IN THE WORKS: RECENT AND ONGOING CWD RESEARCH AND MANAGEMENT PROJECTS

Abstract

The likelihood of project duplication or overlap increases as CWD research and management projects multiply in response to available funding. The purpose of this document is to inform investigators about current and recent work in an effort to prevent the use of limited resources to answer questions that already are being, or recently have been, answered. These projects are funded by a variety of sponsors including state and federal agencies, universities, and NGOs. The summaries/abstracts contained here are presented as we received them. We formatted them for consistency. If you are aware of additional projects that should be included here, please notify Matt Dunfee at mdunfee@wildlifemgt.org

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Contents

CHRONIC WASTING DISEASE AGENT

Immobilization of Chronic Wasting Disease Prions by Pyrogenic Carbonaceous Geosorbents to Reduce Infectivity; Bartz, J (Creighton Univ), H Li (MI State Univ [MSU]), W Zhang (MSU), and Q Yuan (Creighton).

Chronic wasting disease (CWD) is an emerging prion disease with an expanding geographical range that is detrimental to cervid populations and has a poorly defined zoonotic potential. This project proposes to study immobilization of CWD prions by pyrogenic carbonaceous geosorbents (PCGs) to reduce CWD infectivity. PCGs can be produced naturally or artificially by wild or managed fires (chars), and engineered pyrolysis (such as activated charcoal and biochar). The PCGs are affordable, environmentally friendly, and may be used in multiple settings for immobilizing CWD prions (such as bedding materials and soil amendment at contaminated sites). The potential applications of PCGs depend on fundamental understanding of interactions and immobilization of CWD prions with PCGs (specifically activated carbon and biochar) and subsequent effects on prion infectivity and the ecology of CWD. This project will determine kinetic and equilibrium sorption of prions to PCGs, develop computational models of prion-PCG interactions, and evaluate the effectiveness of PCGs to reduce prion infectivity using animal bioassay. This project is aligned with stakeholder priorities in modeling and evaluation of plausible environmental contamination. These findings will be foundational to competing for external grants and allow for development of future large-scale projects to mitigate CWD prions in situ and protect cervids from prion infection.

Chemical Inactivation of Soil-bound CWD Prions; Thomas, S (WI DNR).

Soil is a plausible reservoir of prions in the environment, and CWD prions have been detected in naturally contaminated soils. Prions are notoriously difficult to inactivate, exhibiting remarkable resistance to most methods of inactivation that are effective against conventional pathogens. Past efforts to disinfect prion- contaminated deer and elk pens have proven unsuccessful. The proposed research will test the efficacy of two potential decontamination agents in inactivating CWD prions in soil. We will work out conditions to maximize their efficacy in inactivating prions associated with soil under controlled conditions in experimentally contaminated soils. We will then test the efficacy of an optimized protocol for inactivating prions in soil samples from at least one field site with a high incidence of CWD. The ultimate goal of the project will be a robust decontamination protocol for application to potentially contaminated soil in situ (e.g., captive cervid facilities, mineral licks, scrapes).

Characterizing and Mapping Chronic Wasting Disease Prion Strains Across the United States; Zabel, M (CO State Univ [CSU]) and J Ballard (AR GFC).

Chronic Wasting Disease (CWD) is the only known prion disease affecting captive and free-ranging cervids, including deer, elk, moose, reindeer and caribou. This devastating disease continues to spread unabated across North America, currently affecting cervids in 26 states and three Canadian provinces. Most recently, CWD has been confirmed in reindeer and moose in Norway and Finland, marking the first detection of CWD in wild, free ranging animals in Europe. Mounting consensus agrees that CWD poses a significant threat to free-ranging cervid populations in North America and associated hunting and tourism economies. To date, the basic question of single or multiple emergence events remains virtually untested; likewise, systematic examination of inter-and intra-site prion heterogeneity has not been attempted. We will leverage our experience with classical and novel prion strain typing techniques to facilitate multilateral comparisons and distribution analyses of PrPCWD strains, including disease epicenters in Colorado and Wyoming and newly emerging areas of Michigan, Missouri, Texas and Arkansas. Comparing CWD prion strain properties will lend insight to potential origins of CWD and inform CWD mitigation and management strategies, policies and best practices for state wildlife agencies and the hunting and broader communities they serve.

Assessment of Movement of Prions Across the Captive-Wild Interface; VerCauteren, K (USDA/NWRC) and W Walter (USGS/PSU Coop FW Research Unit).

Pennsylvania has detected chronic wasting disease (CWD) in captive and wild white-tailed deer since 2012. Since first detection occurred in the same year in both captive and wild deer, it is difficult to ascertain the role the captive-wild interface has on disease transmission in the state. Since 2012, over 10 captive cervid facilities and 250 wild deer have tested positive for CWD. Considering Pennsylvania is second only to Texas in the number of captive facilities statewide, assessments of various components of the captive-wild interface are warranted. Previous studies have documented crows were able to transmit infectious prions responsible for CWD in a controlled laboratory setting but field evaluation of this possibility has yet to be tested. Furthermore, limited information exists as to wildlife species' use of captive facilities or areas surrounding these facilities to evaluate the role these species play, if any, of movement of prions around the landscape. Our objectives are to determine potential exchange of infectious prion protein material between captive cervid facilities and surrounding areas using Real-Time Quaking-Induced Conversion (RT-QuIC) assays, and to monitor use of captive cervid facilities by crows and track their movements on and off captive-cervid facilities. Frequency of use of facilities and movements off facilities can provide an index of risk of prion spread even if prions are not detected using RT-QuIC.

DIAGNOSTICS

Trained Canine Detection of Chronic Wasting Disease Infection; Golden, G and S Karns, (CSU).

CWD management is complicated by the lack of a practical, non-invasive, live-animal screening tests. Studies have shown animal biodetectors are capable of detecting changes in odor based on infection status in spite of environmental variation. Experiments conducted at the Monell Chemical Senses Center and USDA National Wildlife Research Center in partnership with Colorado State University have demonstrated that mice, ferrets, and most recently, dogs are capable of detecting avian influenza (AI) infection using fecal volatiles. Not only did ferrets demonstrate they were capable of detecting AI in the feces from asymptomatic ducks, but also in the feces of another species (i.e., chickens). Importantly, ferrets demonstrated that the odor changes used to detect AI were specific to AI infection when given the opportunity to select fecal samples from ducks infected with AI, Newcastle's disease virus, or infectious laryngotracheitis within the same panel of samples. Dogs have demonstrated the ability to detect avian influenza in fecal samples, fecal swabs, cloacal swabs, gastrointestinal tracts, and carcasses. Our current body of research clearly predicts that canine biodetectors can be trained to identify populations and/or individuals infected with CWD via detection of urine and/or feces odors. Such a tool may also prove useful in identifying potentially infected live animals, carcasses, urine, feces, and contaminated environments.

Assessment of PMCA and RT-QuIC for CWD Diagnosis in Animal and Environmental Samples; Lockwood, M (TPWD) and R Morales (TX A&M).

The purpose of this project is to explore the best sample type (tissue/fluid/excreta) and prion replication platform (PMCA/RT- QuIC) for CWD diagnosis. Optimizations to these techniques will also be applied to environmental fomites that potentially contribute to CWD spread.

Evaluating the Diagnostic Efficacy of Using Pooled Samples for CWD Testing and Surveillance; Ruden, R (IA DNR).

This proposal addresses the need for more efficient diagnostic assays given the scale of CWD testing in North America. In Iowa alone we screened over 7,000 samples during the 2019-2020 surveillance period, which still pales in comparison to other states like Michigan and Missouri that screened over 20,000 and 30,000 samples, respectively. Pooled sampling is an approach routinely used in the animal health community to screen for diseases of agricultural significance. Here, we outline studies to validate pooled sampling using both the traditional screening tool, enzyme-linked

immunosorbent assay (ELISA), and a more sensitive amplification assay that is not yet commercially available, real-time quaking induced conversion (RT-QuIC). Once externally validated, we will pilot the pooled sampling technique with RT-QuIC to rescreen 2019-2020 surveillance samples deemed higher risk based on proximity to known positives.

CWD: Field Animal-Side Testing and Improving Laboratory Diagnostic Sensitivity; Sreevatsan, S (MSU), S Bolin (MSU) and K Straka (MI DNR).

The goal of this study is to provide improved hunter service in detection of CWD and the exploration of novel strategies for early disease detection and disease surveillance. The plan is to develop a rapid, portable, field-friendly screening test based on lateral flow technology, which is used for in-home and bedside testing. Researchers will target non-prion biomarker proteins of neurologic disease and develop a platform to expand testing capabilities for CWD into the field. Specifically, the study will focus on the S100 and 14-3-3 proteins, which are released into the cerebrospinal fluid and blood during brain disease. The highly sensitive, advanced RT-QuIC (Realtime Quaking Induced Conversion) technology will be used to examine species-specific conformations of normal deer prion protein to seed amplification and detection of the CWD prion protein (PrP^{CWD}). Researchers will compare the improved RT-QuIC process with the ELISA currently used at the MSU Veterinary Diagnostic Laboratory (VDL). The optimized RT-QuIC will enhance test sensitivity and test accuracy to improve estimation of disease prevalence. The benefits would be detection of deer in the early stages of disease, which would allow design of novel testing strategies. Enhanced test sensitivity may allow testing biological or environmental samples that cannot currently be done.

EDUCATION AND OUTREACH

National Coordination and Technical Assistance for the Prevention, Surveillance, and Management, of Chronic Wasting Disease (CWD); Dunfee, M (CWD Alliance, WMI) and J Fischer (WMI).

Using the expertise of Dr. John Fischer and the coordinator of the CWD Alliance, the highest priority, non-fiscal, CWD-associated needs of state wildlife agencies will be solicited. Based on this information, technical assistance and authoritative guidance will be provided to state wildlife agencies developing or revising CWD prevention, surveillance, and management programs for free-ranging deer, elk, and moose. Examples of assistance will include, but not be limited to, drafting or review of position statements, review of state CWD surveillance and response plans, review of CWD-related hunter and public educational materials (with emphasis on the consistency of messaging and language from state to state across regions and the country), and current updates on CWD developments including geographic and species distribution as well as research results from laboratory and field studies. Assistance also will be provided to the Association of Fish and Wildlife Agencies as it addresses CWD-related administrative policy and legislation at the national level.

Seeing is Believing – People and Deer in CWD Endemic Areas; Eckert, M (CO PW).

Colorado Parks & Wildlife (CPW) proposes the creation and delivery of professional videography to allow those potentially affected by CWD in free-ranging cervids to witness what is actually happening with CWD in Colorado and neighboring states. The proposed documentaries will inform and foster public and especially landowner cooperation, thereby offering a tool for facilitating CWD control and minimizing resistance to or obstruction of landscape-scale management efforts. The produced content would be freely available, distributed widely, and accessible to various publics on multiple websites, thereby reaching a national and perhaps international audience.

