	2.2	0.8
Physical conflict between park visitors and ungulates	1.2	1.0	1.4	0.8	1.0	0.8	1.5	1.5
Park visitors have adverse impacts on ungulates (e.g., backcountry use, displacement)	1.1	1.9	1.3	0.8	0.8	0.7	1.3	1.0
Damage to park infrastructure by ungulates	1.0	0.3	1.0	0.5	1.0	1.3	1.1	1.6
Too few ungulates (habitat could support more)	1.0	2.1	1.3	0.7	0.5	0.3	1.4	0.6

[a] Respondents rated level of concern on the following scale: 0 = No Concern, 1 = Low Concern, 2 = Low–Moderate Concern, 3 = Moderate Concern, 4 = Moderate–High Concern, 5 = High Concern.

Table 10. Level of concern[a] for management issues relating to ungulate species occurring[b] in National Park Service units responding to the survey.

Species	Of Parks with the Species, Percent Indicating Some Level of Concern for its Management[c]	Of Parks with the Species, Percent with at Least Moderate Concern for its Management[d]
Wild species native to the United States or its territories		
Muskox	100%	100%
Bison	100%	88%
Dall's sheep	100%	86%
Mountain goat	100%	71%
Bighorn sheep	97%	91%
White-tailed deer	95%	50%
Caribou	93%	67%
Elk	91%	41%
Mule deer	91%	23%
Moose	89%	58%
Collared peccary	81%	13%
Pronghorn	80%	40%
Wild species not native to the United States or its territories		
Sheep (Barbary, Mouflon)	100%	100%
Horse (feral)	100%	88%
Pig/hog/boar (feral)	100%	84%
Cattle (feral)	100%	80%
Sheep (feral)	100%	80%
Goat (feral)	100%	78%
Burro (feral)	100%	73%
Antelope (Blackbuck, Oryx, Nilghi)	100%	66%
Deer (Axis, Fallow, Philippine, Sika)	100%	63%
Water buffalo	100%	0%
Wild species native to the United States or its territories but not native to NPS unit[e]		
Bison	100%	100%
Mule deer	100%	100%
White-tailed deer	100%	50%
Mountain goat	86%	71%
Elk	80%	80%
Domesticated (non-native) species[f]		
Bison[g]	100%	100%
Reindeer	100%	100%
Sheep	100%	62%
Cattle	98%	54%
Goat	90%	27%
Donkey, horse, llama or mule	89%	32%
Pig/hog	50%	50%

[a] Respondents rated level of concern on the following scale: 0 = No Concern, 1 = Low Concern, 2 = Low–Moderate Concern, 3 = Moderate Concern, 4 = Moderate–High Concern, 5 = High Concern.
[b] Only parks with species currently occurring within boundaries are included in percentages; additional parks indicated concern for management issues relating to many species not currently occurring within park boundaries.
[c] Includes parks indicating Low, Low–Moderate, Moderate, Moderate–High, or High concern.
[d] Includes parks indicating Moderate, Moderate–High, or High concern.
[e] Determination of whether some species are native or not native to individual parks may be under debate.
[f] Includes authorized and trespass animals.
[g] For purposes of this report, domesticated bison are considered non-native.

Table 11. Management activities related to ungulates on which National Park Service units responding to the survey have spent time or money from 2000 through 2011.

Management Activity	Number of Parks
Population monitoring	112
Fencing enclosures or exclosures	90
Education programming	75
Protecting vegetation to reduce impact of ungulate grazing/foraging	64
Disease or genetic monitoring	40
My park has not spent time or money on any of the above (or other) activities related to managing ungulate issues	40
Signage development	35
Culling (defined as using hunting to reduce population size)	31
Eradication efforts	29
Habitat restoration to improve habitat for ungulates	27
Hazing to move animals outside park boundaries	25
Hazing or other behavior modification to move animals to a different area within the park	19
Translocating or destroying individuals that cause problems	17
Provision of food, salt licks, or water	16
Management techniques to reduce potential diseases/parasites	15
Translocating ungulates (to other areas in park or areas outside of park) to reduce population size	15
Artificial fertility control	11
Hazing to keep animals within park boundaries	6
Predator control (to reduce predator numbers)	5
Predator reintroduction (to increase predator numbers)	2

Table 12. Ungulate species for which National Park Service units responding to the survey spent resources (i.e., time or money) on management issues from 2000 through 2011.

