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Review

Management of Yellowstone bison and brucellosis transmission risk – Implications for conservation and restoration

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ABSTRACT

Yellowstone bison (*Bison bison bison*) are managed to reduce the risk of brucellosis (*Brucella abortus*) transmission to cattle while allowing some migration out of Yellowstone National Park to winter ranges in Montana. Intensive management near conservation area boundaries maintained separation between bison and cattle, with no transmission of brucellosis. However, brucellosis prevalence in the bison population was not reduced and the management plan underestimated bison abundance, distribution, and migration, which contributed to larger risk management culls (total >3000 bison) than anticipated. Culls differentially affected breeding herds and altered gender structure, created reduced female cohorts, and dampened productivity. The ecological future of plains bison could be significantly enhanced by resolving issues of disease and social tolerance for Yellowstone bison so that their unique wild state and adaptive capabilities can be used to synergize the restoration of the species. We recommend several adaptive management adjustments that could be implemented to enhance the conservation of plains bison and reduce brucellosis infection. These findings and recommendations are pertinent to wood bison (*Bison bison athabascae*), European bison (*Bison bonasus*), and other large ungulates worldwide that are managed using best practices within a risk framework.

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1. Introduction

Infectious diseases transmitted between wildlife and livestock are increasingly becoming one of the primary drivers threatening the long-term viability of wildlife populations through the isolation of protected areas (Newmark, 2008). The increase in human agricultural activities along the boundaries of wildlife reserves has augmented the sharing of diseases between wildlife, livestock, and humans. These multi-host situations, where the disease has been eradicated or is under control in domestic livestock, are exceptionally difficult to manage because a single transmission from wildlife to livestock can have severe consequences for public health, the region's economy, and wildlife conservation (Gortázar et al., 2007). As a result, wildlife hosts are often restricted to reserves which may not offer all the seasonal habitat requirements for survival and reproduction. This is the case for many migratory ungulates, where most protected areas do not include the entire migratory range and intact ungulate migrations have declined as these conservation areas have become increasingly insularized by human activities (Bolger et al., 2008). A consequence of restricting wildlife access outside reserves is the crowding of hosts within protected areas which can lead to an increase in disease transmission within the wildlife host populations (Lebarbenchon et al.,

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2007) and, ultimately, greater transmission risk to nearby livestock.

Decisions regarding management of wildlife diseases transmissible to humans and domestic livestock have complicated conservation of migratory ungulates worldwide. For example, bovine tuberculosis caused by *Mycobacterium bovis* infects wild ungulates and domestic livestock and is a major conservation problem in protected areas across the world. Wild ungulates infected with tuberculosis include buffalo (*Syncerus caffer*) in Kruger National Park (Cross et al., 2009) and Hluhluwe-Imfolozi Park (Jolles et al., 2005), South Africa; wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), and fallow deer (*Dama dama*) in Doñana National Park, Spain (Gortázar et al., 2008); and elk (*C. elaphus*) in Riding Mountain National Park and wood bison (*Bison bison athabascae*) in Wood Buffalo National Park, Canada (Nishi et al., 2006). The wild state and genetic diversity of these ungulates could be used to synergize restoration efforts if issues of disease and social tolerance could be solved. Protected areas are needed as ecological baselines to discern natural change from those induced by human activities (Boyce, 1998; Sinclair et al., 2007), but the existence of wildlife disease reservoirs complicates wildlife management at conservation area boundaries.

The processes for long-term conservation of free-ranging ungulates operate on large landscapes over long periods of time, while the effectiveness of maintaining livestock health can be observed annually. Thus, management plans attempting to prevent disease transmission from infected wildlife to livestock, while conserving healthy wildlife populations, may have difficulties balancing both of these objectives. We used brucellosis management in Yellowstone bison (*B. b. bison*) as a case study to demonstrate the need for continually reviewing and integrating conservation practices into management policies to better protect migratory ungulates and facilitate the ecological role they play in the system. Though elk in the northern Yellowstone area are also chronically exposed to brucellosis (<5% seroprevalence; Barber-Meyer et al., 2007), we did not consider them in this assessment because transmission between bison and elk appears rare (Proffitt et al., 2010). Also, differences in behavior, distribution, infection rates, and tolerance for elk in Montana will likely lead to different strategies to mitigate brucellosis transmission risk from elk to cattle.