2020 Arkansas Chronic Wasting Disease Outreach Plan; Griffith, S (AR GFC).

In February 2016, an elk harvested in the fall of 2015 near Pruitt, Arkansas in Newton County tested positive for CWD. This was the first documented case of the disease in the State of Arkansas. Also in February 2016, a white-

tailed deer was found sick near Ponca, Arkansas in Newton County and tested positive CWD. An initial sampling effort in the vicinity of these cases found a total CWD prevalence of 23 percent in white-tailed deer from northern Newton County. Additional CWD positives have been found in Benton, Boone, Carroll, Independence, Johnson, Madison, Marion, Pope, Scott, Searcy, Sebastian and Washington counties. Meaning nearly a third of Arkansas counties are directly in our CWD management zone. The AGFC recognizes that the detection of CWD in Arkansas has significant biological, ecological, economic and sociological implications. Now that CWD has been identified in Arkansas, it represents a severe long-term threat to the health of cervids in the state. A key component to wildlife health and disease management is educating the public and staff about these issues. Educational components are intended to maximize participation in sampling efforts by the public, encourage reporting of disease events to facilitate rapid response by the agency, minimize loss of hunting participation associated with disease concerns, and increase awareness of the role of the Arkansas Game and Fish Commission and our public in wildlife management.

Developing a Research-Based Digital Media Campaign to Reduce the Risks of CWD; Hurst, J (NY DEC).

The purpose of our proposed project is to use digital marketing to influence behavior of New York hunters to lower the risk of inadvertent introduction of CWD to New York. CWD was detected in New York State in 2005, but following an intensive management response, it has not been detected again. The primary CWD management goal of the New York State Department of Environmental Conservation (NYSDEC) is to prevent new introductions of CWD to the state. However, a recent survey found that many New York hunters continue to engage in behaviors that pose a risk of CWD introduction or spread. The purpose of our proposed project is to use digital marketing to influence behavior of New York hunters to lower the risk of inadvertent introduction of CWD to New York. CWD was detected in New York State in 2005, but following an intensive management response, it has not been detected again. The primary CWD management goal of the New York State Department of Environmental Conservation (NYSDEC) is to prevent new introductions of CWD to the state. However, a recent survey found that many New York hunters continue to engage in behaviors that pose a risk of CWD introduction or spread.

Arizona CWD Outreach and Education; Justice-Allen, A (AZ GFD) and D Bergman (AZ GFD).

We propose to produce several short public service announcements in a visual format that will describe carcass transport rules, recommendations for carcass handling, Arizona Game and Fish Department (AGFD) surveillance and the desire of the Department for hunters to assist in surveillance, contributions made by taxidermists and meat processors to surveillance and disease prevention, management actions planned by Arizona Game and Fish, and basic information about CWD. We will distribute these videos through various media platforms. Additionally, we will develop highway signs that will be placed on important travel routes to alert hunters to the restrictions on carcass movement. The project will be supervised by permanent staff in the Marketing, Information, and Terrestrial Wildlife Branches. Funding for these individuals is provided by a USFWS grant (Pittman-Robertson).

Employing Collaboration and Innovation to Develop CWD Education and Outreach; Pomeranz, E (MI DNR), H Madill (MSU), J Burroughs (MSU), and D Doberneck (MSU).

This project seeks to co-create a community engagement process to develop an education and outreach plan for CWD in Michigan's core CWD area. Using an abbreviated charrette process, we seek to bring together a diverse range of stakeholders to develop an education and outreach plan, resulting in joint responsibility and commitment from project partners to implement a product.

Engaging Hunters in the Pursuit of CWD Best Management Practices for CWD Testing and Carcass Disposal; Henning, C (WI DNR).

In line with "AFWA Best Management Practices for Prevention, Surveillance, and Management of Chronic Wasting Disease" practices, the USDA names improved management of CWD affected herds and areas as core work for controlling the spread of CWD and enumerates CWD testing, restricted carcass movement and carcass disposal as tactics in pursuit of

those goals. As will be discussed in this proposal, robust testing and widespread, proper deer carcass disposal can only succeed with hunter buy-in and participation. To that end, concerted, consistent, timely and culturally relevant communication are needed to engage hunters on these topics. The communications objectives discussed in this proposal accomplish this task, augmenting ongoing efforts by the DNR to partner with hunters in the management of chronic wasting disease. Objectives 1 address the need in 2020 for widespread and saturated dissemination of messaging to hunters on CWD testing in support of the DNR's surveillance agenda for the year. To meet this objective, the DNR will develop and deliver outreach messaging to motivate hunters to participate in disease detection surveillance statewide with heightened focus on the Northern and Northeast districts. Objective 2 supports participation in proper carcass disposal by raising awareness among hunters on how and why to participate in this practice. To meet this objective, the DNR will develop and deliver outreach materials to educate hunters statewide on ways to reduce the risk of CWD transmission. Objective 3 addresses the need for updated outreach content that can facilitate hunter participation in CWD response and that is contemporary to the current digital communications environment as well as culturally relevant to Wisconsin hunters. To meet this objective, the DNR will develop and deliver guidance for hunters on how they can mitigate the spread of CWD in ways that are clear, action-oriented and culturally relevant to Wisconsin's Hmong and Latino hunting publics.

EPIDEMIOLOGY

Population-level Impacts of Chronic Wasting Disease on Arkansas's White-tailed Deer; Chamberlain, M (Univ of GA [UGA]), G D'Angelo, R Chandler, D Osborn, and R Chitwood (UGA), M Ruder (UGA-SCWDS); C Mathiason, N Denkers, and E Hoover (CSU).

Chronic wasting disease (CWD) is a concern to natural resource managers throughout North America. Contemporary research has provided critical information to help manage CWD transmission and minimize potential for spread of the disease. However, important knowledge gaps exist that continue to compromise the ability for state and federal agencies to properly contain CWD and mitigate its effects. The proposed research will be conducted in Arkansas, where CWD was first detected in 2015. Since then, the disease has been detected in white-tailed deer across 10 counties in the northwest portion of the state. The Arkansas Game and Fish Commission is committed to conducting applied research to provide necessary information that will allow the agency to proactively manage CWD transmission and prevalence, while also understanding individual and population-level effects of CWD. Herein, we propose a comprehensive, multifaceted research program to estimate deer abundance, evaluate influences of CWD on demographic and behavioral parameters, determine infection rates relative to these parameters, and develop a spatially-explicit population model that will forecast effects of agency management actions on the future spread of CWD and the consequences to the white-tailed deer herd.

Evaluation of Deer Population Parameter Estimates and Implications for CWD Management; Christensen, S (MSU), D Williams (MSU) and S Mayhew (MI DNR).

Chronic wasting disease (CWD) is a fatal disease caused by a prion that infects white-tailed deer in North America. White-tailed deer are a culturally and economically important species in the state of Michigan and CWD is jeopardizing the population health of deer within the state. Management actions for controlling CWD are largely dependent on deer regulations and hunter harvest. A current Michigan Department of Natural Resources (MDNR) and Michigan State University (MSU) led research effort is underway to determine how a management regulation, mandatory antler point restriction (APR), will change harvest of deer and ultimately affect deer abundance and age/sec composition in a 5-county area where CWD has been detected. However, limited resources have precluded taking full advantage of this important existing effort and critical gaps remain. In collaboration with Michigan DNR and MSU researchers, we will leverage data collected from this existing APR assessment study to accomplish two objectives: (1) identify optimal strategies of resource allocation to produce precise estimates of abundance and herd composition, and (2)

determine how APR regulations in Michigan could impact CWD prevalence and spread. Addressing these goals will greatly improve our efficient use of camera traps for future population estimation by wildlife professionals and our understanding of how harvest regulations affect disease dynamics.

Chronic Wasting Disease (CWD) Epidemiologic Risk Assessment of Farmed Cervids and Free-Ranging Cervids in Kentucky; Hagan, A (KY Dept of Ag).

Chronic Wasting Disease (CWD) is currently present in six of seven Kentucky-bordering states (Missouri, Illinois, Ohio, West Virginia, Virginia, and Tennessee). With detections of CWD in certified free herds and the natural movement of wild cervids, Kentucky's cervid population is at risk. Management plans to prevent and control CWD, are difficult to develop and implement as they need to consider factors that influence prevalence, incidence, transmission, and geographic spread. Factors such as population dynamics, genetics, animal movement and dispersal, type of cervid population (farmed vs wild) and landscape characteristics are important to understand when developing disease control and mitigation strategies. Current knowledge and data associated with these factors related to the Kentucky's cervid population is lacking. Additionally, Kentucky recognizes that the current CWD certification program, surveillance plan, state laws and regulations may no longer be adequate to prevent the introduction of CWD, especially in Southwestern Kentucky where the introduction of the CWD prion from the adjacent CWD affected area in Tennessee is of greatest concern. Furthermore, within Kentucky the random introduction of CWD through the movement of infected animals, carcasses, or high risk parts poses a non-negligible risk to cervid populations throughout the state. Kentucky's failure to prevent introduction of CWD, would have devastating effects on both the farmed cervid industry as well as the wild recreational cervid hunting activities in the state. Once introduced the long term consequences of persistent environmental contamination will contribute to poor cervid health and welfare and will create severe trade and movement restrictions. To enhance Kentucky's prevention of CWD introduction and proposed mitigation plans, the Department proposes to collect data related to type of population (farmed vs wild), population dynamics, genetics, and landscape characteristics. Data collection expands current knowledge on potential disease introduction and transmission risks factors and enables the development of advanced mitigation methodologies to efficiently and effectively control CWD; were the disease to enter Kentucky. To ensure science and evidence based CWD disease control measures are utilized, revisions to future certified herd management plans will be based on the wild and farmed cervid interactions data and habitat assessments.

Accumulation of Chronic Wasting Disease Prions in Plant Tissues; Pederson, J (Univ WI – Madison).

The primary objectives of this research proposal are to improve our ability to detect chronic wasting disease (CWD) prions associated with plant tissues by adapting the highly sensitive, high-throughput, real-time quaking-induced conversion (RT-QuIC) assay for use with plant tissues. In the first year, we will use model monocot and eudicot plants to define standard plant tissue extraction and RT-QuIC protocols and use these protocols to examine the dynamics of CWD prion accumulation in the leaf and stem tissues of the model plants. Use of model plants will facilitate method development and characterization of CWD prion accumulation by allowing us to test more plants in a shorter period of time due to their small size and rapid development compared to crops. In the second year, we will test the protocols developed in the first year with a subset of crop, forage, and browse plants commonly consumed by cervids (including maize, alfalfa, and soybean), adjusting protocols as necessary for these plants. Once we have established tissue-extraction and RT-QuIC protocols, we will evaluate the dynamics of CWD-prion accumulation in maize, alfalfa, and soybean leaves and stems. This two-year project will result in a set of RT-QuIC protocols that can be applied to common field-contaminated plants, and will provide data on which plant tissues are most likely to harbor CWD prions that have been taken up through the roots. Our anticipated results will provide improved testing protocols and will enable studies on the environmental transmission of CWD prions through plants.

Exploring the Potential for *in utero* Transmission of CWD Prions in White-tailed Deer; Ruder, M (UGA-SCWDS).

Chronic wasting disease (CWD) is among the most significant and complex

conservation challenges facing wildlife managers in North America. Since its initial recognition in the late 1960s, CWD has been documented in captive or free-ranging cervids in 26 states and 4 Provinces, and all native North American cervid species are known to be susceptible. Despite decades of research, we lack a complete understanding of CWD transmission. In utero mother-to-offspring CWD transmission (vertical transmission) appears to be efficient in some cervid species but has not been investigated in white-tailed deer. The overall project goal is to determine if CWD vertical transmission occurs in free-ranging white-tailed deer naturally exposed to CWD prions. To accomplish this, naturally infected, pregnant does will be collected in highly endemic regions of Tennessee, Arkansas, and West Virginia. Highly sensitive assays will be used to detect CWD prions in maternal and fetal tissues, as well as excreta. Vertical transmission of CWD, if it occurs, would represent an additional and important consideration for wildlife managers planning control strategies. In addition to management implications, understanding the potential for vertical transmission is needed to model and project CWD spread and the potential population effects.

