The Wildlife Industry - Trends and New Challenges for Animal Health Agencies

May 2000
USDA, APHIS, VS
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Executive Summary

This paper provides a description of the varied and changing wildlife industry and explores some of the challenges faced by animal health agencies as a result of emerging trends in the wildlife industry. There has been a dramatic increase in the number of captive-held nontraditional species. Free-ranging wildlife populations have expanded in number and geographic range as a result of numerous government and private conservation initiatives. Millions of exotic animals are imported into the US every year.

These trends present new challenges for animal health agencies. The captive wildlife industry presents a whole new set of clients with needs similar to those of traditional livestock producers, such as harmonized regulations regarding interstate movement, animal identification, and slaughter inspection. Both captive and free-ranging wildlife present new challenges for disease control programs. As program diseases are eradicated from traditional domestic livestock, wildlife may become the only remaining reservoir for infection. However, due to the enormous public support for wildlife conservation, traditional methods of disease control in a situation involving wildlife may not be a viable option. Animal health agencies are also faced with increased opportunities for disease transmission as a result of relocations of free-ranging wildlife and imports of exotic species. An area of collaboration between animal health agencies could be better preparation for animal relocations, including risk assessments and pre-movement testing. Finally, known diseases of wildlife relevant to domestic livestock or poultry already are, or may become significant parts of the mission of animal health agencies.

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Introduction

Wildlife issues represent a large, diverse, and growing area of concern for individuals involved with animal health in local, state and federal agencies as well as for private ranchers and farmers. Growth in wildlife populations and increased interest in domestically rearing traditionally wild animals has led to more interactions with domestic livestock, and thereby increased opportunities for disease transmission.

Lack of consistent regulations between states within the US compounds the challenges faced by government agencies and wildlife owners. Although the wildlife industry has similar needs for animal identification and disease control, captive wildlife are not always subjected to the same regulations as traditional livestock. There is a need for leadership in promoting standardized definitions and regulations.

Another dilemma faced by government agencies is the need to serve both agricultural and wildlife interests. Since these interests can be at odds, the challenge is to protect one without harming the other.

Of specific interest to agencies dealing with the health of domestic livestock is the challenge wildlife present in the eradication of diseases such as brucellosis and tuberculosis. As the prevalence of these program diseases reaches the point of eradication in domestic livestock, the only remaining reservoirs for infection may be free-ranging or captive wildlife populations. Lack of adequate surveillance of captive and free ranging wildlife populations nationally may hinder efforts to control the spread of these and other agriculturally important diseases.

The objective of this paper is to provide a brief description of this varied and changing wildlife "industry" and to explore some of the issues associated with this industry which may impact the mission of animal health agencies.

Trends in the Wildlife Industry

The wildlife industry, as used here, includes captive wildlife production, free-ranging wildlife, relocated wildlife, and exotic animal imports. The wildlife industry as a whole is characterized by diversity, growth, and broad support. There has been an increase in the number of captive-held nontraditional species and there are millions of exotic animals imported into the US annually. Free-ranging wildlife populations have expanded as a result of numerous government and private conservation initiatives, including relocations to establish or maintain populations.

The Industry: Captive wildlife

The captive wildlife and alternative livestock industries have seen unprecedented growth since the 1970's. The exotic hoofstock population in Texas in 1966 was 37,500, and by 1996 this population had grown to 198,000.[1, 2] The North American Elk Breeders Association, founded in 1990 with 300 members, had grown to 1,400 members with 90,000 farmed elk by 1997.[3] In just four years, from 1992 to 1996, the estimated number of farmed deer grew from 44,000 to 126,000 with an estimated value of almost $80 million.[4] The American bison industry is reported to be growing by 30% a year, with more than 250,000 farmed bison in 1997, compared with 30,000 bison in 1972.[5,6] The number of llamas in the US was reported at over 123,000 in 1999, up from 53,000 in 1992.[7] Growth of these industries is fueled by the trend towards low-fat products, interest in alternate food products, a growing world market for deer meat and antlers, and financial reward for ranchers.

Since regulations may facilitate the expansion of the industry or discourage its growth, an understanding of state regulations provides a clue to the future of the industry. A 1999 survey of state agriculture departments conducted by Veterinary Services' Centers for Epidemiology and Animal Health (CEAH) found that 25 state departments of agriculture had jurisdiction over cervidae, 6 states reported shared responsibilities with a wildlife agency, and 19 states reported that the state wildlife agency had jurisdiction (Appendix Table 1).[a] Six states, which are among the top ten states in both numbers of captive cervidae and numbers of premises with captive cervidae, reported that the state department of agriculture had jurisdiction of captive cervidae.

All state departments of agriculture had some regulations for imported cervidae, but most did not continue to regulate animals after they had been imported. Regulations for captive wildlife varied by state, with some restricting imports of cervidae from herds without CWD monitoring or from regions where CWD is endemic, while others had no such requirements. Concern about disease transmission has led four states (AL, MD, SC, WY) to prohibit new deer or elk farms, while others have restricted farming of species, such as red deer, due to concerns about diluting the genetics of native elk.[8,9,10] Many other states allowed some deer species, but not others, and the species varied by state.

