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

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

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key informants to engage in exploration of their knowledge and insights, and in many cases to have been provided with unpublished data contributing to our assessment and recommendations.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

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SYNTHESIS AND RECOMMENDATIONS

In 1968, Yellowstone National Park moved from a 33 year (1934-1967) period of culling ungulate populations for achieving predetermined stocking levels to a regime of ecological management under which wildlife populations are allowed to fluctuate in the park without human intervention. Since then, bison management in the YNP area has been dominated by two major linked controversies: 1) the risk to livestock of transmission of brucellosis from bison moving across the boundary; and 2) criticism of the effects of winter use by humans and their machines on bison population dynamics, movements and range expansion, including transboundary movements. This study reviews, integrates and applies knowledge of bison ecology with the specific objective of assessing the nature of bison movements and distribution, and whether grooming roads in YNP induces changes in spatial and population ecology of bison.

The study adopts an Adaptive Environmental Assessment and Management (AEAM) and policy-oriented framework (Blumenthal and Jannink 2000, Clark 2002), including a systems modeling approach (Ford 1999, STELLA u.d.). AEAM is a process of organizing people and their decisions around systems modeling and iterative hypothesis testing (Blumenthal and Jannink 2000). We addressed the issues broadly, defining the ecological and management systems in which road grooming and bison movements create apparent conflict, and to a limited extent evaluated the processes by which management decisions are made and conflicts may be resolved.

Our review of knowledge and the design of a bison movements and population dynamics model enabled us to identify key uncertainties and knowledge gaps and guided recommendations regarding research initiatives and management experiments to improve understanding and offer guidance for future management decisions. Additionally, we recommended approaches to improve the process of creating management policy, drawing on the theories and practices of environmental policy process and collaborative decision making.

Synthesis

1. The bison of Yellowstone National Park are of ecological and evolutionary significance because they are among less than a dozen free-ranging herds exposed to natural regulation and selection regimes and the only free-ranging plains bison population on the continent that exceeds 2000. Prehistorically, YNP bison ranges were probably the extremes of seasonal migration from large source populations associated with expansive grasslands surrounding the Yellowstone Plateau. Historical accounts indicate that interior ranges also supported resident bison populations.

2. Yellowstone National Park is not a self contained ecosystem, covering only 8,983 km^2 or slightly more than 10% of the Greater Yellowstone Ecosystem (80,503

km^2). The movements and population dynamics of large mammal populations need to be viewed at spatial scales significantly larger than the park itself.

3. Key informants identified 5 bison winter ranges and 5 winter movement corridors in YNP. Recent GPS location data confirmed the delineation of the ranges and added new information about two additional movement pathways.

4. In northern YNP, two ranges were identified, Lamar Valley (233.8 km^2) and Gardiner basin (98.4 km^2). The portion of the Gardiner basin bison winter range outside YNP delineated in the 2000 bison management plan included 17.6 km^2 of habitat in Zone 2 and 83.3 km^2 in Zone 3. Management actions are taken in these areas to reduce the risk of brucellosis transmission from bison to cattle. Three bison winter ranges were defined in central YNP: Pelican Valley (55.2 km^2), Mary Mountain (151.8 km^2) and West Yellowstone (79.9 km^2 spanning the park boundary). Hayden Valley was grouped with the Firehole because of continuous movement back and forth between the two valleys over the Mary Mountain trail throughout the winter. Like Gardiner basin, the portion of West Yellowstone bison winter range outside YNP was delineated based on bison management policy and reflects where 100 bison are tolerated before culling actions are taken as opposed to where bison could forage if allowed to expand freely.

5. Bison in Yellowstone attempt to compensate for declining per capita food resources by range expansion, thus maintaining a relatively stable instantaneous density. However, compensation is not exact; population growth rate declines with density because high quality foraging patches are limited in overall area, are patchily distributed, and depleted first, forcing bison to shift to poorer quality patches as density increases. The likely demographic responses are decreased fecundity and increased juvenile mortality.

6. Apparent isolation of bison in separate winter ranges when populations were small likely reflected high per capita availability of forage and low pressure to move or expand. From the evidence, we infer that as populations grew, the area they used expanded, and distributions eventually coalesced. Anecdotal information on bison movements suggests they can break trail for considerable distances through deep snow, but in addition to forage limitation, knowledge of destination is likely an important motivation.

7. At the present time, there are two relatively separate subpopulations, one on the Northern Range and the other on the Central Range. Some exchange occurs via the Mirror Plateau. In recent years, there have been major migrations from the Central Range to Gardiner basin via the road allowance between Madison Junction and Swan Lake Flats. This migratory pattern would not likely have developed in the absence of the groomed road through the Gibbon Canyon.