Group Size, Bioaccumulation, and Baiting: Quantifying Factors Affecting Disease Transmission Among Deer; Williams, D (MSU), D Etter (MI DNR), and S Christensen (MSU).

The occurrence of chronic wasting disease (CWD) in Michigan is challenging the foundation of wildlife conservation efforts, causing reallocation of fiscal and staff-time resources, and posing a threat to the financial cornerstone of fisheries and wildlife programs. Effective disease management strategies depend on understanding how CWD spreads and grows on a landscape. While we have developed advanced models to estimate the spread and growth of CWD in Michigan, there is a critical need to inform the fundamental process that leads to disease transmission among deer: contacts. Transmission pathways for CWD are through direct (deer to deer) and indirect (environment to deer) contacts. Unfortunately, little work has been done to quantify those contacts among free-ranging deer beyond making assumptions about the proximity of radio-collared deer. We propose research designed to quantify how the landscape, deer density, and artificial attractants, such as bait, influence where and to what extent deer congregate, actual physical contact among individuals, and the accumulation and persistence of deer feces. This research will benefit from a concurrent field study on deer movement by leveraging the locations and movements of deer which will be GPS-collared for the duration of this study. Our research will engage local landowners and hunters in participatory research through involvement in distance sampling; we have previously demonstrated success using participatory research to collect this type of data in two areas of Michigan. This research would represent a critical advancement of CWD knowledge, directly inform holes in existing disease modeling efforts, and have clear applications for CWD management. Through strong partnerships and active deer disease research, our Michigan-based team is uniquely positioned and qualified to ensure a successful research project and dissemination of research findings to Michigan stakeholders.

Identifying Genomic Regions Associated with Chronic Wasting Disease in Elk: A Foundation for Understanding an Endemic Disease; Wright, W (AR GFC).

Prion disease in domesticated small ruminants is mitigated by selecting animals for resistant alleles located within the prion gene. The Rocky Mountain elk prion gene has an allele that lengthens the incubation period but does not confer resistance to CWD. White tailed deer, human, and mouse studies have demonstrated genomic regions outside of the prion gene impact prion disease status. Therefore, this proposal aims to identify genomic regions outside of the prion gene that associate with CWD status (detected or not detected) and determine if CWD disease pressure is influencing the genomes of elk. One way to ensure genomic regions identified as associated with CWD will be broadly applicable for all US Rocky Mountain elk (*Cervus elaphus* nelson: hereafter elk), is to sample from geographically distant locations to reduce the number of related animals sampled. For this proposal, elk samples will be from 5 different states, that at the time of sampling, had/have none to varying number of years (greater than 30 years to about 4 years) since CWD was detected at the geographical location. This proposal is in alignment with APHIS priority 4: conduct additional research on predictive genetics. We aim to identify genomic regions that influence resistance or susceptibility of elk to CWD. Identification of elk genomic regions that associate with CWD status will provide wildlife managers and captive breeders with genetic/genomic tools to support healthy elk

populations. In addition, this work may provide the foundation for a genomics-based elk CWD eradication program in the future.

Assessing movements of corvids after scavenging cervid carcasses to spatially understand their potential role in vectoring CWD; VerCauteren, K (USDA/NWRC) and G Wittemyer (CSU).

The emergence and spread of chronic wasting disease (CWD) in cervids has quickly become one of the primary wildlife disease concerns in North America. Transmissible spongiform encephalopathy diseases, including CWD, are problematic to manage due to their prolonged environmental latency. Understanding of CWD's transmission dynamics is still relatively rudimentary, with recognition that primary routes include horizontal and environmental transmission. But key drivers, correlates and factors affecting transmission dynamics require more study and are urgently needed to develop targeted mitigation and management approaches. Recent work suggested birds can serve as CWD vectors by consuming infected tissues or getting exposed environmentally and subsequently shedding pathogens in areas they visit. The ease with which birds travel long distances and traverse contained areas (i.e., fenced areas) could explain some of the less understood emergence events of CWD (e.g. spatially isolated discoveries of CWD positive individuals). Focal studies of American crows (*Corvus brachyrhynchos*) have recently verified their potential as vectors, through translocating infectious prions in their feces. Concerns about the potential of this common, migratory scavenger to translocate infectious prions to disease-free areas have raised new ideas about transmission processes. Corvid scavengers could potentially seed CWD infection where no other initial source of pathogen establishment is known. In addition to the potential pathogen transmission through avian scavengers, recent work has also suggested mammalian scavengers may also play roles in CWD spread. Several key gaps in our understanding of the potential for scavengers to serve as CWD vectors exist related to the potential spatial distribution of pathogen spread by different scavengers as well as the scavenging behavior (i.e., carcass consumption) that may make certain scavengers more or less likely to serve as vectors. Here we propose to address these gaps by quantifying the post carcass consumption movements of the cervid scavenger community to ascertain potential area of prion distribution by scavengers, assessing scavenger consumptive behavior on cervid carcasses, and diagnosing corvid use and selection within and around captive cervid facilities.

Assessing drivers of spread and transmission of chronic wasting disease in Michigan deer; Porter, W (MSU, dec'd) and D Williams (MSU).

The goal of this research is to provide high temporal and spatial resolution information regarding localized deer dispersal rates, timing and direction, seasonal movement patterns, and basic population characteristics to better inform and improve upon current chronic wasting disease (CWD) control strategies. This research is part of a multi-pronged approach to accomplish this goal and compliments another study that is developing new methods for detecting and removing diseased animals. By addressing dispersal rates, directions, and distances; evaluating hypotheses about environmental factors that are likely influencing dispersal behavior; parameterizing risk maps of first-order contact; and creating models of the interaction of landscape contexts (e.g., suburban, rural) and habitat characteristics, we will be able to better direct hunters and biologists to increase the efficiency of surveillance and removal actions.

FARMED CERVID MANAGEMENT

2020 CWD Management Improvement; Reinkemeyer, S (MO Dept of Ag).

The Missouri Department of Agriculture (MDA) is proposing a project that will protect its deer producers statewide and prevent CWD from entering its herds by incorporating the use of RFID tags, and by providing instructional materials to herd veterinarians. Annual herd inventories are presently a time-consuming event lacking in efficiency. This can be problematic in effectively managing herd populations. By issuing high frequency RFID tags to producers, the opportunity for human error during the documentation phase will be greatly reduced and a more accurate database will be created. An accurate database would be essential in

controlling a CWD outbreak and preventing its spread. Testing compliance has been established as a key element in effective herd management. However, it is imperative that producers and herd veterinarians have the tools and training to implement effective testing strategies. In order for CWD tests to provide accurate data, the tissue sample must be collected correctly. This project will allow herd veterinarians to acquire instructional materials and specialty tools that will ensure a valid and usable test sample 100% of the time. At the conclusion of this project, MDA will have a more efficient annual herd inventory, and; see more correctly sampled CWD test submissions.

Identification of Farm and Environmental Factors Associated with Chronic Wasting Disease (CWD) in Cervid Herds; Wells, S (MN Board of Animal Health).

In Minnesota, Pennsylvania, and Wisconsin alone, 40 newly detected herds have been identified since 2016. Once identified as infected, CWD-positive cervid farms are quarantined and most will be depopulated, as there are no treatment or vaccinations available, and no proven method to eliminate infection from exposed herds short of herd depopulation. Infected farms also pose a threat to susceptible wild cervids in the local area. Primary CWD preventive practices at this time are focused on preventing transmission through exposure of farmed cervids to infective prion protein using biosecurity practices and policies. However, transmission is possible through multiple exposure pathways to susceptible farms, and the relative risks of these exposures for CWD have not yet been evaluated across a population of cervid operations. The objectives of this study are to 1) Identify key farm and environmental risk factors associated with CWD-positive herd status on cervid farms; 2) Deliver study results to state farmed cervid industry representatives to help protect cervid farms from CWD infection. These objectives of the project address Objective 2 of the USDA CWD Management and Response Activities 2020 Cooperative Agreements Fiscal Year 2020 Request for Applications, focused on 'Improve the management of CWD affected areas and premises' as well as Objective 1 of the USDA CWD Management and Response Activities 2020 Cooperative Agreements Fiscal Year 2020 Request for Applications, focused on 'Improving the management of CWD affected herds and endemic populations'. Identification of risk factors associated with CWD-positive cervid farm status will improve understanding of disease transmission pathways and will be critical to inform improved disease prevention and surveillance efforts.

HUMAN DIMENSIONS

Carcass Disposal, Human Dimensions Survey, and CWD Communications: Striving to Improve Hunter and Landowner Participation in CWD Management; Almberg, E (MT FWP).

We are requesting funding to address 3 objectives that ultimately aim to improve hunter and landowner support of, and participation in, CWD management. These objectives include 1) the strategic placement of carcass disposal dumpsters around the state during hunting season to improve hunter compliance with carcass disposal rules; 2) two human dimensions surveys – one for hunters and one for private landowners, to assess awareness, support, and concerns over FWP's CWD management program; and 3) using the results from the human dimensions surveys to outline necessary changes to FWP's educational outreach and communication plan to improve public awareness, support of, and participation in CWD management. These objectives address USDA's funding priority issues #1 and #5.

CWD Show and Tell: Gauging Hunters' Willingness to Adopt Management Practices; Christensen, S (MSU), K Schuler (Cornell), N Pinizzotto (National Deer Alliance) and D Ortega (MSU).

Chronic wasting disease (CWD) threatens wild cervid populations and the funds available to manage and conserve wildlife. Despite the increasingly widespread apparent prevalence of this disease, few options to control or manage it have been successful. Many of the disease management options available to state wildlife agencies rely on deer hunters complying with new regulations or voluntarily

changing behavior following suggested best management practices for harvesting and handling potentially infected animals. Research in behavioral psychology has shown improved success with changing human behavior when subjects are provided with visual demonstrations of the desired actions. We will create short (< 2 min) videos for deer hunters that demonstrate a series of best management practices for reducing the spread of CWD. We will assess the impacts of these videos on hunter intent to accept management actions via a survey before deer season and actual behavior via a follow-up survey taken during the fall 2020 deer season. To assess each information treatment against a control, we will randomly select hunters from our total sample to participate in each survey group, including a group that receives no information treatment. Our sample will be taken from the National Deer Alliance membership. Survey results and an information impact assessment will provide critical insight into CWD management acceptance. Information campaigns are resource intensive for state agencies and therefore, must be as effective as possible. Understanding if information videos resulted in differences in hunter behavior will be vital for evaluating and targeting successful CWD management options.

MANAGEMENT

Optimization of CWD Surveillance, Management and Communication Strategies in Virginia; Gwynn, R (VA DWR).