Species	Number of Parks Spending Resources
Wild species native to the United States or its territories	
White-tailed deer	75
Mule deer	30
Elk	29
Bighorn sheep	26
Moose	18
Pronghorn	10
Bison	9
Caribou	9
Dall's sheep	7
Collared peccary	4
Mountain goat	4
Wild species not native to the United States or its territories	
Pig/hog/boar (feral)	34
Horse (feral)	14
Cattle (feral)	10
Burro (feral)	8
Deer (Axis, Fallow, Philippine, Sika)	6
Goats (feral)	6
Sheep (Barbary, Mouflon)	6
Sheep (feral)	5
Antelope (Blackbuck, Oryx, Nilghi)	3
Water buffalo	1
Wild species native to the United States or its territories but not native to NPS unit[a]	
Elk	4
Mountain goat	4
Bison	3
White-tailed deer	2
Mule deer	1
Domesticated (non-native) species[b]	
Cattle	52
Donkey, horse, llama or mule	19
Goat	11
Sheep	8
Pig/hog	1

[a] Determination of whether some species are native or not native to individual parks may be under debate.
[b] Includes authorized and trespass animals.

Table 13. Ungulate species for which conservation or management is specifically included in the enabling legislation[a] of a National Park Service unit responding to the survey.

	Number of parks		
Species	**Alaska Region**	**Intermountain Region**	**Pacific West Region**
Caribou	8		
Moose	8		
Dall's sheep	6		
Elk		1	1
Bighorn sheep		1	
Pronghorn		1	
Mule deer		1	
White-tailed deer		1	

[a] Additionally, one park in each of the Northeast and Southeast regions indicated that (non-native) feral/wild horses are mentioned in subsequent legislation but not in the park's enabling legislation.

Table 14. Ungulate species for which National Park Service units responding to the survey have (currently or in development) a formal management plan[a].

		Region						
Species	**All Regions**	**Alaska**	**Intermountain**	**Midwest**	**National Capital**	**Northeast**	**Pacific West**	**Southeast**
Native species to the United States or its territories								
White-tailed deer	16		1	3	6	4		2
Elk[b]	11		5	2			3	1
Caribou	7	7						
Bighorn sheep	6		3				3	
Bison	6		4	2				
Dall's sheep	2	2						
Mule deer[c]	3		1				2	
Moose	3	3						
Muskox	3	3						
Mountain goat[d]	3	1	1				1	
Pronghorn	1		1					
Collared peccary	0							
Wild species not native to the United States or its territories								
Pig/hog/boar (feral)	15		4	1			3	7
Horse (feral)	6		3			1	1	1
Burro (feral)	4		2				2	
Axis deer	2						2	
Barbary sheep	2		2					
Cattle (feral)	2		1				1	
Goat (feral)	2						1	1
Fallow deer	1						1	
Mouflon sheep	1						1	
Oryx antelope	1		1					
Sheep (feral)	1						1	
Domesticated (non-native) species[e]								
Cattle	6		3				3	
Donkey, horse, llama or mule	2		1				1	
Goat	2							2
Sheep	2				1			1

[a] Management plans can be for a single species, or can include more than one species at a given park.
[b] Includes one park in the Intermountain Region where elk are considered non-native.
[c] Includes one park in the Pacific West Region where mule deer are considered non-native.
[d] Includes two parks, one each in the Intermountain and Pacific West regions, where mountain goats are considered non-native.
[e] Includes both authorized and trespass animals.

Appendix D: Interviews with Key NPS Personnel

Objectives and Methodology

The review of ungulate management activities across the National Park System (see Appendices B and C) offered a unique opportunity to uncover goals, objectives, and philosophies that are the foundation of ungulate management actions in parks. Interviews allowed investigation beyond what actions are being taken to address which issues, to understanding the dynamics that link issues with actions. In-depth interviews with park managers were structured to shed light on the "why" of ungulate management and to begin examining the decision-making processes that lead from problem identification to management action and implementation. Interviews were an opportunity to learn what factors are included in decisions about ungulate management as well as to better understand decision-making models employed by managers.

Interview respondents were initially selected using a purposeful sampling technique (Marshall 1996) to select respondents with relevant experience. All respondents had significant experience with ungulate management in the National Park Service (NPS). The sample was designed to elicit various points of view based on job position, years of service, park region, and park mission. Eighteen individuals were interviewed representing parks from every NPS region. Respondents had varying levels of responsibility, from park biologists to superintendents (NPS 2012b).

Interviews were conducted by telephone, recorded, and transcribed. Respondents were provided with a set of questions prior to the interview. These questions, as well as a summary sheet developed from the park's responses to the ungulate management survey (Appendix C), were used as a rough guide for semi-structured interviews. Interviews lasted from 35 minutes to over one hour. After being transcribed the interviews were reviewed and coded for common themes.

Themes Emerging from Interviews

Overview

Interviews revealed that ungulate management involves a number of highly complex decision-making processes based on multiple criteria. Managers identified that science, policy, and stakeholders (including other state and federal wildlife agencies, residents of adjacent or gateway communities, and national interest groups) must all be considered in ungulate management decisions. Respondents indicated a belief that each park unit is created for a unique purpose and mission and felt it was important to manage in accordance with that mission. The diversity of park attributes and missions is viewed by interviewees as a justification for addressing ungulate issues on a case-by-case basis. However, there was also recognition that parks could make ungulate management decision-making processes more efficient by sharing lessons learned. Although managers seek to employ sound biological, ecological, and social science in decision making, such data were seldom deemed sufficient for deciding on a particular course of action. Additional considerations, such as avoidance of controversy and conflict, and availability of funding and technical expertise, were commonly expressed as determining what action is taken.