8. Snow conditions (e.g. depth, density and snow water equivalence) can have significant impacts on ungulate foraging, survival and movements. In YNP, snow may influence forage availability, energy expenditures, ability to travel, vulnerability to predators and nutritional status of ungulates, including bison. This is a critical consideration in the current management challenge of minimizing contact between bison and cattle as they migrate northward and westward across park boundaries.

9. Snow was deeper and SWE was greater in central YNP than the northern range. Mean February 15th SWE values for central YNP were approximately 20 cm compared to 7.5 cm on the northern range. In addition to snow depth and SWE, other characteristics of snow pack can affect forage availability to ungulates. Key informants identified snow crusts as an important constraint to forage availability for bison, making it difficult or impossible for bison to crater and forcing them to move in search of forage. Growing season precipitation and herbivory also affect forage production and availability.

10. Geothermal activity can also modify snow pack. Thermal features generate heat that can dramatically reduce snow cover and lengthen the growing season in geothermal basins and along the banks of geothermally influenced rivers and streams, thus improving forage availability and reducing travel effort in winter. Geothermal sites may, therefore, be key refugia for bison during severe winters in the Central Range. Reduced snow cover in geothermal areas also reduces movement costs.

11. Removals at the western and northern boundaries to control egress of bison from the park were a direct function of population size, influenced by snow conditions. The relationships were strongest for populations above 1500 for the Central Range and 550 for the Northern Range.

12. Although forage availability influenced by production, use, and snowpack, will continue to be a major factor influencing population increase, distribution and movements, predation may become increasingly important as wolves learn how to kill larger prey. We suggest that wolf predation on bison will continue to increase in the Central ranges, but not on the northern range as long as elk are relatively more abundant there than bison. In systems where wolves show a numerical response to an abundant prey species that is difficult to kill, predation rate on easier prey can be inversely proportional to their density.

13. Strong differences were predicted by the model in immigration and emigration rates between ranges. The Mary Mountain range is clearly the central numerical engine of the YNP bison system. Lamar Valley and Pelican Valley contribute significantly fewer bison to the YNP system. The Gardiner basin and West Yellowstone ranges are clearly net sinks for bison.

14. Information from key informants and results from the YNP Bison Movement and Population Model (based on literature and key informants) suggest that inter-range movements of bison are generally not constrained by winter snowpack in non-road grooming scenarios during most winters. The notable exception to this rule is the Firehole-Mammoth corridor that represents a barrier during all non-road grooming scenarios. Road grooming is likely to have a greater influence on movement of bison between interior ranges (Lamar-Mary Mountain, Mary Mountain-Pelican) than to the peripheral ranges (West Yellowstone, Gardiner basin). Therefore, grooming of winter roads may reduce the variation in and total numbers of bison departing for peripheral ranges during winters of inadequate forage.

15. Bison movement between winter ranges was projected to range from 100 to 4,000 animals, influenced most by per capita forage availability. An average movement of ~1,000 bison occurred in non-road grooming scenarios, and 1200 in road-grooming scenarios.

16. Natural winter mortality is a common, though a highly variable event for bison in the YNP model, representing how the system actually functions. Average simulated annual winter mortality was ~180 bison (5%) for the non-road grooming and 225 for the road-grooming scenario, or about 7% of the YNP herd. However, mortality during occasional extremely harsh winters exceeded 25% of the population.

17. The predicted maximum cull under current boundary management policies periodically exceeded 500 animals, and rarely exceeded 750 animals. Culls exceeded 10% of the total YNP herd in 15% of years in non-road grooming scenarios and 6% of the herd during road grooming scenarios. Cumulative culls during ten 100-year stochastic runs varied considerably, and ranged between annual average culls of 50-90 bison for the non-grooming scenario, and 60-100 for road grooming scenarios. On average, 75 bison would be culled each year from peripheral ranges with or without road grooming.

18. Increasing bison habitat exterior to YNP is an effective strategy to increase the total regional population, but would not be a good strategy to minimize the number of bison that would need to be culled annually in the regional landscape surrounding the park. Although the number of bison to be culled at the boundary of YNP would be significantly reduced in a "repatriation" scenario, a greater number of bison would inevitably be culled in the surrounding region because there would be more bison. For example, the annual cull at the margins of the expanded range would be as follows: (2,500 km^2 = 1,250 culls, 5,000 km^2 = 2,500 culls, 7,500 km^2 = 3,750 culls, 10,000 km^2 = 5,000 culls).

19. Gardiner basin has been considered important winter range for bison since at least the 1940s and is an important component of the Northern winter range. In contrast, the Hebgen Lake area north of West Yellowstone offers no unique

ecological value as winter range. It can be considered an expansion area for the Central subpopulation with the capacity to support 100 to 130 bison at the instantaneous density typical for Central Range bison in winter.

20. Since 1997, population monitoring has been somewhat inconsistent and data do not provide the same opportunity for continued analysis as the data collected between 1970 and 1997. A population monitoring program is needed that will provide for: 1) annual estimates of adult population size (> 1 year); 2) fecundity (calf production); 3) winter density distribution, i.e. during the period when distribution is most responsive to forage limitation; 4) inter-annual population rate of increase; and 4) seasonal and annual calf and adult mortality.