Chronic wasting disease (CWD) is a fatal infectious disease of cervids and is considered one of the most significant threats to the long-term health and stability of Virginia's white-tailed deer population. To date, CWD has been detected in 88 wild white- tailed deer killed in five counties in northwestern Virginia and CWD management and control is one of the top five priorities of the Virginia Department of Wildlife Resources (DWR). This proposal demonstrates a commitment by DWR to improve efficiencies and sensitivities in CWD surveillance and management activities, commitment to proactive intervention, and evaluation of potential management techniques. Development of effective CWD surveillance strategies and management activities to prevent the introduction of CWD into new areas of Virginia and to control the spread of the disease are crucial components of the DWR CWD management and control program. This project aims to improve the efficiency of the DWR's CWD management and control activities through:

1. Evaluation of potential impact(s) of various CWD management activities on the spread of CWD in Virginia to optimize strategies related to management and control of CWD;
2. Improved efficiency and precision of statewide CWD surveillance to more rapidly detect CWD in new areas of Virginia; and
3. Optimization of CWD surveillance data management to target CWD surveillance in high-risk areas.

The DWR will use USDA funds to collaborate with Virginia Tech to accomplish aspects of the proposed work. Deliverables from these collaborations include the development of an eco-epidemiological model to help predict the effectiveness of CWD management activities, and streamlined and expedited CWD data entry that facilitates reporting and analysis.
DWR recognizes the threat that CWD poses to the white-tailed deer populations of Virginia. The agency intends to use this funding to help develop and evaluate effective CWD management and control activities, predict impacts of proposed control activities, and design a cost-effective and efficient CWD surveillance program to control and mitigate spread of CWD in Virginia through early disease detection.

An Innovative Approach to Evaluating Effects of Cervid Population Management for Chronic Wasting Disease on Both Public and Private Lands; Harms, T (IA DNR).

We propose to develop a user-friendly, model-based density estimator using images from remote cameras that will allow managers to directly measure effects of density reduction efforts. We will leverage remote camera imagery from existing investigations in CWD-affected areas to field test our density estimator and protocols. Combined, these goals will provide wildlife managers with a cost-effective and robust statistical tool critical to informing

CWD management decisions. Standardized deployment protocols allow for leveraging of data across jurisdictional boundaries to mount a regional adaptive management effort against CWD, and also allow for deployment on both public and private lands to foster a collaborative effort between managers and citizens.

Using Targeted Culling to Remove Social Groups of CWD-infected Wild White-tailed Deer in Minnesota's Endemic Zone; Jennelle, C (MN DNR).

In November 2016, the Minnesota Department of Natural Resources (MNDNR) discovered chronic wasting disease (CWD) in wild white-tailed deer (*Odocoileus virginianus*) of southeastern Minnesota. CWD is a fatal neurodegenerative disease of the family Cervidae, and appears to be spreading in southeastern Minnesota, albeit at low prevalence. The disease is of particular concern due to potential long-term demographic impacts to infected cervid populations and the economic importance of deer in Minnesota (a 500 million dollar industry). Contact between susceptible and infected individuals is thought to play an important role in increasing prevalence and the geographic diffusion of this disease, and management plans commonly attempt to minimize contact among animals by density reduction. Despite significant efforts on the part of management agencies, CWD has been extremely difficult to suppress using traditional harvest management. There has been some success in CWD management by targeted culling of deer around locations with CWD in Illinois. The MNDNR has implemented targeted culling of deer in this manner for three years since 2016. We intend to use this funding opportunity to support our agency culling efforts again during winter 2021 after the regular hunting season in locations previously found with CWD and potentially locations with new discovery of CWD from the fall 2020 harvest. We will use genetic samples from targeted deer at a very fine spatial scale to examine genetic relatedness and kinship patterns that have the highest likelihood of linkage to known CWD positive deer. We hope to discover kinship networks among deer that may provide the foundation for a genetic tracking tool that helps managers better understand both how long CWD has been in a localized population (disease establishment) and how effective harvest efforts are at removing select social groups with known infected members. Furthermore, we will quantify the variability of the prion protein gene among CWD positive deer and those harvested in close proximity to establish a baseline understanding of the distribution of CWD susceptibility in wild deer of southeastern Minnesota.

Prospective Simulation Assessments of Alternative Harvest Strategies to Mitigate and Control CWD Invasion and Spread; Jennelle, C (MN DNR), E Michel (MN DNR), S Christensen, J Martin (USGS), and D Walsh (USGS-NHWC).

A critical need for agencies managing chronic wasting disease (CWD) is to understand the possible impacts of proposed management actions. Wildlife management agencies have limited resources at their disposal, thus must choose strategies that offer the highest probability of success. We propose to create a user-friendly simulation tool that can evaluate alternative harvest strategies to suppress CWD. The user can experiment with alternative management strategies with user-defined population, epidemiologic, and harvest dynamics. All simulation assessments will be constructed within a Before-After-Control-Impact (BACI) framework allowing user-defined spatial and temporal scales of interest. Adjustment of management actions over time using information learned in a given harvest period will facilitate assessment of structured adaptive management decisions in a safe (simulated) environment. To achieve our goal, we have three main objectives. First, we will determine the optimal simulation architecture. Second, we will create a skeleton (within BACI design) for deterministic and stochastic simulations accounting for spatial and temporal heterogeneity. Third, we will permit time-step specific evaluation of outcomes, and modification of harvest strategies to evaluate alternative adaptive management decisions. We expect this tool to serve as a foundation in developing CWD management plans that offer the greatest likelihood of successful suppression/mitigation of CWD growth and spread. The timeline is as follows: Year 1) we will complete the simulation skeleton with essential functionality, Year 2) we will inform the simulation environment with real-world data, and Year 3) we will produce a final report and prepare manuscripts for publication.

Expanding Proper Deer Carcass Waste Disposal Options Statewide in Wisconsin; Kamps, A (WI DNR).

Chronic wasting disease (CWD) was first detected in Wisconsin in 2002 from three white-

tailed deer harvested during the 2001 deer hunting season. Moving forward, the 2018 deer hunting season was the first year that more than 1,000 CWD positive deer were detected statewide. The movement of dead or alive CWD positive cervid species (natural or human- assisted) is a key pathway in the spread of CWD. The infectious nature of the CWD prion contributes to an increased risk of introduction and spread of CWD if deer carcasses are brought to new areas and not disposed of properly. In 2018, the Wisconsin Department of Natural Resources (DNR) initiated an Adopt-a-Dumpster (AAD) program. The main goal of the AAD program is to provide hunters an option for appropriate deer carcass waste disposal, especially in areas where carcass disposal options are very limited or not already available. During the 2018 deer hunting season there were 16 AAD participants, and in 2019 participation expanded to 61 AAD participants (with 38 of these being cost-share), as well as 32 DNR hosted dumpsters. New in 2019 was a cost-share opportunity for AAD participants in select counties where the DNR provided 50% of the total cost of a dumpster, up to $500, for up to 2 dumpsters in select counties. All 72 counties in the state were given a classification as a tier 1 (CWD affected county with no disposal option), tier 2 (CWD affected county with disposal option or CWD watch county with no disposal option), or tier 3 (CWD watch county with disposal option or non-CWD affected county). The cost share option was available in tier 1 and 2 counties, which were 51 of the 72 counties. A CWD affected county is a county with a CWD or tuberculosis (TB) positive wild deer or farm-raised deer location. A CWD watch county is a county within 10 miles of a CWD or TB positive wild deer or farm-raised deer location. Hunter feedback indicates they appreciate having more deer carcass waste disposal options statewide, and AAD participants are satisfied with their involvement. In preparation for the 2020 deer hunting season, we anticipate the AAD cost-share participation will increase because we have expanded this option to all 72 counties, with four counties in the CWD endemic area in southern Wisconsin approved for up to five AAD cost-share dumpsters. It is also a priority to have DNR hosted dumpsters in tier 1 and 2 counties, if there are no AAD participants. Providing proper carcass disposal options statewide is an action item in Wisconsin's current CWD Response Plan. Carcass disposal is also in the management section of the AFWA Best Management Practices for Prevention, Surveillance, and Management of Chronic Wasting Disease, and is a direct action in priorities 1 (Improve the management of CWD affected herds and endemic populations) and 2 (Improve the management of CWD affected areas or premises) of this grant.

Modeling Spatial Harvest Strategies for Chronic Wasting Disease Transmission; Merrill, E (Univ Alberta [UAB]), M Lewis, and J Xu (UAB).

In 2020 we will complete on-going field studies that focus on obtaining field information as inputs into a spatial epidemiological susceptible-infected (SI) model for assessing how mule deer densities, landscape patterns, and deer behaviors influence the potential direct and environmental exposure to Chronic Wasting Disease (CWD) across landscapes typical of eastern Alberta. A post-doctoral fellow has begun to develop the spatial model built on our past population models but focusing on deer space use and movement responses that are expected to influence direct and indirect transmission. When completed, predictions of changing CWD prevalence and spread will be compared to observed rates of change and spread within selected areas in Alberta. In the current proposal, we request 7 months of funding to extend this work to use the model in an adaptive management framework as part of the planning phase for designing harvest experiments in Alberta. Specifically, we will use the model to stratify areas by potential rates of increase due to landscape carrying capacity and patterns, evaluate two deer harvest scenarios (male harvest relative to timing of rut; selective harvest by targeting infected individuals), and evaluate rates and spatial scales at which these deer harvest strategies need to be applied. Deliverables will include 1) an assessment of harvest strategies, 2) a user-friendly interface for managers to use the model, and 3) popular and scientific articles on model insights. This work is the next step in a sequence of research in Alberta directed at guiding management to minimize the continued spread of CWD.

Genetic Implications in Chronic Wasting Disease Management of Michigan White-tailed Deer; Ott-Conn, C (MI DNR) and J Blanchong (IA State Univ [ISU]).

Since 2015 the Michigan Department of Natural Resources (DNR) has conducted testing on over 80,000 wild deer confirming a

total of 189 wild chronic wasting disease (CWD) positive individuals in 9 counties. As CWD detections continue to expand the management zone, the best available science should be utilized to refine testing distribution and density to maximize opportunities for early detection and reduce the speed of spread for populations inside and outside of fences. Intensive surveillance used to inform our understanding of disease distribution has not yet detected additional CWD outside of the current CWD management zone; however, sustaining this level of testing is not feasible. With surveillance through hunter-harvested deer being the main tool for informing CWD management, consideration should be given to how funding cuts for CWD testing and a declining trend in hunting will affect the usefulness of surveillance as an informative tool. The DNR is proposing to utilize genetic techniques to develop strategies and inform surveillance and control CWD within the state. Two separate techniques are being proposed to address this current knowledge gap. First, we propose to use sequencing techniques applied to the prion gene to calculate the frequency of susceptible genotypes in regions bordering the management zone (Brandt et al., 2015; Miller & Walter, 2019; Robinson et al., 2016). Secondly, we propose to use microsatellite DNA markers, short sequences in non- coding regions of the genome. This microsatellite data will allow us to create a statewide dataset of deer for evaluation of landscape movement patterns to increase our understanding of how demographics may influence disease spread (Farnsworth et al., 2006; Miller et al., 2019). Together this data will allow for the creation of a layered risk assessment to target surveillance areas, inform management efforts, and increase the opportunity for effective management. This work will directly inform Michigan's CWD management and hopefully serve to guide management in other states.

A Standardized, High-Throughput Genetic Resource to Inform White-tailed Deer Population and Disease Management; Ott-Conn, C (MI DNR), J Blanchong (ISU), E Latch (Univ WI-Milwaukee), R DeYoung (Texas A&M), W Larson (NOAA), and D. Walsh (USGS-NWHC).

