MOVING WILD ANIMALS:

Health and Environmental Issues,

Assessing Risks and Benefits

Presented by
the Canadian Cooperative Wildlife Health Centre
and
the WCVM Wildlife Health Fund

Western College of Veterinary Medicine
University of Saskatchewan
Saskatoon, Saskatchewan
March 4-6, 1998

"Legal Implications for the Management of Infectious Disease in Captive Breeding and Re-Introduction Programs" by Margaret E. Cooper, 24(3): 296-303 (1993), Journal of Zoo and Wildlife Medicine, is reprinted with permission of the editor.

Moving Wild Animals - Introduction

Humans are compulsive movers of biological materials. Wild animals are moved locally, nationally and internationally for many reasons. Some movements are for commercial purposes, such as for game farming, zoological collections and the pet trade; other animals are moved for conservation purposes, such as establishing new populations, restoring populations to historic range, and taking endangered species into captivity with the aim of captive breeding with eventual return to the wild; other animals are moved for more mundane reasons, such as disposal of surplus or undesirable animals. The types of movement can be sub-divided in various ways based on the origin and destination of the animals:

		Destination
Origin	**Wild**	**Captivity**
Wild	Translocation	Captive breeding Pet trade Zoos Game farm ⇨ Rehabilitation
Captivity	Reintroduction Unintentional release or escape Rehabilitation ⇨	Captive breeding Zoos Pet trade Game Farm

(adapted from Beck, et al., 1993; J. Zoo Wildl. Med. 24:394)

Movements can also be subdivided in relation to the historic range of the animals:

		Destination
Origin	Within historic range	Outside historic range
Within historic range		
Outside historic range		

Statistics on the number of movements of wildlife that occur are sparse. Griffith et al. 1993, J. Zoo Wildl. Med. 24: 231) reviewed the translocation (*"the movement of one or more animals from the wild or from captivity to the wild with the express purpose of establishing, reestablishing, or augmenting a wild population"*) of terrestrial vertebrates from 1973 to 1986 in Australia, Canada, New Zealand and the USA. During this period, there was an average of 515 translocations/year but the average number per year almost doubled during the period of the study. 92% of the moves involved game species, 7% were of threatened or endangered species.

This course is concerned with health and disease of wild animals in relation to animal movements, so that it is important to define disease. Disease can be defined as *"any impairment that interferes with or modifies the performance of normal functions"*. The emphasis will be primarily on infectious disease, caused by bacteria, viruses, arthropods and worms of various kinds, but non-infectious factors can also result in disease and be translocated. For example, the gene for an inherited disease could be transferred with animals in the same way that a parasite could be moved. Disease can have many manifestations. When the subject of disease is discussed, the examples used often relate to the occurrence of catastrophic mortality of either the introduced animals or some indigenous species at the release site. Dramatic catastrophes do occur; however, in addition to direct mortality, disease can also cause indirect mortality through increased susceptibility to predation, other unfavourable environmental factors and other diseases, and can cause lowered reproductive capacity. These more subtle effects may be more important than direct mortality. Some diseases exert all three effects, e.g., brucellosis and tuberculosis, that were introduced into bison in Wood Buffalo Park, cause a small amount of direct mortality, but also increase susceptibility of infected bison to wolves, and have direct effects of reproduction through abortion.

It is important to distinguish between infection and disease. Infection of an animal with a potential disease agent does not necessarily mean that the animal will have impaired function, i.e., disease. An animal may harbour or carry a virus, bacterium or parasite without suffering any ill effect; however, the same agent in a different animal species, or in the same animal species under different circumstances may cause severe disease.

Most infectious diseases have a limited and defined geographical distribution, in the same way that most animals are only found in specific habitat types. The same types of ecological barriers that determine the distribution of plants and animals apply to living disease agents. For example, the meningeal worm of white-tailed deer (*Parelaphostrongylus tenuis*) appears to be limited from spreading westward by the dry climate of eastern Saskatchewan. (This may be because dry areas are generally unfavourable for the snails required by the parasite to complete its life cycle). Similarly, mountain chains, oceans and deserts often limit the distribution of disease agents. Humans disrupt or circumvent these barriers in a number of ways. The most obvious is by physically moving a disease agent across the barrier to a new area where conditions are favourable for the agent. One of the concerns about meningeal worm is that, while it may not be able to thrive in the dryer parts of the prairies, it might find conditions in more moist northern parklands or in the foothills of the Rocky Mountains very suitable. Human activity may also change the distribution of a disease by introducing a species required for the completion of the life history of a disease, e.g., malaria of birds did not become established in Hawaii until the mosquito that carries the parasite was introduced. Human induced habitat change may remove the actual limiting factor. This has occurred when irrigation of dry areas provided suitable habitat for snails involved in human fluke infections.

Health problems that result from the movement of animals can be divided into four general types:

1. Introduction of disease agents with translocated animals.

This is usually inadvertent and results from the simple biological fact that **it is impossible to sterilize a living animal. When animals are moved, other life forms that live in or on the animals are also moved**. The most important consequences occur when the disease agents that are introduced become established and have a deleterious effect on animals at the destination site. A few examples of this type of situation include:

- transfer of the giant liver fluke *Fascioloides magna* in North American elk to Europe with subsequent severe effects on native European deer.
- transfer of duck plague virus from Europe to North America in ornamental waterfowl.
- transfer of rinderpest virus from India to Africa in domestic cattle with devastating effects on African ungulates.

The effects of the introduced disease are often of on species other than the one that has been moved, but may also be on the indigenous component of the same species. The latter is considered to be a particular problem when dealing with remnant populations that are to be supplemented through translocation. In such circumstances, many infectious diseases may have died out in the small population of indigenous animals, so that the animals have no immunity to disease agents that may be re-introduced.

This type of disease problem is **least likely** to occur when wild animals are transplanted from the wild to the wild, with both the origin and destination of the animals being within the historic range of the species. The greatest risks occur (a) when animals are moved outside their historic range and into the range of species with no prior experience with disease agents carried by translocated animals and (b) when animals are released from captivity, where they may have been exposed to a range of unusual diseases, to the wild.

2. Introduction of wild animals into an area where they are affected by an indigenous disease.

Wild animals that are translocated may be susceptible to disease agents present in the release area. The disease agent is usually resident in some indigenous species and spills over into the introduced animals. Example of this problem include:

- avian malaria in penguins held in zoos in the Northern hemisphere. Without treatment, many penguins will die of malaria, caused by species of *Plasmodium* that circulate widely in native birds and mosquitos without causing significant disease.
- death of caribou as a result of *P. tenuis* infection when the caribou were reintroduced into former range now occupied by white-tailed deer. The parasite was not present until habitat conditions allowed expansion of white-tailed deer range.
- death of whooping cranes being raised in captivity in Maryland as a result of infection with the virus that causes Eastern Equine Encephalomyelitis. This virus cycles in native birds without causing disease.

The greatest risk of this type of problem occurs when wild animals are introduced outside their historic range into areas where disease agents occur with which they have had no experience.

3. Introduction of an animal that changes the ecology of an existing disease.

There are relatively few documented examples of this occurring; however, a situation in New Zealand illustrates the potential problem. Bovine tuberculosis was introduced to New Zealand in domestic cattle many years ago and occurs in cattle, game-farmed deer and wild deer. The brush-tailed possum, a marsupial introduced from Australia, is very susceptible to the disease and has become the main reservoir of infection. Control measures that have been used successfully in other countries to eradicate tuberculosis have failed in New Zealand, because the of the massive population of possums (> 70 million) within which the disease has become well established and very common.

4. Exposure to disease agents during the translocation process or while in captivity:

Animals that are held in dense concentrations, under stressful conditions, are likely to exchange disease agents within the group and, if they have contact with other species, are likely to acquire novel agents. The animals may also have impaired ability to resist disease agents. In general, these risks increase the longer the animals are held in captivity and the further they are held from their historic range.

The remainder of this course will deal with the specifics of identifying, measuring and reducing the health risks associated with animal movement. The first step in this process is recognition of the existence a potential problem. Griffiths et al (op cit) reported that in 24% of the animal translocations they reviewed, there was no professional examination of the animals for parasites, disease or injury prior to release, and in less than one-third of the translocations was there any post-release monitoring.

Risk Factors Associated With Capture and Translocation of wildlife

Nigel Caulkett DVM, MVetSc., DACVA

Capture and translocation of wildlife often poses a significant threat to the well being of the individual animal. Trauma can occur at any point in this process, and can be produced by capture equipment, other animals, or self inflicted trauma as the animal attempts to flee the captors. Anesthesia in an uncontrolled environment can be extremely difficult and may result in death from hypoxemia, hyperthermia, or collapse of the cardiopulmonary system. Animals may also be prone to predation if they experience residual effects of the anesthetic. The stress and exertion of capture and/or confinement can result in trauma, or exertional (capture) myopathy. The incidence of injury and mortality can be kept to a minimum if capture is well planned and stress is kept to a minimum during capture and translocation. The following section deals with some of these risk factors and methods of decreasing risk to the individual animal.

Trauma

Trauma can occur any time during the capture and translocation process. If animals are trapped the trap must be designed to decrease the risk of trauma i.e. leg hold traps should be well padded, and sprung in such a manner that they cause the minimal amount of tissue damage. Corrals should be designed in a manner to decrease the risk of injury, and if animals are manually restrained they should be processed as rapidly as possible.
Trauma can occur during a chase, and chase time should be limited to decrease the incidence of trauma and myopathy.
Capture equipment can produce injury or death. Weights on net gun propelled nets can traumatize animals, and a sudden fall in a poorly netted animal can result in injury.
Darts can produce injury or death. Impact energy of a dart = mass x velocity^2 many companies are manufacturing lightweight darts to decrease impact energy. Most darting systems adjust velocity to extend range. The lowest effective velocity should always be used to decrease the risk of injury or death. Injury or death can also result from poor dart placement, anybody using this equipment should practice dart placement at a variety of ranges.
Trauma can occur post capture if animals are confined. Herd species may not do well if they are confined individually, animals can panic to the point of exhaustion, or traumatize themselves. Animals confined in groups may injure each other as they try to establish their social order. A good knowledge of the animal's behavior can result in decreased injury from dominance aggression. Recent trials have demonstrated that long acting neuroleptic drugs can decrease the risk of injury and death associated with confinement of wildlife. Personnel involved in wildlife capture, should be able to recognize trauma, treat minor trauma, and be able to destroy animals that have severe trauma.

Immobilization and anesthesia

Anesthesia can be risky in a controlled environment. Anesthetized animals tend to develop depression of the cardiovascular, and respiratory systems. Many drugs also disrupt thermoregulation and animals can become hyper or hypothermic. In a controlled situation ventilators can be used to control respiration, Fluids and drugs can be used to support the cardiovascular system, and the environmental temperature can be controlled to maintain body temperature. It is often impossible to carry supportive equipment into a field situation and immobilization of wildlife can pose a serious risk to the animal.

Problems inherent in field anesthesia include:

- Environmental obstacles: Mountainous terrain, thick forest, swamp etc. can pose a problem as animals can be difficult to track, or may become anesthetized in an area where the animal is hard to reach.