21. With the possible exception of the Madison Junction to Mammoth road segment, road grooming likely has not induced range expansion, although roads facilitate bison movements within and between winter ranges where aligned with natural movement corridors. Given the evidence, we concur with the assessments made by Cheville et al. (1998): 1) there is a threshold density effect above which expansion to new ranges occurs and population pressure induces bison to maintain pathways between ranges; and 2) attributing population increase to road grooming rather than the use of groomed roads to population pressure may reverse cause and effect. There is no evidence to suggest that groomed roads have changed population growth rates relative to what may have happened in the absence of road grooming.

22. The two major issues associated with Yellowstone National Park bison management are primarily a consequence of the successful recovery and expansion of bison as a wildlife species and value conflicts resulting from the arbitrary location of the park boundary within a large ecosystem in which people live and derive their livelihoods. Existing organizations and decision processes addressing the two issues have not been effective in defining the common interest or producing stable, broadly supported management plans.

23. The decision processes followed by federal and state agencies to develop the Joint Management Plan appears a divisive, deeply-rooted power-balancing struggle to protect fragmented and overlapping jurisdictions and avoid risk.

24. Both the bison/cattle/brucellosis issue and the winter use issue are highly charged conflicts with public interests having no mechanism for meaningful participation, apart from the low level process prescribed by NEPA. The affected publics are willing to use the courts and sometimes more extreme actions to be heard. The result is ongoing conflict, substantial annual and incremental costs for the agencies in time and resources, and promotion of the notion that more science, more information, will somehow result in wiser outcomes.

Recommendations

Monitoring and Science

1. Yellowstone National Park should implement an internally funded bison population monitoring program that collects and manages data on population size, vital rates and winter distribution in the long term.

Winter surveys of the YNP bison population provided a nearly continuous, though imprecise, time series of population estimates for a hundred years, between 1902 and 1997. Seasonal surveys of population size, distribution and composition were carried out between 1970 and 1997. This is a prestigious and unparalleled record that provides a rich opportunity for examining the long term dynamics of a large herbivore population subject to management and environmental perturbations. The survey system was altered in 1998 when a study was initiated to evaluate and redesign the aerial census program (Hess 2002). Building on that study, we offer recommendations for a population monitoring program that will serve the management needs of the agencies (Figure 7.1).

Well designed winter surveys can provide the basis for estimating annual rate of increase and density distribution patterns in relation to forage availability and other environmental stressors. Summer census during the breeding season when bison are aggregated in large groups within a few small areas provides an opportunity for efficient census (accuracy and precision) and for classifying a large number of bison into recognizable sex and age classes. The population monitoring protocol (Figure 7.1) is adapted from Hess (2002). It incorporates aerial census, winter distribution surveys, and a ground-based composition survey. The protocol is designed to compliment research on the effects of climate, forage production, herbivory, snow pack, and density on demography and spatial ecology of bison in YNP and on boundary ranges in Montana.

Census in early winter will account for bison subject to subsequent winter mortality; density dependent and independent processes will operate on these animals during the winter. Hess (2002) found that group size declined over winter in a log-linear manner and dispersion increased as winter progressed. The most favorable winter census conditions occur in early winter, December or January when bison are still in relatively large groups, yet have moved from high elevation ranges, providing for more efficient census than later in the winter. Winter surveys should be conducted during cold weather when few animals are in forested areas. Distinguishing calves from older bison from an aircraft is difficult in winter. However, experienced observers are able to do so. If this measure can be recorded, the change in calf: adult ratio from summer (August census) to December or January would provide an estimate of pre-winter calf survival. Further, the change in estimated adult (> 1 year) population from time t to $t + 1$ would provide a measure of population increase not inflated by calves. An independent estimate of the rate of increase $LN(N_{t+1}/ N_t)$ can be provided from the number of adult (> 1 year) bison estimated during the breeding season in years t and $t + 1$. During the breeding season (late July to early August) bison are concentrated in large aggregations in few areas (typically three) in open valleys. Aggregation at this time of year provides the opportunity for aerial photo survey of most of the population, reducing variance due to sampling error. Hess (2002) recommended at least one replicate of both the winter and summer censuses to be certain that anomalous conditions during one seasonal survey did not produce a biased estimate that could lead to a spurious conclusion about population change. Population trends are of limited value in the absence of data on vital rates. Age and sex ratio data are critical to understanding population dynamics. Population composition surveys should be carried out during or shortly before the breeding season when all age and sex classes are aggregated. At least 50% of each sub-population should be classified. Sampling should occur throughout the area occupied by bison. Detailed recommendations on census methods and bias compensation (habitat and group size effects) are offered by Hess (2002).

