WILDLIFE DISEASE RESEARCH AT THE APHIS NATIONAL WILDLIFE RESEARCH CENTER

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Research on wildlife diseases at the newly formed Wildlife Disease Program (WDP) at the United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS), National Wildlife Research Center (NWRC) concentrates on wildlife diseases of importance to domestic animal and human health. We are conducting studies on wildlife rabies, bovine tuberculosis (TB), chronic wasting disease (CWD), West Nile virus (WNV), pathogenic bacteria of birds, and pseudorabies (PR). The goal of the research is to develop innovative methods for surveillance, intervention, prevention, and control of these diseases.

NWRC Facility and Capabilities

The NWRC is located on a 43 acre master facility located on the Colorado State University campus in Fort Collins, Colorado. It includes an 83,000 square foot Wildlife Science Building with 30% dedicated to specialized laboratories and 70% in offices and administrative and information areas. There is a 25,000 square foot Animal Research Building (ARB) containing laboratory animal modules, cage washing area, necropsy and surgical rooms, state certified incinerator, and an approximately 2,000 square foot BSL-3 biocontainment area with 6 small and 2 larger rooms for animals and 350 square feet in 3 laboratory rooms and pass-through autoclave. A state of the art complex of 19 outdoor animal pen structures and 4 support buildings has just been completed to hold a variety of mammal and avian species. Construction on a new Invasive Species Building will begin in the fall of 2004. The NWRC employs an animal care veterinarian and animal care staff and has Animal Care and Use and Biosafety Committees to oversee animal care and disease studies.

The NWRC (formerly the Denver Wildlife Research Center) was established in the 1940's. The mission of the NWRC is "to seek to protect wildlife from adverse effects of human activities while also reducing the damage and hazards that wildlife causes to agriculture, forests, industry, and other areas of human involvement and to investigate and manage zoonotic diseases to protect human health" and recently to investigate and manage livestock/wildlife disease interactions. The mission of the WDP of NWRC is to study the ecology of wildlife diseases, to assess the risk of disease transmission among

wildlife, domestic animals, and humans, and to develop methods that reduce or eliminate such transmission.

The WDP has a large 1800 square foot standard BSL-2 laboratory and 3 smaller 200-300 square foot laboratories in the Wildlife Science Building. The small laboratories in the BSL-3 biocontainment suite in the ARB contain two biosafety cabinets and the equipment to work with live viruses and bacteria that are BSL-3 agents. The laboratories are fully equipped to conduct serology and antigen detection, standard bacteriology procedures, specimen processing, and reagent preparation. The diagnostic capabilities of the WDP in virology and bacteriology include methods using standard microbiological procedures; cell and tissue culture for virus isolation; viral identification and serology by cell culture neutralization and rapid focal inhibition (RFIT) tests; molecular genetic analysis by polymerase chain reaction (PCR), electrophoresis, genetic sequencing, and microarrays; antibody and antigen detection by enzyme-linked immunosorbent assay (ELISA), direct and indirect fluorescent antibody (FA and IFA), immunohistochemistry (IHC), and PCR; and histopathology. The laboratory has staff and the equipment to currently process about 500 samples per week, depending upon the tests required, for serology, bacterial isolation, and antigen detection. Additional staff, laboratories, and high through-put processing equipment (robotics) will be needed to dramatically increase the sample processing load. The WDP has a new field station at Texas A&M University-Kingsville in south Texas that will conduct research on wildlife diseases of importance to humans and to livestock, such as pseudorabies in feral pigs.

NWRC is also entering the planning stages to construct a stand alone wildlife disease research building (WDRB) on the NWRC campus to meet BSL-3 criteria and it is the final component of NWRC's facility Master Plan at its Fort Collins headquarters site. The basic principles underlying the need for this building were approved by APHIS officials in 2001. The building, with its BSL-3 containment capability, will allow APHIS to conduct much more extensive wildlife disease monitoring, surveillance, and research projects than NWRC currently can. The existing facilities are not amenable in content or size to the Center's current research requirements, let alone the extensive research NWRC is being asked to do in the future. The NWRC will also be able to separate its biocontainment research from all other types of laboratory wildlife research, giving a much greater margin of safety for staff, for the research being conducted, and to NWRC neighbors.

