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CONFLICTS OF AUTHORITY AND STRATEGIES TO ADDRESS WILDLIFE DISEASES

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Introduction

Although the same basic methods are used to study, diagnose, and manage diseases of domestic animals and wild animals, managers of wild animal diseases face significant difficulties that are relatively unimportant in management of diseases of domestic animals (Wobeser, 1994). Some of these difficulties are inherent in the wild nature of truly free-ranging animals, while others are related to a lack of knowledge and/or tools necessary to effectively manage diseases of concern. All these difficulties are compounded by varying perceptions of ownership and management jurisdiction. In addition, wild animals capture the interest of diverse constituencies, including some advocacy groups that have little concern for the health of domestic animals.

For the purposes of this discussion regarding management of diseases of wild animals, we will limit our comments to free-ranging North American wild ruminants, or big game. We use examples of diseases of wild ruminants because they are most likely to be important to domestic livestock health and, therefore, are of economic (and sometimes of human health) importance because they are often the subject of federal disease control programs, and because they are of direct concern to the United States Animal Health Association. Furthermore, we will restrict our discussion to issues of authority and responsibility for wildlife disease management, strategies for managing important wildlife disease problems, and examples of on-going management programs for wildlife diseases.

Conflicts of Authority

There is considerable debate over which agency, or agencies, has jurisdictional authority to manage diseases in wildlife. This question has been addressed in great depth regarding brucellosis in bison and elk in the Greater Yellowstone Area (GYA) (Keiter and Froelicher 1993, Carlman 1994, Keiter 1997, Melcher 2000); brucellosis in the GYA has resulted in more litigation (Keiter and Froelicher 1993) and controversy than any other recent regional environmental issue. Similar questions have been raised more recently with respect to managing bovine tuberculosis (TB) in white-tailed deer in Michigan (Salman et al. 2000).

Traditionally, states have been responsible for wildlife management on U.S. Forest Service and Bureau of Land Management multiple use federal lands, as well as state and private lands (Coggins and Ward 1981). Federal law governs wildlife management on national park and national wildlife refuge lands (Coggins and Ward 1981). But federal law does not address brucellosis, or other diseases, in wildlife (Keiter 1997). However, based on discussions with General Counsel attorneys who advise the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), Melcher (2000) maintained that APHIS has authority over wildlife that are infected with or are carriers of diseases contagious to domestic livestock. This, apparently, is based on quarantine laws from the 1880s modified by subsequent statutes. In the case of diseased wildlife on national park and wildlife refuge lands, APHIS would seek concurrence of the U.S. Department of Interior before exercising its authority. Elsewhere, APHIS regulations would be administered in cooperation with the appropriate state(s) (Melcher 2000).

According to Keiter and Froelicher (1993), Keiter (1997), and Salman, et al. (2000), jurisdictional authority for diseases of wildlife is fragmented among many state and federal agencies. We will use brucellosis in elk and bison of the GYA as an example because management and control involve more federal (APHIS, National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service, Bureau of Land Management) and state (Wyoming State Livestock Board and Game and Fish Department; Montana Board of Livestock and Department of Fish, Wildlife and Parks; and Idaho Department of Agriculture and Department of Fish and Game) agencies than possibly any other wildlife disease issue and because it was recently reviewed from a legal perspective (Keiter and Froelicher 1993, Carlman 1994, Keiter 1997).

In shaping federal law " "Congress passed the Animal Industry Act of 1884 authorizing the Secretary of Agriculture to regulate contagious animal diseases to prevent their interstate dissemination (21 U.S.C. §111). Congress has since amended the Act to authorize the Secretary "...to control and eradicate any communicable diseases of livestock or poultry including...brucellosis of domestic animals" (21 U.S.C. §114A). To protect livestock against communicable diseases, the Secretary is also empowered to seize, quarantine, and destroy infected animals moving in interstate commerce (21 U.S.C. §134a (a)). The term "animals" includes "...all members of the animal kingdom ...whether domestic or wild" (21 U.S.C. §134(b)) (Keiter 1997:182)." " However, enabling legislation for the National Brucellosis Eradication Program and the Uniform Methods and Rules for Brucellosis Eradication address domestic livestock and do not apply to free-ranging wildlife, which is regulated by states (Parker Land and Cattle Co., Inc. vs. United States 1992, Keiter 1997).