- Lack of supportive equipment: Anesthesia in a controlled environment requires equipment to supply oxygen, support ventilation, blood pressure etc. This equipment is not available in the field, increasing the risk of complications in the animal

- Weather conditions: Many of the anesthetic agents will impair the animals ability to control its body temperature. Animals tend to become hyperthermic in a hot environment, and can become hypothermic with prolonged exposure to the cold.

- Predators: Sleeping animals left unattended are prone to predation.

- Injection site: Drug injection site can influence absorption of the drug and time to induction of anesthesia. For most species the best site is the gluteal muscle mass (hindquarters) or the muscles on the back of the hind limb.

Different species of animals have different risk factors. With ruminants the following factors should be considered:

- Bloat: Bacterial fermentation of injesta results in gas formation in the rumen. If rumen motility is decreased gas can build up in the rumen resulting in ruminal tympany (bloat). If bloat is severe it can impair breathing and blood flow, resulting in hypoxemia and shock. Bloat may be relieved by passage of a stomach tube or rumen trocharization.

- Regurgitation: Anesthetized ruminants are prone to regurgitation, particularly if bloat occurs. If the airway is not protected there is a risk of aspiration pneumonia.

- Hypoxemia: Ruminants are prone to hypoxemia during anesthesia. Oxygenation should be monitored if possible.

- Position: It is preferable to maintain ruminants in sternal recumbency if possible. This is the best position for oxygenation, and it decreases the risk of bloat.

- Myopathy: Ruminants are at high risk for the development of myopathy. Pursuit should be limited to 5 minutes maximum.

- Hyperthermia: Ruminants are at risk for hyperthermia. Immobilization should be avoided during the warm hours of the day if possible.

- Trauma: Care must be taken during induction. Many of the smaller ruminants are very flighty and may traumatize themselves during induction of anesthesia.

- Under dosing: Animals under dosed with alpha-2 agonists may appear to be very sedate, but will flee when approached. Animals under dosed with carfentanil often demonstrate excitement.

With carnivores and omnivores the following risk factors should be considered:

- Vomiting: Monogastrics (one stomached animals) are prone to vomition during induction of anesthesia. The incidence of vomiting is greatly increased if alpha-2 agonist drugs are used. These animals secrete gastric acid into the stomach. If they inhale gastric acid an extremely severe pneumonia (aspiration pneumonia) can develop. The risk of aspiration pneumonia can be decreased by fasting the animal prior to anesthesia.

- Hyperthermia: Like ruminants these animals can become hyperthermic on hot days, and an attempt must be made to keep them cool.

- Capture myopathy: Capture myopathy is much less common than in ruminants.

In the past 20 years there have been very significant advances in drug development for wildlife capture. One of the first drugs used for wildlife capture was the depolarizing muscle relaxant succinylcholine. This drug had a very low margin of safety and a high incidence of mortality. Development of potent dissociative anesthetics, such as tiletamine, potent narcotics, such as carfentanil, and alpha-2 agonists, such as xylazine and medetomidine, have greatly decreased the risk of complications in the individual animal. Some of the potentially useful combinations are outlined below.

Telazol

Marketed as a combination of tiletamine (a drug similar to ketamine) plus the benzodiazepine drug Zolazepam. Onset of activity 5-10 min. following IM injection. Used in a wide variety of species.Telazol has the advantage of being very user friendly. It produces minimal adverse cardiopulmonary effects in the animal and is very predictable. It is a good combination for canids, ursids and mustelids, but is not very useful in ungulates. One of the major disadvantages of telazol is lack of a reversal agent. Combinations of xylazine and telazol or medetomidine and telazol should prove to be reversible and will probably prove to be useful in a wide variety of species, including ungulates.

Xylazine-ketamine

Xylazine is commonly used in combination with ketamine to decrease the convulsive effects of ketamine and produce general anesthesia. This combination has been used in a wide variety of species, and is particularly useful in carnivores. Xylazine decreases sympathetic outflow in the CNS, resulting in hypotension, and bradycardia. Ketamine is a sympathetic stimulant, and tends to counter these effects. Hemodynamic and respiratory perameters are relatively stable with this combination. Animals immobilized with this combination tend to maintain some degree of airway protective reflexes. Immobilization usually occurs 10-15 min. post injection. The combination is somewhat "reversible" with yohimbine or tolazoline, unfortunately reversal of the xylazine can unmask convulsive activity from ketamine, which can pose a threat to the animal.

Medetomidine-ketamine

Medetomidine is a new alpha 2 agonist with a potency about 40 times that of xylazine.
It is very selective for the alpha 2 receptor, administration produces analgesia, sedation, and at high doses medetomidine is reported to produce anesthesia. Side effects include bradycardia, hypotension, and hypoventilation. Ketamine should be included in combination with medetomidine. Ketamine tends to increase the heart rate and counter some of the hypotension produced by medetomidine. Low doses of ketamine are required

allowing a good recovery following reversal of the alpha 2 agonist with atipamazole. A very low dose of medetomidine is required, approximately 80 μg/kg in many ruminants. This can be combined with powdered ketamine to produce a small injection volume. Medetomidine-ketamine has proved to be useful in a wide variety of species and may ultimately replace xylazine-ketamine.

Carfentanil

Carfentanil is an extremely potent narcotic (approximately 10, 000 times as potent as morphine). It is usually combined with acepromazine or xylazine to produce immobilization. Carfentanil has several advantages including: small injection volume, rapid reliable immobilization of many ungulate species, and reliable antagonism with naltrexone. Disadvantages include: excitement on induction, hypoventilation, and frequent hyperthermia.

The above list is somewhat abbreviated but does represent the drugs used most commonly in North America. Adequate monitoring of anesthesia and supportive care will decrease the risk of complications. Any personnel using these drugs should be aware of potential adverse effects and should be able to treat complications as they arise.

Capture myopathy

Capture myopathy is most commonly observed in herbivores, particularly cervids. There are three recognized syndromes. In the acute form apparently healthy animals will experience shock, hyperthermia, and mild acute rhabdomyolysis. The animal usually dies within 3-4 hours post capture. Treatment consists of fluid support, bicarbonate to treat the acidosis, active cooling, and dexamethasone. Treatment is usually unsuccessful. The subacute form occurs several hours to days post capture it is characterized by extensive muscle necrosis, myoglobinuria and renal failure. The chronic form is characterized by rupture of the gastroconemius or semimembranosus muscles. It is seen any time up to four weeks post capture.

Treatment of any form of capture myopathy is difficult and usually not successful. Steps can be taken to prevent the syndrome. Chase time should be minimized prior to capture. Chase should be limited to 5-10 minutes. Animals that are captured by physical means should be handled for the minumum possible time. If animals are confined prior to translocation they should be handled as little as possible. Frequent handling and blood taking is associated with an increased incidence of CM.

If animals are to be translocated it should be done immediately post capture or approximately 30 days post capture as the incidence of CM is highest between these time points. Animals may gradually acclimatize to human presence to decrease stress.

During transport, individual crates are best avoided for social animals. This can allow for the maintenance of family groups and take advantage of mass transport.

Careful attention should be paid to temperature, and thermoregulation, as heat stress may trigger CM.

Long acting neuroleptic drugs may be used to decrease stress and may have a protective effect during confinement and transport. Some of the beneficial effects of these drugs are outlined below.

Long acting neuroleptics

This group of drugs includes phenothiazines such haloperidol and trilafon, it also includes some benzodiazepines, and butyrophenones. These drugs are used as antipsychotics in humans, and have been used to decrease the stress of captivity and transport in wildlife. Beneficial effects include: alteration of the mood of the animal, make the animal indifferent to its surroundings, decrease the fear of humans, and decrease self-inflicted trauma.
These drugs demonstrate great potential for decreasing the stress of captivity and transport their popularity is sure to increase over time.

HEALTH AND DISEASE IN ANIMAL TRANSLOCATIONS

This section of the course considers health issues other than those associated with capture and handling of the animals to be moved. The discussion is subdivided into the following topics:

- Mode of Release
- Nutrition
- Pollution
- Genetics
- Infectious Disease

MODE OF RELEASE

There are two general approaches to release of animals at the destination site:

- Immediate release (also called "hard" release)

- Gradual release (also called "soft" release)

Immediate release implies absence of any attempt to manage the adaptation of the animals to their new environment. Animals are simply taken to the destination site and turned loose. *Gradual release* implies use of some procedures to permit a more gradual adaptation of the animals to the new environment prior to their total independence. Often, this takes the form of holding the animals in an enclosure within the new habitat, then opening the enclosure while continuing to provide food within the enclosure, and gradually reducing the provision of food over some days, weeks or months.

There are advantages and disadvantages to each approach:

Release Option	Possible Advantages	Possible Disadvantages
Immediate	- Cost - likely to cost less - No stress of captivity - No captive management	- Erratic, distant dispersal - Failure to form groups - Social disruptions - Initial malnutrition
Gradual	- Controlled dispersal - Social cohesion - Good initial nutrition - Facilitates monitoring	- Cost - likely to be higher - Captive management required - Stress of captivity

The above lists represent a superficial and incomplete consideration of the issue of most appropriate mode of release. The choice of one or the other mode will depend on the species and habitats involved and on many other details of each particular translocation. For example, moose

were successfully moved from Ontario to Michigan in a program of immediate release. On the other hand, some erratic, unwanted long-distance dispersals of bison have occurred under conditions of immediate release, while gradual release has resulted in establishment of populations at the target location. The important point is that this is an issue that requires due consideration when animal translocations are being considered.

NUTRITION

When animals are moved, two quite different issues regarding their nutrition can arise:

- Diet during captivity

- Diet available in the environment of the release site.

The fist issue will only arise if there is to be a period of captivity, such as with a gradual release program or a period of quarantine. The second issue always must be considered.

1. *Nutrition during captivity*: Often, moving animals requires a period of captivity while animals are assembled at the capture site, held at the release site, etc. These animals must be induced to eat and must be fed a palatable and balanced diet. If they are not, they will be released in less-than-optimal nutritional condition, which may, in turn, increase the likelihood that the translocation program will fail. The importance of diet for captive animals increases in importance with the length of the captive period. However, any period of captivity carries with it a requirement that acceptable food and water be provided.

Zoos have developed a large bank of knowledge about appropriate diets for various wild animal species. Thus, much information is available. However, knowing what is needed does not mean that it is easy to accomplish. For example, an Elephant requires about 170 kg of fresh browse daily; one Moose might require 40 kg (90 lbs) each day. Supplying the daily requirements for such animals can be a major task. On the other hand, wild Bison readily eat regular hay. If there is to be a period of captivity, a feeding strategy must be established carefully and well in advance. Logistical details, in particular, must be fully worked out.

2. *Nutrition available in the environment of the release site.* It can not be assumed that animals moved to a new environment will find an adequate food base at the new location. Even when animals are being moved to range that was occupied by that species previously, the nutritional adequacy of food available should be documented. Habitats change over time and competitors, including both wild and domestic animals, can occupy feeding niches formerly occupied by an extirpated species. A sufficient variety of foods must be available in all seasons when the species of interest is active such that a balanced diet suited to the species is available. Probably, in most cases, translocations will be planned for suitable habitat and it will be determined that the environment can indeed provided adequate nutrition. However, this should not be assumed and an actual on-site assessment should be part of the translocation program.

GENERAL COMMENT: When restoring animals to a former range from which the species has been extirpated, be sure you know why that species was extirpated. If it was because of an inadequate food base, or pollution, or invasion by a competitor, or infectious disease, the condition that led to extirpation may still exist in that environment; if so, the translocation probably will fail.