When completed, the NWRC will have the capability to detect and develop control methods for wildlife diseases in free-ranging wildlife and will provide the laboratory and animal holding/testing facilities necessary to develop methods to identify, monitor, control and possibly prevent the introduction of wildlife-borne foreign animal diseases into

the United States. Scientists at NWRC will be better able to study the ecology and epidemiology of foreign animal diseases and emerging diseases in wildlife and carry out research concerning the control and possible eradication of some wildlife-related diseases such as CWD, WNV, TB, brucellosis, pseudorabies virus (PRV), rabies, hantavirus, leptospirosis, tularemia, plague, and salmonella. The building also will provide APHIS with increased facilities and capacity for use in responding to emergency situations, such as the recent introduction and human infection with monkeypox virus.

Guidelines are being developed by APHIS for membership in the National Animal Health Laboratory Network (NAHLN). Increasingly USDA-APHIS-VS National Veterinary Services Laboratory (NVSL) is relying on member diagnostic and research labs to support its ability to respond to animal health emergencies. While our BSL-3 facilities would not function as a full spectrum diagnostic laboratory, the NWRC mission is consistent in lending emergency diagnostic support for specific organisms, especially those whose reservoirs are in wildlife. Our existing Quality Assurance/Good Laboratory Practice infrastructure along with our laboratory expertise and capabilities will allow us to apply for accreditation and serve as a surge laboratory for specific diseases and pathogens, e.g. avian influenza. Within this context of normal endemic disease emergencies, support for wildlife disease surveillance for foreign animal diseases and support for emergency laboratory testing as a result of a bioterrorism event are within our technical and infrastructure capacity for specific agents and protocols once accreditation is achieved.

In addition, the demand and need for BSL-3 wild animal space to conduct controlled experimental infection studies on diseases of wildlife has increased dramatically during the last 10 years with the introduction and emergence of important zoonotic diseases such as West Nile virus, Bovine TB, hantavirus, rabies, and monkeypox and wildlife diseases like chronic wasting disease. The planned construction of a new WDRB will help address the wild animal needs and will provide APHIS with increased facilities and capacity for use in responding to wildlife disease emergencies and the ability to resolve important disease issues that involve livestock-wildlife and human-wildlife interactions. To support both experimental and field investigations, a complete laboratory infrastructure is needed which will include BSL-3 laboratory rooms, biosafety hoods, and associated equipment to provide laboratory support for lab and field studies, surveillance, and vaccine testing and evaluation. In addition, rapid diagnostics for diseases in wildlife (rabies, TB, WNV, etc) can be developed or modified for use in support of wildlife disease research. The ability to process large numbers of samples for multiple diseases in any surveillance effort will require expanded capabilities for rapid processing of samples. The infra-

structure of the new WDRB would include diagnostic capabilities in the areas of virology and bacteriology, including methods using standard microbiological procedures; cell and tissue culture for virus isolation; viral identification and serology by cell culture neutralization and rapid focal inhibition (RFIT) tests; molecular genetic analysis by polymerase chain reaction (PCR), electrophoresis, genetic sequencing, and microarrays; antibody and antigen detection by enzyme-linked immunosorbent assay (ELISA), direct and indirect fluorescent antibody (FA and IFA), immunohistochemistry (IHC), and PCR; and histopathology.

The NWRC has a centralized library with an information and communication center, conference facilities, centralized computer system, large storage facilities, metal and wood workshops, garage, electronics and chemistry support laboratories, administrative support personnel, fleet of vehicles, and nine field stations located throughout the states to support its research efforts.

Wildlife Diseases of Special Importance

In 2000, The United States Secretary of Agriculture enacted Declarations of Emergency for TB and rabies, citing threats to livestock, and human health and safety. In an effort to eradicate TB and rabies, the NWRC was directed to conduct research that would lead to a reduction or elimination of the potential transmission of these diseases.

Bovine TB in Wildlife. The significance of TB is reflected in the efforts to eradicate it from the United States since 1917, and the USDA-APHIS has made major progress in eliminating the disease. By the mid-1990s, only a few known infected cattle herds remained and it looked like the eradication of the disease in the United States was forthcoming. However, between 1975 and 1998, TB was documented in Michigan white-tailed deer (*Odocoileus virginianus*) with increasing prevalence, and scientific evidence suggested that deer had transmitted the disease to cattle (Schmitt et al. 2002). Consequently, Michigan's "Accredited-Free Status", which allows for unrestricted interstate movement of cattle, was suspended by USDA/APHIS in 1998. Large economic costs are incurred by a state and the livestock industry when the state loses its Accredited-Free status. It has been estimated that Michigan will incur losses of $22-74 million over a 5-year period.