2. Brucellosis in Yellowstone bison

Yellowstone bison historically occupied approximately 20,000 km^2 in the headwaters of the Yellowstone and Madison rivers of the western United States (Schullery and Whittlesey, 2006). However, they were nearly extirpated in the early 20th century, with Yellowstone National Park providing sanctuary to the only relict, wild and free-ranging plains bison (Plumb and Sucec, 2006). The population was restored through husbandry, protection, and translocation (Meagher, 1973) and, today, more than 3000 bison in two breeding herds (central, northern) are an integral part of the northern portion of the greater Yellowstone ecosystem. These bison provide prey for predators and carrion for scavengers, contribute to the recycling of nutrients, and provide the visiting public with an opportunity to observe how this icon of the American frontier existed in the early settlement era (Freese et al., 2007; Sanderson et al., 2008).

The Yellowstone bison population has been infected with brucellosis since at least 1917 (Mohler, 1917), likely from cattle (Meagher and Meyer, 1994). Bovine brucellosis is a bacterial disease caused by *Brucella abortus* that may induce abortions or the birth of non-viable calves in livestock and wildlife (Rhyan et al., 2009). When livestock are infected, economic loss from slaughtering infected cattle herds and imposed trade restrictions affect more than just the owner of the infected stock. The impacts are shared by others in the industry statewide. Brucellosis has been declared eradicated from cattle herds in the United States, but bison and elk persist as the last known reservoirs of infection in the greater Yellowstone area (Cheville et al., 1998). Approximately 40–60% of Yellowstone bison have been exposed to *B. abortus* and some of these animals migrate to winter ranges in Montana where there is a risk of brucellosis transmission to cattle that graze on public and private lands (Treanor et al., 2007; Plumb et al., 2009).

After intensively managing bison numbers for 60 years through husbandry and regular culling, Yellowstone National Park instituted a moratorium on culling ungulates within the park in 1969 and allowed numbers to fluctuate in response to weather, predators, and resource limitations (Cole, 1971). In response to livestock industry concerns over brucellosis, the National Park Service proposed a program to control bison at the boundary of the park and a series of four interim bison management plans through 1996 put specific boundaries and lethal control measures in place (United States Department of the Interior [USDI] and United States Department of Agriculture [USDA], 2000a). However, bison abundance increased rapidly under this management paradigm (Fig. 1) and migrations by hundreds of bison towards the park boundary during winter began during the 1980s when numbers exceeded 500–1000 bison on the northern and central ranges, respectively (Meagher, 1989a,b; Bruggeman et al., 2009). Attempts to deter these movements or bait animals back into the park failed (Meagher, 1989a,b) and deep snow and ice conditions in 1997 contributed to a large-scale migration of bison to the park boundary, seeking accessible forage at lower elevations. Implementation of the interim plan during this severe winter resulted in the removal of 1123 bison (1084 bison were shot or slaughtered and 39 were used for research purposes). Other bison died of starvation or other natural causes, decreasing population size from approximately 3500 bison in autumn 1996 to 2000 animals by spring 1997 (USDI and USDA, 2000a). In total, about 3100 bison were culled from the population during 1985–2000 for attempting to migrate outside the park.

These migrations and culls of Yellowstone bison led to a series of conflicts among various constituencies (environmentalists, stock growers) and management entities regarding issues of bison conservation and disease containment (Cheville et al., 1998). Since the management of bison outside the park in Montana is the prerogative of the state and the Gallatin National Forest on US Forest Service lands, the federal government and the state of Montana negotiated a court settlement in 2000 that established guidelines for cooperatively managing the risk of brucellosis transmission from bison to cattle. The so-called Interagency Bison Management Plan (IBMP) emphasized preserving the bison population as a natural component of the ecosystem and allowing some bison to occupy winter ranges on public lands in Montana (USDI and USDA, 2000a,b). The IBMP established a primary conservation area for bison that included all of Yellowstone National Park, two zones of intensive, adaptive management outside the north and west boundaries of the park where bison are allowed based on various contingencies, and three areas of the Gallatin National Forest where there are no significant wildlife–livestock conflicts and bison are allowed year-round (Fig. 2).

Prior to signing and implementing the IBMP, there was a concerted effort by federal and state agencies to predict the ecological impacts of various management actions on Yellowstone bison and the risk of brucellosis transmission to cattle. Since that time, the signatories have collected substantial information regarding bison, brucellosis, and the management of transmission risk. As biologists charged with implementing the IBMP for the National Park Service, we retrospectively evaluated if reality met expectations by comparing assumptions and predictions for the alternative selected