Interviewees identified the National Environmental Policy Act (NEPA) as one process through which park decision makers examine issues. NEPA processes and formal planning are strong tools when actions are desired because the process invites examination of underlying assumptions held by a variety of stakeholders. However, there are a large number of choices that are made that are not captured in the NEPA process. Decisions to not manage certain species, for example, express particular values without a formal framework for feedback and discussion. As an example, one interviewee discussed their park's decision to manage one non-native species (hogs) and not another (horses). Both have ecological impacts, but managers express concern about public reaction to horse control. The factors included in that decision were not subject to a formal planning process.

Management Contexts

Interviewees noted that acceptability of proposed actions is highly influenced by the nature of the ungulate in question, the perceptions of stakeholders, park mission, and other criteria. For example, a particular white-tailed deer management strategy considered highly successful based on specific goals in one context, may be unsuccessful in a different context or may not be applicable given alternate goals. At one park conducting herd reduction, the superintendent evaluated that park's program as "…much more successful than we could have imagined in our wildest predictions…" but explicitly recognized that their approach would not be practicable in other contexts. That assessment was supported by other interviews. Interviewees emphasized that each park contains a distinctive mix of biological, social, and cultural

components, which create a unique management context for each park. The intersection of these components delineates the decision space in which managers operate and creates a high degree of complexity. Managers' ability to address specific issues or use specific methods is context-dependent. For example, a fenced park can use the fence as a management tool; or a park located near a community with a strong hunting tradition might have access to experienced marksmen as potential volunteers for herd reduction.

Many managers believed that there are no "one-size-fits-all" solutions in ungulate management. The superintendent of one park in which elk are culled was satisfied with that management strategy, and attributed success of their culling program to availability of skilled volunteers and a strong hunting tradition in communities surrounding the park. That superintendent stated that their management strategy has been "successful for a variety of reasons that most parks wouldn't have in place, and so I would not necessarily recommend this particular method of removal of ungulates to any other park." The superintendent of another park concurred with that assessment. While recognizing the success of the previously mentioned park, the second superintendent indicated the approach would not be suitable for his park's context.

While emphasizing that divergent contexts require superintendents retain flexibility in decision making, interviewees voiced significant support for programmatic approaches to common ungulate issues. An interviewee from a park with an emergent ungulate overabundance problem indicated a desire to participate in a multi-park Environmental Impact Statement (EIS) already underway in order to leverage existing investment. Another interviewee indicated the belief that template-based decision-making processes derived from lessons learned from previous plans would be more cost-effective. Respondents felt that, for plans addressing similar species in similar contexts, such approaches would be helpful for making planning and decision making more efficient and avoiding duplication of effort, such as literature reviews, identification of management alternatives, or in some cases, entire planning exercises.

In addition to recognizing physical and social aspects of context, many respondents alluded to the temporal changes that affect contexts. They believed that since ecological and cultural landscapes experience natural and anthropogenic influences, parks must constantly deal with change. They also believed that management actions, even those sanctioned through formal planning processes, can become ineffective in the face of shifting ecological or biological conditions, or unacceptable as a result of changing political or social factors. For example, some interviewees noted that appearance of chronic wasting disease has led to changes in acceptable ungulate management practices. In some cases, changes in ungulate management carried out by agencies outside of the parks have had impacts on park resources.

Science

Respondents referred to science as an important part of their decision-making processes. Biological, ecological, and social sciences are key components of problem identification, planning, and decision making. In some cases interviewees relied on monitoring of biological resources for identifying ungulate issues. In other cases, problems were identified through unsystematic observation and later quantified to clarify severity of an issue or to test causal hypotheses. As stated by one respondent, "There was a general, non-scientific understanding… we followed up with science."

Given the importance interviewees placed on developing a scientific grounding for ungulate issues, lack of data can be a stubborn obstacle that prevents parks from taking action or forces parks to take actions when none is warranted. A number of respondents indicated the need for additional data on crucial factors such as populations and stakeholder views. For example, in one case, communities adjacent to the park complained of nuisance ungulates and had the impression that populations were too high. The park believed that abundance was not a problem because they did not observe clear indications of impacts on resources, such as a clear browse line. However, they did not have up-to-date population numbers or movement models, so were unable to speak to abundance directly.

