Brucellosis: A Study of Cross-Species Transmission Between Elk and Domestic Livestock in Park County, Wyoming.

Abstract: This academic paper was written for Agricultural Sciences Research Methods (Capstone). In this paper, I explore the nature of the highly contagious disease Brucellosis, its economic effects on the state of Wyoming and Wyoming's ranchers, and the future management of wildlife in relation to transmission of Brucellosis between wildlife and domestic livestock. Since the Brucellosis Eradication Programme was implemented in 1934, there has never been such a prevalence of the disease in the state of Wyoming as there is today. This report collaborates with the Wyoming State Veterinary Laboratory, and uses heretofore unpublished data to report on the current status of Brucellosis in Wyoming, with particular focus on cross-species transmission between elk and domestic livestock in Park County.

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Abstract

Since the Brucellosis Eradication Programme was implemented in 1934, there has never been such a prevalence of the disease in the state of Wyoming as there is today. This paper reports on the current status of Brucellosis in Wyoming, with particular focus on cross-species transmission between elk and domestic livestock in Park County.

Introduction

Brucella abortus is a bacteria that causes the disease Brucellosis, and was first isolated in bovines by Fredrick Bang in 1897. Brucellosis is a highly contagious, costly disease, affecting the health of many animals (cattle, swine, bison, elk, sheep, horses, amongst others) and humans, and has serious national and international trade implications. In livestock, the disease can cause abortion, infertility, and arthritis. It is considered one of the most serious diseases of livestock globally. In humans, the disease is known as undulant fever, as it characteristically causes rising and falling fevers, sweats, headaches, and muscle pains. It "undulates," and comes on in waves.

In 1934, a Cooperative State-Federal Brucellosis Eradication Programme was implemented to rid the United States of the highly contagious disease Brucellosis, both due to its severe economic consequences for the cattle industry, and for its effects to human health. This programme has been widely successful, and at the start of 2012, all 50 states maintain Brucellosis-free status in domestic livestock. However, the success of the disease's elimination is limited to livestock, and the disease is still rampant in wildlife in the Greater Yellowstone Area.

Brucellosis in the Greater Yellowstone Area has been the subject of much debate and national attention (Cheville, 1998). Although all 50 of the United States have now achieved Brucellosis-Free status, Wyoming is at great risk of losing this status after recent findings of the disease in Park County.

As the Wyoming Brucellosis Coordination Team states in their Report and Recommendations, "Wyoming's Brucellosis situation is complicated by both scientific and policy issues. These issues include stopping transmission between the different species...a reservoir of disease on lands under Federal control, a lack of basic scientific and economic information about the disease, and a lack of public or social awareness of the complications" (2005). Yet one thing is clear, with the drastic increase in the rate of infected herds, Brucellosis is an issue which will not disappear, and one which absolutely must be addressed by the state and ranchers alike.

Park County, which borders Yellowstone National Park, is, to a certain extent, at a rather obvious risk of the spread of Brucellosis from wildlife to domestic animal herds. It is public knowledge that the bacteria *Brucella abortus* is carried by both bison and elk resident to the Park. When these animals roam outside the Park borders, they come into contact with domestic herds (of both cattle and bison), and the risk of infection is increased.

The only possible way of permanently eliminating Brucellosis from domestic livestock herds is to eliminate it from wildlife too – a far more challenging task, requiring coordination from state and federal authorities, and anyone involved in raising livestock.

The objective of this paper is to report on the most current research on Brucellosis in Park County, Wyoming.

Research Methods

In addition to general research on Brucellosis, in particular using reports from the Wyoming Brucellosis Coordination Team, United States Department of Agriculture, and Animal and Plant Health Inspection Service, the Wyoming State Veterinary Laboratory was consulted, and provided data for analysis in this report.

Background of the disease Brucellosis

Transmission

Brucellosis affects the reproductive organs, mammary glands and lymph nodes of infected animals. The disease is highly contagious and can be passed between animals in a variety of ways, such as the licking of a female's genitalia, and to offspring through colostrum and milk.