We are working to design a suite of efficient, cost effective, collaborative genomic resources for white-tailed deer that will be commercially available to wildlife managers and researchers. These panels will provide the genetic resolution necessary for population assignment of wild deer, distinguish captive and wild deer, screen prion protein gene variation, and investigate the connection between relatedness, landscape dynamics, and spread of disease.

2020 CWD Surveillance and Public Outreach Efforts in South Dakota; Switzer, C (SD DGFP).

The South Dakota Chronic Wasting Disease Action Plan was developed to provide guidance for the South Dakota Department of Game, Fish and Parks (GFP) and GFP Commission regarding the management and public outreach efforts related to chronic wasting disease (CWD). Chronic wasting disease was first confirmed in South Dakota nearly 20 years ago. Some may ask, "why is chronic wasting disease now a priority for the South Dakota Department of Game, Fish, and Parks?" This is a legitimate question. The answer and justification is complex, but can primarily be attributed to the following: new research findings and the suggested negative impact to deer and elk population growth rates; updated and concerning prevalence rates from elk within Wind Cave National Park (WICA) and Custer State Park (CSP); the need to ensure viable populations of deer and elk in the future; and the importance of deer and elk to hunters and their contributions to wildlife management. As a result, GFP has identified the following strategy through its Department Strategic Planning process: "Enhance the department's efforts to manage chronic wasting disease in deer and elk across the state and launch a strategic communications plan to educate and inform public about the safety, risks and any new regulations".

Assessing Harvest Management Influences on Chronic Wasting Disease Trends in the West; Wood, M (CO PW, WY GF) and M Miller (CO PW).

There is an urgent need to identify practical management strategies for chronic wasting disease (CWD) that can minimize impacts on cervid resources nationwide. CWD threatens the health and viability of native cervid populations, but capacity to effectively contain and suppress epidemics remains lacking. Local effects on deer and elk herd viability have been reported, and accumulating evidence suggests more widespread impacts seem likely if effective control

strategies cannot be identified. We propose to assemble and synthesize available, long-term data on herd management and CWD trends from cooperating Western jurisdictions to develop guidance on harvest-based control strategies. A postdoctoral researcher will analyze data to identify harvest practices showing evidence of reducing, limiting, or increasing CWD occurrence. Prior to these analyses, a small workshop will be held for representatives from jurisdictions providing data to discuss analyses approaches and prioritize key regional questions on CWD control. Results will expand the capacity of states/provinces to develop directed management for CWD. Although focused on western systems, results could benefit Midwestern and Eastern states/provinces directly or as a model for similar regional capacity-building. Coordinated assessment of CWD management strategies may be pursued without MSCGP support, but capacity-building likely will be slower and more limited in scope.

Management solutions for chronic wasting disease; Porter, W (MSU, dec'd), D Williams (MSU), and S Christensen (MSU).

The goal of this study is to improve the cost-efficiency and effectiveness of finding and removing chronic wasting disease (CWD) and of managing deer populations in the face of CWD emergence in Michigan. New tools will be developed and recommended for disease management. These tools will assist in early detection and evaluate the factors influencing disease emergence beyond the CWD Management Zone, and will consider the attendant financial and political costs of surveillance. An agent-based model that evaluates alternative management actions to reduce the risk of local cases of CWD transitioning from emergent status to established status. These tools will be used to develop recommendations for monitoring and management outcomes as measured by population abundance and disease prevalence.

SURVEILLANCE AND DATA SHARING

Online Platform for Chronic Wasting Disease Data Sharing Management in North America; Johansen, P (WV DNR), M Marcus (IN DNR), K Straka (MI DNR), and M Dunfee (CWD Alliance, WMI).

This project builds on a 2019 MSCG in which investigators contacted all state and provincial wildlife agencies to assess the need for and potential barriers to comprehensive CWD information sharing. There was widespread interest in building a digital platform (dashboard) to house and share CWD information. We have been working with the CWD Alliance and Cornell to ensure that our parallel MSCG projects do not overlap or duplicate effort, and so we can combine results into a "one-stop-shop" for the CWD information all of us are collecting. The goal of the digital platform is to use a common vocabulary to present CWD surveillance, regulation and harvest data (everything that can be legally shared—which will vary by agency) between and among wildlife agencies. This information will provide managers the opportunity to see if/how CWD is moving across the landscape, learn from experiences of other agencies and assist hunters with regulations that could impact their travels with harvested cervids. If/as allowed by law, the system might also be able to notify agencies about potential movement of CWD-positive carcasses across state/provincial lines. This would allow managers to more effectively respond with communications, surveillance and law enforcement actions to mitigate the spread of CWD.

Southwest CWD Surveillance Project; Justice-Allen, A and D Bergman (AZ GFD).

Critical to the management of CWD is conducting statistically valid surveillance as determined by the biologically relevant population size in order to determine changes in prevalence and to detect spread to new areas, whether by natural animal movement or movement of cervids by people (Gillin and Mawdsley 2018). There are several high value populations of deer and elk which range across the borders of Arizona, Colorado, New Mexico, and Utah. Each of these states has been conducting surveillance for CWD for many years and over time sampling strategies have changed based on the understanding of the disease. Following the recommendations in the AFWA BMP (Gillin and Mawdsley 2018) for enhanced surveillance along borders, we are proposing to further advance our surveillance by considering the cross border distribution of deer and elk population subunits. The Arizona Game and Fish Department is submitting a proposal to implement

a surveillance strategy for deer and elk populations that are shared with neighboring states (New Mexico and Utah), and tribal lands (Hopi Tribe, Navajo Nation, Kaibab Paiute Tribe). The New Mexico Game and Fish Department, the Utah Department of Natural Resources and the Navajo Nation Department of Fish and Wildlife will be contributors to this project. The objectives will be to identify shared cervid populations, develop a surveillance strategy for each using established methods (Belsare et al. 2019, Walsh 2012) to determine meaningful sample sizes for the populations, identify methods that can be used to reach the sampling goals, and analyze the results to estimate the prevalence and distribution of CWD. This information will be used to develop cooperative regional population management objectives and strategies that will limit the impact of CWD and to assess cervid populations in areas which have not been adequately sampled to date (Gillin and Mawdsley 2018, WAFWA 2017). The surveillance conducted under this grant will be in addition to the surveillance already being conducted by the respective state and tribal agencies.

Chronic Wasting Disease Surveillance in Midwestern Indian Country, Development of a Regional Surveillance System to Protect Tribal Subsistence Species; Moore, S (Grand Portage Band of Lake Superior Chippewa).

We propose a regional expansion of a tribal CWD surveillance and outreach program that is currently being piloted for Minnesota tribes. The idea is to develop consistent and easy surveillance for Indian lands and tribal hunters for Minnesota, Wisconsin, and Michigan. The surveillance portion of the project enables the following:1. Incentive-based surveillance-we currently offer copper ammunition in exchange for heads, allowing us to reduce lead toxicity in humans and wildlife from lead bullets while receiving adequate CWD samples. This idea was enthusiastically supported by USFWS that has a 'Get the Lead Out' initiative underway.2. Easy surveillance for tribal biologists who coordinate, but are not responsible for sample extraction, submission, or reporting back to hunters. Tribal biologists have many responsibilities due to low staffing levels and are unable to spend time on the technical aspects of CWD sampling. We will contract leads within each state (Minnesota, Wisconsin, Michigan) to coordinate head collections and sample extractions from each tribal agency and transport them to diagnostic labs. A post-doc/researcher will develop metadata databases and results. Results will be shared back to tribal biologists and hunters. The second part is a regional expansion of tribal CWD management planning, outreach, and education. We have a large ($300k) project funded by LCCMR (Legislative-Citizen Commission on Minnesota Resources) to develop CWD management planning, outreach, and education materials for underserved communities in Minnesota. We are developing tribal CWD management plans and culturally-appropriate outreach and education materials for Minnesota tribes. The APHIS project will expand this work to Wisconsin and Michigan tribes. Both Minnesota-specific projects are scalable and our goal is to expand each to the Midwest region to serve the 33 tribes of this region. The goal of this project is to develop a regional CWD surveillance system, outreach and educational materials, and generate baseline data through a tribal network, in preparation for ongoing surveillance under the expectation that CWD continues to spread in the region. We aim to meet two APHIS CWD Funding Priorities, including #2 Improve the management of CWD affected areas or premises and #5 Develop and/or deliver educational outreach materials or programs, by 1) Developing a surveillance program with partnering tribes and intertribal agencies; 2) Contributing screened samples to the development of a rapid CWD assessment tool underway with University of Minnesota; 3) Developing a team of MN, WI, and MI tribal CWD leads, 4) Evaluating a mechanism to continue effective surveillance in MN, WI, and MI Indian country. The information gained from this project will benefit the Chippewa and Dakota tribes of the upper Midwest, all of which share jurisdictional boundaries and are working to promote the perpetuation of subsistence species. Establishing a regional tribal CWD surveillance program will enable MN, WI, and MI tribes to protect a subsistence lifestyle by contributing to the prevention of spread of wildlife disease.

Improving CWD Surveillance in Utah; Roug, A (UT DWR).

With this project we seek to 1) utilize already existing GPS collar data from mule deer across the state of Utah to identify high risk areas for spread of Chronic Wasting Disease (CWD), both from existing CWD foci in free-ranging cervids and around CWD positive elk ranching facilities, 2) use the data from the spatial risk analysis to modify and improve CWD surveillance as outlined in the 2019 approved CWD management for the State of Utah, and 3) evaluate the feasibility of random mandatory sampling, which was proposed in the CWD management plan as a mean to improve sample sizes for CWD surveillance. The data generated in this project will enhance the effectiveness of CWD management of the State of Utah.

Surveillance Optimization Project for Chronic Wasting Disease Dashboard: A Web Application for Disease Visualization and Data-Driven Decisions; Schuler, K and B Hanley (Cornell), S Christiansen and D Williams (MSU), D Walter (USGS) and D Walsh (USGS-NWHC), and C Jennelle (MN DNR).

Chronic wasting disease (CWD) is a fatal disease of cervids with significant ecological and economic impacts. We are currently engaged in three major components of a larger multi-state effort designed to maximize sampling efficiency for free-ranging white-tailed deer across much of the U.S. to meet the surveillance objectives of state wildlife agencies. The proposal links all the components of this project and others to ensure smooth operations. The first component, “Surveillance Optimization Project for Chronic Wasting Disease (SOP4CWD)”, incorporates a broad range of factors into a host of statistical and mathematical tools that allow agencies to “sample smarter”. The second component, “The Dashboard”, synthesizes these tools into a single online web space, where users can interact with graphical versions of their data. The third component is the development of a single “Data Warehouse” that standardizes, curates, and stores the disease sampling data from the states. To satisfy the unmet technological demands needed to link components, this proposal will build the software needed to autonomously transfer the “informational baton” from field biologists to technological specialists (i.e., data managers, data scientists, computational biologists, web developers) and then complete the loop back to agency decision makers and field biologists.

SOP4CWD Dashboard: A Web Application for Disease Visualization and Data-Driven Decisions; Schuler, K (Cornell), D Williams (MSU), S Christensen (MSU), A Belsare (MSU), D Walter (USGS), D Walsh (USGS-NWHC), C Jennelle (MN DNR), and B. Hanley (Cornell).