Within the GYA, the immediate location of brucellosis-exposed or infected bison and elk determines prevailing legal standards (Keiter and Froelicher 1993). The Yellowstone National Park organic act contains a wildlife preservation provision (16 U.S.C. §26) and clearly provides legal authority over wildlife within the park. However, special enabling legislation for Grand Teton National Park provides that the National Park Service and state of Wyoming share responsibility for protecting elk and allows for hunting of elk within the park under specific statutory limitations (16 U.S.C. §673c); this does not apply to bison. On the National Elk Refuge, which is managed by the U.S. Fish and Wildlife Service, responsibility for elk management is currently the subject of heated litigation (State of Wyoming v. Babbitt, 10th Circuit Court of Appeals, No. 99-8089). On national forests, the U.S. Forest Service is responsible for habitat management and states are responsible for wildlife management (16 U.S.C. §528; U.S.C. §1732(b)). In Parker Land and Cattle Co., Inc. vs. United States (1992) a Dubois, Wyoming, rancher sued the federal government under the Federal Tort Claims Act (28 U.S.C. §2671 et seq.) for monetary damages because he believed his cattle became infected with brucellosis from federally managed wildlife. Although the court denied the claim because it was not convinced federally managed wildlife were responsible, it did send a strong message that federal land managers should take positive steps to protect livestock from brucellosis-infected wildlife (Keiter 1997).

The Wyoming Game and Fish Department is responsible for managing wildlife of the state under Wyoming law (Wyo. Stat. §23-1101 et seq.). Although brucellosis is not directly addressed in either this statute or the wildlife-caused damages law (Wyo. Stat. §23-1-901(c)), the state supreme court has concluded the state could be liable if elk were proven responsible for transmission of brucellosis to livestock (Parker Land and Cattle Co., Inc. vs. Wyoming Game and Fish Commission 1993). In Montana, responsibility for managing wildlife lies with the Department of Fish, Wildlife and Parks (Mont. Code Ann. §87-1-201), but a relatively recent statute provided shared jurisdiction with the Montana Department of Livestock over bison that have been exposed to brucellosis (Mont. Code Ann. §87-1-215). Idaho has only recently recognized a problem with brucellosis in elk; the Department of Fish and Game has jurisdiction, but has cooperated with the Governor's office and state veterinarian in preparation of a brucellosis management plan for elk. The Idaho Department of Agriculture has been given responsibility for shooting or removing wild bison that pose a significant threat to livestock or property (Idaho Code §25-618) (Keiter 1997).

In the GYA, absence of clear legal authority over brucellosis-exposed wild animals provides opportunities for flexibility to administratively develop a regional, multi-agency, cooperative brucellosis management policy (Keiter and Froelicher 1993, Keiter 1997). That is being accomplished, at least in part, through the Greater Yellowstone Interagency Brucellosis Committee

(GYIBC) (Petera et al. 1997, Hillman 1999). Similarly, Salman et al. (2000) recognized that no single agency can control tuberculosis in white-tailed deer in Michigan and that state and federal wildlife management and animal health agencies must cooperate to resolve the problem. A cooperative approach is far preferable to a single agency attempting to assume sole legal authority over, or assuming it has the resources to manage, significant wildlife disease problems. We believe such an approach would be doomed to many years of litigation in the courts, adverse public reaction, or Congressional resolution, and would ultimately fail because none of these options or institutions is likely to arrive at a satisfactory resolution to wildlife disease problems.

Strategies to Address Wildlife Diseases

Wobeser (1994) extensively reviewed disease management in wild animals and provides a valuable reference for anyone contemplating such a program. Disease management for domestic and wild animals readily fits into three categories:

- **Prevention** encompasses measures taken to prevent individuals and/or populations from harboring or being affected by certain diseases. Wild animals benefit from efforts of state and federal animal health officials and livestock producers to prevent introduction of foreign animal diseases, such as foot and mouth disease.
- **Control** encompasses measures taken to restrict distribution and/or frequency of occurrence of diseases at tolerable levels. There may be disagreement about acceptable levels of occurrence within domestic and wild animal populations, and inherent with disease control is acceptance that it must last forever or until a different category is reached.
- **Eradication** encompasses the complete elimination of an existing disease. It usually follows some stage of control and may be a prerequisite for prevention.