In Michigan, the focal point of the disease is in the northeast corner of the lower peninsula. A variety of measures are being, or have been, implemented in Michigan in an interagency attempt to slow the spread of the disease. These include more testing of cattle herds, depopulation of infected cattle herds, liberal hunting seasons to reduce deer density, restrictions on artificial feeding of deer to avoid concentrating deer in small areas where disease transmission is more likely, and the depopulation of a large, private herd of captive cervids (mostly white-

tailed deer) by USDA-APHIS-WS.

Research on TB in Michigan began at the NWRC in 2001 and continues today. The research effort is aimed at understanding the role of wildlife as reservoirs and vectors of the disease. Studies, to date, have found that TB is being transmitted to cattle by deer through indirect routes; i.e. by contaminated feed, rather than by direct contact. Other studies have shown that at least four wildlife species in Michigan, other than deer, are infected with TB: raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), gray fox (*Urocyon cinereoargenteus*), and coyotes (*Canis latrans*). However, only coyotes have an apparent high prevalence of infection with TB, nearly 25%, whereas the other species are less than 4%. Coyotes, therefore, may serve as a good sentinel species because they apparently magnify the infection rate found in Michigan deer which average about 2%.

Current studies are obtaining information on other species that scavenge deer and are sympatric with deer and cattle, such as raccoon and red fox (*Vulpes vulpes*). These species could also serve as effective sentinel species for assessing the presence and prevalence of TB in the environment and aid in understanding and managing TB. To obtain information on their home range sizes, dispersal distances, and proximity to livestock, which are fundamental in determining if they could be effectual sentinel species, we have radio marked 56 raccoons and 5 red foxes throughout a 4.63 km^2 farmland community in the endemic area. Radio marked individuals are further documented at cattle watering sites by data loggers and animal-activated cameras. This effort has just begun and no results are in, though, observationally we are routinely documenting direct and indirect contact between these carnivores and cattle. Whether these wildlife species, other than deer, transmit the disease to other animals is not known but is a subject for future research at NWRC.

Other studies conducted by NWRC scientists attempt to reduce the indirect contact between deer and cattle in the TB infected area in Michigan. Those studies involve the use of fencing, guard dogs, and various scare devises aimed at keeping deer away from cattle and their feed, such as haystacks and silage. Some of these experiments have shown success, including the use of fences around cattle feed sources and the use of dogs to keep deer away from the cattle farms.

The evaluation of livestock protection dogs to minimize direct and indirect contact between potentially TB-infected deer and cattle was conducted on two privately-owned deer farms that contained unnaturally high deer densities to insure a challenging evaluation of the dogs. Protected pastures contained a dog and 4 calves and unprotected pastures contained just 4 calves. We used a variety of tracking and observation methods of data collection. We documented that deer used cattle feed 113 times in unprotected pastures and never in protected

pastures, deer approached within 5 m of cattle 79 times in unprotected pastures and 3 times in protected pastures, and deer use of cattle pastures as detected by video data occurred 3 times in protected pastures and 426 times on unprotected pastures. These data suggest that dogs may reduce the potential for disease transmission from deer to cattle. The efficacy of the dog protection on actual cattle operations in the TB endemic area is being evaluated.

Wildlife Rabies. Rabies is an acute, fatal viral encephalomyelitis of mammals most often transmitted through the bite of a rabid animal. Greater than 90% of all animal cases reported annually to the Centers for Disease Control and Prevention (CDC) now occur in wildlife (Krebs et al. 2000). The principal rabies hosts today are wild carnivores and bats. The majority of rabies cases reported to the CDC each year occur in raccoons, skunks (primarily *Mephitis mephitis*), and bats (Order Chiroptera). However, rabies is maintained in other wildlife including gray fox, red fox, and coyotes.

Although human rabies deaths are now rare in the United States, there are significant impacts associated with rabies. The estimated public health costs associated with rabies detection, prevention, and control have risen to over $300 million annually (Krebs et al. 1995). If rabies strains such as those transmitted by raccoons, gray foxes, and coyotes are not prevented from spreading to new areas of the United States, the health threats and costs associated with rabies are expected to increase substantially as broader geographic areas of the U.S. are affected.

