Update for the North American Wildlife and Natural Resources Conference from the USGS National Wildlife Health Center

March 2024

NWHC updates

LeAnn White appointed NWHC Center Director

Dr. LeAnn White has been selected as the new Center Director of the USGS National Wildlife Health Center (NWHC). Dr. White received a PhD in Infectious Diseases and Pathology and an MPH in Epidemiology from the University of Florida. She joined USGS in 2009 as a Field Epidemiologist and studied the ecology of diseases in multiple systems with field work focused on double-crested cormorants (*Phalacrocorax auratus*) and sea otters (*Enhydra lutris*). From 2014-2020, Dr. White served as Chief of the Wildlife Epidemiology and Emerging Diseases Branch and broadened her focus to include developing standards for wildlife disease data and using social sciences to influence conservation action. As Deputy Center Director from 2020-2024, she assisted with day-to-day Center operations and incorporated systems thinking into the planning and evaluation of NWHC science directions and business operations.

As Center Director, Dr. White plans to focus on developing conditions (facilities, processes, and workforce) that will allow the Center to accomplish its vision of creating comprehensive solutions needed to improve wildlife health. She is looking forward to working with partners both internal and external to USGS to co-produce science needed to address ecosystem challenges, while continuing to build upon the Center's reputation for excellence. From more information, please contact LeAnn White, clwhite@usgs.gov.

Figure 1. Dr. LeAnn White, National Wildlife Health Center Director.

How NWHC is challenging its own paradigm

A substantial portion of the historic national wildlife disease model, common among natural resource agencies and at the National Wildlife Health Center (NWHC), is a focus on identifying and communicating about departures from health. However, with ecosystem resilience (i.e., the ability of a natural system to absorb the effects of change, reorganize itself, and adapt to new and changing environments) becoming a central focus for the conservation community, NWHC is taking an opportunity to thoughtfully assess our science programs and ensure that they align with the changing needs of the community. NWHC has historically used a large proportion of its resources to support diagnostic services (i.e., passive surveillance) for partner agencies, and thus primarily informed situational awareness and risk communications. Several efforts are underway to examine our role in the community, evaluate our internal processes for efficiencies, measure the return on investment for our products, and estimate the overall impact of our science to wildlife conservation.

Asking hard questions of ourselves and others is a challenging, but necessary, aspect of how the center is planning to strategically move towards a future where our collective focus is more aligned with informing wildlife and system health rather than primarily documenting departures from health. Center efforts have initially been focused internally (team-based strategic planning exercises coupled with structured committee work to evaluate our diagnostics and overall science impacts). However, we will be

How NWHC is challenging its own paradigm, continued

coordinating with partners throughout this process to understand their current and future needs so we can continue to align ourselves with the changing conservation community.

We look forward to engaging with partners during these efforts, and continuing to maximize the value we provide to the communities we serve. For more information, please contact Bryan Richards (brichards@usgs.gov) or LeAnn White (clwhite@usgs.gov).

NWHC modernization update

As previously reported, Congress appropriated $55,500,000 for the first phase of renovation at the USGS National Wildlife Health Center (NWHC) in the Consolidated Appropriations Act of 2021 (PL 116-260). This appropriation supports the work of NWHC and "its important role in zoonotic research, detecting novel pathogens and emerging infectious diseases, developing rapid diagnostic tests, conducting disease surveillance, and designing vaccines used to control diseases in wildlife" (Consolidated Appropriations Act of 2021, Division G).

NWHC continues to work with the USGS Office of Management Services and Flad Architects on the design for NWHC's new facility, which will be built at the current NWHC location in Madison, Wisconsin with a projected move-in date in early 2028. The new facility will include offices, diagnostic and research laboratories (BSL-2 and BSL-3 biocontainment), and a vivarium (ABSL-2, ABSL-3, and ABSL-3 Ag). The project is currently in the design development phase, during which details on materials, furnishings, and building systems are added to the plans. Next steps include generating construction documents, which are expected to be completed by early 2025.

Concurrent with the design phase, USGS is conducting an environmental impact assessment for this project. After a public scoping period in September-October 2023, the Draft Environmental Impact Statement (EIS) is in preparation and will be available for public review in Spring 2024. The Draft EIS will be a comprehensive document that will thoroughly outline potential impacts of the proposed action on the environment and is being carried out in accordance with the National Environmental Policy Act. Once published in the Federal Register, the Draft EIS will be the subject of a 45-day public review period to allow interested parties to comment on the proposed action and analysis and provide additional information for consideration. For more information, please visit the NWHC website, or contact Julia Lankton, jlankton@usgs.gov.

Figure 2. Conceptual illustration of the future USGS National Wildlife Health Center, courtesy of Flad Architects.