The capacity to describe the dynamics of bison population and spatial ecology depends on sustaining consistent long term monitoring such as the program carried out between 1967 and 1997.

2. Yellowstone National Park should define a minimum viable bison population for the Northern Range.

The bison population on the Northern range has existed as a semi-independent subunit and exhibits biological traits (genotypes, fetal growth, tooth wear patterns) distinctive from Central range bison. Historical data indicates that most of the northern range bison may migrate into the Gardiner basin during harsh winters, returning to the Lamar Valley unless removals occur. The potential exists for most of the population to be culled if it exits the park. Seasonal migration between low elevation, low snow cover range in the Gardiner basin and high elevation summer range is an ecological phenomenon not supported by the current management system. If the northern range is depopulated, grazing by bison would also become a lost ecological process in the northern range until it becomes recolonized by Central range bison. Current research by Dr. J. Gross (NPS, Fort Collins) will contribute to defining population viability for national park herds (Gross and Wang 2005). A specific PVA analysis is recommended for the Northern herd to provide a threshold size and structure below which culling may adversely affect population viability. We perceived no threat to the viability of the Central population from boundary control at West Yellowstone.

3. Yellowstone National Park should encourage and coordinate research focused on reducing key uncertainties over a full range of densities as the population fluctuates in response to environmental stochasticity or management actions.

Research on bison population ecology, and distribution and movement behaviour in YNP has been conducted in the short to intermediate term (>30 years). Researchers have been able to study the system for discrete periods during their professional careers. Basic research is needed on bison population ecology and behaviour focusing on the full range of density dependent and independent influences on the population and its spatial behavior over meaningful periods of time (>50 years). Considerable research has been carried out on plant herbivore dynamics in the Northern Range generating a wealth of knowledge about density dependence in elk populations. Similar research is needed for bison.

Key uncertainties identified in this review deserving of particular research attention are:

- Threshold depth/density of snow at which low and high density forage-limited bison cannot move through corridors in search of better foraging conditions.
- Terrain characteristics (slope, ruggedness) that affect the above snow depth/density threshold preventing movements.
- Snowpack characteristics in the Pelican Valley in relation to other ranges.
- The relationship (shape and scale of the curve) between winter forage availability, bison density and bison over-winter mortality.
- The relationship (shape and scale of the curve) between winter forage availability and probability of bison movement.
- Density related effects of bison on vegetation communities and terrain, especially geothermal habitat.
- There was contradictory opinion whether the unroaded Mirror Plateau Corridor is a functional barrier to movements in winter between the Pelican Valley and the Lamar Valley when bison numbers are high and per capita forage is limited.
- Inter-range variability in forage productivity in response to precipitation and growing season length. In particular, one key informant suggested the growing season is shortest in the Pelican Valley range because of a long period of snow cover typically followed by spring flooding.
- Relationship between incidence of sero-positive bison and proportion of the herd that has been vaccinated.
- Systematic research has not been carried out on the ability of bison to move through snow under the variety of circumstances present in Yellowstone National Park.
- Snow conditions in the Pelican Valley are limited to subjective observations rather than consistent records from strategically-placed snow stations. Two modeling efforts thus far have not been able to precisely model the dynamic of snow conditions in this isolated valley of the park. Calibration of models in one location of the park does not allow large scale inference.
- The future role wolf predation plays in bison population dynamics is uncertain in Central Yellowstone ranges and is likely increasing at present. Mechanisms underlying how YNP wolves limit bison abundance and distribution have received limited attention.
- There is uncertainty of the extent of the interchange between the Northern and Central bison herds. This information is important for understanding how to conserve the spatial and genetic structuring of this population and maintenance of bison on the Northern Range under current boundary management.
- Data now being obtained from GPS collars will allow key questions about movement ecology to be addressed, including the timing and extent of movements in relation to plant phenology, snow conditions, forage production and utilization. In addition, with this technology research is now possible to address questions

about the effects of roads and other anthropogenic or natural features on movements about which some uncertainty remains.

The YNP bison population will continue to experience perturbations and high amplitude fluctuations in the long term providing ongoing opportunities to study ecological dynamics at varying densities. A systems-based approach to understanding the dynamics of the YNP bison subpopulations can exploit these anticipated meteorological and management perturbations and use them to learn about key uncertainties.

4. An adaptive management experiment should be designed to test permeability of the Firehole to Mammoth corridor under varible snow conditions with a specific focus on the road section between the Madison Administrative Area and Norris Junction.