POLLUTION AND POISONS

Is the destination site a suitable place to live for the species being moved, or is it too polluted to sustain a population ? This is a question of increasing importance. The earth's human population is about to reach 6,000,000,000. That's more people than have ever died ! Our population has doubled twice this century and is on an exponential roll. Inevitably, wildlife habitat is increasingly dominated by the effects of human activity and is a depot for human waste. Thus, the suitability of habitat for an introduced species can not be assumed; it must be assessed.

Aquatic habitat often no longer is suitable. For example, many wetlands in western Canada managed for waterbird reproduction contain water that is lethal to ducklings because of its content of natural salts; most freshwater wetlands have been lost to agriculture. The Kesterson Wildlife Refuge in California was created as a new haven for aquatic life. Water for the refuge came from irrigation run-off. Unfortunately, this water contained so much selenium that massive poisoning of waterbirds was the net result of creation of the refuge; now, wildlife must be actively deterred from using the area. Some wetlands contain huge amounts of lead shot from hunting. The recovery program for the Trumpeter Swan at Wye Marsh in Ontario has been seriously impeded by lead poisoning from this source of lead. The Beluga Whales of the St Lawrence estuary suffer a high rate of cancer that most probably is due to severe chemical pollution of their habitat. A translocation of beluga whales from the arctic to augment this population, for example, probably would fail since the environment may no longer be able to sustain a healthy Beluga population. Translocations of fish to waters heavily contaminated with mercury may make no sense if the intention of the translocation is to help sustain a fishery in which the fish are used for human food. Translocations of insectivorous animals to habitats regularly treated with insecticides or of waterbirds to marshes subject to regular outbreaks of botulism are likely to fail because of direct poisoning.

Thus, it no longer is legitimate to assume that possible destination habitats that seem appropriate on superficial assessment will, in fact, be able to sustain populations of the animals proposed for translocation. Toxicological issues also must be considered.

ISSUES INVOLVING GENETICS

At least two quite different issues concerning genes and genetic heritage must be considered when an animal translocation is being contemplated:

1. Will the genetic identity of species or subspecies be affected ?

2. Is this the 'correct' (or 'natural') race or subspecies for the destination habitat ?

Genetic issues will be of major importance in some translocations and unimportant in others.

Genetic identity of species/subspecies: Subspecies or races of a particular species can interbreed and hybridize. There also can be hybridization between taxonomic species, oten resulting in infertile offspring. When hybridization occurs, the genetic distinction among the affected taxa is lost and, potentially, a branch of evolution is lost with it.. For example, the European Red Deer (*Cervus elaphus elaphus*) can hybridize with the North American Elk or Wapiti (*Cervus elaphus canadensis*). Similarly, Mule Deer and Black-tailed Deer can hybridize, as can Wood Bison and Plains Bison. When over 6,000 Plains Bison were translocated from Wainwright, Alberta to Wood Buffalo National Park in the 1920's, the Wood Bison, as a subspecies, nearly was made extinct through hybridization. A number of native trout populations are threatened by hybridization with related species or subspecies introduced through stocking programs. This issues works both ways. Genetic harm may be done to the animals being translocated, or to animals in the destination environment, or to both.

'Correct' Race or Subspecies: Different subspecies or races of animals have evolved in response to selection pressures unique to their natural environment. Translocations intended to restore or augment depleted populations should recognize this in selecting source populations. In some translocations, this will not be an issue, while in others it will loom as a major consideration. Should Peregrine Falcon chicks from the Queen Charlotte Islands be used to re-constitute mid-continent Peregrine populations ? Should Canadian Bighorn Sheep be used to augment populations of Desert Bighorn Sheep ? Such issues usually have biological and non-biological components. The biological issue, at least, should always be assessed completely and objectively.

The above are examples of two commonly-encountered genetic issues associated with moving wild animals. Other genetic issues also may pertain in particular situations.

INFECTIOUS DISEASES

Infectious diseases are a major concern whenever wild animals are moved from one place to another. They also are a major concern when domestic animals are moved from place to place. Many of the major diseases of domestic livestock have been controlled through regulations that governed when and how livestock could be moved. As these diseases have been systematically eliminated from Canada, restrictions on domestic animal movements have been eased. Federal regulations still govern some of the most economically-important infectious diseases of livestock, and provincial regulations govern some others. By and large, such regulations are not in place to reduce the risk posed by infectious diseases in association with translocation of wild animals. Thus, wildlife personnel must accept all or most of the responsibility for ensuring that such risks are minimized, and they will be held accountable for any negative consequences. It is no one else's responsibility.

Infectious disease is a major focus of this course. What follows is a general introduction to the range of issues associated with infectious disease in translocation programs. Elsewhere, specific examples are given more in-depth consideration.

There are two different kinds of risk with respect to infectious diseases and wildlife translocations:

1) Risks to the animals being moved.

2) Risks to the destination ecosystem

Risks to the Animals Being Moved

These can further be subdivided into two different categories of risk:

- Diseases acquired during the translocation procedure

- Diseases encountered in the destination environment

Diseases Acquired During Translocation: This risk increases when animals remain captive for periods of time in holding facilities, quarantine stations or similar conditions. The stress of captivity can weaken resistance to infectious diseases and result in illness in captive animals that would resist these particular infections in the wild. Captive animals also may be exposed to new infectious agents in the holding facility. For example, African Elephants and Rhinoceros have died in African facilities from infection with the bacterium *Salmonella.* It is thought that these infections came from humans working with the animals. Similarly, wild-caught cheetahs have acquired a fatal virus disease called Feline Infectious Peritonitis in holding facilities. This is a common disease of domestic cats but has not been found in surveys of wild Cheetahs. Holding animals in zoo, farms or other facilities shared by other animals carries some

risk that infectious agents from the neighbouring animals will cause disease in the animals being held. Similarly, use of chutes, corals, trucks and other equipment used for other animals and not disinfected prior to use in the translocation program risks infections passing from these other animals to the animals being moved.

Diseases Encountered in the Destination Environment: This is a grave risk if there are diseases at the new location to which the arriving animals are susceptible and to which they have not developed resistance from previous exposure. For example, as discussed in more detail elsewhere in this course, every wild cervid present in western Canada except the white-tailed deer risks fatal infection with the nematode parasite *Parelaphostrongylus tenuis* (the brain worm of White-tailed Deer) if moved into any habitat east of the Manitoba-Saskatchewan border that is occupied by White-tailed Deer. Several attempts to restore Woodland Caribou to their former range in eastern Canada have failed because of this disease. Bighorn Sheep moved into habitat shared with domestic sheep risk severe pneumonia due to a form of the bacterium *Pasteurella haemolytica* carried by domestic sheep. In South Africa, attempts to restore the Springbok, a native antelope, to some areas of its former range have failed because of the establishment of a new disease (Heartwater) in these areas. Springbok are highly susceptible to this disease, which persists in the environment through infection of other ungulate species that are less susceptible.

It might be supposed that, if animals of the same species already are present in the destination environment, the likelihood that the destination environment will hold important disease risks for arriving animals of that species will be small. This is not true. It is possible for a population of animals to develop a significant degree of resistance to infectious diseases which they regularly encounter such that the disease has a greatly reduced impact on the resident population. Translocated animals of the same species that have not developed such resistance can suffer severely when placed in this seemingly low-risk environment.

It is evident that, if a significant proportion of the translocated animals die from diseases they acquire during translocation or in the destination environment, the translocation will have been a failure. Thus, a full assessment of this potential risk should precede each translocation.

Risks to the Destination Ecosystem

Dr. Bill Samuel (University of Alberta) refers to animal translocations as "Moving the Zoo". By this, he means that every animal that is moved, whether it is a Moose or a frog's egg, carries with it a "zoo" of parasitic organisms, large and small. A large proportion of the total of the earth's biological diversity is vested in parasitic organisms. Thus, translocations are never just of Moose or of frogs but, in reality, are of the total assemblage of species carried on or in the host animal package we want to move to a new place. Some of the organisms that will be moved with the host animal have the potential to cause significant disease in one or several species in the destination environment. This, in turn, has the potential to alter the destination ecosystem in ways that may be trivial or profound.

The potential harm caused by diseases introduced into the destination environment probably always is far greater than that caused by diseases present in the destination environment that might affect the translocated animals. While the latter might cause the translocation effort itself to fail, the former has the potential to release new disease-causing agents into an environment, agents that may affect several species and thereby alter the entire ecosystem and which almost never can be retrieved or eradicated once released.

Tuberculosis and Brucellosis in Bison: A well-known example of diseases moved to a new environment by animal translocation is the translocation of bovine brucellosis and tuberculosis to Wood Buffalo National Park when Plains Bison were moved there in large numbers in the 1920's. After a period of population expansion coincident with intensive killing of wolves, this infected population began a decline that has persisted to this day and has resulted in a greatly diminished Bison population in the park. Population models indicate that the decline is due to the effects of these two diseases which condition the population to be highly susceptibility to wolf predation. Currently, about half the animals have tuberculosis and a third are infected with *Brucella*. The population is shrinking by about 15% per year. An expanding population of bison in the Mackenzie Bison Sanctuary now is threatened with the possibility of making contact with the diseased herd in the park, thereby acquiring these two diseases which currently it does not have. Thus, these diseases remain a significant management issue for the long-term welfare of northern Bison populations in Canada.

Malaria and Pox in Hawaiian Birds: Over half of the native birds of the Hawaiian Islands became extinct between 1800 and 1940. Predatory rats, pigs, cats, mongooses and humans all have had important effects. Two introduced diseases have had a major impact as well. Avian Malaria and Avian Pox, both carried from bird to bird by mosquitos, have killed off many species and now severely limit the distribution of the remaining native birds. Neither disease nor mosquitos existed on the Islands until 1826, when mosquito larvae from Mexico were poured into a Hawaiian stream by sailors refilling their ship's water kegs. The virus that causes Avian Pox and the protozoan that causes Avian Malaria were imported to the Islands with various species of birds brought to the Islands in the 19th century. Severe losses of native birds to Pox was noted in the late 1800's, while important losses to Malaria were first recorded in the 1920's . A current program to restore the extirpated Hawaiian Goose to its former range through captive propagation and release is stalled by fatal Malaria in geese released back into the wild.

Whirling Disease and other Parasitic Diseases of Fish: In 1970, Dr. Glenn Hoffman of the U.S. Bureau of Sport Fisheries and Wildlife listed 48 parasites of freshwater fish that had become established at new locations through translocation of fish. The most serious of these was the protozoan *Myxobolus cerebralis*, a benign parasite of the European Brown Trout that now causes a severe disease known as Whirling Disease in Rainbow Trout. The disease first was recognized in Rainbow Trout imported and released in Europe. Subsequently, it has been translocated around the world in fish and fish products. It is widespread in the United States. Thus far, Canada has excluded this disease through testing of imported fish. Rainbow Trout are the most susceptible species, but Sockeye Salmon, Golden Trout, Cut-throat Trout and Brook Trout also can suffer disease from this infection. The importance of this disease to wild fish

stocks in uncertain; it is primarily a problem in hatcheries, many of which supply fish for release into the wild.