This example illustrates another theme common to the use of science in parks. Decisions are sometimes supported by data that are not specifically related to the most controversial aspects of issues because those data are unavailable or uncertain. In these cases, parks look to related issues for which strong data exist and can be linked directly to park resource objectives. Several respondents noted that, in formal planning exercises, tree regeneration was a primary measure used to justify ungulate management actions even when other factors such as crop damage or animal-vehicle collisions were among motivating factors for their planning exercise. One respondent explained that they "hang their hats on regeneration of trees" because it is relatively easy to measure, is firmly established in the literature, tied to park purpose, and is not controversial. They also noted that this

approach leaves a number of ungulate issues, such as the complaints related to ungulate damage adjacent to the park, unmanaged. Natural resource science, although extremely important and well-respected by all respondents, is costly and time consuming. As one respondent stated, "Because it just takes so much to document one thing, …we focused our attention on regeneration of woodlands and successive crop yields, those are the two resources key to our…mission." This respondent recognizes that it would be desirable to provide data to support assessment of impacts on other resources, but collection of such information is too costly. Parks make decisions about which issues to focus data collection on and which issues not to. Still, it is often difficult for managers to clearly articulate the explicit basis for such trades-offs.

When speaking of formal planning, however, some respondents indicated there may be over-reliance on biological concerns in determining a course of action. Interviewees suggested a strong need for more social science related to resources and for better integration of that social science with biological science. Respondents believed that resolution of ungulate issues requires a better understanding of stakeholder issues, incentives for changing behavior, acceptable trade-offs, and strategic communication.

Additional Considerations in Decision Making

Managers indicated that decisions would ideally be science-*based*; but in reality, social and ecological scientific information is considered in conjunction with other management concerns (such as park mission), leading rather to science-*informed* decisions. Other concerns that were most frequently noted included availability of funding, expertise, and data. Stakeholder views, relationships with other agencies, and policy mandates were also frequently mentioned. As one respondent stated, "… 'what should we do' is the first thing that we try to figure out and then we figure out, okay, is there something getting in the way that makes it hard to do that, based on politics or stakeholder interests or something like that." In discussing future issues one respondent stated, "… we have got to figure out, number 1, which [future issues] we wanted to take on, which ones we can take on…"

Individual experience and expertise often influences how issues are framed and how the context is defined. Respondents frequently framed issues in terms of areas of their own expertise. In the words of one interviewee, "I went ahead because I do have a forestry background, to make sure that we have really good flow surveys done that can be tied into ecological systems, modeling, if you will." This suggests that identification of data needs and tools may be influenced by prior experience of decision makers. In another case, where park neighbors complained about damage to residential vegetation from "park deer," a biologist indicated that they had no real ungulate issues because there were no indicators of overabundance. The lack of biological evidence of overabundance within the park was used as the framing criteria for the issue rather than public concern about damage.

Other respondents indicated that level of potential controversy was a key component of selecting alternatives and often informs how and which ungulate issues are addressed. There may be biological justification for action but if the potential for conflict is too high, a park may opt for less effective management actions or avoid management actions completely. For example, feral horses present a particular challenge because they have well-organized interest groups and are a major attraction for visitors. In some cases, impacts from non-native feral horses on other park resources are tolerated because removal of horses would cause too much controversy.

Proactive versus Reactive Management

One of the most common themes to arise from the interviews is the idea that parks are generally in a reactive position although they desire to be more proactive. Parks prioritize spending on, and often are required to address, acute issues rather than investing time and money to "get ahead" of an anticipated or potential issue. Parks with increasing, but not yet critical, abundance of ungulates have requested funding for planning and management activities before there are long-lasting ecological impacts. Their proposals may not compete well when they are compared to funding requests for imminent impacts.

Interviewees frequently referred to factors that prevented them from looking forward and planning for changes in habitat and ungulate populations. Primary among these was funding constraints on planning processes and how projects are selected for funding. They also expressed a need to address emergent issues quickly with the practices and tools available, even if they were not ideal or part of a comprehensive plan. Some interviewees indicated they faced staffing and funding limitations that prevented them from addressing ungulate issues until issues became acute. Interviewees generally supported the concept of addressing ungulate issues before they had lasting impacts on other resources, as the recovery of those damaged resources would represent an additional expenditure of park funds and staff time. They called for mechanisms such as coordinated planning efforts between parks.

Conclusions

Interviewing NPS professionals with significant experience in managing ungulates expanded our understanding of some of the criteria used in decision making. Identification of themes that emerged from the interviews was intended to summarize key issues and provide insight into how parks handle complex ungulate management issues. These interviews suggest that parks use multiple criteria in formulating ungulate management decisions. Objective data and subjective impressions are combined, within a particular context, to create unique approaches that can appear to be inconsistent across the park system. The prevalence of some themes across interviews, such as the need for taking steps to protect park resources, the desire to be proactive rather than reactive, and the need to incorporate context-relevant science, suggests there are common needs within the system regardless of the specific context or ungulate species. NPS would benefit from developing servicewide guiding principles for ungulate management that would serve as the general framework by which each park could process their unique circumstances while remaining consistent with a coherent servicewide strategy.