It is important to recognize some of the problems that are more-or-less unique to managers of wildlife diseases and to appreciate the difficulties inherent in developing and implementing strategies to manage wildlife diseases. Detecting the presence of important diseases in wildlife can be surprisingly difficult. Surveillance by serologic tests (where available) is feasible, but may be expensive and time-consuming because of difficulties inherent in obtaining sera from hunter-killed and trapped animals; retesting of "suspect" animals is usually impossible. Sensitivity and specificity of serologic tests developed for domestic animals and used on wild animals frequently are not known, and often they are not the same. Few wild animals are individually marked for re-identification, and they are seldom controlled by fences, corrals, etc. Many wild animals are seasonally migratory and they never respect jurisdictional boundaries or property lines. Carcasses of wild animals are frequently recycled back into the environment before they are located and submitted for necropsy; consequently, a disease outbreak might not be detected until quite advanced. Compared to domestic animals, live wild animals are intractable, and restraint and manipulation for veterinary procedures may induce a spectrum of perturbations, such as capture myopathy, not encountered with domestic animals; these physiologic processes may confound diagnostic and disease management procedures. Moreover, it is rarely possible to capture all, or even a majority, of all the individuals in a free-ranging population. A major obstacle to disease prevention is that vaccines and vaccine delivery systems developed for domestic animals may not be safe, effective, or suitable for wild animals. Finally, there is a unique human relations factor relative to disease management with wild animals. While there is strong personal or economic incentive to control diseases of domestic animals, wild animals are often viewed as belonging to everyone or belonging to no one and capable of overcoming diseases on their own if we simply restore the balance of nature or remove domestic animals. By domestic animal standards, these factors as well as others not listed make epidemiology and disease management considerably more difficult with wild animals. If such factors are taken into consideration, however, attempts to manage important wildlife diseases may be more effective.

Whether it is even desirable to manage diseases is more difficult to resolve with wild animals than with domestic animals. There are some people and groups that believe diseases of wild animals are natural and a part of the balance of nature. To them any disease management strategy is unnatural interference and, therefore, inappropriate. The common failure of disease management advocates to consider or plan for mitigation of resources impacted or lost in the course of such activities may help foster such sentiment. This philosophical obstacle to disease management is seldom, if ever, encountered for domestic animals (Wobeser 1994). Desirability of wildlife disease management is complicated further in western states with large public land holdings. There, some people believe that not only is disease management unnatural, but that the only necessary strategy is to eliminate public land grazing and remove all livestock from public lands, thus eliminating any threat to domestic animals. This short-sighted viewpoint ignores the fact that wild animals, along with domestic animals, also depend on private lands and that the philosophy of multiple use on federal land, including grazing, is well established in law.

Feasibility is often perceived to be an obstacle to attempting disease management in wild animals (Wobeser 1994). To some people, it is not practical to address diseases in wild animals because it is difficult or impossible to treat or immunize wild animals, or because such strategies are unnatural. However, many environmental, habitat, and population factors influence diseases of wild animals and can be manipulated as disease management strategies. Investments in research and development of practical tools for aiding in detection and management of diseases in free-ranging wildlife could help diminish inaction based on the perceived futility of such attempts.

Desirability and feasibility aside, Wobeser (1994) provided three major reasons to control diseases in wild animals:

- Diseases have deleterious effects on species considered important to man; pasteurellosis in bighorn sheep and hemorrhagic disease in white-tailed deer are examples.
- Diseases can constitute threats to human health; brucellosis in elk and bison and bovine TB in white-tailed deer are examples.
- Diseases can threaten health of domestic animals; again brucellosis and bovine TB are examples.

Among wild animals there are three basic determinants of disease: the disease agent, the host, and the environment. Management strategies are based on manipulation of one or more of these determinants, as appropriate, and on influencing human activities. Wobeser (1994) extensively discussed strategies that have been or could be used for management of diseases of wild animals:

- **Controlling the causative agent** of a disease or its vector is the most direct strategy. A disease eradication program has an ultimate objective of time- and place-specific elimination of a causative agent. The screw worm (*Callitroga hominovorax*) program in Florida, the southwest U.S., and Mexico eliminated the fly through release of irradiated, sterile but sexually active males. Although this highly successful program was intended primarily to benefit domestic animals, it also greatly reduced screw worm-induced losses of deer, especially fawns, by controlling the agent (Strickland et al. 1981).
- **Manipulation of host populations** for disease management can occur through restrictions on distribution, selective removal (i.e., culling) of diseased animals, and reduction of population density. Disease- and host-specific factors may influence the potential efficacy of respective strategies (Barlow 1996). Population manipulation is generally intended to reduce or prevent disease transmission; but at its extreme, which is depopulation, it may eliminate a disease.
- Disease management **through treatment or immunization** may have application under certain circumstances. Treatment of wild animals is rarely attempted, but has occasionally been used with individuals or small populations of species at risk or of critical concern. Immunization of wild animals may have greater utility under appropriate conditions (Barlow 1996), but requires safe and effective vaccines and delivery systems that will reach a sufficiently large portion of the population to protect exposed individuals and/or reduce transmission. Vaccination of free-ranging elk to control brucellosis in Wyoming is an example.