Chronic wasting disease (CWD) is a fatal disease of cervids with significant ecological and economic impacts. We are currently engaged in an eleven-state effort, Surveillance Optimization Project for Chronic Wasting Disease (SOP4CWD) to maximize sampling efficiency and improve its’ effectiveness to benefit state agencies. Our diverse team is building on CWD surveillance and disease characteristics, captive cervid facility activity, hunter harvested carcasses, and disposal methods, to ‘sample smarter’. The product of this synthesis will be a set of tools that integrates local harvest and disease prevalence data with data science, mathematical and statistical modeling techniques to benefit the future efforts of a region-wide consortium of state agencies. After meeting with representatives of state wildlife agencies, we recognized the vast unmet technological demands on state agencies for CWD surveillance and response. Synthesizing these technological products are beyond the capacity of most state and federal agencies, but decision makers need model outputs to be made more accessible through intuitive data analytics and visualization tools that are collected into a single online and user-friendly location. Our current funding does not allow for the development of such an interactive ‘Dashboard’ as desired by wildlife agencies; therefore, we seek additional support for ‘Phase II’ to create this product. The interface will make accessible all modeling outputs from Phase I, including the inventory, diagnosis, prognosis, exploration, and prescription of alternatives for disease surveillance efforts, each at the local, state, or regional scale. The Dashboard will facilitate the flow of information for CWD surveillance between the real-time data, modelers, and agencies, while enhancing our ability to respond to and manage CWD in the Great Lakes region and beyond.

A Collaborative Network-Based Tool for Improved Chronic Wasting Disease Management in North America; Straka, K (MI DNR), N Boedecker and M Marcus (IN DNR).

Chronic wasting disease (CWD) is a fatal disease threatening long-term cervid population health and diverting critical resources for wildlife management. An acknowledged risk factor for spread of CWD is the transport and improper disposal of infected carcasses and parts from areas where CWD is present. Hunters who travel across state/provincial boundaries may return with CWD infected carcasses, unknowingly risking introduction of disease. While wildlife agencies have internal CWD mitigation strategies, no infrastructure to facilitate consistent information sharing between state/provincial entities currently exists. There is urgent need for a tool that allows for sharing and integration of disease-related data between wildlife agencies, improving collective surveillance and management planning. Acknowledging the complexities of information-sharing, this project will meet this need by applying a systematic approach to understanding the CWD data sharing desires and constraints of wildlife agencies and developing an adaptive tool that optimizes effectiveness for all participants. This will be accomplished through interviews with state/provincial representatives to identify barriers to CWD data-sharing followed by a workshop to develop solutions to these problems. Using this input, a conceptual model of a widely acceptable information-sharing network will be developed. Future grant opportunities will be sought to allow for building and implementation of the network.

APPENDIX I

Recently Published Works

Bloodgood, J, M Kiupel, J Melotti, K Straka. 2021. Chronic Wasting Disease Diagnostic Discrepancies: The Importance of Testing Both Medial Retropharyngeal Lymph Nodes. *J Wildl Dis* (2021) 57 (1): 194–198.

Chronic wasting disease (CWD) of white-tailed deer (*Odocoileus virginianus*) is a fatal neurologic disease that is spreading across North America. A common surveillance protocol for CWD currently involves screening with an enzyme-linked immunosorbent assay (ELISA) followed by confirmatory testing with immunohistochemistry (IHC). Medial retropharyngeal lymph nodes (MRPLN) are the tissue of choice to diagnose CWD in free-ranging white-tailed deer. We examined left and right MRPLN from 101 ELISA-positive deer harvested from 2015 to 2019 to determine the prevalence of cases in which prion protein was not detected by IHC as well as differences in IHC labeling between contralateral lymph nodes. Prion protein was not detected using IHC in either MRPLN in 5.9% (6/101) of cases. There was a significant but weak positive relationship between the number of IHC-positive follicles and ELISA optical density values (R^2=0.08, P=0.039). Mean optical density values in IHC-positive MRPLN were higher than in IHC-negative MRPLN; however, this was not statistically significant (P=0.260). Failure to confirm ELISA diagnoses with IHC may have been because the methods tested different areas of MRPLN, or that there were differences in test sensitivity or antibody affinity. An additional 5.9% (6/101) of cases had one IHC-positive MRPLN, whereas the contralateral MRPLN was IHC negative. Therefore, testing a single MRPLN for CWD may lead to false-negative results, regardless of methodology, which highlights the importance of collecting and testing both MRPLN.

Booth, C, S Lichtenberg, R Chappell, J Pederson. 2021. Chemical Inactivation of Prions Is Altered by Binding to the Soil Mineral Montmorillonite. *ACS Infect. Dis.* 2021, 7, 4, 859–870.

Environmental routes of transmission contribute to the spread of the prion diseases chronic wasting disease of deer and elk and scrapie of sheep and goats. Prions can persist in soils and other environmental matrices and remain infectious for years. Prions bind avidly to the common soil mineral montmorillonite, and such binding can dramatically increase oral disease transmission. Decontamination of soil in captive facilities and natural habitats requires inactivation agents that are effective when prions are bound to soil microparticles. Here, we investigate the inactivation of free and montmorillonite-bound prions with sodium hydroxide, acidic pH, Environ LpH, and sodium hypochlorite. Immunoblotting and bioassays confirm that sodium hydroxide and sodium hypochlorite are effective for prion deactivation, although montmorillonite appears to reduce the efficacy of hypochlorite. Acidic conditions slightly reduce prion infectivity, and the acidic phenolic disinfectant Environ LpH produces slight reductions in infectivity and immunoreactivity. The extent to which the association with montmorillonite protects prions from chemical inactivation appears influenced by the effect of chemical agents on the clay structure and surface pH. When clay morphology remains relatively unaltered, as when exposed to hypochlorite, montmorillonite-bound prions appear to be protected from inactivation. In contrast, when the clay structure is substantially transformed, as when exposed to high concentrations of sodium hydroxide, the attachment to montmorillonite does not slow degradation. A reduction in surface pH appears to cause slight disruptions in clay structure, which enhances degradation under these conditions. We expect our findings will aid the development of remediation approaches for successful decontamination of prion-contaminated sites.

Ferreira, N, J Charco, J Plagenz, C Orru, N Denkers, M Metrick II, A Hughson, K Griffin, B Race, E Hoover, J Castilla, TA Nichols, M Miller, B Caughey. Detection of chronic wasting disease in mule and white-tailed deer by RT-QuIC analysis of outer ear. *Sci Rep* April 8, 2021: 11, Article number: 7702.

Efforts to contain the spread of chronic wasting disease (CWD), a fatal,

contagious prion disease of cervids, would be aided by the availability of additional diagnostic tools. RT-QuIC assays allow ultrasensitive detection of prion seeds in a wide variety of cervid tissues, fluids and excreta. The best documented antemortem diagnostic test involving RT-QuIC analysis targets lymphoid tissue in rectal biopsies. Here we have tested a more easily accessed specimen, ear pinna punches, using an improved RT-QuIC assay involving iron oxide magnetic extraction to detect CWD infections in asymptomatic mule and white-tailed deer. Comparison of multiple parts of the ear pinna indicated that a central punch spanning the auricular nerve provided the most consistent detection of CWD infection. When compared to results obtained from gold-standard retropharyngeal lymph node specimens, our RT-QuIC analyses of ear samples provided apparent diagnostic sensitivity (81%) and specificity (91%) that rivaled, or improved upon, those observed in previous analyses of rectal biopsies using RT-QuIC. These results provide evidence that RT-QuIC analysis of ear pinna punches may be a useful approach to detecting CWD infections in cervids.

Hopkins MC, CM Carlson, PC Cross, CJ Johnson, BJ Richards, RE Russell, MD Samuel, GA Sargeant, DP Walsh, WD Walter. (2019) Chronic wasting disease—Research by the U.S. Geological Survey and partners (ver. 2.0, November 2019): U.S. Geological Survey Open-File Report 2019–1109, 29 p., https://doi.org/10.3133/ofr20191109. Chronic wasting disease (CWD) is the only transmissible spongiform encephalopathy, a class of invariably fatal neurodegenerative mammalian diseases associated with a misfolded cellular prion protein found in wild free-ranging animals. Because it has a long incubation period, affected animals in Cervidae (the deer family; referred to as "cervids") may not show signs of disease for several years. While signs are not specific to CWD, affected cervids (deer, elk, moose, and reindeer) show changes in appearance (such as progressive weight loss) and changes in behavior such as stumbling, tremors, and teeth grinding. CWD can be transmitted by direct contact or through a contaminated environment. The causative prion agent is highly resistant to degradation. In recent decades, CWD has transitioned from a novel, obscure prion disease of cervids with limited geographical distribution, to a disease that poses substantial ecological, agricultural, and economic risks across large regions of North America. Since its discovery in free-ranging elk and deer populations in the western United States in the 1980s, CWD has been reported in captive or free-ranging cervid populations in 26 States, 3 Canadian Provinces, the Republic of South Korea, Finland, Sweden, and Norway. In addition, the proportion of CWD-infected animals is increasing in many areas where the disease is already established. In some heavily affected areas, total cervid numbers have decreased over time due to CWD, which suggests that these cervid populations may not be sustainable in the long-term. The U.S. Geological Survey (USGS) conducts wildlife disease surveillance and research to support management of CWD-affected species and their habitats. The scientific information is relevant to governmental agencies that manage wildlife and their habitats including the U.S. Fish and Wildlife Service, the National Park Service, the U.S. Department of Agriculture, and other Federal, State, and Tribal agencies as well as conservation partners (non-governmental organizations, businesses, and private landowners). Each project description in this report (1–30) includes the non-USGS collaborators (Federal, State, Tribal agencies, universities) and a USGS point of contact (principal investigator). If there are USGS publications associated with the project, a publication list is provided at the end of each project description.

Kondru N, Manne S, Kokemuller R, Greenlee J, Greenlee MHW, Nichols T, Kong Q, Anantharam V, Kanthasamy A, Halbur P, Kanthasamy AG. (2020) An *ex vivo* brain slice culture model of chronic wasting disease: implications for disease pathogenesis and therapeutic development. *Sci Rep* May 6;10(1):7640. Chronic wasting disease (CWD) is a rapidly spreading prion disease of cervids, yet it remains difficult to diagnose premortem, treat, or control. Our recently developed integrated organotypic slice culture assay for sensitive detection of scrapie prions using ultrasensitive prion seeding. However, this model was not established for CWD prions due to their strong transmission barrier from deer to standard laboratory mice (*Mus musculus*). To develop and characterize the *ex-vivo* brain slice culture model for CWD, we utilized a transgenic mouse model that expresses the elk prion protein gene (*PRNP*) (Tg12; *prnp*$^{+/-}$). We tested for CWD infectivity in the cultured

slices using sensitive seeding assays such as real-time quaking-induced conversion (RT-QuIC) and protein misfolding cyclic amplification (PMCA). Slice cultures from Tg12 mouse brains tested positive for CWD, but *prnp*$^{-/-}$ slices did not. Slice-generated CWD prions transmitted efficiently to transgenic mice. Furthermore, we established the activity of anti-prion compounds and screening for infectivity of a biological sample in this CWD slice culture model. Our results demonstrate this integrated brain slice model of CWD enables the study of pathogenic mechanisms as well as the translational implications of managing CWD with respect to drug screening, diagnosis, and therapeutic strategies.