Chronic Wasting Disease - A Cautionary Tale: A newly-recognized disease in North American wild deer is cause for concern. Chronic Wasting Disease (CWD) is a disease of uncertain cause that is very similar to Bovine Spongiform Encephalopathy (BSE) or "Mad Cow" disease. CWD occurs in wild Elk, Mule Deer and White-tailed Deer in a relatively small area of South-Central Wyoming and adjacent north-Central Colorado. It also has occurred in captive animals of the same species, including two occurrences in Canada (one zoo, one game farm). Infection may occur years before the disease becomes evident. There is no test to detect infected animals well in advance of the development of clinical disease. Thus, this is a disease that could be moved from place to through animal translocations but would only be recognized years after it had become established in new, wild populations. The economic impact of the establishment of this disease in wild ungulate populations in Canada would greatly exceed its importance to the wild populations themselves, due to public health concerns.

The potential to spread important infectious diseases to new ecosystems must <u>always</u> be examined when assessing the relative risks and benefits of animal translocations.

INFECTIOUS DISEASES AND DOMESTIC ANIMALS

Infectious organisms and diseases are moved from place to place with domestic animals in the same way that they are with wild animals. A large number of parasites and diseases can affect both domestic and wild animal species. Thus, disease problems may be caused in wildlife by the movement of domestic stock, and movement of wild animals can introduce new diseases to farms and ranches. This sharing of pathogens and diseases has been enhanced by the development of game farming in which native wild species have been brought into captivity and managed like traditional domestic livestock. In these settings, the wild and domestic animals can be the same biological species and are certain to share diseases readily. Thus, wildlife managers have become stakeholders in issues involving movement of game farm animals as well as of traditional livestock. Equally, there can be significant impact on agriculture when diseases are moved from place to place during wild animal translocations.

Several examples of disease transmission between wild and domestic animals can be cited.

Duck Plague: In 1967,a virus disease of European waterfowl, Duck Plague, arrived in North America through importation of domestic birds. It first caused outbreaks among domestic ducks on Long island, New York, in the United States, but very quickly caused moderate outbreaks among local populations of wild ducks, and swans. Suddenly, in 1973, a massive outbreak of Duck Plague killed 40,000 wild mallards and smaller numbers of other ducks and geese on the Lake Andes Wildlife Refuge in South Dakota. There has never been another massive outbreak of duck plague, but smaller outbreaks, some causing mortality in the thousands, have occurred sporadically throughout the continent.

Newcastle Disease: In the early 1990's, it became evident that a severe virus disease of poultry called Newcastle Disease occurs regularly on nesting colonies of Double-crested Cormorants throughout much of their extensive breeding range in North America. The impact on the cormorants may be substantial in some years and minor in others. However, the potential impact of this disease on the poultry industry is enormous. This disease has been eliminated from poultry in North American a great cost. Its occurrence in commercial poultry flocks would trigger an eradication campaign and would severely reduce access of Canadian and American poultry products to world markets. The disease is known to have passed from cormorants to one commercial Turkey farm in the United States, resulting in the depopulation of the entire 25,000 turkeys on the affected farm.

Salmon Diseases in Norway: Two major diseases have been established in wild stocks of Atlantic Salmon in Norway by importation of fish for fish farming. A trematode parasite, *Gyrodactylus salaris*, had spread to 32 different rivers as of 1991. It infects 100% of the wild salmon in some rivers and is causing significant disease. The bacterium *Aeromonas salmonicida*, the cause of the disease Furunculosis, had spread to 72 rivers as of 1994 and was causing disease in wild populations of Atlantic Salmon and Brown Trout.

African Horse Sickness: In 1987, 10 wild-caught Zebras were imported into Spain

from Namibia following three weeks of quarantine and health assessment. Zebra's are the natural host for African Horse Sickness, a virus disease carried from animal to animal by midges (*Culicoides* sp.). In Zebra's, infection does not produce disease, but it is fatal in horses. Horses in the area where the Zebra's were kept began to die a month or so after the Zebras' arrival. The disease was eradicated through slaughter and vaccination of horses at a cost of about $20,000,000.

Cattle in Northern Alberta: Cattle have been moved into the Peace River agricultural area of northern Alberta to develop and extend agriculture in this area. This movement places the cattle adjacent to the Bison in Wood Buffalo National Park which are the only reservoirs of bovine brucellosis and tuberculosis that remain in Canada. As a consequence, government agencies must spend large sums of money to maintain constant vigilance against these disease spreading into the domestic cattle herd. Re-establishment of these diseases in cattle would jeopardize national and international trade in beef cattle and all products derived from them.

Llama's in the Wilderness: For reasons both mystical and practical, Llama's increasingly are being used as pack animals in wilderness areas. The complete inventory of diseases that may be carried by Llamas, or to which they are susceptible, has yet to be established in North America. Among known diseases of concern are Orf, or Contagious Ecthyma, a disease caused by a pox virus and to which wild sheep and goats are susceptible, and Johne's Disease, or Paratuberculosis, a disease caused by the bacterium *Mycobacterium paratuberculosis*. This disease also has occurred in wild sheep and goats in contact with domestic livestock that can carry the disease. Wildlife managers are being required to assess the potential disease risks posed by Llamas relative to the economic and aesthetic benefits demanded by outfitters and tourists, and to establish regulations for Llamas on this basis.

Translocation of wild animals and associated health risks

Introduction

Historically, many references can be found to the deliberate attempts by humans to translocate numerous species of wild animals. Animal populations have been moved from one geographic area to another, all over the world, often without the benefit of experience or adequate knowledge of the ecology and biology of the animals selected. The primary motivation was often for the exclusive benefit to humans as a result of sentimentalism, curiosity, or the desire to establish populations of wild animals that could be hunted, trapped, or otherwise utilized. Although some of the early animal introductions were successful, failure to establish viable populations was common, and a fair number of times the translocated species impacted detrimentally on the area into which they were introduced in what can simply be described as ecological disasters.

Translocation of Wild Animals (Nielsen and Brown, 1989) defines translocation as "The transport and release of free-ranging, wild animals primarily for conservation or ecological reasons in a location different from which they come, but where the species may presently occur or historically have occurred naturally." Unfortunately, this definition is a bit idealistic in terms of what has happened in the past and what is happening today with respect to the deliberate movements of animals by humans for reasons other than conservation or ecology. As well, it is unfortunate that many private organizations and individuals likely do not consult available literature or their state/provincial agencies to look into the appropriateness of what they are about to do.

In more recent times, the translocation of a rabies virus variant from one location to another has been identified with increasing frequency in the United States. There have been reports that the interstate transport of wildlife from geographic areas with enzootic hazards to new areas has resulted in disease outbreaks associated with significant public health and economic consequences. Unfortunately, federal and state regulations in the United States are not consistently applied to the interstate movement of native wildlife and in Canada the situation is much the same with regard to interprovinicial movement of native wildlife.

OTHER HEALTH RISKS

Potential health risks associated with the translocation of wildlife, include both the introduction of foreign pathogens in release areas and manmade escalation of enzootic pathogens (Schaffer et al., 1981) ..... apart from rabies, additional public health risks associated with wildlife translocation include zoonotic infections such as brucellosis, echinococcosis (Alveolar hydatid disease in humans), ehrlichiosis, plague, tularemia, Hantavirus pulmonary syndrome, Lyme disease, and Rocky Mountain Spotted Fever.

Recent Examples of Translocation of Rabies

Rabies Virus Variants

Before the development of monoclonal antibodies (MAbs) in the 1970s, and more recently nucleotide sequencing and polymerase chain reaction (PCR) tests, it was believed that the rabies viruses isolated from different mammalian species were identical. Today, rabies virus isolates can be differentiated based on their reactions with panels of MAbs and also by genetic analysis. Recognition of both antigenic and genetic differences among rabies viruses helps to explain earlier findings that suggested species differences in both susceptibility and reaction to infection. A variety of rabies viral strains, or more appropriately variants, have now been identified. A distinct species-associated rabies virus variant characterizes each of the major terrestrial hosts. As well, multiple bat rabies virus variants are known.

In North America, there are host-adapted rabies virus variants in raccoons, skunks, red (and Arctic) foxes, gray foxes, coyotes (and dogs), and bats. In a given area, one animal species is usually the rabies reservoir. Other species of wildlife, domestic animals, and human beings can and do become infected ('spillover') but do not keep the cycle going. Since rabies virus variants are not the same everywhere, new rabies outbreaks can be started by the introduction of infected wildlife.

Raccoon Rabies

The rabies virus variant associated with raccoons has been present in Florida since the first case was reported on the east central coast in 1947. During the 1950s, enzootic rabies spread north and south in raccoons along major waterways in Florida, becoming well-established throughout peninsular Florida. In the early 1960s the spread continued northward, reaching Georgia in 1962. This extension continued across Georgia and reached South Carolina in 1972. Raccoon rabies remained enzootic in most areas behind the periodically expanding epizootic front (Winkler and Jenkins, 1991).

Then in 1977 one rabid raccoon was reported in West Virginia. Additionally, three rabid raccoons were reported in contiguous counties of Virginia in 1978. Initially, these were thought to be isolated and sporadic cases. By 1981 these cases were recognized as the start of a significant new outbreak when Virginia reported 102 rabid raccoons (CDC, 1982). The antigenic characteristics, as determined by a panel of monoclonal antibodies (MAbs), suggested that this new mid-Atlantic epizootic of rabies in raccoons was the same as the rabies virus variant found in raccoons in the southeastern United States (Smith et al., 1984).

There is convincing evidence which supports the hypothesis that the sudden appearance of the raccoon rabies variant in West Virginia and Virginia in 1977 originated as a result of the actions of humans. Prior to that time, the nearest cases of raccoon rabies were in South Carolina. Thus, this first example comes from the introduction of the raccoon rabies virus variant into the Mid-Atlantic region in the mid-1970s, probably as the result of translocation of rabid raccoons from the southeastern United States (Nettles et al., 1979, Smith et al., 1984). The origin of the infection is believed to be importation of wild raccoons by hunters from one of the southeastern states, such as Florida or Georgia.

Documented evidence exists to explain such an occurrence. More than 3,500 raccoons trapped in Florida and accompanied by lawful permits and health certificates were brought into Virginia between 1977 and 1981. Rabid raccoons are known to have been included in these shipments (Winkler and Jenkins, 1991). As well, rabid raccoons have been found in similar shipments of raccoons from Florida to North Carolina (Nettles et al., 1979).

As the mid-Atlantic epizootic spread, infected raccoons were subsequently reported from Maryland in 1981, the District of Columbia and Pennsylvania in 1982, Delaware in 1987, New Jersey in 1989, New York in 1990, Connecticut and North Carolina in 1991, Massachusetts and New Hampshire in 1992, Rhode Island, Vermont and Maine in 1994, and Ohio in 1996 and 1997 (CDC, 1997). From what started as separate epizootics, the two raccoon rabies epizootics have enlarged and combined to include 18 eastern states and the District of Columbia, from Maine to Florida. Raccoons are now the primary rabies reservoir in the US.

The speed with which raccoon rabies spread throughout the mid-Atlantic region may be a reflection of the density of raccoon populations associated with plentiful food supplies and denning sites in urban and suburban areas. Although westward progression of the epizootic was slowed by geographic barriers such as the Great Lakes, Chesapeake Bay, the Potomac, Susquehanna, and Ohio Rivers, and Appalachian Mountains, if rabies infection becomes established in raccoons in the Ohio Valley, the epizootic may spread more rapidly across the mid-West (Rupprecht at al., 1995).