Appendix E: Ungulate Management Workshop

Objectives and Methodology

A workshop titled "Ungulate Management in the National Park Service" was convened from February 22 to 24, 2012 in National Park Service (NPS) offices in Fort Collins, Colorado. Participants included the ungulate management working group and other invited NPS personnel, academics, and researchers who were attending concurrent workshops in NPS offices the same week. The workshop was divided into two sections: synthesizing current management practices and principles around management of native overabundant and non-native ungulates, and examining management and planning needs.

The workshop was informed by a review of ungulate management plans (Appendix B), a survey conducted November 2011–January 2012 (Appendix C), and interviews conducted January–February 2012 (Appendix D). The survey, interviews, and previous working group discussions indicated that primary management contexts of concern for the NPS were managing overabundant native ungulates, non-native ungulates, and a broad variety of activities that could collectively be classified as "ungulate conservation." Because management of overabundant or non-native ungulates comprised the bulk of concerns, the workshop focused on learning more about how managers think about and address these management contexts across the NPS. Objectives of the workshop were to: (1) gather additional information towards addressing the project's guiding questions, (2) discuss preliminary results from the survey and interviews, and (3) decide next steps for the project.

The workshop began with introductions and an orientation to the project, which was especially important for non-working group participants. The overview explained the rationale of dividing the workshop into two sections: it would allow participants to examine "what is" (i.e., the NPS current management portfolio, messages, precedents, and policies) and discuss how this aligns with what participants think our focus "should be" (e.g., are there needs for additional planning tools, or emphasis on other management topics.) The overview was followed by breakout sessions around each of the project's guiding questions, which related to principles, goals and objectives, issues and concerns, and management actions.

Participants were divided into four groups that rotated through discussions of each of the above topics in the context of managing overabundant native ungulates. This exercise was repeated for the context of managing non-native ungulates. Each group discussion was audio recorded and facilitators noted key concepts on flip charts. The remainder of the workshop was spent on synthesis discussions to review concepts discussed in the breakout sessions, identify areas of clear consistency or inconsistency, determine questions that needed to be resolved before a strategic approach could be developed, and prioritize topic areas needing attention.

Key Findings

In general, groups had difficulty discussing the guiding questions without first having a discussion about definitions. Even the terms "overabundance" and "non-native" species were not interpreted consistently by participants. Animal population level is considered in NPS policy (2006a, section 4.4.2) but "overabundance" is not explicitly defined. Participants recognized that "abundance" can be a natural occurrence based on ungulate population and subsequent vegetation cycles. Thus, determination of a species being "over-" abundant is not based on numbers alone, but rather evaluation of the impacts that a species is having on park resources. Participants noted that impacts may be perceived differently by different stakeholders, both in terms of observability of interactions with ungulates and the meaning or importance placed on those interactions. Collectively, these differences in perceptions often result in varying levels of "acceptance" for ungulate populations.

Similarly, participants found it difficult to clearly differentiate principles, goals and objectives, and issues or concerns, noting that how one phrases the topic can easily transform it from a statement of concern to an objective. In addition, participants had difficulty articulating broad concepts in the absence of a specific park context; they noted that principles, objectives, and issues may vary for the same species depending on the management context, especially the type of NPS unit and its specific purpose as outlined in enabling legislation. Participants also discussed that assessment of impacts related to the management context is what determines when a park would take action to manage ungulates (e.g., are they negatively affecting other aspects of the natural and cultural system, and are these effects likely to become irreversible), and that "overabundance" may not be the most appropriate term.

Discussions related to managing non-native ungulates also suffered from difficulty with definitions, albeit to a lesser degree since non-native (i.e., "exotic") species are defined in NPS policy (2006a, section 4.4.1.3). Conditions for introduction, maintenance, and removal of exotic species are also outlined in NPS policy (2006a, section 4.4.4). However, participants noted that many of these conditions are subject to interpretation, such as the evolutionary history within the park, the degree to which non-natives fill an ecological niche where native correlates are lacking, and the cultural value of charismatic non-natives. Participants also questioned how changing environments might affect definitions and management of native and non-native species in the future (e.g., how we interpret species' ranges that shift due to climate change). While the workshop originally was structured to address overabundance of native ungulates and management of non-native ungulates separately, most responses to the guiding questions were similar in both contexts and will be reported together; for each guiding question, concerns unique to overabundance or non-natives are identified accordingly.