Case definitions for wildlife

A team of pathologists, veterinarians, and biologists at the USGS National Wildlife Health Center (NWHC) and the Canadian Wildlife Health Cooperative (CWHC) recently published the first of many collaboratively developed case definitions for wildlife diagnosticians. There are multiple ways to reach a diagnosis, some of which have a higher degree of certainty than others. A case definition provides a standardized, science-based set of criteria for diagnosing disease and pathogens that includes an assessment of diagnostic certainty. Based on the information available for individual, place, time, history, clinical signs, diagnostic observations, and diagnostic test results, specimens and samples are classified as "confirmed," "presumptive," or "suspected" when diagnosing a specific disease or "exposed" or "present/detected" for detecting a pathogen or toxin.

Case definitions are regularly used in human medicine and with certain domestic animal diseases of concern, but less commonly in wildlife. The consistent use of diagnostic case definitions among pathologists and across institutions forms a necessary foundation for data sharing because they provide a common understanding of the basis for the diagnosis.

The USGS and CWHC Case Definition Joint Working Group produced a template and instructions for drafting new case definitions that is available as a fillable Word document. Creating the template and case definitions was a collaborative process involving the joint working group and pathologists at both institutions. The documents were then peer-reviewed as part of the USGS Techniques and Methods publication process. Case definitions have now been published for avian botulism, electrocution, and snake fungal disease, with West Nile virus and Stony Coral Tissue Loss Disease nearing publication. The NWHC-CWHC working group has additional draft case definitions in process, including avian cholera, distemper, chronic wasting disease, aspergillosis, brucellosis, duck virus enteritis, and lead poisoning. The template and all published case definitions are available online. Case definitions will be periodically reviewed and updated to incorporate new scientific techniques and information as needed.

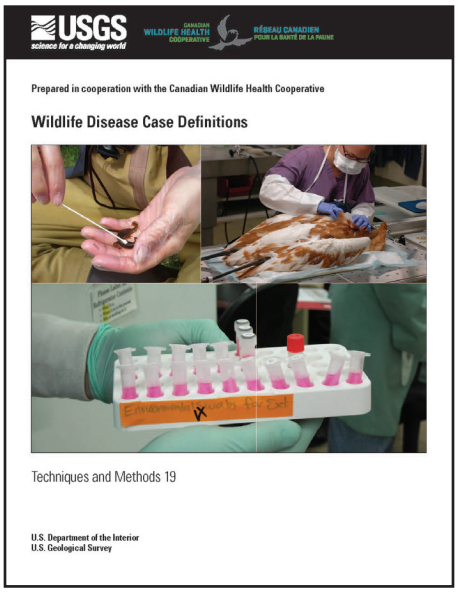

Figure 3. The USGS and CWHC Case Definition Joint Working Group has released Wildlife Disease Case Definitions, available online.

The NWHC-CWHC working group would like to acknowledge the generous collective input and expertise of the staff, pathologists, students, and colleagues at both institutions and other additional contributors, as well as the USGS Science Publishing Network for guidance in the development of these case definitions. For more information, please contact Kim Miller, kjmiller@usgs.gov.

WHISPers and National Wildlife Disease Database (NWDD) update

Informed by partner input, significant platform updates to WHISPers (Wildlife Health Information Sharing Partnership - event reporting system) are in progress.

The first set of new and enhanced WHISPers usability features, released in October 2023, included an administrative dashboard that enables participating partner agencies to enroll and manage their own agency's users. It gives partners complete control over who enters, manages, and releases wildlife health event information on their organization's behalf. Another new feature is a map-based location finder which simplifies documenting and auto-filling location(s) of sick and dead wildlife in an event report (specific location information remains visible only to users with advanced permission granted by the event owner). A new three-minute "What is WHISPers" video and administrator user guide were also developed and posted. The WHISPers event entry and management forms have been completely redesigned with a smoother, more intuitive workflow and are set to be released this spring. Finally, a mobile device reporting platform will be piloted this spring to test field-based data entry.

In addition to WHISPers usability enhancements, efforts have also shifted towards scoping and developing the congressionally mandated (ARPA) National Wildlife Disease Database (NWDD). USGS National Wildlife Health Center (NWHC) staff have conducted 12 formal structured scoping sessions,

WHISPers and National Wildlife Disease Database (NWDD) update, continued

plus multiple additional informal information gathering events, to help identify partner information needs, data sharing concerns, and impediments to participation. Scoping sessions were held with partners including the Southeast Association of Fish and Wildlife Agencies, Midwest Association of Fish and Wildlife Agencies, Southeastern Cooperative Wildlife Disease Study, U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Wildlife Services, U.S. Centers for Disease Control and Prevention, U.S. Fish & Wildlife Service, National Park Service, and Department of Homeland Security-Countering Weapons of Mass Destruction-National Biosurveillance Integration Center, with additional sessions planned. Understanding the needs and concerns of the broader conservation community will be critical to inform system development. In addition, a NWDD Steering Committee, comprised of executive-level leaders from select federal, state, and tribal partner organizations, was established to guide and facilitate NWDD development, and will prioritize high-level platform direction and outcomes, as well as address impediments to development, deployment, and utilization.