[a] A telephone survey was conducted in the summer of 1999. A representative of each state agriculture department was asked questions regarding population data, which agency has jurisdiction over cervidae, whether farming of cervidae or bison is allowed, and other regulatory questions.

Cervidae

Of the states which track captive cervidae, Wisconsin, Texas and Michigan have the largest number of premises with captive cervidae (Table 1 and Appendix Table 2). Although Texas has by far the most captive cervidae, deer and elk are not recorded separately. Of the states that document deer and elk separately, Colorado has the most captive elk and Michigan has the most captive deer.

Table 1. Top ten states with captive cervidae populations, by numbers of animals and numbers of premises, 1999*

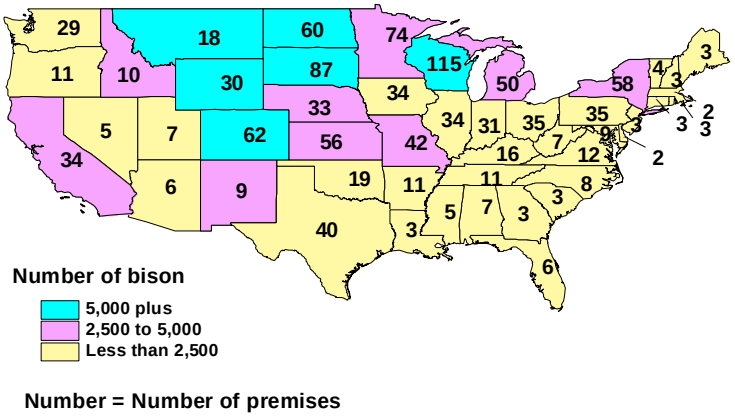
Numbers of animals		Numbers of premises	
State	**Numbers (% of total)**	**State**	**Numbers (% of total)**
Texas	90,629 (57.7%)	Wisconsin	836 (15.6%)
Michigan	18,800 (12.0%)	Texas	770 (14.4%)
Wisconsin	8,630 (5.5%)	Michigan	720 (13.5%)
Colorado	7,503 (4.8%)	Pennsylvania	603 (11.3%)
New York	7,500 (4.8%)	New York	360 (6.7%)
Minnesota	5,771 (3.7%)	Kentucky	265 (5.0%)
Montana	3,250 (2.1%)	Iowa	203(3.8%)
Nebraska	2,685 (1.8%)	Minnesota	171(3.2%)
North Dakota	2,600 (1.7%)	Arizona	125 (2.3%)
Oregon	2,041 (1.3%)	North Dakota	93 (1.7%)
- *subtotal*	*149,409 (95%)*	- *subtotal*	*4,146 (78 %)*
All states total	157,191	All states total	5,342

* available only for states which collect this information. Some states collect information for deer but not elk, or visa versa.

Bison

Most states regard bison as livestock and subject them to the same regulations as cattle. A 1997 survey by the National Bison Association (NBA) revealed that only Hawaii regarded bison as exotic. However, a state veterinarian in Hawaii indicated during the CEAH survey that they were in the process of changing the regulations so bison would be

Bison: Number of premises and number of animals



considered livestock and thus would be removed from a permanent quarantine. In the 1997 NBA survey, only 3 states considered bison to be wildlife: New Hampshire, New Jersey, and Rhode Island. The three states with the largest populations of farmed bison are South Dakota, Montana, and North Dakota (Appendix Table 2).

Other species

Oregon, California, and Washington have the highest numbers of llamas, with over 10,000 each (Appendix Table 2). The same three states also have the largest number of premises with llamas.

Captive wildlife are also present in zoos and other animal exhibits, where exhibitors are defined as having 'animals on display to the public or [conducting] performances featuring animals'.[11] The total number of animal exhibitors in the US in 1994 and 1999 was 2,268 and 2,249, respectively. Florida and California had the most animal exhibitors in 1999, with over 200 each, followed by Texas, Illinois, and New York, each with over 100 exhibitors (Appendix Table 3).

The Industry: Free-ranging wildlife

Both the federal government and private organizations administer numerous programs aimed at wildlife conservation. The programs range from establishment and maintenance of wildlife refuges to financial incentives for individuals to develop wildlife-friendly habitat.

Wildlife conservation programs

Federal support for wildlife conservation began in 1903 in what was to become the **National Wildlife Refuge System** (NWRS), with the establishment of the first refuge on Pelican Island in Florida. The NWRS has been successful in its mission of administering "..a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans".[12] This success has resulted in large tracts of land being returned to a condition suitable for maintaining free-ranging wildlife. In 1998, a total of 514 national wildlife refuges encompassed 93 million acres. The NWRS received an unprecedented budget increase of $41 million, for a total 1998 budget of $220 million. It was estimated that almost 30 million visitors to wildlife refuges generated more than $400 million in sales in regional economies during 1995 (USFWS @ refuges.fws.gov Public education and recreation).[12]

In a series of federal legislative acts, the federal government has allowed for the encouragement and protection of wildlife in the US. In 1937, the **Federal Aid in Wildlife Restoration Act** was established and allowed for the creation of a fund from the federal excise tax on sporting arms and ammunition. The money was returned to the states and matched 3

to 1 state hunting license fees.[13] These funds are used for wildlife management and research programs, habitat acquisition, wildlife area and shooting range development, and hunter education programs.[14]

In 1966, Congress passed the Endangered Species Preservation Act, allowing the listing of native species as endangered, and providing limited means for protection of those species.[12] This was followed by the **Endangered Species Act** of 1973, which has remained the most important regulation protecting endangered and threatened species worldwide. Among other provisions, this act required all federal agencies to undertake programs for the conservation of endangered and threatened species, and provided authority for the acquisition of land for listed plants and animals.