Principles

Clusters of topics suggested by participants reflected the following principles:

- Decisions should be guided by: law and policy (informed by political science, case law), including enabling (and subsequent) legislation, compendium; ecology (informed by ecological science); and public values (informed by social science).
- It is important to engage the human dimensions of ungulate conservation, which occurs at a number of different junctures: recognizing that ungulates and ungulate management have different meanings to different people; responding to public concerns; and sustaining the values of ungulates to the public.
- All decisions should have a scientific basis. There was recognition that this is often assumed to mean a biological basis in *determining* all decisions rather than *informing* all decisions. Emphasis was placed on informing decisions. NPS should employ the best available science (ecological and social) and employ a socio-ecological systems approach.
- Properly integrate science and policy.
- Overarching principle: manage ungulates, whether they are native or non-native, when they threaten park resources and values (that is, when they are perceived to be "overabundant"); and do not allow ungulates to have negative impacts on other aspects of the natural and cultural system, or manage them when their net negative impacts outweigh any positive impacts/benefits.

A number of suggestions also focused on processes:

- Be proactive.
- Commit to open/transparent processes.
- Engage stakeholders in ungulate management.
- Recognize context specificity—allow for different contexts and inputs, flexibility; maintain uniqueness of parks by developing tailored approaches.
- Adaptively manage toward measurable desired/target conditions.
- Consider how much we can realistically do; seek partnerships (both internal and external) where cooperation increases efficacy/capacity.

Some principles unique to managing native species were mentioned, although they did not necessarily apply only to the context of overabundance. These included: maintain predator-prey relationships (with a note that this may actually be a goal), conserve ungulates and their evolved/evolving ecologies, and facilitate resilience (the ability of systems to respond to stressors and recover quickly). For non-native ungulates, their interference with the NPS mission to restore native species and cultural attachment to specific non-native species were noted.

Goals and Objectives

Participants noted that the interpretation of principles in a given context leads to specific goals/objectives, but they were concerned about how to ensure consistency between different contexts. In general, participants focused on preservation, restoration, and protection of natural/cultural resources. There were many suggestions for goals related to the overarching principle of *preventing ungulates from causing negative impacts to other aspects of park systems*. One variation was ensuring that ungulates do not cause ecosystem disruptions (e.g., act as invasives). Participants noted that the main difference between goals for native and non-native ungulates may be that there is typically a population goal of "some" for natives, but "none" for non-natives. However, they also noted that depending on how established the non-natives are and the degree of invasiveness, parks may need to live with a goal of some non-natives. An additional difference was the desire to prevent establishment of new populations of non-native ungulates, which presumably would not be the case for natives.

Issues and Concerns

A range of different types of impacts of concern were articulated, including impacts to resources (e.g., damage to vegetation or cultural/historic structures; negative effects on other wildlife or biodiversity in general; effects on physical processes such as hydrology, nutrient cycling, soil conditions, fire ecology, invasive species; effects on viewsheds; behavior change such as food conditioning), impacts to stakeholders (e.g., vehicle-ungulate collisions, providing ungulate viewing experiences, perception of disease associated with ungulates, perceptions of ungulate behavior), and collateral impacts from management (e.g., public views on NPS management actions, incompatibility between management actions used by NPS and other agencies).

Concerns about diseases that affect ungulates were unique to native species; although non-native ungulates were recognized as sources and/or maintenance populations for some of those diseases. Concerns unique to non-native species included: encroachment, introduction of non-native species, and ecological niches filled by non-natives that preclude restoration of native species or provide ecological services in the absence of native species. Participants also observed that different treatment of non-native species (e.g., as domesticated, feral, or "wildlife") may lead to different expectations and acceptable approaches for management.

Management Actions

Types of actions suggested fell into the following categories: monitoring, communication about management actions, managing visitor/staff behavior, protecting other resources (e.g., vegetation, cultural resources), habitat modification, redistribution of ungulate populations, and population control of current and future ungulate populations. Participants noted that consistent decision criteria are needed to assist in choosing actions. They suggested categories for criteria: cost effectiveness, science, decision processes, and time horizon (i.e., short term versus long term). Many participants also felt strongly that types of actions were not unique to native or non-native species. However, intensity of the action or degree of implementation may vary depending on an ungulate's designation as native or non-native; size of the population that is being managed; and whether the animal is feral, domestic, charismatic, or stigmatized. For non-native species, actions may be undertaken to prevent species from becoming established in a park, while this would not be an issue for native species. Managers also believed that extreme measures (e.g., lethal control) may be more easily justified for management of non-native species.

Synthesis Discussion

Perceptions of inconsistency across the NPS were a major concern. It was noted that inconsistencies decrease trust. A few different dimensions of inconsistencies were identified. The first was inconsistency in management actions across parks; parks need tools to ensure they are using the same information base, as well as thought process criteria to determine a course of action. Participants identified the need for situation analysis tools (to assess the situation) and structured decision-making tools (to help make decisions within context of a specific situation.) The second dimension of inconsistency was perceived inconsistency in management actions across parks, especially by external stakeholders. This is exacerbated by broad policies with wide latitude for discretion at the park level and the range of park purposes that may result in different management actions for the same species. The third dimension of inconsistency related to communication: degree of communication, terminology, and capacity for transforming *conflict* with stakeholders to *engagement* through productive dialogue and collaboration.