The primary means of controlling wildlife rabies in the United States has been through the use of oral rabies vaccination (ORV) (Slate et al. 2003). Since the first field release of the *Vaccinia*-Rabies recombinant (V-RG) vaccine-laden baits in 1990, the annual number of oral vaccine baits produced and distributed has risen nearly exponentially to a total of well over 10,000,000 in 2003. These baits are designed to target raccoons in the eastern and southeastern United States and for control of rabies strains in coyotes and gray foxes in south and west-central Texas. Though the ORV program has been used successfully for nearly 15 years, a number of issues regarding its safety and efficacy have not been fully addressed. For example, improved vaccination rates in target populations, effects on non-target populations, potential for vaccinated animals to shed recombinant *vaccinia* virus, optimal barrier widths for vaccination, more efficient delivery systems, and on alternative vaccines. Scientists at the NWRC are addressing these issues by conducting field studies on raccoons, skunks, and gray fox, and experimental pen studies on a number of species.

Research by NWRC scientists have found new bait design and formulations to use in skunks and are working on better baits to use in raccoons for delivery of the oral V-RG vaccine. Field studies by NWRC

scientists are presently underway to evaluate these baits in 5 states. In collaboration with various universities, NWRC scientists are conducting research on raccoon and skunk ecology in urban as well as rural settings, on better techniques to estimate raccoon density and on the effects of density and target population distribution on vaccine bait distribution.

Although several studies have previously looked at the question of bio-safety concerning the rabies vaccine being used in wildlife, some species were not evaluated. Therefore, pen-studies are underway at NWRC to address concerns of bio-safety of the recombinant *vaccinia* virus associated with rabies vaccine in selected avian and mammalian species. To date evaluations have found no lesions or safety concerns due to the *vaccinia* in several species of wildlife. The rabies vaccine, V-RG, appears to be safe for use in the field for wildlife.

Studies will soon be underway on evaluating the persistence of protective antibody of rabies once an animal has been vaccinated with the oral V-RG. Past studies have only evaluated the protection of the vaccine on a short-term basis. Our studies will evaluate protection long-term, up to 18 months. Also, studies will soon begin on gray fox ecology associated with the ORV zone in Texas. Studies are in the planning stage to assist with development of an oral rabies vaccine for skunks, since the V-RG being used in raccoons is not efficacious in striped skunks.

Other Wildlife Diseases of Importance

In 2003, the NWRC began research studies on CWD in collaboration with USDA-APHIS-VS; Wildlife Disease Surveillance, Monitoring, and Research as part of the National WDP of WS; and PRV and other diseases of importance to livestock and humans in Texas.

Chronic Wasting Disease. In May 2003, the NWRC received $500,000 from the USDA-APHIS-VS line item in the FY03 budget with Congressional language to address CWD. As a result, the NWRC Wildlife Disease Research Program developed a CWD research project, selected a Project Leader and devoted the remainder of FY03 to project planning and meeting with federal, state, and academic scientists involved with CWD. The initial funding was used to initiate the project and develop infrastructure and to establish cooperative research studies in several states. These field studies are providing basic information on CWD epidemiology, and are developing and implementing methods for decreasing prevalence and transmission within and among cervid species and between captive and wild cervids. Funding for research in FY04 increased 50% and has allowed us to expand ongoing collaborative studies and initiate new research.

One of the primary concerns of APHIS was the potential transmission of CWD between captive and free-ranging cervids (Miller and

Williams, 2004) and NWRC has begun research to understand the rates and types of contacts between them and is developing cost-effective barrier techniques and strategies to reduce or eliminate contact. We are using track plots and motion-activated video to determine how common interactions through game farm fences are between farmed and wild cervids (mule deer [*Odocoileus hemionus*], white-tailed deer, and Rocky Mountain elk [*Cervus elaphus nelsoni*]). Our primary objective is to determine if disease transmission risk exists along game farm fences. We are evaluating 9 fences around elk farms in Colorado and 5 fences around white-tailed deer farms in Michigan. Track-plot data are collected bi-weekly and video data are collected continuously. Track plots document where animals visited the same point during a 24-hour period. Video documents when wild or farmed animals were at the fence and the nature of interactions. We are finding considerable variation in the species, sex, age class, and number of wild cervids that frequent game farm fence lines. Preliminarily, direct interactions between farmed and wild white-tailed deer (1) appear less common than between farmed and wild elk (71). We are using a Geographic Information System (GIS) to document relationships between farmed and wild cervid interactions and landscape attributes. Game farm management practices appear to impact fence-line activity. Stocking rates, proximity of males to females, feeding procedures, and fence construction all appear to contribute directly to the potential for interaction. Based on our results, we will develop recommendations for methods of reducing interactions.