However, the most common form of transmission of Brucellosis is through contact with infected aborted foetuses, usually by touching, licking or ingestion of placental membranes and fluids (Cheville, 1998). Young animals are particularly curious, and therefore susceptible.

Although most cows will expel a placenta 30 to 45 days after abortion, it can be expelled as late as nine months after parturition, and *Brucella abortus* is able to survive outside of the body for almost one year in placental and aborted foetal material. Therefore, if elk have aborted foetuses in the vicinity of domestic livestock, the livestock can become infected long after the elk have moved out of the area (Wills, Rebecca, personal communication, 2012).

The reason that elk continue to transmit the disease among themselves is because they travel far more than domestic livestock do, and therefore when they abort an infected foetus, it is likely to be over a far larger area, as opposed to cattle that are generally confined to pastures during the likely time of abortion. Abortion usually occurs after 5 months of pregnancy, which in elk, with a birthing period of May and June, would be between February and May; and cattle and bison, with a gestation period of approximately nine months, and a calving period any time from January to May (in Park County), would likely occur any time after September.

Brucellosis can also cause serious human disease. In humans, the disease is called "undulant fever," and most commonly occurs from the ingestion of unpasteurised dairy products

of infected cattle. However, less frequently, it can result from exposure to foetal fluids or from exposure to the vaccine (Wyoming Brucellosis Coordination Team, 2005). It causes flu-like symptoms and may develop into a variety of chronic conditions, including arthritis. Although humans can be treated for Brucellosis with antibiotics, lifelong infection is not unusual (Shea, 2010).

Humans most at risk are ranchers, veterinarians, hunters, laboratory workers, and wildlife personnel (Wyoming Brucellosis Coordination Team, 2005).

Interim Rule

On December 27, 2010, the United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) announced an interim rule amending its previous Brucellosis regulations (USDA, 2010). These regulations came into force after near successful elimination of the disease in most states, with the exception of the Greater Yellowstone Area. As far as Park County is concerned, the two most important changes are as follows:

1. To remove the provision for automatic reclassification of any Class Free state or area to a lower status if two or more herds are found to have Brucellosis within a two-year period or if a single Brucellosis-affected herd is not depopulated within 60 days;
2. To add a requirement that any Class Free state or area with *Brucella abortus* in wildlife must develop and implement an APHIS-approved Brucellosis management plan in order to maintain Class Free status (USDA, 2010).

It is these amendments that have allowed the state of Wyoming to retain its Class Free status, despite four recent cases of infected herds in Park County.

Designated Surveillance Area (DSA)

The Designated Surveillance Area in Wyoming was expanded on April 30th, 2011, to the east and south, to include the whole of Park County and Sublette County, portions of Hot Springs County, and a greater portion of Lincoln County. (See Figure 1).