Treatment of non-natives may represent the most inconsistency. For example, non-natives may be maintained as wild populations (e.g., mountain goats at Olympic National Park), maintained as captive domesticated species (e.g., Ossabaw Island hogs at George Washington Birthplace National Monument), or managed towards removal (e.g., elk and feral hogs at Channel Islands National Park). In addition, some must be managed per legislation (e.g., feral horses at Assateague Island National Seashore). Whether a species is invasive as well as non-native also affects how it is managed. Participants noted that there are some advantages to maintaining the spectrum of approaches to manage non-native ungulates: it provides options that in a specific context can help avoid controversy, justify variability in management decisions, and keep visitors happy. Yet there are also disadvantages: it can result in mixed messages across NPS units, NPS management decisions may be called into question, it confuses the public, and it can create controversy.

There was a suggestion that thinking in terms of classes of parks might address some of the inconsistencies. We engaged in a discussion about the classes of parks that might be reflected across the system. An observation was made that only a small minority of parks may be able to have the majority of influence on ecosystems within their parks' boundaries (i.e., are functionally ecologically isolated). This could be because they have a large enough land mass or because they are functional islands for the ungulate species in question, or actual islands such as occurs at Channel Islands National Park.

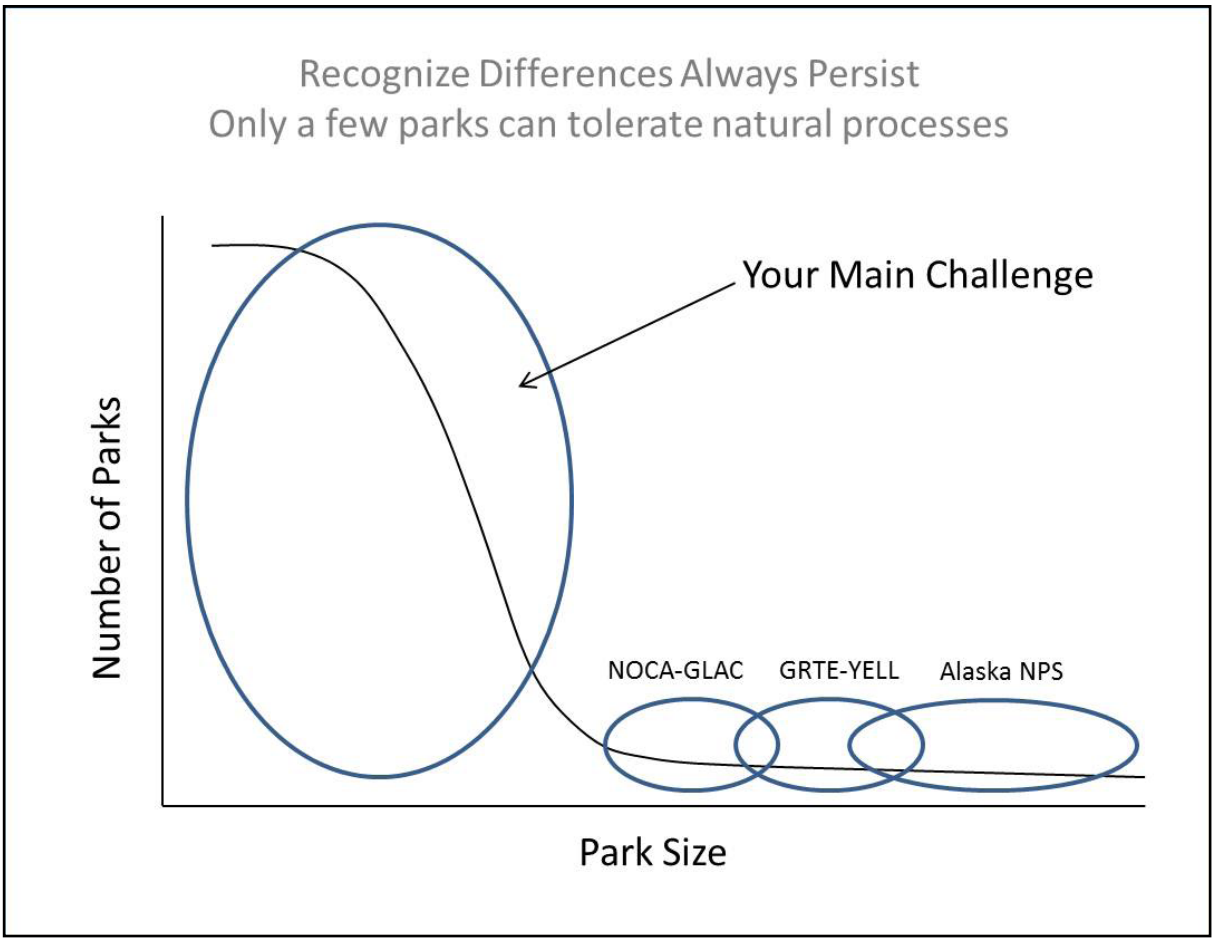

Figure 24. From a summary presentation during the 2012 workshop "Ungulate Management in the NPS" held in Fort Collins, Colorado. Dr. Joel Berger compared the number of parks that have ungulates with the size of the parks. NOCA = North Cascades National Park, GLAC = Glacier National Park, GRTE = Grand Teton National Park, YELL = Yellowstone National Park, Alaska NPS = NPS units in Alaska.