Although there have not been any documented human rabies cases in the United States associated with the raccoon rabies virus variant (CDC, 1997), this has come at a price. The costs associated with rabies control and prevention in the northeastern United States have increased in direct relation to the spread of the raccoon rabies epizootic. Millions of dollars have been spent on increased laboratory submissions and testing, animal control and public health measures, especially the greatly increased number of postexposure prophylactic (PEP) treatments that have been administered. For example, in Connecticut, the estimated number of persons to whom PEP was administered increased from 41 in 1990 to 887 during the first 9 months of 1994 as the raccoon rabies epizootic spread statewide, at a median cost of $1,500 per person exposed (CDC, 1996). As well, from 1988 (before the introduction of raccoon rabies) through 1990 (the year the epizootic became established), rabies control in two New Jersey counties accounted for a cost increase of $1.2 million (Uhaa et al., 1992).

Foxes and Coyotes

Vaccination campaigns and control programs during the 1940s and 1950s virtually eliminated the canine variants of the rabies virus cycling in North American canids by the 1960s. Thus, the reemergence of a rabies virus variant well adapted to dogs during the late 1970s and early 1980s in south Texas has been a cause for much concern (Krebs et al., 1997). The maintenance and transmission of a canine rabies virus variant along the Mexico-Texas border as a result of long-standing interaction among coyotes and (unvaccinated) dogs has caused outbreaks of rabies in canids in south Texas. The transmission of another canid variant found mainly in gray foxes has resulted in a separate epizootic in central Texas.

Fox hunting, the recreational pursuit of foxes with hounds, has been a popular sport in the United States since colonial times. One style of fox hunting that is widely practiced today involves individuals or small groups of people on foot with their hounds. This is often done at night in large fox hunting enclosures commonly called fox pens. As a result of the development of subdivisions and the problem of trespassing by hounds on private property, a relatively new but increasingly frequent practice has been the evolution of fenced enclosures built on large tracts of land. These enclosures have become very popular and, within the last 10-15 years, the number of fox pens in the southeastern United States has greatly increased. It has been estimated that there are at least 450 pens in the southeastern states (V. Nettles, DVM, Southeastern Cooperative Wildlife Disease Study, Athens, Georgia - personal communication).

Many operators have not been able to maintain foxes in their enclosures, even when food and artificial dens are provided. As a result, it is believed that nearly all fox pens are periodically restocked by releasing wild-caught foxes and coyotes into the enclosures (Davidson et al, 1992). This restocking practice has resulted in the frequent sale of wild-caught canids, sometimes from local sources, but animals are often imported from other states hundreds of miles away. There is evidence accumulating that this long-distance movement of wild foxes and coyotes is creating serious health risks to humans, domestic animals, livestock, and wildlife, including native foxes and coyotes.

During a covert investigation of fox pens carried out in 1989 and 1990 by the South Carolina Wildlife and Marine Resources Department, red foxes and coyotes were confiscated from an animal dealer based in Ohio and gray foxes were purchased from an animal dealer in Indiana. Data was collected on the diseases and parasites of these animals as well as information on the current form of private sector translocation and release of wild canids in fox pens. Based on records obtained during this investigation, it was determined that thousands of animals from the same source as the confiscated red foxes and coyotes had been supplied to fox pens in 17 states (Davidson et al, 1992). Although the disease survey of confiscated and purchased wild canids did not reveal any positive cases of rabies (Davidson et al, 1992), the frequent presence of bite wounds on the foxes and coyotes suggests that the potential for transmission of rabies virus is excellent. This finding was also observed among raccoons translocated under similar

conditions (Nettles et al., 1979). Several researchers previously found that translocated raccoons were infected with rabies virus, parvovirus, and pathogenic parasites. As well, Echinococcus multilocularis has been found in red foxes illegally imported into South Carolina from northeastern states. As a result of these findings, the translocation of raccoons and wild canids has been identified as being 'biologically hazardous' (Davidson et al.,1992; Nettles et al., 1979, 1980; Schaffer et al., 1981).

It is feared that the fox or coyote rabies virus variants will be introduced into a new area through translocation of foxes or coyotes. Even now, there have been three alarming instances that this can occur. The first occurred in 1993 when the Texas coyote variant was detected in a rabid dog infected on an Alabama hunting compound. The foxhound belonged to a fox pen owner who was suspected to have imported and released coyotes from Texas (CDC, 1995; Krebs et al., 1996). The hunting enclosure was closed and all wild carnivores were depopulated.

A year later, the Texas coyote rabies virus variant was detected in at least five rabid dogs that were used to hunt animals in a fox pen in Florida. These hounds had been exposed to coyotes used to stock the pens. Although these coyotes were reportedly captured in Florida, the suspected source of infection was translocation of infected coyotes from Texas. Increased sales of wild canids for fox pens has been occurring due to a recent surge in the popularity of coyote hunting in the southeastern United States. Although coyotes are indigenous to Florida, some of the animals may have been imported illegally since the rabies virus variant identified in Florida is not present in animal populations of the southeastern United States but had been found exclusively in 17 counties in southern Texas at the time (CDC, 1995). Raccoon and bat rabies virus variants are the only ones present in the southeastern United States.

The third incident occurred in 1995, when the Texas gray fox variant was reported to have been detected in two rabid gray foxes translocated for stocking purposes to Montana (Krebs et al., 1996). In response to my inquiry for further information, I received the following details:

> *On January 3, 1995, four gray foxes and two porcupines were shipped from the Dallas-Fort Worth airport to Boseman, Montana. The intended recipient in Montana was a wildlife photographer. Upon arrival at the Montana airport, one fox was symptomatic for rabies and was taken directly to a veterinary clinic, euthanized, and the brain tested positive for rabies (fluorescent antibody). The remaining foxes were euthanized and submitted for rabies testing; one was positive. Four human exposures occurred in Montana as a result of the two positive foxes. Subsequent investigation revealed the shipper to be licensed by the USDA and Texas Parks and Wildlife to conduct his business. He reported recently shipping animals to Germany, Great Britain, Amsterdam, Philippines, Georgia, Indiana, Missouri, Nevada, Oklahoma, and other parts of Texas. Despite the presence of veterinary health certificates, it appears that the animals had not been quarantined in Texas before shipment. Officials of the USDA-APHIS-VS notified Germany and the Netherlands that they received animals which were potentially in contact with rabid foxes. Two*

gray foxes in a shipment to a pet store in the Netherlands by way of Frankfort, Germany died and one tested positive for rabies. The other fox had died first and was incinerated. The pet store owner had to undergo post-exposure prophylaxis (PEP) and, due to concern of rabies virus contamination of urine leaked from the cages, other persons in the airport in Frankfort and the Netherlands are also receiving PEP (G. Fearneyhough, DVM and G. M. Moore, Texas Department of Health, Zoonosis Control Division - personal communications). Rapid responses to these translocations appears to have prevented the establishment and spread of rabies virus as a result of these introductions . Texas has since passed legislation to outlaw the practice of exporting Texas animals that might be incubating rabies (Krebs et al., 1996), although determination of this condition and enforcement might be a problem.

"These events bears strong similarities to those that may have been responsible for the introduction of the raccoon variant into the mid-Atlantic states during the early to mid-1970s. Rapid responses to these introductions appear to have prevented their establishment and spread (Krebs et al., 1995)."

Bats .....

The rabies virus variants maintained by bats appear to circulate separately to those in terrestrial mammalian reservoirs, although there have been documented spillovers. There are both rabies and non-rabies lyssavirus genotypes in Europe, Asia, Africa and Pacific Oceania that can cause illness and death in humans and occasionally domestic animals. Although it is unlikely that the introduction of exotic bat species could occur without human intervention due to the distances between the various continents and North America, three recent occurrences reveal the opportunity for rabies-infected bats to be transferred across oceans. In March 1986, a big brown bat (*Eptesicus fuscus*) that was incubating rabies was unknowingly included in a shipment of bats from Canada to researchers in Tubingen, Germany. It was only when the bat became ill and was euthanized, that a diagnosis of rabies was made. A similar incident occurred when twelve big brown bats caught from the wild in Massachusetts by researchers in Boston during July 1994 were exported to colleagues in Denmark. Six of the imported bats were dead by December 1994 and were confirmed as being rabies virus positive (Rupprecht et al., 1995).

The unintentional translocation of animals infected with rabies virus can also occur during everyday business ventures. The inadvertent introduction of a big brown bat resulted in the first confirmed non-indigenous case of rabies in Hawaii when a bat was captured within a transport container unloaded from a ship in Honolulu harbor in March 1991. Automobiles from Michigan had been loaded into the container ship in California. A health department laboratory in Hawaii diagnosed rabies; the virus was characterized antigenically as being a variant common to big brown bats in the Midwestern and western United States (Sasaki et al., 1992).

Although none of these three instances of unintentional bat translocations appear to have resulted in secondary cases or establishment of the rabies virus in foreign animal populations, it may only be a matter of time before this occurs.

..... and the pet trade

During 1994, several federal permits were inappropriately issued, allowing up to several thousand wild bats to be imported for sale in the US commercial pet trade. Several bat species were imported, although Egyptian tomb bats (Rousettus aegytiacus) were the most common species. The sale of imported bats and their offspring to private collectors or as pets is prohibited in the United States. Those animals that may be vectors of zoonotic diseases are only allowed entrance for limited uses at accredited zoos or research institutions, where contact with the general public is restricted. Although there have been no reports of lyssa viruses being isolated from Egyptian fruit bats, active surveillance for these viruses has not been done. The adaptability of these bats is a cause for concern due to the potential for survival and interaction among indigenous bats in North America.

WHAT CAN BE DONE?

Health certificates, blood tests, quarantines, and vaccines cannot prevent the risk of introducing rabies with translocated wild animals. Animals that are incubating the disease appear normal, and the only reliable test is to sacrifice the animal and test brain tissue for the presence of rabies virus. Quarantines are not effective as the maximum length of the incubation period is unknown for wild animals such as foxes and coyotes; it may extend beyond one year. Inactivated/killed virus vaccines, although not licensed, could help protect wildlife, but there is no guarantee that a vaccine will work if an animal is already incubating the disease. Because of the public health risks and lack of practical methods to certify animals as free of many of these zoonotic agents, it has been said that "restrictions on the movement of native wildlife may need to be considered" in both the United States and Canada (CDC 1995).

To prevent translocation of wildlife for hunting and other restocking purposes, new regulations were drafted in Texas because of the possibility that animals incubating rabies might subsequently introduce a rabies virus variant into areas of the United States where it does not presently occur. This legislation was precipitated by the discovery of animals in several other states infected with rabies virus variants previously found only in Texas. As a result, Texas has passed legislation prohibiting the practice of exporting animals that might be incubating rabies. The Rabies Control Act was amended such that "It is illegal for a person to transport certain animals that are high risk for transmitting rabies to, from, or within the state." The animals included are coyotes, foxes, skunks, raccoons and bats.

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Managing Risk -- Risk Assessment

Nancy de With, DVM
05 March 1998

The concept of risk comes from our recognition of future uncertainty. It is the inability to know what the future will bring in response to an action taken today. Risk implies that a given action has more than one possible outcome. It is important to note that risk can be either subjective or objective, and deciding that something is risky requires personal judgment (even for objective risks).