As always, we greatly appreciate the support state, federal, and tribal partners, and AFWA have provided throughout WHISPers development. We will continue to work closely with agency partners and AFWA, through multiple informal and formal venues, to assure that future development is robust, user friendly, addresses partner needs and concerns, better informs wildlife health, and fulfills Congress' direction to develop a National Wildlife Disease Database. For more information, please contact Bryan Richards (brichards@usgs.gov) or Katie Richgels (krichgels@usgs.gov). To learn more about WHISPers and how to participate please visit the WHISPers landing page or contact whispers@usgs.gov.

Chronic wasting disease

Plants as vectors for environmental prion transmission

Prions, misfolded isoforms of a normal mammalian cellular protein, cause progressive, fatal neurodenerative diseases including chronic wasting disease (CWD) in cervids, scrapie in sheep and goats, bovine spongiform encephalopathy (often referred to as "mad cow disease") in cattle, and Creutzfeldt-Jakob disease in humans. Prions exhibit extraordinary resistance to common treatments used to denature other infectious agents, such as ultraviolet and ionizing radiation, exposure to chemical disinfectants, and heat treatments. With CWD and scrapie, infectious prions may be transmitted to healthy, naïve, susceptible animal hosts via environmental routes and the ability of plants to accumulate and subsequently transmit disease has been hypothesized.

Pritzkow, et al. (2015) demonstrated that prions can bind to roots and leaves of plants that were surface contaminated with prion-containing solutions (e.g., brain homogenate, urine, feces) and that these prion-contaminated plants could cause disease when orally consumed by experimental laboratory animals. They also demonstrated uptake and deposition of prions in stems and leaves of plants grown in prion-spiked soils, but did not demonstrate whether consumption of these plants could cause infection.

Scientists from the USGS National Wildlife Health Center, University of Wisconsin-Madison, University of Texas Health Science Center, University of Pennsylvania, Universidad Bernardo O'Higgins, and Johns Hopkins University built upon Pritzkow et al. by examining not only whether plants could uptake and deposit prions in aerial tissues,

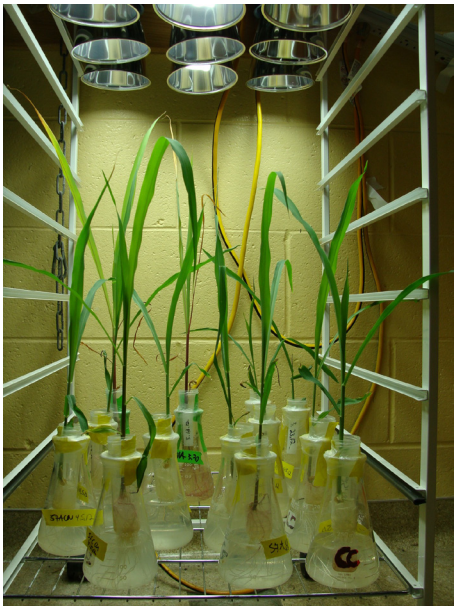

Figure 4. Plants were grown in prion-spiked growth media at the National Wildlife Health Center to investigate the role of prion contaminated plants in CWD transmission dynamics.

Plants as vectors for environmental prion transmission, continued

but also whether these plants could serve as vectors for prion diseases via oral consumption. Carlson et al. (2023) demonstrated the ability of several crop species, including alfalfa and barley, commonly consumed by cervids and livestock, to uptake prions via their roots and translocate them to above-ground tissues from various growth media, including soils, spiked with prions. And while plants cannot amplify prion burden like mammals, they were shown to accumulate prions in above-ground tissues in levels sufficient to transmit disease after oral ingestion by mice. The results of this study corroborate and extend the work of Pritzkow et al. and highlight mechanisms by which plants may serve as vectors for prion transmission in the environment. While this study has potential implications for wildlife conservation, agriculture, and public health, the authors have highlighted that this work was conducted in a laboratory environment (not in a field setting) with artificially-contaminated soils, did not use CWD or scrapie prions, did not use a ruminant model, and that additional investigations will be required to evaluate the degree to which prion-contaminated plants contribute to CWD and scrapie transmission dynamics. For more information, please contact Bryan Richards, brichards@usgs.gov.

Expanding range of CWD in North America

According to state- and province-based surveillance for chronic wasting disease (CWD), detections of CWD in free-ranging cervids occurred in 43 new counties in 21 states in the United States (U.S.) and three new management zones in three provinces in Canada between January 2023-March 2024 (Figure 5). Florida, Kentucky, Oklahoma, and British Columbia recorded their first CWD detections in wild cervids during this sampling period. As of March 2024, CWD has been documented in free-ranging cervids in a total of 505 counties in 32 U.S. states and 143 management zones in four Canada provinces. The distribution of CWD in commercial captive cervid facilities has also expanded, with 29 new facilities in nine states in the U.S., and eight new facilities in two provinces in Canada (Figure 5). Mississippi recorded their first CWD-positive captive facility in February 2024. To date, CWD has been detected in 226 commercial captive cervid facilities in 19 U.S. states and 152 facilities in three provinces in Canada. The current CWD distribution map (Figure 6), based on best-available data, is available from the USGS National Wildlife Health Center. For more information, contact Bryan Richards, brichards@usgs.gov.