The NWRC is investigating and comparing the density, movement, and habitat use of white-tailed deer and mule deer and how these characteristics relate to the manifestation, transmission, and spread of CWD in Nebraska. In western Nebraska, where CWD occurs, NWRC is using telemetry to learn about the ranges and movements of mule and white-tailed deer. Concurrently, we are conducting fine-scale surveillance to locate infected deer. Deer range in the area centers on the North Platte River, and the potential exists that CWD could move east along the river rather quickly if management actions are not taken. At the same time, we are continuing a long-term study of the ecology of deer along the Missouri River. Data from this study will be used in the development of models and formation of management decisions.

Investigations of a potential CWD vaccine using scrapie prions in mouse and rabbit models have begun at NWRC as well as collaboration on the development of rapid tests to identify prions in biological and environmental samples and on methods to decontaminated surfaces and environmental samples. Studies are planned to investigate the role of predators and scavengers in the possible transmission and/or dissemination of CWD and to improve capture and census techniques for wild cervids.

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Bacterial Pathogens Associated With Wild Birds. The growing populations of non-migratory Canada geese have raised public health concerns about the transport of cattle and human bacterial pathogens by these birds (Kullas et al. 2002). These disease concerns focus on two areas: fecal contamination of public water-ways and lawns and contamination of cattle herds. There are many factors involved in calculating disease risk, including presence of pathogens in the environment, how humans or livestock may become exposed to the pathogens, and the susceptibility of the host to the pathogen. Our research is directed toward determining the nature of the pathogen population found in goose feces and the possible role geese may have in transporting pathogens across the landscape. We radio collared Canada geese in southeastern Pennsylvania to determine their movement patterns across agriculture and urban landscapes. We found that local populations of geese moved from rural pasture settings where they foraged in dairy cattle pastures to urban parks, amusement parks, and lawns. We isolated and characterized *E. coli* strains in geese, beef cattle, dairy cattle feces as well as in grass and soil substrates, and found strains of human or cattle pathogenic E. coli in goose feces. We were also able to determine that these strains contained genetic virulence markers for K1 (a trait to help the bacteria evade the immune system), *eae* (a trait that allows the pathogenic strain to attach to the intestine), and SLT-2 (a gene responsible for producing shiga-like toxin associated with hemorrhagic disease). These results suggest that geese may pick up pathogens from one site and transport them to another site, and that goose feces contain pathogenic bacteria of concern to human and cattle health.

Dairy cattle that are no longer productive generally enter the human food chain as the source of ground beef. If the cattle are infected with pathogenic bacteria at the time of slaughter, fecal contamination of the beef is possible. A single infected cow can contaminate multiple beef products at the slaughter-house level. One means of minimizing this risk is to increase biosecurity at the farm site. In an effort to better understand sources of infection of cattle with human pathogens we surveyed local pigeon populations at dairy farms in Colorado. Pigeons were identified as carriers of pathogenic *Salmonella* and *E. coli*. Eight percent of pigeons carried some type of virulence marker gene associated with hemorrhagic disease in humans. Three percent of pigeons carried pathogenic *Salmonella*. Pigeons should be viewed as agents of transport or reservoir for human and cattle pathogens and pigeons control should be incorporated as part of routine farm-side biosecurity measures.

Pseudorabies Virus Studies in Feral Hogs. As part of the research project at the new NWRC Field Station at Texas A&M University-Kingsville, we are determining the prevalence of diseases, prima-

rily PRV, in feral hogs and evaluating the potential for disease transmission from feral to domestic swine. We are using global positioning system (GPS) collars to monitor the movements of feral hogs across the landscape and determine their home range and movement patterns. Partial disease results for some of the initial 30 captured hogs have documented PS and brucellosis infections in free-ranging populations.

Surveillance, Monitoring, and Research of Wildlife Diseases. The NWRC-WDP provides technical advice, training, support and laboratory analyses of specimens for a variety of collaborative research studies on WNV in a number of avian and mammal species for cooperators in Wildlife Services, Centers for Disease Control and Prevention (CDC), local and state health departments, state and federal wildlife agencies, universities, and others. Some of the wildlife disease research conducted by NWRC under this project is described below.