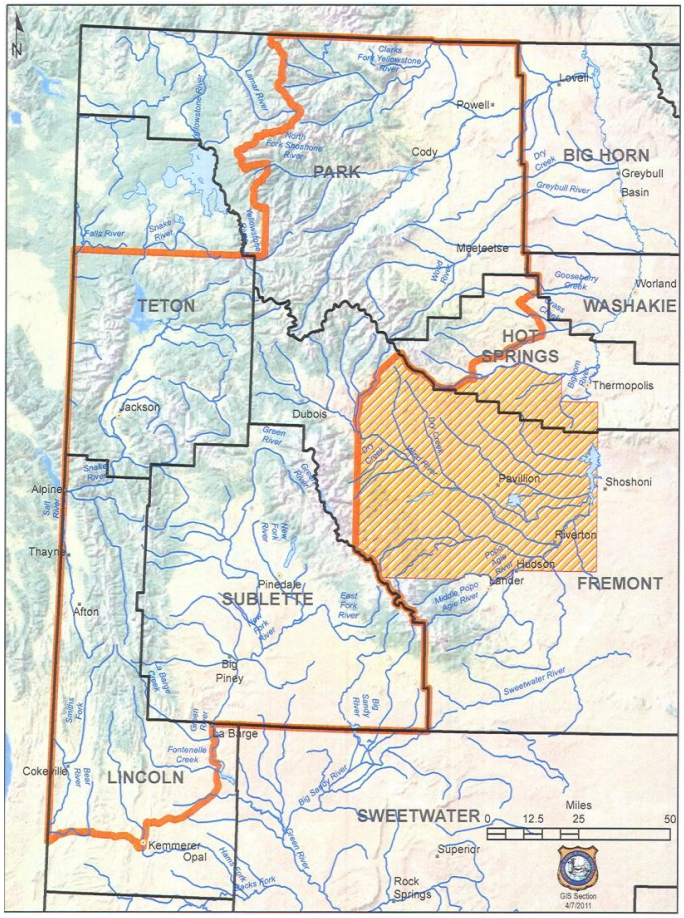

Figure 1. Designated Surveillance Area borders in Wyoming (Wyoming Livestock Board Animal Health Unit, 2011.)

Current Control Methods

There is currently no known cure for Brucellosis, only prevention. The best prevention is to protect healthy animals from becoming exposed. The three main methods of control are

currently: test and slaughter of seropositive[1] animals, vaccination of sexually immature animals, and preventative management practices (Thorne, 1997).

Titers

When animals are tested for the bacteria *Brucella abortus*, it is the titers in the blood serum that are measured. (Serum is the blood plasma, which includes electrolytes, hormones, and antibodies.) A titer is a measure of antibody level – a low titer indicates poor immunity, whereas a high titer indicates good immunity, or that the animal is a carrier of the disease.

There are two ways that a titer can be raised – either through vaccination, or through contraction of the disease itself. When vaccinations are given, a small amount of the disease is actually given to the animal, so that the animal's immune system can step up and produce antibodies to fight it. These antibodies then provide a resistance against contraction of the disease from other animals. (This can be likened to the vaccination against Measles in humans.) This process of vaccination is not a cure, nor is it 100% effective, but, to date, it is the best method of prevention available.

As previously mentioned, if an animal is a carrier of the bacteria *Brucella abortus*, it will also have a high titer. This is because the animal's immune system is producing antibodies at a high rate to counteract the disease, much as it would to fight the vaccine.

This can obviously lead to some confusion as to whether an animal has a high titer due to vaccination, or due to a reaction to the disease itself.

Strain 19 vaccine

Strain 19 is a live vaccine developed for use in cattle, and was the cornerstone of the United States Department of Agriculture programme of Brucellosis eradication in cattle from the

[1] Seropositivity shows the presence of an antibody of a specific type in the blood serum – it is useful in identifying many types of diseases.

1930s to 1996 (Cheville, 1998). When administered at the optimum age, i.e. before sexual maturity, Strain 19 has a 67% successful prevention rate.

Like most vaccines, Strain 19 has advantages and disadvantages. It produces a reaction in the body that resulted in a very high titer, which means high resistance to natural infection by the disease.

However, Strain 19 simultaneously demonstrates the capacity to infect both humans and cattle with the disease (Adams, 1990). It has also produced a series of "false-positive" results, meaning that it is difficult to interpret the results of testing and distinguish whether a high titer was as a result of vaccination or infection of disease itself. There has also been found to be a narrow tolerance of the vaccination age in cattle, and the vaccine is less successful if administered later in life (Adams, 1990).

In 1996, the Strain 19 vaccine was replaced nationwide for use in livestock in favour of the more newly developed vaccine RB51. Vaccinated elk continue to receive the Strain 19 vaccine.

RB51 vaccine

RB51 is also a live vaccine developed for use in domestic livestock. The vaccine is administered in calfhood between three and ten months of age (Cheville, 1998). The vaccine administers a lower bacteria count than Strain 19, which results in a more accurate distinction between animals who have been vaccinated, and animals that have contracted the disease. However, although the vaccine is administered in a lower dosage, it is equally effective as Strain 19.

Depopulation

Current livestock owners have a choice when dealing with Brucellosis infected animals. Formerly, the government sponsored their plan to eliminate Brucellosis by compensating ranchers who were required to depopulate their herds. However, this is now a subject under some debate. If the latter option is chosen, the entire herd (even after culling) must be retested three times. Although this retesting should eliminate Brucellosis within the herd, it will not prevent reinfection at a later date (Wills, Rebecca, personal communication, 2012).