Kramm, C, P Soto, TA Nichols , and R Morales (2020). Chronic wasting disease (CWD) prion detection in blood from pre-symptomatic white-tailed deer. *Sci Rep* Nov 13; 10(1):19763. Chronic wasting disease (CWD) is a prionopathy affecting wild and farmed cervids. This disease is endemic in North America and has been recently identified in Europe. Ante-mortem CWD tests of preclinical cervids may be an important tool in helping control the spread of this disease. Unfortunately, current CWD diagnostic methods are not suitable for non-tissue type samples. We reported that CWD prions can be detected in blood of pre-clinical CWD-infected white-tailed deer (WTD) with high sensitivity and specificity using the Protein Misfolding Cyclic Amplification (PMCA) assay. However, that report only included animals homozygous for codon 96G, the most common polymorphic version of the prion protein within this animal species. Here, we report CWD prion detection using blood of naturally infected WTD coding one or two copies of the PrP-96S polymorphic variant. Our results, from a blinded screening, show 100% specificity and ~ 58% sensitivity for animals harboring one 96S codon, regardless of their stage within the pre-clinical phase. Detection efficiency for PrP-96S homozygous animals was substantially lower, suggesting that this allele affect peripheral prion replication/tropism. These results provide additional information on the influence of codon 96 polymorphisms and the ability of PMCA to detect CWD in the blood of pre-clinical WTD harboring PRNP polymorphic variants.

Miller, M, J Runge, A Holland, M Eckert. Hunting pressure modulates prion infection risk in mule deer herds. *J Wildl Dis* (2020) 56 (4): 781–790. (https://doi.org/10.7589/JWD-D-20-00054. The emergence of chronic wasting disease, an infectious prion disease of multiple deer species, has motivated international calls for sustainable, socially accepted control measures. Here, we describe long-term, spatially replicated relationships in Colorado, US, mule deer (*Odocoileus hemionus*) herds that show hunting pressure can modulate apparent epidemic dynamics as reflected by prevalence trends. Across 12 areas in Colorado studied between 2002–18, those with the largest declines in annual hunting license numbers (pressure) showed the largest increases in the proportion of infected adult (≥2–yr-old) male deer killed by hunters (prevalence); prevalence trends were comparatively flat in most areas where license numbers had been maintained or increased. The mean number of licenses issued in the 2 yr prior best explained observed patterns: increasing licenses lowered subsequent risk of harvesting an infected deer, and decreasing licenses increased that risk. Our findings suggest that harvesting mule deer with sufficient hunting pressure might control chronic wasting disease—especially when prevalence is low—but that harvest prescriptions promoting an abundance of mature male deer contribute to the exponential growth of epidemics.

Nalls, A, E McNulty, A Mayfield, J Crum, M Keel, E Hoover, M Ruder, C Mathiason. 2021. Detection of Chronic Wasting Disease prions in fetal tissues of free-ranging white-tailed deer. doi: https://doi.org/10.1101/2021.03.13.435248. The transmission of chronic wasting disease (CWD) has largely been attributed to contact with infectious prions shed in excretions (saliva, urine, feces, blood) by direct animal-to-animal exposure or indirect contact with the environment. Less-well studied has been the role mother-to-offspring transmission may play in the facile transmission of CWD. We asked whether such extensive spread may also be due to mother-to-offspring transmission, perhaps before birth. We thereby focused on a population of white-tailed deer from West Virginia, USA, in which CWD has been detected. Fetal tissues, ranging from 113 to 158 days of gestation, were harvested from the uteri of CWD+ dams in the asymptomatic phase of infection. Using serial protein misfolding amplification (sPMCA),

we detected evidence of prion seeds in 6 of 14 in utero harvested fetuses, with earliest detection at 113 gestational days. This is the first report of CWD detection in free ranging white-tailed deer fetal tissues. Further investigation within cervid populations across North America will help define the role and impact of mother-to-offspring vertical transmission of CWD.

Nichols, TA (APHIS), E Nicholson, Y Liu, W Tao, T Spraker, M Lavelle, J Fischer, Q Kong, K VerCauteren. 2021 (Submitted). Detection of Two Dissimilar Chronic Wasting Disease Isolates in Two Captive Rocky Mountain Elk (*Cervus canadensis*) Herds. There is limited knowledge about the variety and characteristics of isolates or strains of CWD that exist on the landscape and their implications on wild and captive cervid herds. Obex samples of several elk from each site were compared for CWD prion strain deposition, genotype at prion protein gene codon 132, and conformational stability of CWD prions. Differences in conformational stability were identified between the two sites that were independent of genotype at codon 132. These findings indicate the existence of different CWD isolates between the two sites and suggest potential differential disease attack rates for different CWD strains.

Schroeder, S, A Landon, L Cornicelli, D Fulton, L McInenly. 2021. Cognitive and behavioral coping in response to wildlife disease: The case of hunters and chronic wasting disease. *Human Dimensions of Wildlife*, DOI: 10.1080/10871209.2021.1919340. The transactional model of stress and coping (TMSC) provides a conceptual framework for understanding adaptations to stressors like chronic wasting disease (CWD). Understanding hunter response to stressors is important because decreased participation and satisfaction can affect individual well-being, cultural traditions, agency revenue, and local economies. Using TMSC, we explored how deer hunters coped with CWD. We also compared involvement, and impacts and emotions related to CWD, inside and outside a CWD management zone. Then we examined coping related to CWD presence, and if the disease affected human health. Most hunters would cope using product shift (i.e., eating meat after a negative test result) rather than displacement (i.e., hunting elsewhere) or dropout. Hunters who may be displaced reported lower involvement in deer hunting, and increased worry about CWD. Results suggest that CWD information and testing may increase hunter worry. Funding expanded testing without prompting displacement or dropout are important management considerations.

Seabury C, Oldeschulte D, Bhattarai E, Legare D, Ferro P, Metz R, Johnson C, Lockwood M, Nichols T (2020) Accurate Genomic Predictions for Chronic Wasting Disease in U.S. White-Tailed Deer. *G3: Genes, Genomes, Genetics* April 1, 2020 vol. 10 no. 4 1433-1441; https://doi.org/10.1534/g3.119.401002. The geographic expansion of chronic wasting disease (CWD) in U.S. white-tailed deer (*Odocoileus virginianus*) has been largely unabated by best management practices, diagnostic surveillance, and depopulation of positive herds. Using a custom Affymetrix Axiom single nucleotide polymorphism (SNP) array, we demonstrate that both differential susceptibility to CWD, and natural variation in disease progression, are moderately to highly heritable (h2 ¼ 0:337 6 0:079 — 0:637 6 0:070Þ among farmed U.S. white-tailed deer, and that loci other than PRNP are involved. Genome-wide association analyses using 123,987 quality filtered SNPs for a geographically diverse cohort of 807 farmed U.S. white-tailed deer (n = 284 CWD positive; n = 523 CWD non-detect) confirmed the prion gene (PRNP; G96S) as a large effect risk locus (P-value , 6.3E-11), as evidenced by the estimated proportion of phenotypic variance explained (PVE $ 0.05), but also demonstrated that more phenotypic variance was collectively explained by loci other than PRNP. Genomic best linear unbiased prediction (GBLUP; n = 123,987 SNPs) with k-fold cross validation (k = 3; k = 5) and random sampling (n = 50 iterations) for the same cohort of 807 farmed U.S. white-tailed deer produced mean genomic prediction

accuracies $ 0.81; thereby providing the necessary foundation for exploring a genomically-estimated CWD eradication program.

APPENDIX II

North American Interdisciplinary Chronic Wasting Disease Research Consortium

Multistate Project NC1209 - Overview (Content Provided by Team Leads)

Research Priorities and Progress - March 2021 White Paper Series

Executive Board: Chair – Dr. Jason Bartz, Vice-chair – Dr. Dan Walsh, Secretary – Marc Schwabenlander, Past chairs – Drs. Sonja Christensen and Joel Pedersen

Importance of the problem. Chronic wasting disease (CWD) of cervids (e.g., deer, elk, moose) was first identified in the 1970s in Colorado and Wyoming and has subsequently been identified in captive and free-ranging cervids in 26 US States, 3 Canadian provinces, the Republic of South Korea, and Scandinavia. The geographic distribution of CWD continues to expand and the prevalence of CWD within certain cervid populations can approach 50%. Prions can persist in the environment for years, facilitating facile transmissionbetween cervids, further complicating mitigation strategies. Overall, these combined factors have resulted in CWD having detrimental effects on cervid populations. CWD belongs to a group of diseases that are caused by prions, infectious proteins, that infect a wide range of species including humans, are inevitably fatal, and have no known therapies or cures. It is known that prions from one species can infect new species (e.g., transmission of mad cow disease to humans), however, the species host-range of CWD is unknown. There are 11.4 million deer hunters in the USA and it is estimated that up to 15,000 CWD-infected cervids are consumed annually. Additionally, the geographic range of CWD overlaps with other species that may be susceptible to CWD via contact with cervids or CWD contaminated environments (e.g. feral swine). If left unabated, CWD poses a threat to cervid populations, poses risk to human and animal health and threatens long-standing hunting traditions and the economic benefits that come with it to both private citizens and government agencies.

Goal and significance of the program. Combating this bourgeoning disease requires the cooperation of individuals and groups with wide-ranging scientific and management expertise from across many jurisdictions. The overall goals of this Consortium are to leverage the combined knowledge of an interdisciplinary group of CWD experts to serve as a scientific resource for wildlife management agencies, policy makers and the public, and to advance the scientific understanding of the etiology and management of CWD through collaborative research. The Consortium will initially accomplish these goals by focusing research efforts to develop novel means of CWD diagnostics, treatment, and mitigation; effective public communication; and coordination of management strategies across agencies. The significance of these efforts is multifold. First, as described above, CWD is a once-in-a- lifetime challenge for wildlife conservation that has the potential threat of transmission to other species, including humans. Second, the Consortium is the largest organized group of CWD experts who are working together towards a better understanding of CWD to aid in solving this problem. Lastly, there is a pressing need for an organized science-based response to CWD, which the Consortium is facilitating.

Outcomes and benefits. The long-term goal of this Consortium is the reduction of CWD in North America. A step towards this goal is to identity top research priorities, craft strategic plans around them and work towards implementation of the plans. Measurable outcomes from this program will include publications, grant submissions, inter-institutional collaboration,and science-based policy and management decisions. Benefits of the Consortium are the communication, development of ideas, and collaboration between the members that would not have been possible without the Consortium. These efforts build a foundation for science- driven advances in the fight against CWD in North American and throughout the world.

Research Priority 1: National CWD Tissue and Reagents Repository

Importance of the problem. Chronic wasting disease (CWD) of cervids (deer, elk, moose) was first identified in the 1970s in Colorado and Wyoming and has subsequently been identified in captive and free-ranging cervids in 26 US States, 3 Canadian provinces, the Republic of South Korea, and Scandinavia. The prevalence of CWD within cervid populations can approach 50% and, since CWD is always fatal, CWD can have detrimental effects on cervid populations. CWD belongs to a group of diseases that are caused by prions, infectious proteins that can infect new species (e.g.transmission of mad cow disease to humans). There are 11.4 million deer hunters in the USA and it is currently estimated that up to 15,000 CWD-infected cervids are consumed annually. In part, due to the increase in the prevalence of CWD this may increase 20% per year indicating that CWD will constitute a mounting risk to humans and sympatric animal species. Compounding this problem is the identification of distinct strains of CWD. Since prion strains can differ in the ability to cause disease in cervids and the potential to infect a new species, a understanding of the distribution and prevalence of CWD strains is needed to manage CWD and to assess risk of zoonotic transmission. Unfortunately, a centralized collection of CWD tissues is not currently available for research addressing these issues.