To make risk analysis more systematic, formal model frameworks have been developed. These frameworks can act as a 'check-list' that help all personnel involved to understand the specific requirements of each risk analysis situation.

The risk analysis model that will be described and demonstrated, has been adapted from the Risk Assessment Frameworks of the Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA), authored by W.B. McNab, D.M. Alves, A.E. Stahavitch, R.S. Morley, and A.M. Lammerding. The full document is available on the internet at: <www.gov.on.ca/omafra>

There are computer programs available (such as @Risk, Palisade Corporation, Newfield, NY) that can make the task of risk analysis easier. These programs help to quantify risk, that is, to determine all the possible values a risk variable could take and determine the relative likelihood of each value. However, the future risk must still be estimated with the best information that is available at the present time. Quantitative risk analysis techniques are simply tools that can be used to help make decisions and arrive at solutions.

The final decision making process should be based on both the results of modeling, and personal judgment.

Definitions

Risk: The likelihood of the occurrence (probability of harm) and the consequences (severity of impact) of an adverse event

Hazard: A thing or action that can cause an adverse effect (Ex. an agent that is a cause of an animal disease)

Risk Assessment: The process of identifying an adverse hazard, and characterizing or estimating the risk presented by that hazard. Can be qualitative or quantitative.

Risk Management: The process of identifying, evaluating, selecting, and implementing alternatives for mitigating risk.

Risk Communication: The open exchange of information and opinion involving risk and risk-related decisions.

Summary of Animal Health Risk Assessment Components

The Question (process initiation)

- Exactly what is the situation to be assessed?
- What is being requested, by whom, what animals or commodity, processed how, to come from where, how many, to go where, to be used for what, why?

Concerns (hazard identification)

- What can go wrong?
- What disease agents/hazards could enter the scenario?
- What is the outcome of concern (Ex. infection, clinical disease, death, lost sales)?

Likelihood of Going Wrong (probability component of risk)

Probability of Entry/Contamination
- What is the likelihood of the hazard entering the area of concern?

Probability of Exposure/Transmission
- What is the likelihood of exposure/transmission to susceptible hosts (vector, animal, human)?

Probability of Spread
- What is the biology/epidemiology of the disease agent/host relationship and the likelihood of spread from the primary exposure/outbreak, and the likelihood of outbreak control or eradication?

Consequences of Going Wrong

Biological Impact
- What is the biological impact (dose/response) on animal health, including the range of potential host species expected to be affected?

Economic Impact
- What is the expected economic impact (in $ if possible, or relative terms - Ex. 50% reduction in production)

Environmental Impact
- What are the expected or potential environmental impacts?

Uncertainty and Summary of Risk Assessment

- Describe the uncertainty of the data used.
- Summary of risk in terms of probability, impact and uncertainty.

Recommendations

- Options, and suggestions for actions, for consideration by managers.

Risk Assessment Request

(to be completed by managers)

ADMINISTRATIVE INFORMATION

To:

From:

Priority:

Date Submitted:

Desired Return Date:

Estimated Return Date:

PRELIMINARY RISK PROFILE

Brief Description of Commodity of Disease to be Assessed:

Brief History & Background of the Request:

Values(s) Potentially at Risk:

Potential Negative Consequences:

Public Perception of the Risk(s):

Risk Producer-Beneficiaries:
- *What groups benefit from taking the risk?*

Risk-Bearers:
- *What groups bear the risk and would benefit from risk management?*

Risk-Benefit Distribution:
- *Describe the distribution of the risks and benefits in society.*

Risk Internalization and Voluntary Self-Management Options:
- *Describe how groups or individuals might voluntarily manage the risk.*

Known Management Characteristics of the Risk:

COMMODITY PROFILE

What:

- *Exactly what is the commodity in question (Ex. animal species/subspecies, age, sex, number of source herds/flocks/family units, etc.)?*
- *What volume and frequency of movement is expected?*
- *What is the current volume and frequency of movement (into and out of a region) that might be affected if disease were introduced?*

Why:

- *Note why the commodity is being moved, and its intended use.*
- *What are the short, mid, and long term objectives of the importation?*
- *What are the expected and potential benefits to the commodity itself, the environment, or to the public.*
- *What are the expected and potential markets of enterprise, and their time frame?*
- *What is the expected and potential employment generated by the enterprise, and its time frame?*

Where:

- *Define as precisely as possible from where the commodity will come and to where the commodity will go.*

When:

- *Describe the expected time frames of commodity movement (Ex. seasonal).*
- *Is the intent to move/import only one shipment, or many consignments on a continuos basis?*

How:

- *How is the commodity expected to be selected, tested, transported? What is the known history and tests/treatments of herds/flocks/family units of origin? What is the known history and tests/treatments of specific animals?*
- *Describe the expected marshaling and transportation (Ex. means, routes, in-transit duration, ports of entry, etc.).*
- *What are the pre- and post-entry tests/treatments/quarantines that will be performed?*

Familiarity:

- *Is the organization/department/ministry familiar with this commodity or disease situation?*
- *How is it similar to other situations that the organization/department/ministry has dealt with?*
- *How is this commodity different fro those situations (and thus requiring risk assessment)?*

Trade Agreements:

- *Describe restrictions (if any) imposed by international or other trade agreements (Ex. CITES), or any other legal considerations.*

HAZARDS POTENTIALLY ASSOCIATED WITH THE COMMODITY

SCIENTIFIC AND COMMON NAMES	OCCURRENCE AT SOURCE	OCCURRENCE AT FINAL DESTINATION
Viruses (and Prions)		
Rickettsiae		
Bacteria		
Protozoa		
Parasites		
Fungi		
Other: Chemical Physical		

Summary:
Disease agents requiring further assessment include:
- *List*

DISEASE AGENT FACT SHEET

Etiology
What is the organism/agent involved (name, synonyms, common names)?

Disease
Name of disease (include common names and synonyms).
Summarize the main disease (in one or two sentences).

Descriptive Epidemiology and Host Range
Distribution (world, North American, provincial, state, etc.), with particular reference to regions at source(s) and final destination(s).

Clinical Findings
What are the signs of disease in various host species?

Detection and Diagnosis
Describe the tests available, including test sensitivity and specificity for each host species of concern.

Treatment
How can individuals or herds/flocks/family units by treated?

Prevention and Control
Is there a method available to prevent infection (Ex. immunization, treatment, quarantine, etc.)?
Can the agent/disease be controlled or eradicated if it were to be introduced into the region?

Risk Characterization

For Disease Agent: _____

PROBABILITY OF DISEASE

Probability of Entry:
- *expected volume of animal/commodity movement*
- *veterinary infrastructure*
- *incubation, duration, mortality, carriers*
- *prevalence and distribution*
- *pre-embarkation measures and quality control*
- *agent survival in the commodity, predilection sites, processing and transit conditions*
- *potential for contamination en route*
- *inspection and testing at entry*
- *preventative measures at destination*
- *comment on critical threshold*

Probability of Exposure:
- *the intended commodity use and distribution*
- *mode of transmission of the disease*
- *the biotic and abiotic factors that affect the agent/s survival*
- *the number, variety, and distribution of susceptible hosts*
- *presence of potential vectors*
- *calendar period of importation*
- *primary, secondary, and intermediate hosts of the agent*

Probability of Disease Outbreak:
probability of entry x probability of exposure

Spread Potential:
- *natural spread through contact, vectors, wind, water, feed*
- *"man made" spread through production or commercial practices*
- *mapping*

Summary of Probability of Disease:
- *schematic diagrams*
- *textual description*
- *mathematical model results (if possible)*

IMPACT OF THE AGENT/DISEASE

Host Range and Health Impact:
- *host range (humans, domestic or wildlife species)*
- *disease severity, morbidity, mortality*

Economic/Social Impact:
- *points of view*
- *anticipated export and domestic trade restrictions and impact*
- *duration of impact*

- *treatment, eradication, and clean-up*
- *overall expected dollar value of impact*

Environmental Impact:
- *direct health effect on wild species*
- *recreation and aesthetic values*
- *potential environmental impact of clean-up*
- *potential environmental impact of commodity itself*

Summary of Impact:
- *statement summarizing impact*

SUMMARY OF RISK AND UNCERTAINTY

Probability and impact.
Model sensitivity assessment.
Uncertainty assessment.
Overall rating -- negligible, low, medium, or high risk.
Statement concerning risk to human health.

Risk Management Considerations

For Disease Agent Commodity: _____

Summary Statement of Agent/Commodity/Pathway Assumptions
- *assumptions used*

Summary Statement of Overall Risk
- *overall risk rating for the commodity/pathway*

Summary of Detection Systems
- *identification methods and diagnostic tools*
- *limitation, sensitivity, specificity*
- *needs*

Eradication Potential
- *comment on feasibility of eradication under three (low, medium, high) prevalence assumptions*
- *examples of eradication efforts and their outcome*

Technical, Control Options
- *available prevention and control measures*
- *physical, chemical, biological options*

Recommendations
- *from a biological, technical point of view*
- *recommendation for further action (yes or no)*
- *list of specific technical recommendations*

ANIMAL TRANSLOCATIONS AND TESTING FOR DISEASE

- good to have a validated diagnostic test that accurately identifies those animals with the disease of concern

- unvalidated or inaccurate diagnostic tests can be seriously misleading and can give you a false sense of security

What can go wrong with a diagnostic test?

- false negatives
  - where the test is negative, but the animal is actually harboring the disease organism
  - many reasons for this depending on the type of test, including testing during the pre-patent period (period before the animal is shedding organisms), using the wrong test, using an insensitive test, reporting of wrong results, etc.
  - tests with low sensitivity give many false negative results
- false positives
  - where the test is positive, but the animal is healthy and is NOT harboring the disease organism
  - many reasons for this, once again depending on the type of test, including using a test that is not specific (so that it "cross-reacts" with other things, showing a positive result in the absence of the disease organism), reporting of wrong results, etc.
  - tests with low specificity will give many false positive results

How do I know how accurate a diagnostic test is?

- it should have been validated properly, with results that allow you to calculate its false positive and false negative rates

- How should it be validated?

- let's say, for example, that somebody has developed a blood test for disease X (the disease of concern), where a blood

sample is taken from the animal, and it is called "positive" if the blood turns green after having a small amount of a chemical added to it

- (1) you need to know that an animal whose blood turns green really does, in fact, have the disease organism inside it
  - somebody needs to have compared the test results with some other more direct method ("gold standard" method) of diagnosing the disease (like pathology) in animals who had been naturally infected with the disease organism
  - and they should have calculated the test sensitivity, which gives you the false negative rate
    - test sensitivity is the proportion of diseased animals who test positive
    - if they say the sensitivity of a test is 90%, they are saying that 90% of the diseased animals will test positive; therefore, 10% of the diseased animals will test negative, and will be false negatives
    - **some diagnostic tests being used widely have a sensitivity well under 50%, meaning they have a false negative rate of well over 50%: these tests will miss over 50% of the diseased animals!**
- (2) you also need to know that an animal whose blood does not turn green really is, in fact, healthy and is not infected with the disease organism
  - somebody has to have used the test on healthy animals, and on animals that have conditions that could be confused with disease X
  - and they should have calculated the test specificity, which gives you the false positive rate
    - if they say the specificity of the test is 95%, they are saying that 95% of the healthy animals will test negative; therefore, 5% of the healthy animals will test positive, and will be false positives
    - **if test specificity is under 50%, more than half of the healthy animals will be false positives: you would be saying incorrectly that 1 out of 2 healthy animals are diseased!**

- if you do not know the sensitivity and specificity of the diagnostic test, you have absolutely no idea what your test results mean
  - and you have no idea how much risk you might be taking by including only *test negative* animals in your translocated group
- you should also have an idea about how high the disease rate is in the translocation animals' place of origin
  - in order, once again, to interpret your diagnostic test results in terms of risk
  - the higher the disease rate in the animals' place-of-origin, the greater the chance of bringing along a false negative animal
  - the lower the disease rate in the animals' place-of-origin, the greater the chance that a test positive animal is really a false positive

How do I increase test sensitivity to ensure I catch all the diseased animals?