The Wyoming Livestock Board receives money from Wyoming legislature in order to pay for mandatory testing of livestock within the Designation Surveillance Area.

Elk Feeding Grounds

Winter feeds grounds, such as near Pinedale, Wyoming, and the National Elk Refuge in Jackson, Wyoming, have been established in order to keep elk off cattle feeding grounds, and therefore reduce the comingling of species. However, these feeding grounds have a certain double standard, in that although they assist in reducing the transmission of Brucellosis to livestock, they increase within-species rates of infection. In fact, up to 30% of elk visiting artificial winter feeding grounds are infected with Brucellosis (Wyoming Brucellosis Coordination Team, 2005). These winter feeding grounds may be a temporary fix to inter-species comingling, yet are of no benefit towards the goal of eliminating Brucellosis as a disease – in livestock or in wildlife.

However, these feed grounds do provide a basis for state testing and vaccinating of elk, which is an important management tool in the surveillance of Brucellosis.

Vaccination of Wildlife

Elk on twenty-one of the twenty-two State elk feed grounds are vaccinated with the Strain 19 vaccine, via ballistic bio-bullets. This is undertaken by the Wyoming Game and Fish Department, and only targets elk visiting these feed grounds. As in cattle, vaccination in elk does not prevent Brucellosis infection, but it does cause a reduction in abortion rates (Wyoming Brucellosis Coordination Team, 2005), and therefore of aborted foetuses which easily transfer the disease to livestock.