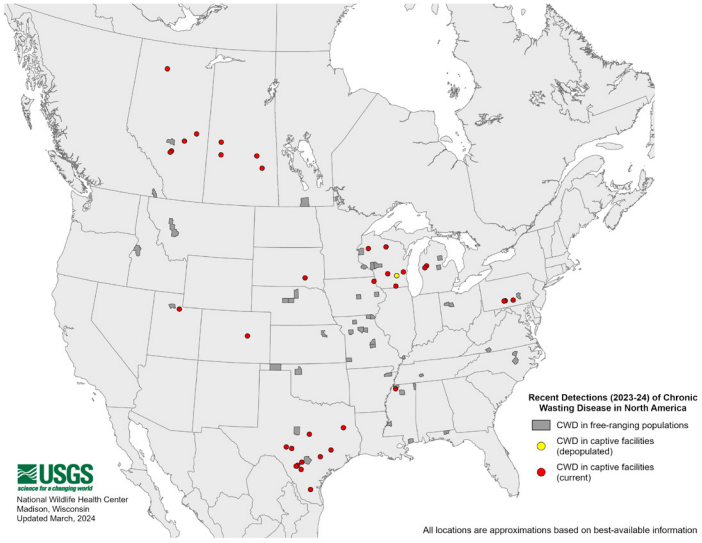

Figure 5. Recent (2023-2024) initial detections of chronic wasting disease in North America.

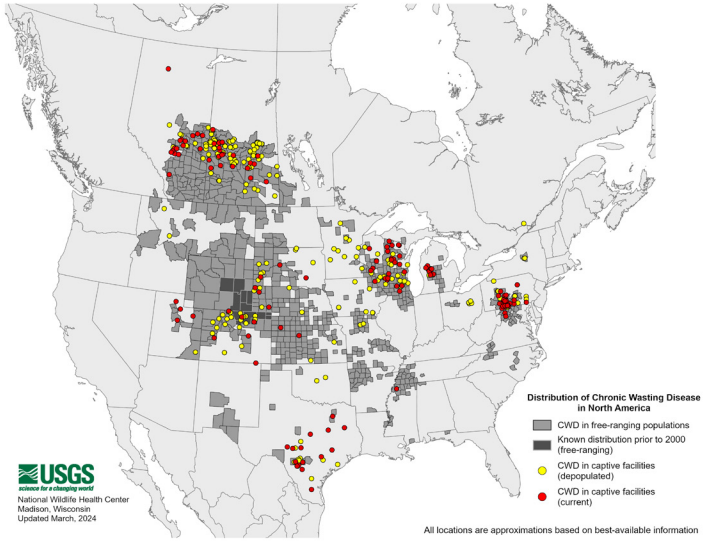

Figure 6. Documented distribution of chronic wasting disease in North America, based on best available data as of March 2024.

White-nose syndrome

National white-nose syndrome/*P. destructans* 2023/2024 surveillance season update

A hybrid sampling approach continues to be used to monitor the expanding range of *Pseudogymnoascus destructans* (*Pd*), the fungus that causes white-nose syndrome (WNS). This approach combines an adaptive ecological diffusion model (Oh et al. 2023) to identify areas at high risk for *Pd* spread in western and southern states with more intensive sampling at select long-term monitoring sites to assess WNS impacts on western bat species. Population declines attributed to WNS in the eastern half of the United States underscore the importance of continued surveillance for both *Pd* and WNS in these naïve bat populations to help inform the most effective treatment/management actions in support of bat conservation.