While modern agriculture has generally had a negative impact on wildlife populations, farmers are now encouraged to develop wildlife habitat and use wildlife-friendly farming techniques.[15,16] The **Habitat Conservation Plan**, a program begun in 1982 and administered by the US Fish and Wildlife Service, aims to balance private individuals' property rights with wildlife needs. Through the plan, landowners are permitted to build homes or other developments where preservation of wildlife habitat would otherwise take precedence, in exchange for other conservation measures taken by the landowner.[17]

Under the 1996 Farm Bill, a new conservation program, the **Wildlife Habitat Incentives Program** (WHIP), was initiated to protect critically important wildlife habitat. Under this program, land owners (not just agricultural land) are eligible for financial assistance to improve wildlife habitat on their property. This program provides technical assistance and cost-share payments up to 75% of the cost of installing wildlife habitat practices.

Support for growth in wildlife populations has also been strong within the private sector. More land is being made available to wildlife through development of wildlife friendly backyards. Urban sprawl has increased the amount of bluegrass lawns and shrubs available to elk and deer in the Rocky Mountain foothills. According to the Colorado Division of Wildlife, the elk and deer population is about 100 times what it was in the early 1900's, and the mountain lion population is about 10 times what it was then. The National Wildlife Federation, in 1973, introduced a successful **Backyard Wildlife Habitat Program** where members of the public may receive certification for having a wildlife friendly backyard. As of early 1998, over a half-million people had taken advantage of the program to create wildlife-friendly yards.[18]

Wildlife organizations

Numerous private organizations attest to the public interest in wildlife conservation. Some of the larger organizations are the National Wildlife Federation, reporting 4.4 million members; the World Wildlife Fund, with more than 1 million members in the US alone; the National Audobon Society, with 550,000 members; the Nature Conservancy, with 900,000 members; and the Defenders of Wildlife, with 250,000 members.[19]

Economic benefits

Although wildlife conservation tends to be associated with ethical or aesthetic motives, free-ranging wildlife also has enormous economic benefits. The most recent survey by the US Fish and Wildlife Service found that 77 million Americans aged 16 and older (nearly 40% of US adults) either fished, hunted or watched wildlife in 1996.[20] This survey also documented that approximately $104 billion is spent each year on fishing, hunting and wildlife-associated recreation. By comparison, the US horse industry produces goods and services valued at $25.3 billion annually, and 1998 total agricultural exports were valued $52 billion.[21,22]

The Industry: Relocated wildlife

When a wildlife species population is either too low in numbers, or not present at all, deliberate release of animals in the wild is used as a tool to increase population numbers. A number of terms describe this intentional movement of animals (translocation, reintroduction, reestablishment, restocking, repatriation) depending on where the animals originated and whether they are being released at a habitat in which the species of animal previously lived. For the purposes of this report the term relocation will be used to describe any intentional movement of animals from one location to another, the animals can be derived from either captive-propagated or wild-caught animals.

State-sponsored relocation efforts in the US usually involving game species desired by hunters and trappers, date back to the turn of the century.[23] Some early examples aimed at conservation include the reintroduction of elk into Pennsylvania between 1913 and 1926, as well as into Minnesota in 1935.[24,25] In the late 1930's federal money for wildlife relocation became available through the Federal Aid in Wildlife Restoration Act. Several beginning initiatives funded by this act in Virginia included restocking beavers in the 1940's, raccoons in the 1940's and 50's, and pheasants in the 1950's.[13] Another early program restocked deer in the southeastern US.[26]

Relocation efforts have escalated in the last three decades. A survey of biologists, zoos, and conservation agencies found that about 500 relocation programs were conducted annually from 1973-1986 in North America.[27,28] Based on the finding that the number of programs had doubled from 1974 to 1981, the authors estimated that nearly 700

relocations were being done annually in the late 1980's. More than 90% of the relocations during the review were game species, with ungulates comprising 39% of the game species. A survey conducted in 1990-1991 found that pronghorn, deer, or bison were restored in 233 areas of the United States; wolves, bears, weasels, or cats were restored in 114 areas; bighorn sheep in 182 areas; elk in 88 areas; and the gray wolf in 17 areas of the US.[29]

A survey of US state wildlife agencies in 1986 found that 29 of the 45 responding states had relocated mammals during 1985.[30] While the top reason given for relocation was to restore native animals to historic habitat (25 states), the second most common reason was to establish new populations, including exotics (15 states). It was also reported that private groups had relocated mammals in 19 states. State wildlife departments sometimes exchange wildlife; past trades have involved turkeys, moose, bighorn sheep, and bears.[31]

The Industry: Exotic animal imports

The exotic pet trade has grown as more individuals develop an interest in owning wildlife species as pets or investments. Millions of exotic animals are imported every year, many of which go to pet shops, private collections, or roadside zoos. A pet industry trade association reported that the number of pet reptiles and amphibians in the US increased from 2 million in 1990 to 7.3 million in 1996.[32] According to a database maintained by the US Fish and Wildlife Service, the US imported 77 thousand mammals and 1.9 million live reptiles in 1998.