Goal and significance of the program. The overall goal of this program is to establisha national CWD tissue and reagents repository. The significance of this program is multifold. First, a repository of CWD field isolates from a wide-ranging geographic location in North America will allow, for the first time, the means to begin to assess the distribution and frequency of CWD strains in North America. Since prion strains can differ in pathogenicity and host range, this is essential data for the determination for risk of interspecies prion transmission to humans and to domestic livestock and wildlife.Second, this repository can provide uniform standardized CWD-infected and uninfectedsources of tissue for diagnostic development, mitigation testing and for basic research purposes. Finally, the implementation of the repository will facilitate cooperation between the various state agencies that could lead to new collaborative efforts.

Outcomes and benefits. Outcomes from this program will include a survey of CWD strains over a wide geographical region. Additionally, polymorphisms of the host prion protein can be determined. This data will be useful in combination with environmental and weather patterns in determining factors that may influence the distribution of prion strains, how changes in long-term weather patterns may alter this distribution. This data may be used to better predict what population of cervids and in what environments that CWD may more likely spread to that can be used to focus surveillance resources. Strain distribution, in conjunction with studies on how strains ofCWD affect zoonotic potential, can be used to address areas where zoonotic potential of CWD is the greatest to focus mitigation resources. Monitoring these data over time will provide important information regarding CWD strain dynamics and will allow for identification of novel emerging strains that may have altered pathogenicity and/or zoonotic potential compared to currently circulating CWD strains.

Research Priority 2: Large-Scale Research Facilities for Controlled CWD Research

***Importance of the problem*.** Most chronic wasting disease research occurs in highly controlled but artificial circumstances, like laboratories or small pens, or in large, naturaldeer populations without adequate controls. While each of these research approaches has value, testing CWD management strategies and understanding transmission in

free-ranging deer are two examples of research questions that are difficult to address inthe lab or in free-ranging deer populations. To advance several important research objectives, scientists need facilities that bridge the scale from small pens to replicated field studies in fenced enclosures at larger scales, where animal behavior and importantecological processes operate naturally.

Goal and significance of the program. This program seeks to identify research facilities where scientists can study CWD transmission in controlled and spatially replicated studies. This approach will produce results more directly applicable to naturalconditions and provide wildlife managers with the information needed to make informeddecisions on effective management and mitigation. Applied research into these topics requires deer in a research environment where their natural behavior can manifest and important ecological process operate.

***Outcomes and benefits*.** This research group has identified 5 facilities or properties where CWD could be studied at a meaningful ecological scale and in natural conditions.These sites are in Tennessee, Mississippi, Michigan, Wisconsin, and Texas. Some sites could host studies soon and others will require additional resources and approvals.Most sites have deer that have tested positive for CWD and could begin studies that require CWD-positive animals. Deer are not allowed on one site but this small facility could be used to evaluate mitigation strategies for soil and fomites. CWD has not been detected in deer on one site but the disease has been detected in the area and so this facility could be valuable to track changes in a deer population as CWD becomes established. We will assess each of these facilities to determine the types of research projects they can support and share this information with CWD scientists. These effortswill benefit CWD management efforts by providing the research infrastructure necessaryto test and develop methods to address CWD in free-ranging deer.

Research Priority 3: CWD Diagnostics

Detection of CWD by diagnostic assays is a key tool in controlling CWD both in wild andfarmed cervid populations. Postmortem detection in wild cervid populations helps identify the distribution of CWD on the landscape well as develop prevalence estimates,and in farmed cervids determines a herd's status and ability to move animals. Officially approved postmortem CWD diagnostic tests include immunohistochemistry (IHC) and ELISA of the medial retropharyngeal lymph nodes and the obex. These tests are highly specific, but like all diagnostic assays, have minimum detection levels that might miss early CWD cases. While postmortem detection is valuable, there are advantages to detecting CWD in live animals. Currently, antemortem (live animal testing) is limited to IHC of rectal and tonsil biopsies. The USDA has approved the use of antemortem rectalbiopsy IHC under select circumstances for farmed white-tailed deer herds under quarantine due to potential exposure to a CWD positive animal. (This type of testing is not approved to reduce or remove quarantine from a known CWD positive herd.) The development of highly sensitive amplification assays, such as protein misfolding cyclic amplification (PMCA) and real-time quaking-induced conversion (RT-QuIC), has openedup new possibilities for both post and ante mortem CWD diagnostic testing. These assays have been shown to detect minute levels of CWD that are undetectable by conventional methods such as IHC and ELISA. With the advancement of PMCA and

RT-QuIC, the type of samples that could be used for testing has expanded into novelCWD sample types like feces, saliva, and skin. There is a great deal of interest in theuse of the RT-QuIC assay, but before a diagnostic assay can be approved for officialuse by the USDA controlled tests must be conducted for each sample of interest.

The USDA Veterinary Services Cervid Health Program has partnered with the USDA Agricultural Research Service, the USGS National Wildlife Health Center, and the NIHRocky Mountain Laboratory to develop a standardized RT-QuIC protocol and is in the process of assessing the sensitivity and specificity of RT-QuIC for potential use as an official CWD diagnostic assay for antemortem rectal biopsy and tonsil biopsy samplesas well as postmortem medial retropharyngeal lymph node samples. The USDA Veterinary Services Cervid Health Program has also partnered with the NIH Rocky Mountain Laboratory to expand upon their recent preliminary findings which indicate that deer ear skin could be a novel sample tissue for RT-QuIC antemortem CWD testing.

Novel diagnostic tests and sample types could greatly improve our ability to detect CWDearlier, allowing a more rapid response to CWD cases by wildlife and agriculture agencies.

Research Priority 4: Evaluating Management Strategies Across State Boundaries

Importance of the problem: Management of chronic wasting disease (CWD) is one of the mostsignificant challenges facing many wildlife agencies in North America. One of the difficulties in managing this disease is that CWD-affected species range across jurisdictional boundaries; yet currently there is little communication or coordination among management agencies regarding CWD response. Additionally, although scientific approaches are used to inform management decisions, science is less commonly factored into the evaluation of the impacts of management actions. Unified efforts to evaluate the effectiveness of the suite of management actions that agencies have applied for disease control are lacking. This consortium objective is aimed at filling these gaps by leveraging historical information maintained by state agencies to evaluate impacts of CWD management activities on population and disease dynamics and establishing a framework that will improve coordination and information exchange. This framework will serve as the basis for the creation of an adaptive management strategy for CWD mitigation among state and federal, wildlife management agencies.

Proposed Research Plan: Recognizing that harvest management of white-tailed deer populations is the main tool available for agencies to control both deer population sizes and CWD and how it is applied varies widely across state agencies, we will first begin by investigating the impacts of harvest regulations on the realized harvest within and between states (other management actions will be investigated subsequently). Specifically, regulation- driven changes in the size and age/sex structure of the harvest will be the focus of the initial work. The next step will be to tie the estimated realized harvest of the various harvest management approaches to CWD dynamics. We will employ stochastic compartmental disease models to simulate CWD burden and introduce harvest regulations and associated harvest ratesinto the system and measure the potential effects of harvest regulations on disease processes and outcomes. This will permit us to make recommendations on the harvest regulations most likely to have the desired outcome for managing CWD. Lastly, we will work with the participating state agencies to initiate the harvest regulations in their CWD-affected areas that the results of the models indicate are the most effective using an adaptive management framework. Thus, the over-arching goal of this research is to capitalize on the breadth of management responses that agencies have made after CWD introduction, to assess the impact of management on deer and CWD dynamics, and to coordinate a unified effort to initiate adaptive CWD management among wildlife management agencies.

Expected Outcomes: The expected outcome of this objective will be an improved ability to manage CWD. This will be accomplished by providing managers with critical information regarding the efficacy of various management tools for this disease, fostering multi-jurisdictionalcollaboration, and initiate an adaptive management strategy that will lead to regional disease response efforts. Secondary outcomes will include: 1) a standardized dataset related to deer harvest rates and regulations that will encompass information from wildlife management agencies across the Midwest; 2) mathematical models that will be used to forecast the most efficacious regulations for CWD management; 3) a platform for enhanced communication and coordination among wildlife management agencies; and 4) coordination to initiate an adaptive management strategy for CWD and deer management that is multi-jurisdictional.

Research Priority 5: Using Social Science to Inform CWD Management

Importance of the problem. Chronic wasting disease (CWD) is a fatal prion disease affecting species in the deer family (e.g., deer, moose, elk). It has been reported in free-ranging deer, elk and/or moose in at least 26 states and four Canadian provinces. CWD is always fatal in infected hosts. When the disease becomes established in a population, it can drive down the population size and reduce hunting opportunities and participation. The potential effects of consumption of infected hosts on human health are as of yet unclear. Prions are shed from infected animals (including carcasses) and can be transmitted directly or indirectly to other cervids. Because prions are hard to inactivate and may persist in the environment for a long time, it is important to handle infectious material in a way that does not allow for further transmission. For that reason, agencies have adopted regulations and recommendations aimed at hunters and agricultural operations to reduce the risk of the introduction and spread of CWD in new areas. Little is known, however, about the range of approaches taken by state, provincial, federal, and tribal governments to obtain behavioral support for CWD management and whether and how key stakeholder groups respond to these approaches. While social science researchers have conducted some research on how key stakeholders respond to CWD in specific locations, there has been little coordination of that research across states and provinces. Collaborative research across multiple management, demographic, and cultural contexts is needed to inform communication campaigns aimed at promoting risk minimization by hunters and agricultural operations. Research can help tailor communication for jurisdictions with different socioecological contexts and approaches to managing CWD.

Research plan. The goal of this research program is to improve understanding of stakeholder groups whose behavioral support is needed in CWD management efforts through coordinated, collaborative research. Our specific research objectives are to:

- Characterize the range of management approaches to CWD in selected jurisdictions with varying levels of CWD prevalence and characterize the ecological contexts in those areas.
- Characterize the range of approaches to stakeholder engagement and building behavioral support for CWD management and assess the consistency of these efforts.
- Assess key stakeholder groups' CWD-related attitudes, risk perceptions and behaviorsand determine how they vary with cultural, ecological and management contexts.
- Identify factors that encourage or inhibit practice of CWD risk-minimization behaviors by key stakeholder groups and determine how they vary with ecological and management contexts.
- Test risk communication to determine how it influences intentions to take specific CWD risk-minimization actions.

Outcomes and benefits. This research will contribute to more consistent approaches to CWD management, communication, and data collection. By comparing approaches to management and stakeholder engagement across different ecological and management contexts, and assessing the outcomes of those approaches, we will be able to offer recommendations about how to tailor stakeholder engagement efforts to different contexts. State, provincial, federal, and tribal agencies will be able to use these recommendations to improve their ability to enlist behavioral support from key stakeholder groups.