The road segment through the Gibbon Canyon is the single area in the park where snow cover in combination with steep terrain may deter bison movements in the absence of grooming and snow compaction by over snow vehicles. Beginning in the mid 1990s, bison learned to migrate along the road allowance and adjacent habitat between the Madison Junction and the Northern Range near Gardiner Montana. In some recent winters, large numbers of bison have used this migration pathway. Bison from the Central Range may reach and be subject to management actions at both the western and northern boundaries. To date there is no evidence that Northern Range bison have moved to the western boundary. Under the current management plan for bison, it is possible that the defined tolerance for bison emigration to the northern boundary of the park could be satisfied early in the winter by bison moving from the Central subpopulation. If large numbers of Northern Range bison move to the boundary later in the winter in response to severe conditions, there is risk that most of the northern subpopulation could be subject to removal, leaving the Northern Range of the park ecologically impaired. Furthermore, there is evidence that rare alleles are unevenly distributed among subpopulations (Gross and Wang 2005); depopulation of the Northern Range could place genetic diversity at risk.

An experiment is warranted to test the hypothesis that the Central population's movement to the Northern Range is possible only with grooming of the snow pack on the road, in particularly in the Gibbon Canyon. This action was previously proposed. Readers are referred to a settlement agreement approved on October 27, 1997, in federal court, Washington D.C. that called for the NPS to prepare an environmental assessment evaluating the closure of groomed road segments in YNP to study the effects of groomed roads on bison movements. An environmental assessment was completed in November 1997 evaluating options for temporary closures of sections of the road system in winter including the section identified here (NPS 1997). The experiment recommended here should be designed to test the effectiveness of unaltered snow pack as a barrier to winter movements between the Central and Northern Ranges in relation to varying environmental conditions including forage production, winter severity, and population size.

5. Yellowstone National Park should install a SNOTEL or Snow course station in the Pelican Valley, monitor snow conditions in

the Pelican-Hayden Corridor, and re-evaluate the two existing snow models.

Winter conditions in the Pelican Valley have been described as the most severe among bison winter ranges in Yellowstone National Park (Meagher 1971, 1974:12, Meagher et al. 2002:135). It has the highest elevation (7800 ft) and the longest duration of snow cover (late October to early May) among winter ranges. Meagher (1971), citing reports from ranger ski patrols, described snow depth in the Pelican Valley as "usually a few inches deeper than those of the Lake snow course", with average depths of 40 to 45 inches. In addition, the east-west orientation of the Pelican Valley exposes it to packing from the prevailing wind. The harshness of this environment and trapping effect of snow in the undisturbed corridor between Pelican Valley and Hayden Valley were the basis for the argument that in the absence grooming of winter roads the Pelican winter range is self-regulating, and with road grooming the "domino effect" of bison emigrating from Pelican drives expansion of bison to the western boundary of the park. However, snow conditions in the Pelican Valley and the Pelican-Hayden corridor have not been systematically measured nor have the effects of snow on foraging and movements studied. Snow conditions in the Pelican Valley and Northern range predicted with the two models yielded discordant results. The Yellowstone Snow Model (Wockner et al. 2002) generates SWE values closer to observed Lake SNOTEL station values than the LANGUR Model (Chapter 4). The latter model generated mid February SWE values for the Pelican Valley similar to the Northern Range and were clearly discordant with the common view that conditions are the most severe in the Pelican Valley and least severe on the Northern Range among bison winter ranges in YNP. Clearly, this discrepancy needs to be addressed. Furthermore, there needs to be well designed research on the effects of snow (SWE, depth and density) on foraging, movements, and population dynamics of bison.

Adaptive and Collaborative Management Structures and Processes

Managing bison or any other natural resource within the context of a large ecosystem that includes complex, partially understood interactions between biotic and physical elements of the environment, people, their endeavors, and competing value systems, is enormously challenging. While good science is necessary to inform wise decisions, scientific knowledge is typically developed and championed by people in a discipline without reference to knowledge from the many disciplines and multitude of values that bear on management of an ecosystem. Similarly, single agencies are not mandated to manage human activities and ecological processes across jurisdictions and agencies must necessarily work together to achieve outcomes in keeping with the common interest of society. Collaboration is necessary to define what is acceptable; science is necessary to define what is possible; organizing people to use knowledge to design and implement management in the face of uncertainty is fundamental.

The issues of managing transboundary movements of bison to contain the risk of brucellosis transmission to livestock and winter use management in YNP as it affects bison movements have been dealt with separately despite broad overlaps in the interests of stakeholders engaged in these issues. Existing organizations and decision processes addressing these issues have not been effective in defining the common interest or producing stable, broadly supported plans. For successful resolution of YNP bison management conflicts, new organizational structures and decision processes are needed to provide legitimacy, integrative problem solving, shared learning, and decision-making among resource agencies and citizens at scales meaningful to stakeholders. The recommendations offered in this section reflect the need for a new approach to management planning, and the key roles of science and systems modeling for aiding multi-party decision-making, where change is inevitable and uncertainty and unpredictability are inherent properties of the ecosystem.

6. Engage the U.S. Institute for Environmental Conflict Resolution in an independent situation assessment that includes advice on designing an integrated agency and public involvement planning strategy to represent the common interest.