- **Environmental and habitat modifications** are strategies that may be used to manage diseases of wild animals. Objectives generally are to reduce survival of specific disease agents or vectors, or lower population densities and reduce transmission rates. Habitat modifications usually should not be expected to produce rapid results, but the results should be relatively long lasting. Habitat enhancements to disperse bighorn sheep in winter serve to reduce disease transmission.
- Finally, diseases of wild animals may be managed by **influencing human activities**. The best example is taking measures to be sure diseases are not moved or introduced through translocation and reintroduction of wild or domestic animals. Specifically, some western states have restrictions on translocation of white-tailed deer from the east to prevent introduction of meningeal worm (*Paraelaphostrongylus tenuis*) to the west. Of greater long-term importance may be modifying public opinion through education and information programs to improve acceptance of disease management in wild animals.

Ongoing Wildlife Disease Management Programs

Currently there are at least three examples of important diseases of free-ranging wild animals, which are being cooperatively managed by multiple agencies using a variety of strategies specific for wild animals. Two of these, brucellosis in elk and bison of the GYA and bovine TB in white-tailed deer of Michigan, have important domestic animal and human health ramifications, and the third, chronic wasting disease (CWD) of cervids in southeast Wyoming and northeast Colorado, has national significance because of its uniqueness as a transmissible spongiform encephalopathy (TSE) in wild animals.

Chronic Wasting Disease of Cervids in Wyoming and Colorado

Chronic wasting disease is a TSE of native deer and elk that is endemic throughout northeastern Colorado and southeastern Wyoming. It was first recognized among captive cervids in the late 1960s and was diagnosed in free-ranging deer and elk during the 1980s (Williams and Young 1992). Estimated infection rates range from <1-15% in deer and ≤1% in elk residing in these endemic areas (Miller et al. 2000). Models suggest CWD has been present in free-ranging populations in areas of Colorado and Wyoming for more than 30 years (Miller et al. 2000). Although CWD occurs in three species of cervids, there is no evidence that humans (World Health Organization 2000) or domestic livestock are susceptible to CWD by natural routes of exposure.

Through the 1980s and early 1990s, the presence of CWD in Colorado and Wyoming led to considerable interagency cooperation at the state wildlife management level. Surveillance for CWD in free-ranging deer began in

Wyoming in 1983 and has been continually expanded in both states overtime. Following the onset of the bovine spongiform encephalopathy (BSE) epidemic in the United Kingdom and with the recognition of the relationship of variant Creutzfeldt-Jacob disease of humans and BSE, interest in the TSEs in general, and CWD in particular, greatly increased. This led to expansion of agencies and industries with legitimate concern about this disease and increased interagency communication and cooperation. An *ad hoc* committee (the Colorado-Wyoming Interstate Forum on CWD) was formed for exchanging information on CWD and included representatives from the Colorado Division of Wildlife, Wyoming Game and Fish Department, Colorado and Wyoming Departments of Agriculture, State Veterinarians of both states, USDA/APHIS, University of Wyoming, Colorado State University, Colorado and Wyoming Public Health Departments, and representatives of cattle, sheep, and alternative livestock industries. Meetings among the wildlife management agencies of Colorado, Wyoming, South Dakota, and Nebraska to discuss CWD have occurred periodically. Yearly meetings specifically to address advances in CWD research involve scientists from across the country representing a spectrum of state and federal institutions and agencies.