- switch to a test with demonstrated 100% sensitivity
- or test the whole herd or flock of the animals at the place-of-origin, and disqualify the whole herd or flock if only one animal tests positive

Mitigating the Health Risks of Animal Movement

If after doing a complete assessment of the risks, a decision is made to proceed with the movement of animals, consideration should be given to measures that can be used to reduce those risks as much as possible.

Mitigation is used here in the sense of "*to make less severe, intense or painful*" and none of the measures proposed should be taken as a way of eliminating risk. This is particularly true of the risk associated with the inadvertent transfer of disease agents along with the animals because **it is impossible to sterilize living animals**.

The tools that are available include immunization (vaccination), treatment, quarantine, and division of the transplanted animals into discrete sub-populations.

Immunization or vaccination

Immunization is done with the objective of increasing the individual animal's resistance to infectious disease agents. General features of immunization include:

- no immunization protocol is 100% effective, i.e., some individuals in any population do not develop immunity.

- very few vaccines have been developed for use in wild animals. Most of those available have been developed for use in domestic animals and are used in wild animals without adequate testing to ensure that they are effective.

- vaccines only protect the individual immunized animal and do not confer any protective effective on their offspring. Thus, vaccination might be used to "*soften*" the initial exposure or to "*condition*" animals against diseases they will encounter after release but will not protect future generations.

- immunizations are relatively effective against some bacterial and viral diseases but are generally ineffective against protozoan and helminth (worm) parasites.

- many immunizations have a relatively short effective life without administration of booster doses.

- immunization may interfere with the test procedures required as part of a disease prevention protocol.

- immunization has relatively limited usefulness in reducing the risk of transfer of disease agents.

Treatment

Treatment of animals with various drugs may be used to eliminate specific disease agents prior to transfer, to protect animals during the transplantation process, or to "*soften*" the immediate post-release period. General features of treatment include:

- no treatment protocol is 100% effective, i.e., some individuals in any population do not respond in the expected manner.

- very few treatments have been developed for use in wild animals. Most of those available have been developed for use in domestic animals and are used in wild animals without adequate testing to ensure that they are effective.

- effects of treatment are transient.

-treatment may interfere with the test procedures required as part of a disease prevention protocol. In some circumstances, it may be necessary to develop test procedures to ensure that the animals have not been treated prior to testing.

Quarantine

The word quarantine is defined as "*to detain or isolate on account of suspected contagion*" or "*a strict isolation imposed to prevent the spread of disease*". General features of quarantine include:

- it must be possible to maintain strict isolation with no possibility of contact with sources of infection. This requires both totally separate adequate facilities and a rigid enforcement.

- the length of the quarantine is determined by the specific disease. The duration must be sufficiently long so that either pre-existing disease agents will have disappeared or become non-infectious, or that they would become evident if present (i.e., longer than the prodromal or prepatent period). There is no suitable quarantine period for diseases, such as herpesvirus infections, that have a life-long carrier state).

- there must be regular repeated testing during the quarantine period.

- every animal that becomes sick or dies during quarantine must be the subject of a complete clinical and necropsy investigation.

- groups of animals should be divided into small sub-groups held in isolation.

- there must be pre-release standards specified; if an animal or group of animals fails to meet the standard no release occurs.

- animals may exchange disease agents within the group during the quarantine period.

- quarantine may be done at the site of origin or at the release site, or both. There are disadvantages to each type of quarantine.

Division of transplanted animals into sub-groups

- best way of reducing the risk that a single epidemic might cause extinction of the entire population.

- disadvantages of inbreeding, loss of heterozygosity, susceptibility to stochastic events.

Journal of Zoo and Wildlife Medicine 24(3): 296–303, 1993

LEGAL IMPLICATIONS FOR THE MANAGEMENT OF INFECTIOUS DISEASE IN CAPTIVE BREEDING AND REINTRODUCTION PROGRAMS

Margaret E. Cooper, LL.B., F.L.S.

Abstract: Programs for the captive breeding, introduction, reintroduction, or translocation of an animal can involve a chain of events including capture, captivity, propagation, movement, veterinary diagnosis and treatment, and scientific procedures. All such activities may be subject to legislation that may be applied at international, national, regional, or local levels. It can relate inter alia to conservation, animal health, welfare and research, administration, and to human safety. The diversity of the relevant law necessitates the planning and management of programs to ensure compliance with regulatory requirements in the course of achieving scientific objectives.

Key words: Legislation, wildlife, permit, import, welfare, safety.

INTRODUCTION

Scientists concerned with the conservation of endangered species have, over the past decade, come to recognize that disease may have an impact on populations at risk. The smaller the population the more serious is a loss from whatever cause; the outbreak of infectious disease may have a dramatic impact on the survival of a declining population. Likewise, the effectiveness of the procedures that have been developed to assist the recovery of a population, such as captive breeding and reintroduction, may be limited by the incidence or prevalence of the infectious disease.

Techniques and practices used for the detection, prevention, and treatment of infectious disease are of increasing importance in captive breeding and reintroduction programs. These programs may include the capture, holding in captivity, transportation, and release of animals. Disease prevention, surveillance, monitoring, and treatment may require the taking and processing of diagnostic and postmortem samples in addition to the handling and management of animals. In many cases such work has to be carried out in the field, often in remote areas with limited facilities, which may necessitate the movement of the animals or samples involved.

All the activities described above are subject, to a greater or lesser degree, to legislative supervision and regulation, which must be taken into consideration at an early stage in planning any project.

PRINCIPLES OF LEGISLATION

It is the aim of this paper to discuss the main principles of legislation that are of significance in the management of infectious disease in captive breeding and reintroduction of endangered species. Because the form and details of legislation vary from one country to another, it is intended that this paper should focus on the broad legal principles applicable to the situations outlined above. These principles have been identified to enable those involved in a specific situation to seek out the relevant legislation of the appropriate jurisdiction (Table 1). These areas will be discussed in general terms to give an indication of their scope. Examination of the specific legislation and reliable guidance or current knowledge is necessary to ascertain the precise requirements for any particular project.

Attitudes, implementation, and enforcement are also highly variable. It is important to bear in mind that any guidelines or principles formulated may have to be implemented in either highly sophisticated countries with strong enforcement facilities

Durrell Institute of Conservation and Ecology, University of Kent, Canterbury, Kent CT2 7NX, United Kingdom.

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or in those countries of the world where legislation may be old fashioned, enforcement may be haphazard, and the impact of bureaucracy may be unpredictable yet crucial to success.

The relevant areas of law are: 1) wildlife conservation, 2) animal health, 3) import and export, 4) welfare, 5) transport, 6) veterinary law, 7) research, and 8) health safety and liability.

Wildlife conservation

Conservation legislation is designed to protect free-living wildlife. Consequently, most activities involving the movement of threatened species are likely to be affected by such laws. In particular, capture, taking, marking, releasing, recapture, and methods of capture require authorization. Applicable laws also require that the subsequent possession of the wild animal be authorized. In such cases it is important that captive breeding projects maintain careful records of animals entering and leaving a project and of animals bred, because the onus is on the project or animal manager to prove that animals have not been illegally obtained from the wild.

Animal health

Most countries have passed legislation aimed at controlling the spread of diseases, such as anthrax, tuberculosis, foot and mouth, rinderpest, swine fever, Newcastle disease, chlamydiosis, or salmonellosis, which are likely to endanger domestic species of commercial significance or where there may be a threat to human health.

Such regulation is normally administered by the ministry or department responsible for agriculture, which will have extensive powers to constrain a disease outbreak by restricting the movement of affected animals, requiring isolation, slaughter, cleansing and disinfection of vehicles and premises, and, in some circumstances, vaccination of animals. While these provisions generally apply to domestic species, there may be situations in which disease in nondomesticated species must be reported or subjected to an investigation.

Import and export

Animal health: Animal health legislation also regulates the import of animals, and many nondomesticated species of animals are also affected. An import permit or license must be obtained prior to the animal's arrival at a designated port of entry. Other requirements include, in the country of export, veterinary examination, health certificates containing information as to the health of the animal and the disease status of the country, and quarantine both before exportation and following importation.

The import of dead animals, specimens, eggs, embryos, and any potentially pathogenic material also requires an import license.

Movement of endangered species: The international movement of animals is regulated with a view to the reduction of the threat that commerce poses on endangered species. The ministry or the department responsible for the environment normally operates these controls. These provisions are imposed by the national laws of individual countries, which implement the global Convention on International Trade in Endangered Species of Wild Fauna and Flora (known as CITES or the Washington Convention).[2] The European Community (EC) directly imposes the CITES provisions within the EC by way of a regulation that takes direct effect in the 12 member countries. CITES provisions apply whenever an animal listed in its appendices is moved across national boundaries (e.g., for scientific and captive breeding purposes) even if no commercial element is involved. Movement of animals listed in Appendices I, II, and III of CITES must be authorized. Permits for Appendix I species are not available for primarily commercial purposes, Appendix II permits are issued to monitor trade levels in such specimens, and Appendix III of CITES lists species that individual countries wish to regulate. Permits can only

Table 1. Some significant national and regional laws and regulations pertaining to wildlife.[a]

Area of law	USA[6,9]	UK[5]	EC[b]	Other countries[c]
Wildlife conservation	ESA BEPA (50CFR22)[e] MBTA MMPA (50CFR220)[e] (NMFS) State laws	Wildlife & Countryside Act 1981 Orders[f]	Directives[d] 79/409/EEC 92/43/EEC	Most have laws or regulations
Animal health	9CFR92, 160 (USDA) 9CFR71, 72 (USDA)	Animal Health Act 1981 Orders[f]	Various directives	Many have laws or regulations
Import and export (Animal health)	9CFR92, 98[e] (USDA/APHIS) 21CFR1240[e] 42CFR71[e]	Animal Health Act 1981 Orders[f]	Various directives	Many have laws or regulations
Import and export (CITES/ESA)	50CFR13,[e] 23 (USFWS)	EC Regulation 3626/82[g] Endangered Species (Import and export) Act 1976	Regulation 3626/82[g]	Approximately 190 countries have laws or regulations
Import and export (Other)	PHSA 42CFR71 (CDC) 21CFR1240 (CDC) WBCA (USFWS)			
Welfare	State laws Animal Welfare Act 9CFR1, 2, 3[e] (USDA/APHIS)	Protection of Animals Act 1911-88	See[d]	North American, European, British Commonwealth (and some other) countries have laws and regulations
Transport	9CFR3, 70, 92 (USDA/APHIS) 50CFR23 (USFWS) Lacey Act 50CFR14 (j) (USFWS)	Animal Health Act 1981 Welfare of Animals During Transport Order 1992	Directives 90/425/EEC 91/496/EEC 91/628/EEC	Some countries have laws and regulations

wildlife.[a]

Table 1. Continued.