A new surveillance method to provide an early warning predictor of human WNV activity was investigated utilizing cliff swallows (*Hirundo pyrrhonota*) in the western United States. We empirically conducted surveillance for WNV in cliff swallow colonies and were able to detect cliff swallow infection five weeks prior to the human epidemic. We believe that this system has utility as an early warning system for human public health risk and are working with local city and county health officials. These groups are using our spatial data of virus occurrence to help guide their vector control efforts. Swallows are a good model for early detection of WNV. They breed in habitats that have high mosquito populations, thus exposing them to high numbers of vectors early in the season. They are abundant and ubiquitously distributed. Their nesting colonies occur at almost every overpass and culvert throughout the western United States. We chose to monitor nestlings because they represent stationary targets that integrate virus activity in local geographic areas and are easy to sample. Nestlings may become infected by being bitten by mosquitoes, nestling may be fed infected mosquitoes by their parents, and nestlings may be infected by nest parasites (Cimicid bugs) that live in nests and were infected during the previous year. We are in the process of documenting all of these routes of infection.

A multi-year mark-recapture study of forest passerine birds and serological survey for WNV is being conducted in southeastern Pennsylvania. The objective of the study is to characterize time-structured epidemiological information on the disease dynamics of WNV in deciduous forest-passerine ecosystems. Using mist-nets we are marking local bird populations. We have been able to recapture birds between and within seasons, taking blood samples at these intervals, totally 2000 samples to date. From these data we are able to determine WNV prevalence and risk of exposure, and to estimate survivorship within

the populations. These field data will allow us to quantitatively estimate the impact of WNV on birds and the data will also be useful in parameterizing simulation models we are developing.

Little is known about the distribution and susceptibility of small mammals to WNV, i.e., whether small mammals are dead-end hosts or potential amplifying hosts and reservoirs for disease. In collaboration with CDC, we conducted a sero-survey for West Nile virus in small mammals in five states throughout the United States and in white-tailed deer in one state to determine which species were frequently infected with WNV. Raccoons, opossum, white-tailed deer, and squirrels (fox, *Sciurus niger*, and gray, *S. carolinensis*) all showed evidence of high exposure of local populations to the virus. Experimental infection studies will be conducted to characterize morbidity, mortality, viremia and antibody response over time to determine if any of these mammal species are competent reservoirs and/or useful for surveillance. The data will be used in the development of epidemiologic models.

Greater Sage-Grouse (*Centrocercus urophasianus*) suffered significant mortality from WNV infection in 2003 (Naugle et al. 2004) and we investigated their susceptibility to WNV during experimental studies conducted in collaboration with the U.S. Fish and Wildlife Service and Colorado State University. In completing the study objective we housed grouse under captive conditions. No study had successfully maintained wild sage grouse in captivity for extended periods of time. We were able to do so, and we were able to get two of the birds to reproduce in captivity. This was an unexpected added benefit to this study that will prove useful in the conservation of this species. Greater Sage-Grouse appear to be the most susceptible species to WNV studied to date. Mortality is 100%, with 80% of birds dying within 3 days of infection. Infected grouse circulated high titers of virus by the time of death, suggesting that during this time period the birds were highly infectious. This species is likely to be listed by the U.S. Fish and Wildlife Service as a threatened species. This news of its susceptibility is not encouraging for long-term conservation efforts. Extensions to these experimental studies are being contemplated for the future.

Geographically explicit, agent-based simulation models for the establishment, persistence, and spread of mosquito-borne diseases, e.g. WNV, are being developed in collaboration with the University of Pennsylvania. A multi-host/multi-vector model was developed and coded for computer simulations. The stochastic spatial model was compared to traditional epidemiological multi-host models (SIR models), the standard for the discipline, and was found to produce similar results. We are now poised to further develop this model to incorporate spatial aspects (something the SIR models cannot do) and validate the model under different ecological settings mentioned above. This model will be useful in evaluating “what-if” scenarios, e.g. mosquito control strat-

egies, and their impact on disease dynamics (e.g., spread, establishment, persistence). The model is intended as an aid in disease management. The model will be adaptable for other disease systems, e.g. TB, rabies, etc.

Summary

The types, frequency, and distribution of wildlife diseases are expanding in the United States (Friend et al. 2001) which increases the risks to livestock and human health. Some significant diseases of livestock were nearly eradicated (bovine TB, brucellosis, pseudorabies), but reservoirs in wildlife have emerged and threatened the eradication status. New and emerging zoonotic diseases of wildlife are impacting public health and both bring new challenges and controversy surrounding disease management when a highly valued public resource, such as wildlife, is involved. The NWRC is conducting research on a variety of wildlife diseases and is developing methods and strategies to reduce or eliminate transmission to domestic animals and humans. Our studies, of course, depend upon a lot of cooperation and collaboration among many public agencies, both state and federal, and private property owners who own much of the land inhabited by our wildlife species.

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