Table 2: Imports of live mammals and reptiles, 1998

	Mammals	Reptiles
Number of animals	77,398	1,921,272
Value ($)	17,922,083	6,368,272
Number of countries of origin	57	80

Source: US Fish & Wildlife Service

Challenges for Animal Health Agencies

New Clients

As a result of the changes in the wildlife industry, animal health agencies are faced with many new challenges. The expanding popularity of raising alternative livestock is bringing with it a whole new and diverse set of clients. Animal health agencies no longer deal only with producers that raise cattle, swine, poultry, or sheep. They now must be prepared to confront issues that are relevant to producers of deer, elk, bison, llamas, and other captive wildlife.

Members of the wildlife industry indicated in a 1998 survey that federal involvement is needed with regulatory authority over movement of captive wildlife and exotic species, and with monitoring of disease with the goal of disease prevention.[33] There is also interest in having all farmed species treated the same as other livestock, including the mandatory inspection of nontraditional livestock carcasses at slaughter. The National Institute for Animal Agriculture (NIAA) has adopted resolutions aimed at increasing federal involvement with captive wildlife and alternative livestock. One resolution requests the development of "a protocol that can be used by various states for the interstate movement of captive wildlife and alternative livestock."[34] Another NIAA resolution recommends that since "considerable concern exists regarding the potential impact of growing numbers of nontraditional livestock on the brucellosis eradication effort", USDA should conduct a risk analysis of brucellosis in these alternative species.

APHIS, Veterinary Services has begun to meet these challenges. One initiative has been the incorporation of wildlife issues into the agency's strategic plan.[35] The plan has expanded the "definitions of livestock to cover those wildlife or exotic species which are now being raised and produced like traditional forms of livestock". Other plan objectives include establishing agreements with state or federal agencies dealing with wildlife to prevent the transmission of disease to livestock; and including captive exotic/wildlife species in animal identification progams. VS has also established a Wildlife Unit, whose purpose is to coordinate and participate in activities regarding diseases transmittable between wildlife and domestic animals, including those diseases affecting nontraditional livestock.

The US Food and Drug Administration is also recognizing the importance of wildlife and alternative livestock species. The agency planned, in 1998, to propose measures to encourage pharmaceutical companies to develop and seek approval of drugs for minor species.[36] 'Minor species' include all US wildlife, minor species farmed for food, and exotic pets. In a preliminary set of proposals, an FDA working group stated that "It is clearly in the public interest to treat such diseases [of minor species] before they are transmitted to people or other animals".[36]

Constraints on disease control programs

The broad and increasing support for conservation of free-ranging wildlife brings new emphasis to another challenge for animal health agencies: the need to protect free-ranging wildlife while also serving agricultural interests. This presents constraints to disease control programs for traditional domestic livestock.

Additional evidence attesting to this dilemma is the new field of animal law. Both Harvard and Georgetown law schools are now offering courses in animal law, the goal of which is to recognize animals' higher levels of cognition and social development and to give them individual rights rather than be treated as property.[37] While this has yet to impact wildlife, it is not inconceivable that in the future, market value compensation for destroying infected wildlife will be considered inadequate, and perhaps inappropriate. Consequently, traditional methods of disease control in an outbreak situation involving wildlife may not be a viable option.

New emphasis on the role of wildlife in disease transmission

The practices used to facilitate wildlife diversity and wildlife production in captivity are often not harmonious with control of disease transmission. Movement of animals, be it relocation of domestic wildlife, trade of captive species, or imports of exotics, brings with it some risks.

RELOCATIONS

Relocation of animals has resulted in disease transmission from the introduced animals to the resident population. Two well known examples are the introduction of the brushtail possum, which resulted in transmission of bovine tuberculosis to farmed cattle and deer in New Zealand, and the introduction of raccoon rabies to the mid-Atlantic area of the US when infected raccoons were translocated from the southeastern US. Less well known is the infection of wood bison at the Wood Buffalo National Park in Canada with bovine tuberculosis and brucellosis, attributed to the relocation of infected plains bison from the US.[38] More recently, red foxes in the process of being relocated were found to harbor Echinococcus multilocularis, the tapeworm which causes hydatid disease in humans.[38] Relocated bighorn sheep from Arizona introduced viral pneumonia to local bighorns in New Mexico.[39] Feral pig populations are known to be infected with pseudorabies and swine brucellosis and yet have often been relocated to new areas and states by both government agencies and private individuals.