Brucellosis in Wyoming

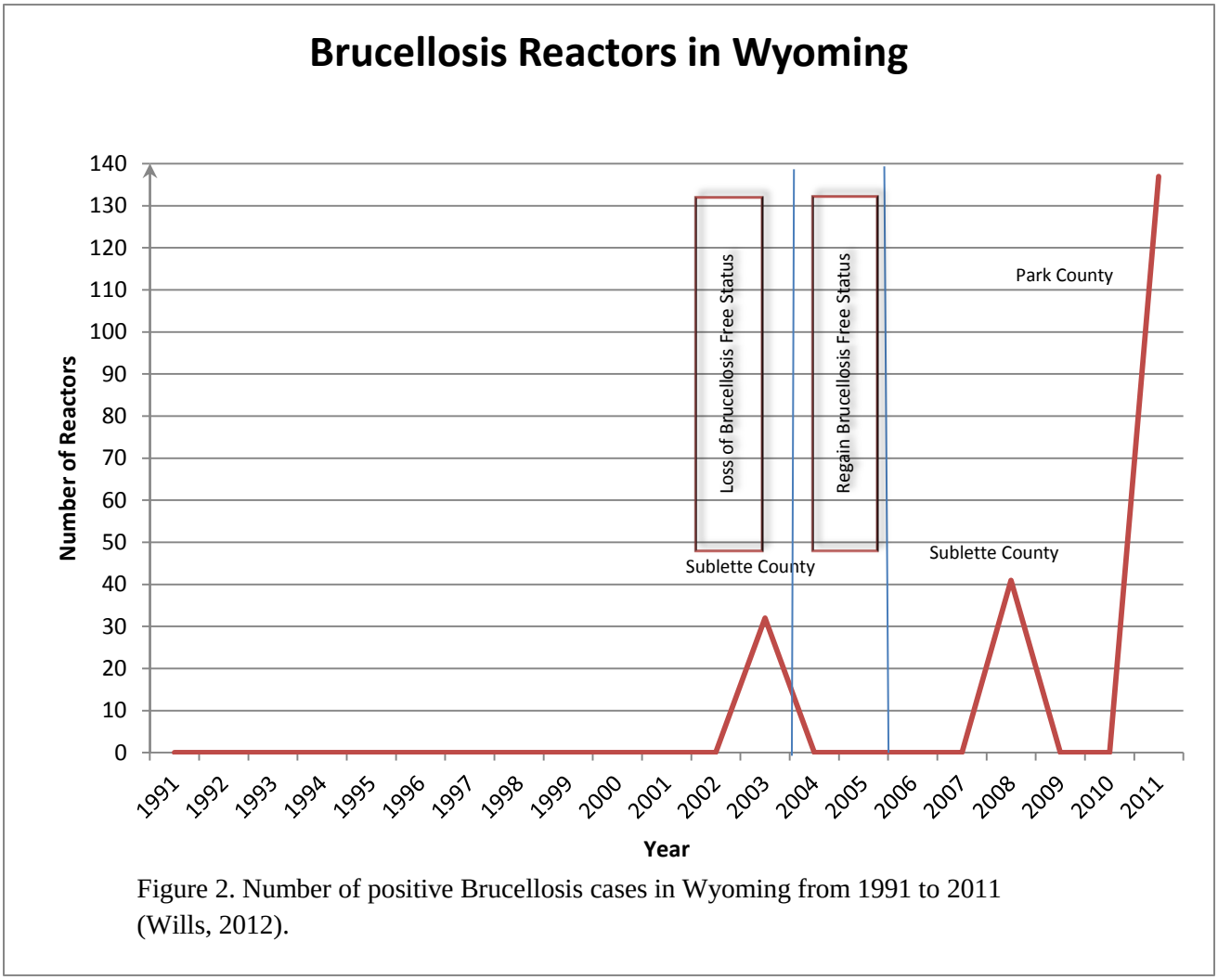

Figure 2. Number of positive Brucellosis cases in Wyoming from 1991 to 2011 (Wills, 2012).

Wyoming first obtained Brucellosis-Free Status in 1985, and this was continued for nearly twenty years, until 2004.

Figure 2 shows the numbers of Brucellosis reactors in the state of Wyoming over the last twenty years. 32 reactors were found in the year 2003, in two herds, which resulted in the State's loss of Brucellosis-Free status in 2004. After no more positive reactors were found in the state for two years, Wyoming regained Brucellosis-Free status in 2006. However, in 2008, Wyoming once again came at risk of losing its Free-Status when 41 reactors were found in Sublette County – an increase of 128% from 2003. No further reactors were found in herds throughout the state, meaning that Wyoming did not lose Free-status. In 2010, the Interim Rule was implemented, no longer requiring the depopulation of herds. According to Rebecca Wills at the Wyoming State Veterinary Laboratory, this may have been as a direct result to the increase in reactors found in Sublette County in 2008. In 2011, 137 reactors were found in Park County, Wyoming, over four separate herds. This is an increase of 428% since 2003. Testing of these herds continues, and the herds have not been depopulated, although are all in the DSA.

With an increase in the number of Brucellosis infected animals of 428% in the last ten years alone, this graph shows that, despite brief Brucellosis-Free periods, Brucellosis persists among domestic livestock in the State of Wyoming. These statistics hold even more weight due to the fact that they have been obtained from the Wyoming State Veterinary Laboratory, and have heretofore never been widely published. They distinctly show the importance of recognising Brucellosis as a continuing problem in the state, and the ever increasing need for efficient management between livestock and wildlife. The state of Wyoming is dangerously near the brink of losing Brucellosis-Free Status.

According to the "Elk Feedgrounds in Wyoming" report of 2004, Wyoming lost its Brucellosis-free status in the February of that year due to a bovine Brucellosis outbreak that was likely due to transmission from elk wintering on a feedground. Wyoming and federal livestock health officials have identified seven occurrences of bovine Brucellosis outbreaks they believe were transmitted from elk or bison in Wyoming since the early 1960s (Dean, Ron et al., 2004).

Health and Economic Impacts

Bovine Brucellosis has significant animal health, human health, and national and international trade consequences (United States Department of Agriculture, 2010).

As written by the economist Amy Bittner in her report, "An Overview and the Economic Impacts Associate with Mandatory Brucellosis Testing in Wyoming Cattle," every year, between 100 and 200 human cases of Brucellosis infection are reported in the United States, and human infection can last for years. In fact, the bacteria *Brucella abortus* is listed as a potential bioterrorism agent, due to its extremely high level of contagiousness (2004).

Agriculture has always been an important part of not only Wyoming's economy, but Wyoming's cultural identity. Livestock production comprises the largest segment of Wyoming agriculture (Bittner, 2004).