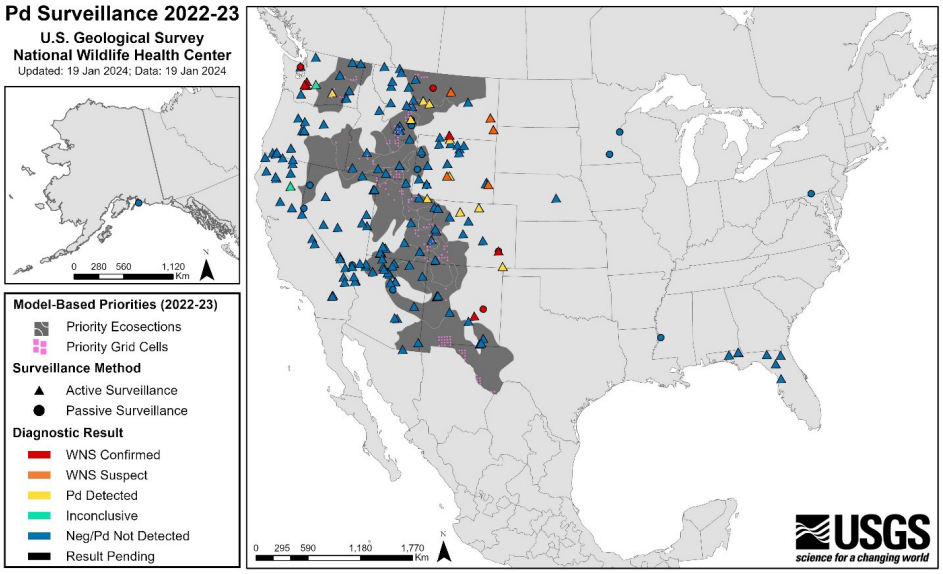

Figure 7. Results from the 2022/2023 *Pd*/WNS surveillance season analyzed by USGS NWHC (as of 1/19/2024). Gray polygons identify the high priority ecosections predicted by the *Pd* risk model for *Pd* range expansion during the 2022/2023 surveillance season.

For the 2023/2024 surveillance season, the USGS National Wildlife Health Center (NWHC) is providing U.S. partners in western and southeastern states with ~190 *Pd* surveillance kits for use at winter hibernacula or spring/early summer bat congregation sites (to facilitate early detection of *Pd* range expansion), and continues to assist with opportunistic surveillance of sick and/or dead bats meeting the NWHC diagnostic submission criteria. An additional ~25 sites across eight states (California, Colorado, Montana, New Mexico, South Dakota, Texas, Washington, and Wyoming) have been identified for long-term monitoring of WNS progression in western bat species. Sample analysis for this season is underway and as of late February 2024, 819 samples (500 bat-origin, 319 environmental) from more than 21 unique locations have been received for analysis.

Last season, NWHC evaluated 4,400 samples collected from over 200 locations in 18 states in the U.S.; *Pd* was detected at 24 of these sites, including four new counties in Montana (Carbon, Cascade, Jefferson, Judith Basin) and two new counties each in Washington (Benton, Jefferson) and Wyoming (Laramie, Sweetwater) (Figure 7). California reported its first definitive *Pd* detection on two Yuma bats (*Myotis yumanensis*) captured in Humboldt County, reducing the number of states where *Pd* has not yet been documented to seven (Alaska, Arizona, Florida, Hawaii, Nevada, Oregon, and Utah). The number of North American bat species confirmed with WNS remains at 12, despite the disease's continued westward expansion into areas with higher bat diversity. Overall, *Pd* was detected at six of 19 (32%) long-term monitoring sites located in five states (Colorado, Montana, South Dakota, Washington, and Wyoming) with *Pd* prevalence ranging from 0%-100% among bats sampled at each site.

NWHC provided *Pd* surveillance kits to partners in Mexico for the seventh consecutive year and is assisting with development of local diagnostic capacity by sharing established laboratory protocols. To date, *Pd* has not been detected in Mexico. For more information, please contact Anne Ballmann, aballmann@usgs.gov.

White-nose syndrome vaccine research update

To assess the efficacy of vaccination to reduce the impact of white-nose syndrome (WNS) in bats, researchers from the USGS National Wildlife Health Center (NWHC) are conducting field studies in several populations of susceptible bats. Initial trials conducted in cooperation with the Wisconsin Department of Natural Resources suggest that vaccination against WNS is likely to be more effective prior to or immediately after disease emergence. Additional vaccine field trials are continuing in western states in several maternity colonies in Washington and Idaho, and most recently in Wyoming. Additional sites will be added this year in Montana and Colorado. Preliminary results indicate spring returns of bats vaccinated the previous year were significantly higher in at least two mixed maternity colonies of little brown bats (*Myots lucifigus*) and Yuma myotis (*M. yumanensis*) in Idaho and Washington compared to unvaccinated bats. Higher spring returns suggests improved survival of vaccinated bats, but additional data is needed to confirm these findings. Endangered Northern long-eared bats (*M. septentrionalis*) at maternity roosts in Wyoming were also vaccinated as a preventative measure in 2023 and this effort will continue in 2024. For more information, please contact Tonie Rocke, trocke@usgs.gov.