While any single relocation has the potential to transmit disease from one area to another, documentation of disease-related aspects of relocations is sporadic at best. A study conducted to review potential disease transmission as a result of animal relocation found that animals in nearly 25% of relocations were not given a physical examination by a biologist or veterinarian prior to release.[b,28] Even when preventive measures are taken, such as examining and testing animals, it is not always possible to

[b] The study included relocations in Australia, Canada, New Zealand, and the US.

know what parasite or other infection might be transferred when animals are relocated.[40]

One area of collaboration between animal health agencies could be better preparation for animal relocations, including risk assessments and pre-movement testing.

Animal Exhibits

Animal exhibitors may also play a role in disease transmission through animal movement with exposure to other animals, and by selling to captive exotic animal owners. The American Zoo and Aquarium Association documented that more than 1,000 mammals are sold, donated or traded to dealers and brokers each year by affiliated zoos.[41] The surplus animals may end up at auction markets, in hunting preserves, or in the pet trade.

Exotic imports

Nonnative plant and animal species, whether imported intentionally or accidentally, have caused extensive damage, reported at $123 billion a year.[42] Two examples, both in the Great Lakes, are zebra mussels, which clog water pipes, and sea lampreys, which have reduced populations of trout and other native fish.[42,43]

As a result, a presidential directive has allocated $28.8 million for an interagency task force to address research and other issues regarding invasive species. The task force will have representatives from the Departments of Commerce, Interior, and Agriculture. While federal efforts until now have focused on aquatic species, the expanded effort will target all invasive plants and animals '... from insects to reptiles'.[42]

APHIS, VS' strategic plan includes an objective aimed at preventing the introduction and establishment of nonindigenous invasive species that may cause harm to domestic livestock, poultry, wildlife, or aquacultural products. The first step is regulations to prevent the introduction of vectors of heartwater. Other diseases transmissible by exotic imports may come to light as a result of the increased interest in these species, significantly impacting import activities. APHIS has also granted funds for the Entomological Society of America to develop a list of destructive, non-indigenous insect species that may come into the country on animal imports or packing materials.[44]

Increased recognition of wildlife diseases

As diseases are eradicated from traditional livestock, both captive and free-ranging wildlife may present known or unknown reservoirs for infection. Testing procedures used to detect disease in traditional livestock may be ineffective in nontraditional species.

A few of the known diseases of wildlife relevant to domestic livestock or poultry are grouped below according to their immediate relevance to animal health agencies, in terms of disease-program and trade implications. That does not mean that lower-ranked diseases are of any less importance in the long run. Awareness of disease in wildlife does not necessarily mean the risks posed to other groups of animals or species are fully understood. Even if the risks are understood, strategies to reduce or eliminate risk from disease must consider many, often conflicting interests.

✓ High relevance

- *Bovine tuberculosis* - Bovine tuberculosis (TB) has been confirmed in numerous captive cervid herds since 1991. Since 1991, regulations applying to TB testing of captive cervidae have been implemented by various states.

  Bovine TB was first found in free ranging cervidae in Michigan in 1975. The disease was again found in a Michigan white-tailed deer in 1994, and has since been found in free ranging white-tailed deer in a six county area of Michigan. Annual white-tailed deer surveys have been conducted in what is called the Bovine TB Management Area which includes, but is larger than, the affected six counties in Michigan. During the years 1995 through 1998, these surveys indicated an infection prevalence ranging from 3.3% to 0.9%.[45] In 1999, a sample of 19,500 deer indicated an infection prevalence of 0.2%.

  It is believed that supplemental feeding, used in this area to increase populations and congregate animals, has contributed to the spread of tuberculosis. As a result, in 1999 supplemental feeding was banned in the affected areas. Control of tuberculosis in this population is hampered, in part, because of the economic, social and political impacts of deer hunting.

  The discovery of bovine TB in free-ranging deer prompted extensive surveillance of cattle in the affected areas. As of late 1999, the disease had been confirmed in 4 cattle herds, prompting the USDA to issue an interim rule allowing Michigan to have 2 TB status zones, with the affected area considered a nonmodified accredited free zone while the rest of the state is still considered accredited free.[45]

Bovine TB was endemic on the island of Molokai until all cattle were removed in 1986. The disease reemerged in cattle in 1997. A study was initiated in late 1997 to evaluate the possibility of a TB reservoir in wildlife on that island, specifically focusing on deer, wild swine, goats and mongoose. As of December 1999, one animal of 100 feral swine tested was found to be culture positive for *Mycobacterium bovis*.[46]

- *Brucellosis in elk and bison* - Wild elk and bison in the Yellowstone National Park area in western Wyoming are known to be infected with bovine brucellosis. Brucellosis was first detected in Wyoming bison in 1917 and in elk in 1930.[47,48] Winter feeding of the elk concentrates animals on the feed grounds and females aborting their calves facilitates transmission of the bacterium, thereby maintaining brucellosis in these herds. The disease has not been reported in elk populations without artificial winter feeding grounds.[47]