The 1998 Environmental Policy and Conflict Resolution Act (P.L. 105-156) created the U.S. Institute for Environmental Conflict Resolution[61] to assist parties in resolving environmental conflicts involving federal agencies or interests. The Institute provides assistance in consensus-based processes, such as negotiated rule-making, community-based collaborations, and policy dialogues.

The Institute should be engaged to do the following:

- Using document analysis and stakeholder surveys, thoroughly assess the range of issues and interests of those affected by or engaged actively in bison management in the YNP/Montana transboundary area and in winter use management in YNP, including agencies and publics;
- Survey representative stakeholders (agencies and publics) about their perspectives on public involvement and interagency coordinated planning;
- Assess the effectiveness of current management planning structures and processes, including public involvement;
- Propose options for organizational structures and processes for policy-oriented integrative planning, including higher levels of public involvement than currently practiced;
- Draft charters (Terms of Reference) for each organizational body (see below for suggested organization).

We suggest consideration of an organizational structure (framework) that provides for integrated agency and public involvement, shared learning and valued-based integrative decision-making, informed by expert knowledge and decision support models and other tools. The framework consists of three interacting bodies (Figure 7.2):

1) An interagency planning team representing the agencies holding authority;

2) A multi-party working group representing affected interests, including agency managers and public interest representatives; and

[61] U.S. Institute for Environmental Conflict Resolution, 130 S. Scott Ave. • Tucson, AZ 85701 • Tel. (520) 670-5299, Fax (520) 670-5530

3) An interdisciplinary science council serving the information and analytical needs of both the planning team and the working group.

The interagency planning team would negotiate a goal-driven, results-based management plan for bison in YNP and adjacent Montana, informed by input from the working group and the interdisciplinary science council. The working group would work with the planning team to reach agreements on the issues to be addressed in the management plan, and on goals and objectives, and to develop criteria for assessing and selecting the most appropriate management alternatives. The interdisciplinary science council would be responsible for integrating a broad range of knowledge and skills in both natural and social sciences, developing models to support and inform value-based decision-making, designing management experiments, and recommending basic research for YNP and GYE to fill information gaps. Both the planning process and organizational structures would be authorized by the authorities under a common agreement (e.g. Memorandum of Understanding). The MOU would define agency roles and responsibilities, ground rules for cooperation, the decision process, available resources, designated representation on the interagency planning team, and direct interactions between the planning team and the other two bodies.

We recommend using a problem solving model (Webne-Behrman 1998:52) for decision-making by the planning team and the working group, based on facilitated interest-based negotiation practice. Each body would require a specific charter that defines its task, decision process, ground rules, membership, communications strategy, and reporting relationships. Shoulder to shoulder working relationships between the interagency planning team and the working group would be desirable (Figure 7.2).

> *7. The Yellowstone Center for Resources (YCR) should play a lead role among agencies and researchers in coordinating data sharing and data-base management, research and monitoring of bison and other research relevant to bison ecology and management, by developing a stable collaborative science and management framework.*

A variety of research interests are engaged or have been engaged in more or less independent studies on bison ecology, epidemiology and management of brucellosis, ecology of other species, and ecological processes or human activities that affect bison in Yellowstone National Park. Independent scientists can engage in research in the park under a permit system that does not require them to contribute to the park data base or management programs of the park, or indeed to provide data. Coordination of research has been left largely to outside organizations such as the Greater Yellowstone Interagency Coordination Committee under which the Greater Yellowstone Interagency Brucellosis Committee functions. Between 1997 and 2003, the U.S. Geological Survey attempted to coordinate research on bison ecology and the effects of removals on population viability. Numerous researchers typically associated with universities have carried out independent research.

Fragmentation of effort and inefficient coordination and use of knowledge have been the rule rather than the exception. Mandate conflicts between agencies, competition between research groups and individual researchers for funding, and failure to share data to protect publication rights are all recognized as contributing to the fragmented science effort. In the absence of coordination, there is a risk that researchers who work independently in specific geographic areas or for relatively short periods of time may come to narrow or ill considered conclusions.

The authors are aware of a substantial volume of data on bison ecology in the park that has neither been published nor shared with YCR. The data are proprietary, held by research camps or independent scientists who do not communicate with or trust each other. Internally, concerns were expressed to the authors about the limited opportunity for input by YCR scientists and managers into management plans, EAs, EIS and rule making in which bison are an aspect.

YCR should define personnel and financial resources necessary to coordinate the science effort and sustain a core applied research program.

8. Develop or refine appropriate systems models and other decision support tools to help agencies and other stakeholders to understand key uncertainties and system properties, and to evaluate outcomes of management scenarios defined through value-based decision processes.