There is no precedent for attempting to manage a TSE in free-ranging wildlife. Programs for managing or eliminating scrapie of domestic sheep have proven only marginally successful to date, and the epidemiologic differences between CWD and other TSEs make such programs rather poor models for prospective CWD management. Limited understanding of the epidemiology of CWD makes development and implementation of strategies to prevent, control, and eradicate CWD extremely difficult. Therefore a primary goal of the wildlife management agencies in Colorado and Wyoming has been to invest resources in applied research to understand the epidemiology, distribution, and prevalence of CWD in affected areas (e.g., Miller and Kahn 1999). Common sense preventive measures have been instituted, including bans on relocation of cervids from the CWD endemic areas, halting artificial feeding of deer and elk by the public in areas where CWD occurs, and culling of deer and elk showing clinical signs of CWD. It may be possible to manage affected deer or elk populations to reduce CWD prevalence in endemic foci (Gross and Miller 2000), but prevalence reduction will require a long-term commitment and may not eliminate CWD from endemic areas. A cooperative experiment assessing the efficacy of alternative deer management strategies in changing CWD prevalence is underway in two game management units with high CWD prevalence in Colorado and Wyoming. Considering the difficulties inherent in addressing disease in free-ranging wildlife, an adaptive resource management approach (Holling 1978, Walters and Holling 1990) to test candidate strategies for reducing CWD prevalence and distribution is imperative.

CONFLICTS OF AUTHORITY AND STRATEGIES TO ADDRESS WILDLIFE DISEASES

Bovine Tuberculosis in Michigan Wildlife and Livestock

Since 1994, the state of Michigan has recognized a problem with bovine TB, caused by *Mycobacterium bovis*, in free-ranging white-tailed deer from an 11 county area in northeastern Lower Michigan. A total of 41,500 free-ranging deer have been tested and 285 were positive for *M. bovis*. The disease has been found in other wildlife species, including 8 coyotes, 2 raccoons, 2 opossums, 2 bobcats, 1 black bear, and 1 red fox, and beginning in 1998, in domestic cattle. To date 9 beef and 2 dairy cattle herds have been diagnosed with bovine tuberculosis.

Recognizing the potential economic and public health consequences of bovine tuberculosis to the state, the governor issued orders to eradicate *M. bovis* from the state's deer population. Unfortunately, the situation is unique in that there have never been reports of self-sustaining bovine TB in a wild, free-ranging cervid population in North America. There are no existing control programs for bovine TB in free-ranging deer, and there is much about bovine TB in deer that is currently unknown. Scientists, biologists, epidemiologists, and veterinarians that have studied this situation have concluded that the most logical explanation is that high deer densities, the focal concentration caused by baiting (the practice of hunting deer over feed), and feeding are the factors most likely responsible for the establishment of self-sustaining bovine TB in free-ranging Michigan deer (Schmitt et al. 1997). By repeatedly concentrating deer into close contact with each other, baiting and feeding provide ideal conditions for the transmission of bovine TB via both inhalation of infectious aerosols and ingestion of bovine TB contaminated feed (Whipple and Palmer 2000).

The extremely important goal of eliminating bovine TB from free-ranging deer is likely to be difficult to accomplish. It will require cooperation and collaboration of state and federal animal health and wildlife resource agencies. Animal health agencies do not have sufficient expertise in wildlife biology and management techniques to address the situation independently, while the same can be said for wildlife resource agencies faced with diseases in domestic animal populations. Therefore, multiple agencies must rely on each other and work collaboratively to deal with the control of disease in wildlife; unilateral efforts cannot be expected to succeed. It should be understood that wildlife resource agencies want their free-ranging wildlife populations to be free of disease just as much as animal health agencies want domestic animals to be free of disease.

A management strategy recommended by a multi-agency committee composed of individuals with disease expertise and jurisdiction included surveying wildlife populations, testing livestock, educating the public about bovine TB, eliminating feeding and baiting of deer, reducing the deer density through legal hunting in areas of Michigan where bovine TB has been found, and banning the transport of free-ranging deer from the infected area.

A comprehensive statewide program of surveillance of free-ranging deer populations is necessary to identify areas that will need intensified management practices and to monitor success of management strategies. Continued evaluation of the prevalence of the disease allows the Michigan Department of Natural Resources to determine the reservoir of existing disease, define geographic areas of infection, and assess trends in disease occurrence. Such information will need to be collected for many years in order to interpret trends. The deer surveillance plan focuses on areas that are most likely to have bovine TB-positive free-ranging deer. The plan is science-based using past and present livestock infection rates, locations of livestock, areas of deer density, and appropriate sample sizes for statistical analysis. It is coordinated with surveillance in livestock conducted by the Michigan Department of Agriculture, and it is practical in terms of manpower, money, and laboratory capacities.