Brucellosis-free status is threatened for Idaho, Montana, and Wyoming as a result of the disease in elk and bison. It has been shown that elk and bison can transmit brucellosis to cattle under laboratory conditions.[47,48] In addition, epidemiologic evidence cited in a 1999 report by the Greater Yellowstone Interagency Brucellosis Committee suggests that natural transmission of brucellosis from elk and bison to domestic cattle has occurred in the area.[49]

The Yellowstone situation is bound to impact other efforts to reintroduce elk or bison. Cattle industry officials in Kentucky and Tennessee voiced strong opposition to a proposed release of 600 elk in those states.[50]

- *Brucellosis and pseudorabies in feral swine* - While the domestic swine industry has nearly eradicated swine brucellosis and pseudorabies, eradication in domestic swine will not eliminate the disease from the US. Feral swine serve as a reservoir of infection for both of these economically important diseases, and their populations have flourished. They continue to spread to new states and have recently been documented in 23 states, probably as a result of both natural spread and uncontrolled intentional release by hunters. In California in the 1960's, feral swine existed in 12 counties and they now have been documented in 53 of the state's 58 counties.[51] Indiana has documented feral swine populations in two areas where they did not exist 6 years ago. Because of their revenue- producing potential as a game source for sportsmen, and their potential for a niche wild boar market in Europe, there is support for these populations to exist, if not continue growing.

In Florida, approximately one third of all domestic swine pseudorabies is due to transmission from feral swine.[52] Recent studies have shown that venereal, not respiratory, transmission is the primary means for natural transmission of pseudorabies amongst feral swine populations, and from feral swine to domestic animals.[53] In serosurveys conducted in feral swine populations during the years 1962 through 1997, the prevalence of *Brucella suis* infection ranged from 10 to 24%.[54] The most common route of transmission is through animal to animal contact or oral contact with contaminated reproductive tissues.

• *Chronic wasting disease in mule deer, elk, and white-tailed deer* - A member of the family of transmissible spongiform encephalopathies, chronic wasting disease (CWD) was first observed in captive research animals, and has since been reported in free-ranging populations of mule deer, white-tailed deer, and elk in Colorado and Wyoming. Surveys of hunter-killed deer and elk have reported the disease at a prevalence of 2.9% in deer and 0.4% in elk.[55] CWD has also been diagnosed in captive elk herds in South Dakota, Nebraska, and in one herd in Oklahoma where the infected elk were traced to a farm in Montana.[56]

✓ Medium relevance

•*E. coli O157:H7 in deer* - In 1995, a hunter-killed black-tailed deer was confirmed as the source of an outbreak of human disease in Oregon. The same year, the organism was also isolated from white-tailed deer feces in Texas. A study has shown that white-tailed deer inoculated with O157:H7 are capable of carrying and shedding the bacteria. A 1992 survey of 100 white-tailed deer in the southeastern US found no evidence of O157:H7 infection.[57] Another survey of 300 deer fecal samples and 400 hunter-killed deer from 1997-1998 in Georgia yielded three deer positive for O157:H7.[58]

• *Mycobacterium paratuberculosis* - Paratuberculosis, or Johne's disease, is endemic in domestic cattle, primarily dairy, in the United States. It has been found in many wildlife species, mostly ruminants, in countries worldwide.[59] It has been isolated from farmed deer in New Zealand, farmed alpacas in Australia, and free-ranging deer in Scotland.[60,61,62] The disease has also been found in wild rabbits in Scotland.[63] Surveys showed that the prevalence of disease in rabbits was higher in areas that also had above-average prevalence in domestic livestock.

Paratuberculosis has been isolated from farmed deer in the US.[64] The disease has also been confirmed in llamas, and is known to occur in a population of free-ranging Rocky Mountain Bighorn Sheep in Colorado.[65,66] This prompted the National Park Service to ban the

use of llamas as pack animals in some national parks, for fear that llamas would transmit the disease to wild Desert Bighorn Sheep.[67]

•*Velogenic newcastle disease* - Velogenic newcastle disease is considered a foreign animal disease in the US. However, since 1990 the disease has been found in native birds; specifically, the double-crested cormorant, white pelican, and ring-billed gull. The only reported domestic poultry outbreak traced to wild birds (cormorants) occurred in domestic turkeys in North Dakota in 1992.[55]

•*Vesicular stomatitis virus (VSV)* - Vesicular stomatitis is considered to be enzootic on Ossabaw Island, Georgia. Surveys have also shown serologic evidence of VSV in numerous wildlife species including white-tailed deer and feral swine in areas of Louisiana and Florida, and mule deer, elk, and pronghorn in Colorado.[57,68] During the last 20 years, most outbreaks of VSV in domestic animals have occurred in the western US.

✓ Lower relevance

• *Hemorrhagic diseases in deer* - Hemorrhagic disease in white tailed deer may be caused by either bluetongue or epizootic hemorrhagic disease (EHD) viruses. Serological evidence indicates that EHD virus has infected white-tailed deer and other ruminant wildlife species throughout the US, although infection with EHD does not always result in hemorrhagic disease. Cattle have been reported to be infected with EHD most commonly without clinical signs, although there have been reports of outbreaks in Oregon and Tennessee with attendant illness. During 1998, mortality rates of up to 90% were reported in free-ranging white tailed deer populations in many central states and Washington. EHD virus was isolated from deer in several of these states.[69] Though the risk appears to be low, EHD does pose a risk to US livestock not only in terms of the health of livestock, but also for potential trade implications.