Systems models allow participants to evaluate alternatives today that reveal potential futures and consider uncertainties rather than waiting to evaluate outcomes of actual management interventions. System models, such as the one developed in this assessment, should be encouraged to evolve through time as new information is revealed by scientific study, or as new possible management actions are proposed by stakeholder interests. The primary role of these models is not to reveal “truth”, but to assist stakeholders in understanding the emergent properties of how the system functions, to assist YNP managers in identifying key uncertainties that prevent improved management strategies, and to help stakeholders distinguish perceived from real problems.

9. The National Park Service should increase its support for the appropriate agencies to secure key winter range for bison and other wildlife adjacent to the park in the Northern range.

The Gardiner basin is part of a prehistoric seasonal range use system for bison occupying the Northern range. Under current circumstances, it can be considered refuge habitat for bison during severe winters, serving a role similar to geothermally influenced refuge habitat in the Central Range. The bison management plan presumed that the lands north of Yellowstone National Park in the Gardiner basin would be free of cattle after the winter of 2001-2002. However, the Church Universal and Triumphant is still running cattle on the Royal Teton Ranch (RTR) adjacent to the park. Consequently, Step 1 of the management plan is still in place on the north side. Removing cattle from this area was a critical underpinning of the bison management plan and a goal of a $13 million federal-private land exchange initiative of 1999. The Record of Decision requires in Step 1 that the agencies "cooperate with RTR to develop a Bison Management Plan for the Royal Teton Ranch that is consistent with the provisions of the Joint Management Plan."

The NPS is engaged in low key discussions with the Church Universal and Triumphant in defining the terms of an agreement consistent with the bison management plan, including removal of cattle from RTR holdings. NPS is encouraged to step up its efforts to obtain an agreement to secure winter range for bison adjacent to the park as refuge habitat during extreme winters.