Area of law	USA[6,9]	UK[3]	EC[b]	Other countries[c]
Veterinary practice	Veterinary Practice Act Acts in state statutory codes 9CFR160 Accreditation	Veterinary Surgeons Act 1966 Orders[f]	Directives 78/1026/EEC 78/1027/EEC	Some countries have laws and regulations
Research	Animal Welfare Act 9CFR1, 2, 3 (USDA/APHIS) HREA (NIH) ISLAA (NIH)	Animal (Scientific Procedures) Act 1986	Directive 86/609/EEC	Approximately 100 countries have laws and regulations Some have voluntary codes for institutions
Medicines	FDCA (FDA) CSA (DEA) 21CFR (HHS) State laws	Medicines Act 1966 Misuse of Drugs Act 1971 Orders and regulations	Various directives	Most countries have laws and regulations

[a] Acronyms defined as follows (USA agencies responsible for enforcement are shown in parentheses): AWA = Animal Welfare Act, BEPA = Bald Eagle Protection Act, CDC = Centers for Disease Control and Prevention, CFR = Code of Federal Regulations, CSA = Controlled Substances Act, DEA = Drug Enforcement Agency, EEC = European Economic Community, ESA = Endangered Species Act, FDA = Food and Drug Administration, FDCA = Food, Drug, and Cosmetic Act, HHS = Health and Human Services, HREA = Health Research Extension Act, ISLAA = Improved Standards for Laboratory Animals Act, MBTA = Migratory Birds Treaty Act, MMPA = Marine Mammal Protection Act, NIH = National Institutes of Health, NMFS = National Marine Fisheries Service, PHSA = Public Health Service Act, USDA/APHIS = United States Department of Agriculture/Animal and Plant Health Inspection Service, USFWS = United States Fish and Wildlife Service, WBCA = Wild Bird Conservation Act.

[b] The European Community (EC) includes 12 countries. Regulations have a direct effect in member countries without the need for national legislation. Directives must be implemented in each country through national legislation or by administrative edict.

[c] Other countries have such a large number and variety of laws and regulations that these cannot be presented in detail. Legislation and regulations may be national or, in federal governments (e.g., Australia), they may be national, regional (i.e., state, province, canton), or both.

[d] The Council of Europe includes approximately 25 countries. It has produced conventions in the subjects indicated. Such conventions are implemented through national legislation in member countries.

[e] Permit regulation/licensing.

[f] Orders and regulations in the United Kingdom (UK) are derived from Acts. They are subsidiary to legislation, similar to the USA Code of Federal Regulations (CFR). In this table, Orders are derived from the Acts listed above them.

[g] As amended and under review.

Other countries[c]

Most have laws or regulations

Many have laws or regulations

Many have laws or regulations

Approximately 190 countries have laws or regulations

North American, European, British Commonwealth (and some other) countries have laws and regulations

Some countries have laws and regulations

be issued if certain conditions designed to safeguard populations are satisfied. Some countries may apply stricter controls than those laid down by CITES itself; e.g., the EC extends its CITES controls to certain species at particular risk to trade in Western Europe, and individual countries may choose to regulate the import and export of non-CITES species. CITES regulates not only live animals but, also, dead specimens and "derivatives," i.e., parts of animals and samples taken from listed species. CITES Resolution Conf. 5.9 requires the application of Appendices I–III controls to "any specimens which appear from an accompanying document, the packaging or a mark or label, or from any other circumstances, to be parts or derivatives . . . ." [10] Although there is a limited exemption for exchanges between designated scientific institutions, the general principle is that derivatives should be subject to CITES controls. A proposal for a resolution to relax such provision with regard to DNA samples was submitted by Denmark to the Eighth Meeting of the Conference by the Parties to CITES in 1992, but this was not accepted.

General: It is essential to appreciate that the import of endangered species is likely to be subject to animal health as well as endangered species controls outlined above.[5] Because import controls vary according to country and species and, in the case of animal health, are subject to frequent change, it is necessary to make inquiries of the appropriate department prior to any shipment. Failure to comply with administrative and legal formalities can put a project as much at risk as failure to follow correct scientific and veterinary procedures. Penalties for noncompliance may include confiscation, destruction, or return to the country of export of an animal or its derivatives as well as fines and imprisonment. Failure to provide the correct or properly completed documentation can cause delays at customs points or the refusal to allow an animal into the country, requiring its destruction or return to its country of origin. Many countries do not have adequate holding facilities at ports or airports, and animals may suffer or even die before the import formalities are completed.

Welfare

Whenever animals are involved, the issue of animal welfare cannot be far away and, in the light of public concern, it must be considered a significant factor whenever dealing with live animals. It is important that the relevant legal requirements and ethical standards are built into a project at the planning stage.

Legislation intended to prevent cruelty to animals rarely affects free-living wild animals but normally applies to domestic species at all times and to other species while held in captivity; invertebrates are rarely protected. For those working in a country where the legal welfare requirements are limited, it may be advisable to voluntarily apply the higher standards of humane treatment that are accepted elsewhere. Education and supervision of staff not accustomed to such standards may have to be provided for in planning projects.

The approach and content of animal welfare laws can vary considerably; however, the prohibition of overt acts of cruelty, and more generally, the causing of unnecessary suffering are normally the core provisions.[8] Any factor, such as failure to provide appropriate food, water, accommodation, or necessary veterinary care may amount to causing unnecessary suffering.

Transport

Live animals: Welfare considerations are widely applied to the transportation of animals on a national, interstate, and international basis. Legislation requires that animals should not be injured or suffer unnecessarily in transit and often has provisions regarding the vehicles, containers, environment, attendance, food, and water to be provided. In some countries, legislation specifies other matters such as cage sizes, journey times, rest periods, cleaning, and

disinfection provisions. It is usually forbidden to load animals that are about to give birth or are ill, and there may be requirements for the separation of species and sexes, for the prevention of overcrowding, and other factors. Where standards are not set by law, care should be taken to provide conditions appropriate to the animals concerned and to the avoidance of suffering.

Specific requirements for air transport, particularly relating to crate dimensions, have been laid down by the International Air Transport Association (IATA)[7] and are implemented by all major airlines usually on a voluntary basis. However, EC countries are required to implement the EC Directive, a1/628/EEC on animal transportation, which incorporates the IATA Regulations and CITES Guidelines. The British Welfare of Animals During Transport Order (1992) does this in a way that makes failure to comply with the Regulations or Guidelines an offense that may be prosecuted under the Animal Health Act (1981). The CITES Secretariat has produced guidelines[3] for the transport, by any method, of species to which the Convention applies. The Convention itself, in Articles III, IV, and V, requires that a living animal must be "so prepared and shipped as to minimize the risk of injury, damage to health or cruel treatment."

Postal services: Postal services restrict the type of material that may be sent by mail. This may apply to biological and pathological samples since they are potentially harmful to people. Post office rules exist in some countries for carrying pathological samples regarding packaging, labeling, and method of dispatch. There may be different requirements for inland and overseas mail. Diagnostic laboratories may provide special packaging and advice for the dispatch to them of slides and biomaterial.

Veterinary law

Procedures constituting veterinary surgery must be carried out by veterinarians duly authorized by the country or state in which the work is performed. Legislation normally defines the scope of the veterinarian's authority. Veterinary practice is often defined as the diagnosis and the medical and surgical treatment of animals. It also defines the procedures that must be performed by a veterinarian and which animals must be treated by a veterinarian.[1,4,9] There are often exceptions to these requirements, which allow for care to be given as first aid in an emergency by a lay person, for scientific research, and in special situations. There may be some common factors between work done as veterinary surgery, scientific research, and animal management. It is important to distinguish these categories and the authorization required and to ensure that the appropriate legislation is followed.

Veterinary legislation normally defines the animals that must be treated by a veterinarian. For example, "animal" may be defined as warm-blooded animals, all vertebrates, or the term "animal" may be given a restricted meaning leaving certain classes (e.g., fish) that may be treated by nonveterinarians.

The supply, possession, and administration of drugs are normally strictly controlled and often subject to the prescription, advice, or supervision of a veterinarian. In the case of nondomestic animals the use of many drugs is not licensed for such species and the drugs must be used with appropriate safeguards for consultation with the client, and if there is any risk of the animal being used as food, the application of the appropriate withdrawal periods. Holders of dangerous drugs such as those used for immobilization may be required to meet prescribed standards of safe storage. In countries where such safeguards are not imposed or are not enforced, the higher standards should be observed voluntarily.

Research

Much of the work carried out on endangered species is conducted as scientific research. When this is the case it is necessary

to ensure that the work is carried out in conformity with the relevant legislation or codes of practice. Many countries have passed legislation concerned with scientific research in the laboratory, and in some cases, field studies are also subject to regulation. This may require authorization of the research worker, the procedures used, and the type of animal involved. The law often requires observance of codes of practice or guidelines. Enforcement may be by way of official inspection or self regulation through animal care and use committees. The more effective incentive for compliance is the loss of funding or authorization rather than prosecution under the legislation. Some institutions in countries without appropriate laws apply their own codes of practice in animal usage.

In countries where there is little or no regulation of the methods of scientific research, including field work, it is advisable (for visiting workers in particular) still to ascertain whether a general research authorization is required in order to carry out research or to use academic facilities such as a library. Sometimes conditions are imposed, which require that when specimens are collected a corresponding set must be left at an appropriate institution in the host country.

Health, safety, and liability

The procedures associated with the study of disease in endangered species may present risks to the people carrying out the work involved. The handling of samples, parasites, medicines, chemicals, and equipment often present hazards. Likewise, field work may take place in dangerous situations or harsh climatic conditions. Programs and projects must have health and safety provisions incorporated at the planning stage. This will help to ensure that suitable equipment, protective clothing, and systems of work are provided and budgeted for from the outset.

High standards of health, safety, and welfare are set in some countries' legislation and apply to employees, students, and voluntary workers; codes of practice are used to put the requirements into effect. It is advisable to encourage the adoption of high levels of safety even where there are no legal requirements or standards are low. Rigorous training and supervision may be needed to ensure the appropriate standards, especially in areas where hygiene is normally poor.

There is also a need to protect against civil liability for avoidable accidents. Failure to do so can lead to claims for substantial compensation for damage when an accident would have been preventable. Insurance is an important element in making provisions against liability when accident prevention procedures fail.

CONCLUSIONS

The discussion of the legal principles relevant to the impact of infectious disease in captive breeding and reintroduction programs for endangered species has been set out in the most general terms. Once the general principles appropriate to a project have been identified, the requirements of the specific laws can be taken into consideration.

It is essential that relevant legal issues are discussed and incorporated in any project from an early stage. Compliance with regulatory procedures and satisfying the demands of bureaucracy can consume much time and patience, but good preparation may prevent people and animals from being put at risk and may avoid loss of or damage to important biological samples. While scientific, environmental, and social requirements are the raison d'être of any program relating to endangered species, failure to take into consideration legislative and administrative requirements may prejudice the success of a project.

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Received for publication 15 December 1992.