A strong education program is necessary to bring about public understanding of, develop support for, and encourage participation in the TB eradication project. Improved communications, both at the grass roots level and through statewide marketing, is vital to success of the education program. Continued and enhanced contact with key audiences (i.e. livestock producers, industry representatives, media, hunters, and recreational wildlife viewers) will lead to an understanding of the recommended strategies for *M. bovis* eradication in white tailed deer and livestock populations. Examples of ongoing education efforts include Michigan Department of Natural Resources/ Michigan Department of Agriculture/Michigan State University extension training sessions, bovine TB brochures and newsletters, the annual Bovine TB in Michigan Conference, bovine TB web site, infomercials, satellite training sessions, and press packets.

Methods employed for eradicating bovine TB from free-ranging Michigan deer should decrease the transmission of bovine TB among deer. Reduction of transmission can be enhanced in two ways: reduction in the number of infected animals and reduction in the amount of contact (direct or indirect) between infected and susceptible animals. Increasing the hunter harvest of deer will reduce the overall number of deer as well as reduce the average age of the deer population. Hunting regulations should be liberalized to remove greater numbers of antlerless deer in order to control deer populations and to remove greater numbers of adult males because a higher prevalence of bovine TB has been observed in adult male deer in Michigan. The goal of liberalized hunting regulations should be a smaller deer herd with a younger age structure.

Elimination of baiting and supplemental feeding of deer will reduce the deer population as the herd density approaches the carrying capacity of the land, as well as decrease contact among deer. Artificial feed supplies (baiting and supplemental feeding) increase the density of deer populations beyond the carrying capacity. Even if the deer herd density is not artificially inflated, the presence of feed and bait encourage unnatural congregation of the animals, thereby increasing contact among deer and enhancing the transmission of infectious agents. Large numbers of animals in close proximity for extended periods of time are more likely to inhale infected aerosolized droplets or to consume food contaminated by coughing and exhalation (Schmitt et al, 1997).

In summary, the two main strategies for eradicating bovine TB from free-ranging Michigan deer are to minimize concentrations of deer by eliminating baiting and feeding and to reduce deer numbers through hunting to the biological carrying capacity. Baiting and feeding have been banned since 1998 in counties where the disease has been found. In addition, the deer herd has been reduced by 50% in the endemic area with the use of unlimited antlerless permits. The measures of apparent bovine TB prevalence have decreased by half since 1997, providing hopeful preliminary evidence that eradication strategies are succeeding.

Brucellosis in Bison and Elk of the Greater Yellowstone Area

The GYA is the largest and most nearly intact ecosystem and encompasses some of the most inaccessible and rugged country in the lower 48 states. It occupies approximately 7.3 million ha in Wyoming, Montana, and Idaho. Within the GYA there are approximately 120,000 elk, about 25,000 of which are artificially maintained during the winter by feeding hay on the National Elk Refuge and on 23 additional feedgrounds managed by the Wyoming Game and Fish Department. In addition, there are 3,000 to 4,000 free-ranging bison, most belonging to the Yellowstone population. Almost all the GYA's elk and bison are migratory to one degree or another. Over 1 million cattle occur in the GYA, and most are managed as cow-calf operations.

Brucellosis was first detected in bison of Yellowstone National Park in 1917 (Mohler 1917) and in elk on the National Elk Refuge in 1930 (Murie 1951), and brucellosis has probably been present in the GYA's elk and bison herds for around 100 years. Brucellosis is now recognized to be present in all 25 elk populations and the two bison populations of the GYA, and for many years it has been the source of controversy and conflict (Hillman 1999, Toman et al. 1997, Thorne et al. 1997). The problem is extensively discussed in Thorne et al. (1997) and other publications.

Each of the 13 state and federal agencies with management authority over animals and lands in the GYA is developing or participating in implementation of strategies to address the brucellosis problem. It is not the purpose of this summary to describe all strategies in play in the GYA.