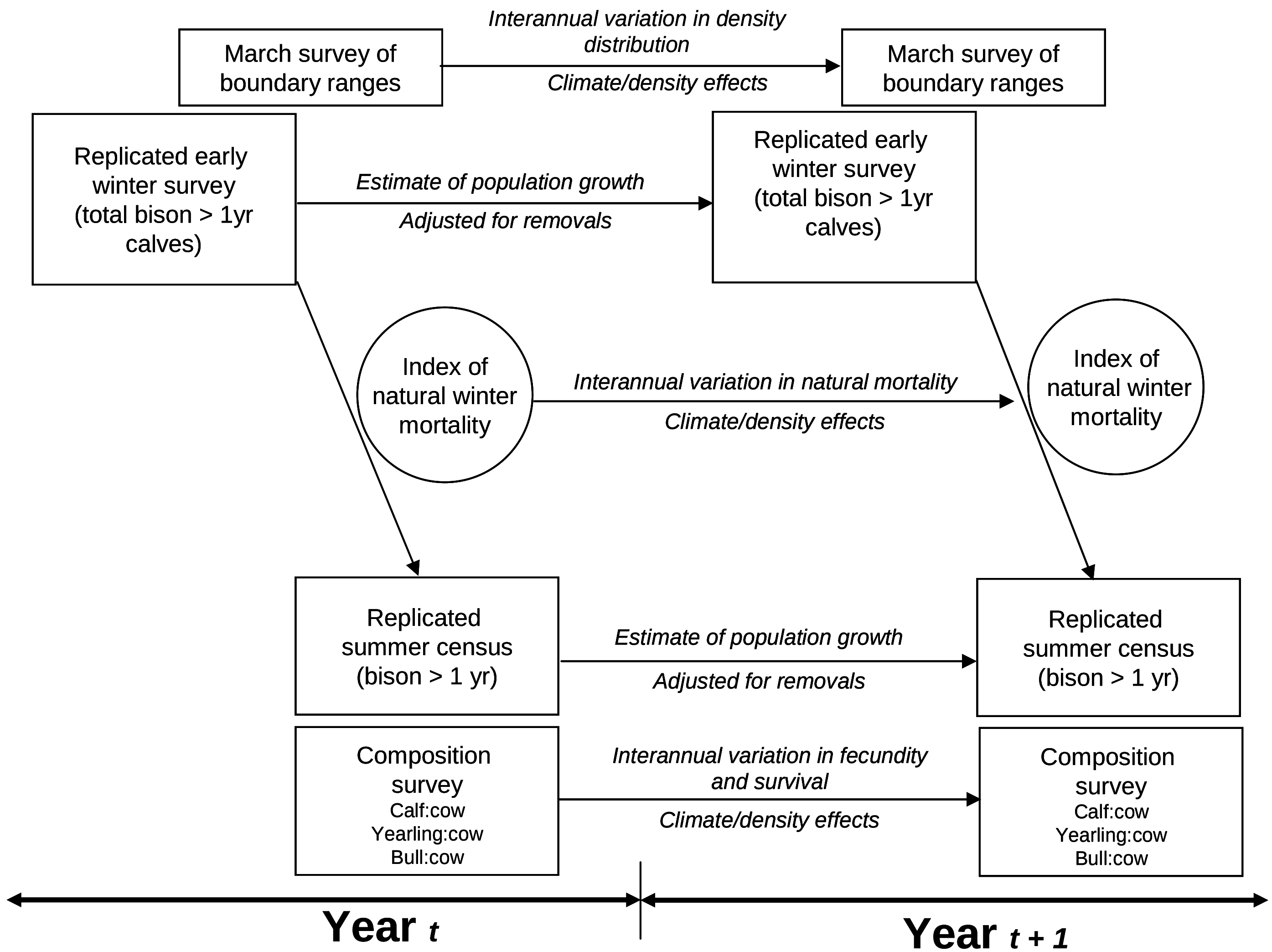

Figure 7.1. Conceptual diagram of a population monitoring program for bison in Yellowstone National Park. Adapted from Hess (2002).

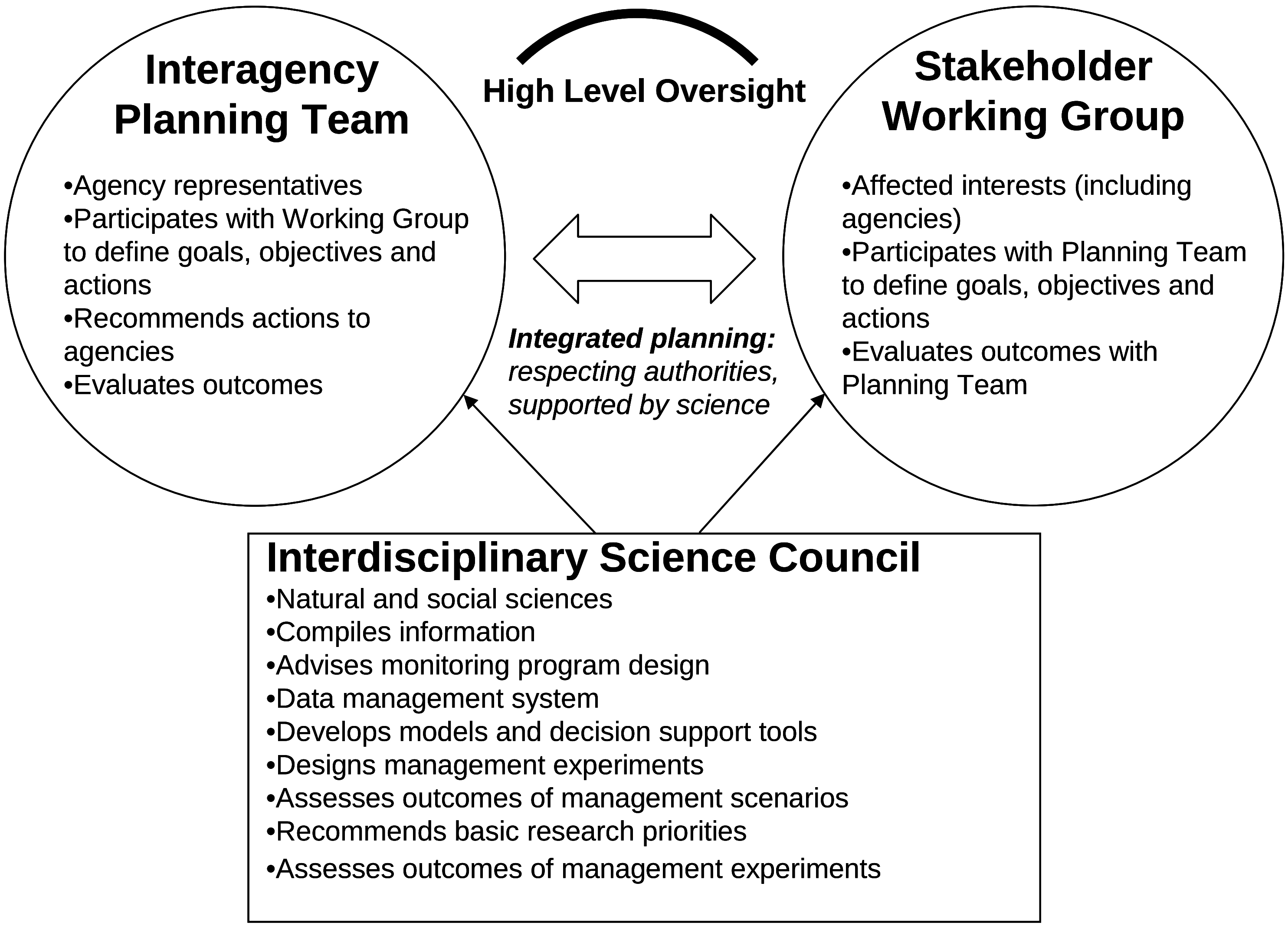

Figure 7.2 Organizational framework for collaborative and adaptive management of YNP/Montana bison.