Coral health

Interagency coordination on coral health

The USGS National Wildlife Health Center (NWHC) supports coral health through participation in two interagency coordination bodies, the Florida Disturbance Advisory Committee, which is focused on joint management of the Florida Coral Reef Tract, and the U.S. Coral Reef Task Force, which is focused on joint management of reef resources within U.S. Territories in both the Caribbean and Pacific. NWHC's participation in these interagency groups was initiated pursuant to a request to support early intervention and response efforts to stony coral tissue loss disease (SCTLD). SCTLD was first identified in 2014 and has since spread through the entire Florida reef tract, covering more than 400 nautical miles. SCTLD causes high morbidity and mortality in over 20 reef building coral species, highlighting concerns for long-term viability of the Florida reefs. In October 2023, NWHC participated in a Pacific preparedness workshop hosted by the disease working group at the U.S. Coral Reef Task Force meeting in the U.S. Virgin Islands. The workshop's purpose was to provide hands on training in how to recognize gross lesions consistent with SCTLD, develop response plans including a communication/coordination contact network, and identify potential treatments to slow disease spread. A portion of the NWHC coral disease program involves sampling and diagnostic support for coral disease outbreaks. The workshop provided an opportunity to raise awareness of NWHC services and capability to support coordinated response efforts in the U.S. Pacific territories. NWHC will continue to provide technical expertise to these two interagency groups as SCTLD and other major disturbances are increasing in frequency, severity, and extent of affected reefs. For more information, please contact Katie Richgels, krichgels@usgs.gov.

Recent coral disease technical support to partners in Caribbean and Pacific

The USGS National Wildlife Health Center (NWHC) has provided technical support for coral health in both the Caribbean and Pacific for the last several decades. As part of this work NWHC, in partnership with The Nature Conservancy, Red Arrecifal Dominicana, Fundación Grupo Puntacana, and FUNDEMAR, recently sampled five Dominican Republic reefs experiencing coral mortality. Histological findings suggested multiple etiologies including ciliates, endolithic hypermycosis, lytic necrosis, and a novel corallivorous flatworm. Corallivorous flatworms have not previously been described in the Caribbean; investigations to identify the species involved and their potential role in coral disease are ongoing. Initial histopathology results from this coral mortality event, along with protocols for collecting and curating coral samples and histopathology, were recently presented to The Nature Conservancy

Recent coral disease technical support to partners in Caribbean and Pacific, continued

and partners in the Dominican Republic. Separately, NWHC Honolulu Field Station staff (HFS) participated in a joint field expedition with the Smithsonian Environmental Research Center to investigate coral mortalities in Belize in the summer of 2023. NWHC also analyzed a set of 280 tissues collected from a coral mortality event in the Caiman Islands and delivered a detailed report on observed mortality processes and morphologic diagnoses to the Caiman Islands Department of Environment.

As part of a larger effort to link field response to laboratory capacity for coral disease investigations in the Pacific, NWHC HFS staff conducted workshops in Saipan, Guam, and American Samoa to help inform response capacity for coral disease outbreaks. These workshops included both lecture and practical field exercises to empower local jurisdictions to properly collect samples for laboratory investigations of coral disease outbreaks.

Finally, the NWHC HFS has developed a new laboratory technique examining coral cells using cytology. This method will allow inexpensive evaluation of corals, using commonly available equipment, including microscopes, slides, and readily available salts and stains, and adds a valuable tool for investigating coral disease and health. For more information, please contact Thierry Work, thierry_work@usgs.gov or Aine Hawthorne, ahawthorn@usgs.gov.

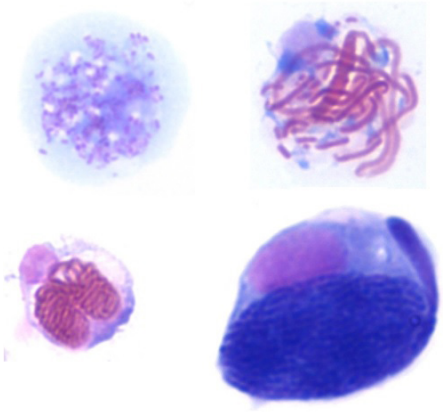

Figure 8. Examples of different coral cell types visualized with new technique using cytology.

Summary of 2023 avian morbidity/mortality reported to regional Flyway Councils

Each year, the USGS National Wildlife Health Center (NWHC) Epidemiology Team participates in the four regional Flyway Council Waterfowl Technical Committee meetings. NWHC presentations to the committees include a summary of avian morbidity and mortality events reported to NWHC. The following is an overview of this information.

In 2023, 360 avian morbidity and mortality events affecting an estimated 22,483 individuals were reported and entered in the Wildlife Health Information Sharing Partnership - event reporting system (WHISPers) (Figure 9). Events were entered and managed by NWHC, the Southeastern Cooperative Wildlife Disease Study, and multiple additional partner natural resource agencies. Reported events declined in compared to 2022, potentially