• *Sparganosis in feral swine* - This zoonotic parasitic disease of feral swine has been documented in feral swine from Florida and Texas.[70] The true prevalence and distribution of this disease in the United States remains unknown. Although reports of infection in humans in the US are rare (70 cases from 1908-1991), they do occur, and uncooked feral swine meat has been suspected as the cause of infection in some of the cases. This infection appears not to be clinically significant in swine, and has not been diagnosed in domestic herds. While it is not an OIE list disease and reporting is not required at this time, it may pose a risk to human health and could threaten exports of feral hog meat.

Conclusion

The trends presented in this paper signify new challenges for animal health agencies. The captive wildlife industry presents a whole new set of clients with needs similar to those of traditional livestock producers, such as harmonized regulations regarding interstate movement, animal identification, and slaughter inspection. Both captive and free-ranging wildlife present new challenges for disease control programs. As program diseases are eradicated from traditional domestic livestock, wildlife may become the only remaining reservoir for infection. However, due to the enormous public support for wildlife conservation, traditional methods of disease control in a situation involving wildlife may not be a viable option.

Animal health agencies are also faced with increased opportunities for disease transmission as a result of trade in captive species, relocations of free-ranging wildlife, and imports of exotic species. Some of the known diseases of wildlife that may play important roles in disease transmission to traditional livestock, poultry, or humans are grouped according to their immediate relevance to animal health agencies, in terms of disease-program and trade implications.

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Appendix Table 1 - Captive cervidae regulations by state, 1999

State	Agency with jurisdiction	Is farming of cervidae allowed?	Population or premises data collected?	Import quarantine for animals which meet guidelines?	Individual ID required?	Report required when animal sold or purchased?
AL	Agriculture	Prohibited - although privately enclosing free ranging cervidae for the purposes of hunting is allowed, premises with pet elk exist	No		No	No
AK	Wildlife	Allowed	Yes	n/a	No	No
AZ	Wildlife	Restricted: no elk (unless grandfathered), no native deer species (mule or white tail)	Yes	No	n/a	Yes
AR	Wildlife	Allowed	No	No	No	No
CA	Wildlife	Restricted: fallow deer only	No	No	No	No
CO	Shared	Restricted: no white tail deer	Y	???Y	Yes	Yes
CT	Agriculture	Allowed	No	No	No	Yes
DE	Agriculture	Allowed	No	No	No	Yes
FL	Agriculture	"	No	No	No	Yes
GA	Shared	"	No	No	Yes	Yes
HI	Agriculture	"	Yes	Permanent	Yes	Yes
ID	Shared	"	Yes	No	Yes	No
IL	Natural Resources	"	No	No	No	No
IN	Agriculture	"	No	Pending retest in 90 days if from herd which is not accredited	Yes	Yes
IA	Agriculture	"	Yes	No	No	Yes
KS	Agriculture	"	Yes	Pending retest of elk from GYA	Yes	No
KY	Wildlife	"	No	No	No	No
LA	Agriculture	"	Yes	No	Yes	No
ME	Agriculture	Restricted: red/fallow deer, reindeer only	No	No	Yes	No
MD	Natural Resources	Prohibited	n/a	n/a	Yes	No
MA	Wildlife	Restricted: no elk	Yes	No	Yes	No

State	Agency with jurisdiction	Is farming of cervidae allowed?	Population or premises data collected?	Import quarantine for animals which meet guidelines?	Individual ID required?	Report required when animal sold or purchased?
MI	Agriculture	Allowed	Yes	No	Yes	Yes
MN	Agriculture	"	Yes	No	Yes	Yes
MS	Wildlife	Restricted: white tail/mule deer prohibited	Yes	No	No	No
MO	Agriculture	Allowed	No	No	Yes	No
MT	Shared	Restricted: Red deer and red deer hybrids prohibited. White tail deer west of 100th meridian restricted	Yes	30 day minimum pending Brucellosis retest	Yes	Yes
NE	Agriculture	Restricted: no white tail or red deer (or red deer hybrids) allowed	Yes	90 day quarantine pending TB retest	Yes	Yes?
NV	Agriculture	Allowed	No	No	Yes	No
NH	Wildlife	"	Yes	No	Yes	No
NJ	Wildlife	"	Yes	No	No	No
NM	Wildlife	"	Yes	30 day quarantine	Yes	Yes
NY	Agriculture	Restricted: no white tail	Yes	No	No	Yes
NC	Wildlife	Allowed	Yes	No	No	No
ND	Agriculture	"	Yes	No	Yes	Yes
OH	Agriculture	"	Yes	No	No	No
OK	Agriculture	"	Yes	No	No	Yes
OR	Wildlife	Restricted: new permits rarely allowed, no white tail or red deer/ or red deer hybrids	Yes	No	Yes	Yes
PA	Wildlife	Allowed	Yes	No	No	No
RI	Shared	"	Yes	No	Yes	Yes
SC	Wildlife	Prohibited	n/a	n/a	n/a	n/a
SD	Agriculture	Allowed	Yes	No	Yes	No
TN	Agriculture	Restricted: fallow only	No	No	No	No
TX	Agriculture	Allowed	Yes	No	No	No
UT	Agriculture	Restricted: elk only	Yes	No	Yes	Yes
VT	Dept. Ag	Allowed	Yes	45 day minimum pending brucellosis retest	No	No
VA	Wildlife	Restricted: fallow only	Yes	No	No	No
WA	Wildlife	Restricted: reindeer and fallow deer only	No	No	Yes	No