As academic advisors to the working group, Drs. Joel Berger (conservation biology) and Dan Decker (human dimensions) were asked to provide their reflections on the workshop. Dr. Berger emphasized the need to address terms that do not have a biological definition, such as "healthy", "in-tact", "natural", and "overabundant." He reiterated the need to develop goals for clusters of parks and emphasized the inverse relationship between the number of parks and the size of parks in the National Park System (see Figure 30). He observed that there are only a few parks large enough to incorporate landscape-level natural processes [see Wright et al. 1933, Leopold et al. 1963, and National Park System Advisory Board 2012], yet these do not reflect the majority of parks within the NPS system. Dr. Berger suggested that the main challenge for NPS managers with respect to ungulate management lies with the numerous, smaller parks that are embedded within landscape-level processes, and that this is where the report generated by this Ungulate Management Review effort needs to provide guidance.

Dr. Decker emphasized the difference between science and management, recognizing that management relies on applying values filters to scientific findings. He noted that values-based judgements enter at all stages of problem definition and decision processes. He suggested that managers need to pay more attention to which values they apply and why, and how knowledge of social systems interacts with ecological systems (see Figure 31).

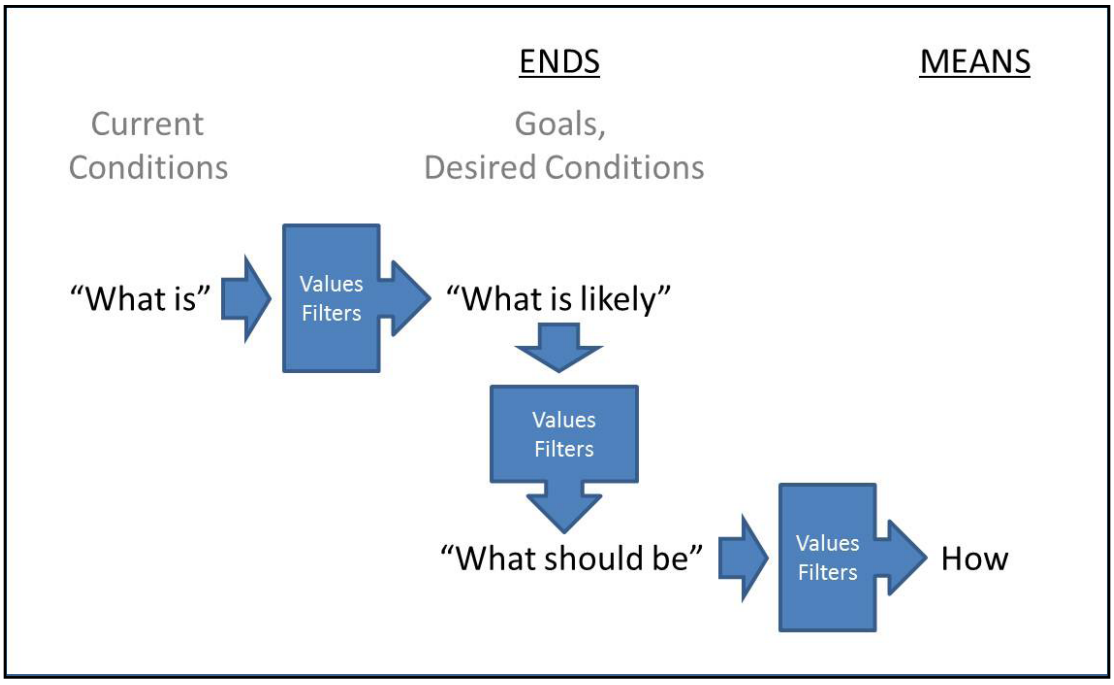

Figure 25. From a summary presentation during the workshop "Ungulate Management in the NPS" held February 2012 in Fort Collins, Colorado. Dr. Dan Decker emphasized the necessity of clarifying definitions and different perceptions of impacts. The schematic identifies points in the problem definition and decision-making process that are filtered through human values.

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NPS 999/127574, December 2014

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