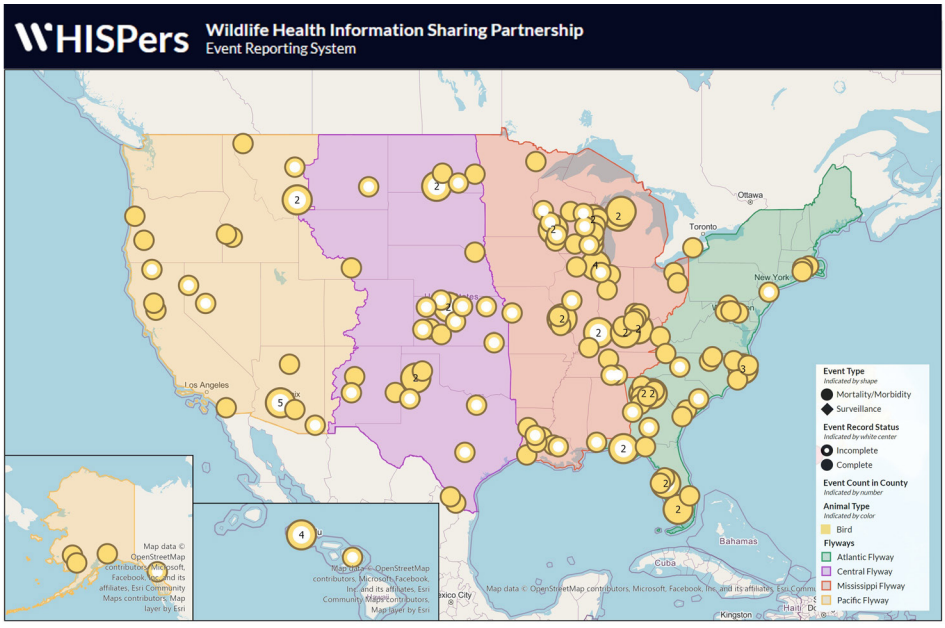

Figure 9. Map of avian morbidity and mortality events reported to WHISPers in 2023, by flyway.

Summary of 2023 avian morbidity/mortality reported to regional Flyway Councils, cont.

reflecting the 2022 surge in highly pathogenic avian influenza (HPAI) event reporting. A longer-term decline in event reporting has been ongoing since 2017. It is unclear whether this trend represents a true reduction in morbidity/mortality events over time or reflects other factors such as changes in voluntarily reporting.

Identified disease processes included nine infectious (viral, bacterial, fungal, parasitic) and five non-infectious (emaciation/nutritional, trauma, toxicosis, electrocution) etiologies. Twenty seven percent of total events (98) remain undetermined/pending, where cause of the mortality could not or has not been determined. Trauma and highly pathogenic avian influenza (HPAI) were the most common causes of mortality in 2023. HPAI accounted for more than 50% of avian morbidity/mortality in the Central and Pacific Flyways. Toxicosis (primarily lead) accounted for the largest proportion of bird mortality in the Atlantic Flyway, and trauma was the largest identified cause of mortality in the Mississippi Flyway (complete data available here).

Highly pathogenic avian influenza virus H5N1 (HPAIv) continued to circulate in wild bird populations in the U.S. in 2023. According to posted USDA data, there were 2,503 wild bird detections of HPAIv in 80 avian species from 12 orders under the category "morbidity/mortality." In 2023, 47 states had reports of HPAIv in wild birds (no reports from Hawaii, Vermont, and West Virginia).

For more information, please contact the NWHC Epidemiology Team at nwhc-epi@usgs.gov.

Modeling the response of an endangered rabbit population to RHDV2 and vaccination

Rabbit hemorrhagic disease virus 2 (RHDV2), a Lagovirus in the family Caliciviridae, has caused substantial mortality in wild lagomorph (rabbit and hare) populations in North America. Since its initial detection in wild rabbits in the southwestern United States and adjacent northwestern Mexico in 2020, concern has developed regarding RHDV2's potential population level impacts, particularly to threatened and endangered species and subspecies. To date, RHDV2 has been confirmed in seven North American wild lagomorph species in 14 U.S. states (USDA APHIS 2023), in addition to multiple jurisdictions in Mexico.

The riparian brush rabbit (*Sylvilagus bachmani riparius*) is a federally endangered subspecies of brush rabbit (*S. bachmani*), whose range is limited to specific riparian corridors in the northern San Joaquin Valley of California. Due to their endangered species status and limited geographic range (three known remnant populations), RHDV2 poses a substantial threat to their continued recovery and vaccination against the virus is being implemented by the U.S. Fish and Wildlife Service and partners. To help inform vaccination strategies, Russell et al. (2024) modeled the effects of RHDV2 introduction on riparian brush rabbits and simulated varying levels of vaccination against RHDV2 as a management intervention. Using a range of parameters, an initial population size of ~1,500 rabbits, and continued RHDV2 exposure, the model estimated a surviving population of 538 rabbits after one year with a 0-10% vaccination rate. At the highest modeled vaccination rate of 30-40%, the estimated surviving population after one year was 774 rabbits. Given the resources necessary to implement and maintain an intensive injection-based vaccination program for RHDV2 in wild rabbits, especially given their relatively short lifespan, these strategies are most likely to be successful in small target populations where high vaccination rates can be maintained. For more information, please contact Bob Dusek, rdusek@usgs.gov.