According to the Animal and Plant Health Inspection Services, annual losses from lowered milk production, aborted calves and reduced breeding efficiency have decreased from more than $400 million in 1952 to less than $1 million today, and studies have shown that if Brucellosis eradication programme efforts were stopped, the costs of producing beef and milk would increase by an estimated $80 million annually in less than 10 years.

Continued surveillance is important to the United States, as it sends out the message to international beef trading partners that the country maintains Brucellosis free status. Loss of

status in states will considerably affect the marketability of cattle, not only for those particular states but also for the nation as a whole. For example, when the state of Wyoming lost Brucellosis free status is 2004, not only was the marketability of cattle in Wyoming negatively impacted, but a continuing focus on cattle in the Greater Yellowstone Area was started by other states and Brucellosis free countries trading with the United States (Dean, Ron et al. 2004).

When Wyoming was downgraded from Free to Class A status in 2004, certain requirements were implemented that affected all cattle producers in the state – requirements which would be imposed should the state lose Free status in the future. These requirements mandated that all test-eligible cattle be tested and demonstrated to be free of Brucellosis within 30 days prior to interstate movement or change of ownership. This was at a cost of between $3-10 per head (Dean, Ron et al., 2004) – a significant additional cost to producers in an industry where profit margins are already so fine.

In 2004, when Wyoming lost Brucellosis free status, livestock producer Jeff Page managed a bred heifer programme for Paint Rock Canyon Enterprises (PRCE) in Hyattville, Wyoming. In an interview with Page, he explained the direct economic impact of this loss of status to the business. The ranch ran 1,700 head of heifers, and guaranteed calving ease[2]. These heifers were generally sold in small groups of approximately 50 animals at a time. After prospective buyers had chosen their animals, the heifers would have to be separated from the rest of the herd for testing, and maintained in confinement until results of testing came back – on average around ten days. The cost to the ranch of keeping these heifers segregated and fed was approximately $1 a day, plus $5 per head for Brucellosis testing. This placed a huge economic burden on the business, Page says. Holding heifers for ten days, and having them tested for

[2] Calving ease was not affected by Brucellosis itself, but did mean that heifers tended to be sold in smaller groups.

Brucellosis, resulted in an increased overhead cost of $15 per animal, or $22,500 for the entire herd – excluding the obvious additional labour costs involved in keeping small groups of animals separated in corrals. Page stated that without additional financial backing, the ranch would not have been able to successfully run their bred heifer programme through the loss of Brucellosis free status in the state of Wyoming (Page, Jeff, personal communication, 2012). Paint Rock Canyon Enterprises no longer runs a bred heifer programme.[3]

Because of the reservoir of Brucellosis carried by elk and bison in the Greater Yellowstone Area, livestock producers in the states surrounding the Park – Wyoming, Idaho, and Montana – will continue to be required to vaccinate their cattle and participate in surveillance programmes, likely indefinitely. These activities are expensive and are not necessary or required in states where there is no reservoir of Brucellosis (Dean, Ron et al., 2004). However, the cost of vaccination and surveillance is considerably less than the costs incurred should the states lose Free status, or through calf losses to the disease itself.

Although ranches having to depopulate their herd in the Designated Surveillance Area are paid federal indemnity, meaning that the government will pay them fair market value for each animal, as Bittner writes, genetic progress and quality of the herd may suffer, as well as the reputation of the livestock producer (Bittner, 2004).

As Page stated in his interview, ranches struggle to incorporate the extra costs of Brucellosis testing, and for many (especially small scale) producers, these costs could prove too much for businesses to bear. In an industry where profit margins are already so fine, the loss of Brucellosis free status could result in higher unemployment rates in the agricultural industry, and, ultimately, the liquidation of ranches. This is reiterated by Bittner's report, which states that of the 6,200 cattle producers in the state of Wyoming, over 90% are considered small scale. Even

[3] PRCE has, to date, never had a positive Brucellosis reactor.

if testing for Brucellosis in the DSA is subsidised by the Wyoming legislature, Wyoming ranchers face a cost of anywhere between $495,000 and $3.8 million a year – a huge economic impact on the state's livestock industry.