The federal agencies must comply with the National Environmental Policy Act (42 U.S.C. §4321-61) (NEPA) for most federal actions, and much of their efforts to date have gone into Environmental Impact Statement (EIS) preparation and participating in implementation of interim plans until EISs are completed. In Montana, strategies to manage brucellosis-exposed bison that leave Yellowstone National Park have included agency destruction by shooting and slaughter of known test-positive bison, pregnant potentially latently infected female bison, and exposed bison of uncertain status; confining exposed bison until they can be returned to the park; hazing bison back into the park; allowing bison to stay outside the park for limited periods and in specific areas so that temporal and spatial separation from cattle can be assured. Research on feasibility of vaccinating bison is ongoing. With the minor exception of population manipulation through destruction of bison and removal of test-positive animals, both of which occur on a small scale relative to the population's size, these strategies are accomplishing little to control brucellosis within Yellowstone's bison. But they are managing the disease to nearly eliminate risk to cattle.

In Idaho, bison from Yellowstone are not tolerated and are removed as soon as they enter the state, but this is a very rare event. Idaho has a relatively small number of elk on the western edge of the GYA that use feedgrounds in winter and are infected or exposed to brucellosis. Idaho has prepared and implemented a management plan that employs disease management strategies of removal of test-positive elk, population density reduction by hunting, and habitat manipulation to provide alternatives to feedgrounds. These strategies are intended to eliminate brucellosis from Idaho elk as soon as possible.

The largest number of brucellosis infected and exposed elk occur in Wyoming. In addition, Wyoming has the relatively small Jackson Bison Herd, and a few bison exit the east gate of Yellowstone National Park into the state. In addition to an extensive research program initiated in 1971, a number of disease management strategies have been implemented. East of Yellowstone National Park, only a small number of male bison are tolerated in an area where there are no cattle, and female bison and excess males are removed by hunting regardless of brucellosis status. The Jackson Bison Herd summers in Grand Teton National Park and winters on feedlines on the National Park Refuge. Litigation by the Fund for Animals has precluded population reduction as disease management, except for a very few animals hunted on U.S. Forest Service and private lands under Wyoming Game and Fish regulations. The litigation also has prompted federal agencies to embark on an extensive, controversial NEPA process. Grand Teton National Park, where enabling legislation provides for cattle grazing during summer, manages cattle grazing times and locations and bison distribution to preclude brucellosis transmission to cattle. None of the strategies currently implemented in Wyoming serve to control brucellosis in bison.

The Wyoming Game and Fish Department has implemented numerous strategies to control brucellosis in elk with a goal of eventual elimination of the disease and reducing the threat of transmission to cattle. This is done under an integrated program called the Brucellosis-Feedground-Habitat program. Some strategies have been in place for decades, and draft Brucellosis Management Action Plans are being revised, updated, and formalized. Strategies to reduce the risk of transmission of brucellosis to cattle include feeding elk on feedgrounds so they do not commingle with cattle in winter; hazing elk away from private property with wintering cattle; fencing hay stored for cattle so it will not attract elk in winter; removal of elk from private property with wintering cattle by special depredation hunts and agency removal; and manipulation of winter habitat to attract elk away from cattle. These strategies greatly reduce risk to cattle, but with the exception of habitat manipulation, these strategies do not control the occurrence of brucellosis in elk, and feeding elk during winter encourages elk to elk transmission of brucellosis by artificially crowding them during mid-pregnancy.

Management strategies to control brucellosis in Wyoming elk include ballistic vaccination of feedground elk with strain 19 vaccine delivered via biobullet; moving elk feedlines to new, clean snow daily, if possible; habitat manipulation to encourage elk to leave feedgrounds earlier in the spring and to attract some elk away from feedgrounds; and monitoring for prevalence of brucellosis by testing hunter-killed non-feedground elk and testing trapped feedground elk to determine brucellosis management priorities and measure program success. These strategies, especially vaccination, have been demonstrated to be successfully reducing the occurrence of brucellosis. As an example, at Greys River Feedground, where elk have been vaccinated since 1985, seroprevalence has been reduced from a pre-vaccination (1971-1976) level of 46 percent to a post-vaccination (1993-2000) level of 11 percent.

Two notable strategies common to all agencies and states are to not translocate any elk or bison from the GYA and to participate in the GYIBC. With limited success, the GYIBC provides coordination and encourages implementation of brucellosis management strategies. It also encourages coordinated research necessary to develop additional strategies (Hillman 1999).

Summary

In summary, we believe many important wildlife disease problems may be successfully managed for the benefit of both wildlife and livestock interests. Success will depend on sharing both responsibility and support for such management among a broad range of agencies and constituencies, on setting realistic goals and timetables for disease management in free-ranging populations, and on recognizing and overcoming technical challenges unique to managing the health and viability of valuable wildlife resources.

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