State	Agency with jurisdiction	Is farming of cervidae allowed?	Population or premises data collected?	Import quarantine for animals which meet guidelines?	Individual ID required?	Report required when animal sold or purchased?
WV	Shared	Allowed	No	No	Yes	No
WI	Agriculture	"	Yes	No	Yes	No
WY	Wildlife	Prohibited: some elk grandfathered	n/a	n/a	n/a	n/a

Appendix Table 2 - Captive deer, elk, bison, and llama populations by state, 1999

	Deer		Elk		Bison		Llamas	
State	No. animals	No. premises	No. animals	No. premises	No. animals	No. premises	No. animals	No. premises
AL	0	0	0	0	72	7	620	56
AK	250	-	100	-	0	0	205	21
AZ	0	0	-	2	231	6	721	72
AR	-	125	0	0	232	11	869	68
CA	-	20	0	0	3,680	34	11,323	878
CO	156	1	7,347	136	5,821	62	6,127	481
CT	-	-	-	-	93	3	626	78
DE	-	-	-	-	101	2	90	6
FL	-	-	-	-	121	6	1,073	115
GA	-	9*	-	*	71	3	1,475	145
HI	0	0	150	1	220	2	65	6
ID	174	13	1,684	52	2,898	10	3,461	257
IL	-	-	-	-	844	34	2,815	208
IN	-	-	-	-	1,081	31	5,077	313
IA	-	201	-	2	1,431	34	2,670	257
KS	-	19	-	41	4,060	56	1,713	186
KY	-	250	-	15	1,763	16	1,533	153
LA	-	66*	-	*	41	3	318	18
ME	-	77	0	0	42	3	567	44
MD	-	-	-	-	120	9	787	78
MA	-	24	0	0	96	2	1,015	108
MI	16,800	550	2,000	170	2,984	50	3,739	332
MN	391	21	5,380	151	4,150	74	2,702	225
MS	-	-	-	2	60	5	232	30
MO	-	-	-	-	2,882	42	2,978	287
MT	50	5	3,200	78	17,735	18	4,469	288
NE	675	90	2,010	55	2,581	33	2,467	135
NV	0	0	0	0	180	5	1,097	73
NH	-	24*	-	*	44	3	617	73
NJ	999	74	194	7	37	3	551	48
NM	-	-	-	-	2,876	9	1,069	99
NY	7,500*	360*	*	*	2,500	58	2,329	198
NC	-	65*	-	*	301	8	1,303	133

	Deer		Elk		Bison		Llamas	
State	No. animals	No. premises	No. animals	No. premises	No. animals	No. premises	No. animals	No. premises
ND	250	22	2,350	71	9,860	60	657	54
OH	94	51	284	15	1,656	35	5,453	664
OK	-	68*	-	*	2,157	19	2,660	263
OR	1,569	53	472	15	1,141	11	13,511	946
PA	-	524	-	79	1,587	35	2,929	306
RI	60	3	2	1	10	3	88	10
SC	-	-	-	-	15	3	360	32
SD	250	23	1,735	39	20,727	87	921	67
TN	-	-	-	-	391	11	1,647	197
TX	90,629*	770*	*	*	1,370	40	7,254	635
UT	0	0	557	21	975	7	1,393	121
VT	302	36	197	4	242	4	708	70
VA	750	4	0	0	713	12	2,085	180
WA	-	-	0	0	1,398	29	10,441	816
WV	-	-	-	-	159	7	307	45
WI	4,580	645	4,050	191	5,000	115	4,700	457
WY	0	0	-	1	5,933	30	1,345	105

(-) State did not have this information; (*) Only available as all cervidae - not differentiated between deer and elk

Sources: CEAH Survey (Cervidae); National Bison Association (Bison); International Lama Registry (Llamas)

Appendix Table 3 - Number of animal exhibitors, 1999

State	No. exhibitors		State	No. exhibitors
AL	36		MT	18
AK	10		ND	14
AZ	32		NE	13
AR	26		NV	51
CA	222		NJ	39
CO	29		NM	13
CT	35		NY	112
DE	6		NC	31
FL	246		ND	13
GA	28		NH	18
HI	15		OH	65
ID	16		OK	25
IL	138		OR	43
IN	62		PA	93
IA	36		RI	8
KS	22		SC	15
KY	16		SD	19
LA	18		TN	30
ME	11		TX	167
MD	18		VT	2
MA	53		VA	42
MI	85		WA	31
MN	56		WV	12
MS	14		WI	93
MO	51		WY	1

Source: USDA, APHIS, Animal Care, March 1999