Future goals and Research

As previously stated, the Brucellosis issue is complicated by both scientific and policy issues – there is no "magic bullet solution" (Wyoming Brucellosis Coordination Team, 2005). Completely eradicating the totality of elk and bison herds in the area is highly unethical, and similarly, eradicating the disease in these animals is improbable. As the National Research Council's report states, "Total eradication of Brucellosis as a goal is more a statement of principle than a workable programme" (Cheville, 1998). There is currently no way to effectively vaccinate all the elk in the Greater Yellowstone Area, especially as they travel so far outside of the Park, and vaccinating bison in the Park itself would prove highly intrusive. And although the issue of Brucellosis mainly affects the state of Wyoming, it will take federal involvement to even hold any hope of eradicating the disease nationwide. In the state of Wyoming alone, elk cross jurisdictions of private ranchers, the Bureau of Land Management and the Forest Service. It will involve cooperation and collaboration between all of these agencies before eradication of the disease is even on the horizon.

However, a huge expansion on current research is still possible. Although the bacteria *Brucellosis abortus* is currently dominant in elk, bison, and cattle, it does not affect deer and antelope. Research into the genetic immunities of these mammals, and comparisons to affected species, will prove to be fundamental in the vaccination processes and elimination of Brucellosis in both livestock and wildlife species nationwide.

Although in the long term future, especially with continuing advancements in veterinary medicine, the hope of eliminating Brucellosis from all species may be a determinable goal; in the present, any realistic control of the disease must focus around management practices. Management practices involve a great number of aspects, not least of which the social. Public opinion holds a great part in the management of any wildlife species, from sage grouse, to wolves, to elk. It is not only how the greater public, outside of the state of Wyoming, view elk and bison from a tourist point of view, but what emphasis they see fit to put on the disease of these animals in the Greater Yellowstone Area. The effect of the tourist industry on the state of Wyoming cannot be underestimated. Elk and bison draw tourists to the Park year after year, and are therefore not cultivated for production purposes. The disease, although detrimental to affected species, could be viewed as naturally manageable. Whatever the management plan imposed, as the National Park Service states, any action to accomplish Brucellosis elimination must be conducted in such a manner that will ensure that wild and free ranging wildlife resources will be left unimpaired for future generations (National Park Service, 2003).

Continued monitoring of elk feedgrounds and vaccination of animals on these feedgrounds will remain a good management tool for the successful monitoring of elk herd health. The ultimate goal of closing elk feedgrounds would be ideal to assist in preventing such high rates of intraspecies Brucellosis transmission but should not occur before the completed integration of alternative elk wintering grounds.

The most immediate management practice that ranches are able to implement is at the introduction of new livestock. Brucellosis tends to be carried from one herd to another by infected animals, which most commonly occurs at the purchase of new breeding animals. All replacement animals integrated into a new herd should be tested when purchased and then

retested before being introduced to a new herd (Bittner, 2004). Continued work with livestock owners and the mapping of feed areas and elk and livestock movement is crucial to future research in Brucellosis and other wildlife diseases.

The most practical, and currently effective, way of managing Brucellosis is through ecosystem management. Ecosystem management is the key to the management of wildlife movement, and therefore the transfer of wildlife disease. Ecology itself is the study of interrelationships, which in turn could not more accurately describe the complexity of the social and political interests involved in the management of Brucellosis.

Management should be focused on the historic feeding grounds of elk, their current state, and how government land can be managed to encourage elk to relocate there. With an increasing human population, there is an increased focus on developing rangelands, which naturally affects the movement patterns of wildlife. It also increases the possible interaction between wildlife and domestic livestock. It is this interaction that must be controlled in order to successfully manage such a contagious disease.

However, although ecosystem management is able to focus on the winter feeding grounds of elk, it should not be limited to such. A management of the species of the whole, following their year round movements, is need for a full understanding of the cross-species transmission. Although this cross-transmission may never be fully prevented, there are ways that it can be effectively managed to allow for the successful coexistence of both wildlife and man-managed species. For a harmonious existence between wildlife and production agriculture, monitoring and management of the ecosystem will remain key.

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