Figure 10. San Joaquin River Riparian Brush Rabbit, San Luis National Wildlife Refuge, CA. Photo by Lee Eastman/USFWS.

Paranannizziopsis spp. infections in wild snakes and a qPCR assay for detection of the fungus

Infectious disease is increasingly recognized as a threat to the conservation of wild reptiles, yet disease has been poorly studied in most reptile species in North America. The emergence of snake fungal disease (SFD; ophidiomycosis), caused by the fungus *Ophidiomyces ophidiicola*, in the United States has drawn attention to the potential impacts of such diseases. Several other fungi are known to cause outbreaks of fatal infections in captive reptiles, but these fungi have rarely been reported from wild reptiles. As part of the National Wildlife Health Center's (NWHC) investigation into SFD, Lorch et al. (2023) discovered that fungi in the genera *Paranannizziopsis* (which is closely related to *O. ophidiicola*) are found on wild snakes in the United States and Canada. Although much rarer than *O. ophidiicola*, *Paranannizziopsis* is widespread (detected in Florida, Minnesota, Louisiana, and Washington, USA; and British Columbia, Canada), causes skin infections similar to SFD, and infects a variety of snake species. At least three species of *Paranannizziopsis* were detected on wild snakes, and these species may vary in the severity of disease they cause.

The origin of *Paranannizziopsis* in North America is unknown. However, given the frequency with which this fungus occurs in captive reptiles, *Paranannizziopsis* may represent an introduced pathogen. A cluster of severe cases of *Paranannizziopsis* infection in gartersnakes (*Thamnophis* spp.) in British Columbia and Washington is especially concerning and in need of further monitoring and investigation. Detection of *Paranannizziopsis* is challenging because clinical signs of infection mirror those of SFD and coinfections of *Paranannizziopsis* and *Ophidiomyces* can occur. The NWHC has developed a rapid PCR-based detection method for *Paranannizziopsis* to assist in pathogen screening and accurate diagnosis of the disease. For more information, please contact Jeff Lorch, jlorch@usgs.gov.

Recent NWHC publications

Bartz JC, Benavente R, Caughey B, Christensen S, Herbst A, Hoover EA, Mathiason CK, Mckenzie D, Morales R, Schwabenlander MD, Walsh DP, and The North American Interdisciplinary Chronic Wasting Disease Research Consortium Members. 2024. Chronic wasting disease: State of the science. Pathogens 2024, 13(2), 138; https://doi.org/10.3390/pathogens13020138

Belasen AM, Peek RA, Adams AJ, Russell ID, De León ME, Adams MJ, Bettaso J, Breedveld KGH, Catenazzi A, Dillingham CP, Grear DA, Halstead BJ, Johnson PG, Kleeman PM, Koo MS, Koppl CW, Lauder JD, Padgett-Flohr G, Piovia-Scott J, Pope KL, Vredenburg V, Westphal M, Wiseman K, and Kupferberg SJ. 2024. Chytrid infections exhibit historical spread and contemporary seasonality in a declining stream-breeding frog. Royal Society Open Science 11: 231270. https://doi.org/10.1098/rsos.231270

Carlson CM, Thomas S, Keating MW, Gibbs NM, Chang H, Wiepz JK, Austin AG, Schneider JR, Johnson CJ, and Pedersen JA. 2023. Plants as vectors for environmental prion transmission. iScience 26. https://doi.org/10.1016/j.isci.2023.108428

Eads DA, Biggins DE, Ramakrishnan S, Goldberg AR, Eads SL, and Rocke TE. 2024. Prairie dog responses to vector control and vaccination during an initial *Yersinia pestis* invasion. International Journal of Parasitology: Parasites and Wildlife 23. https://doi.org/10.1016/j.ijppaw.2023.12.001

Elsmo EJ, Wünschmann A, Beckmen KB, Broughton-Neiswanger LB, Buckles EL, Ellis JH, Fitzgerald SD, Gerlach R, Hawkins S, Ip HS, Lankton JS, Lemley EM, Lenoch JB, Killian ML, Lantz K, Long L, Maes R, Mainenti M, Melotti J, Moriarty ME, Nakagun S, Ruden RM, Shearn-Bochsler VI, Thompson DA, Torchetti MK, Van Wettere AJ, Wise AG, and Lim AL. 2023. Highly pathogenic avian influenza A(H5N1) virus clade 2.3.4.4b infections in wild terrestrial mammals, United States, 2022. Emerging Infectious Diseases 29: 2451-2460. https://doi.org/10.3201/eid2912.230464

Hofmeister E, Clark E, Lund M, and Grear D. 2024. Serologic survey of selected arthropod-borne pathogens in free-ranging snowshoe hares (*Lepus americanus*) captured in northern Michigan, USA. Journal of Wildlife Diseases. https://pubmed.ncbi.nlm.nih.gov/38345469/

Lorch JM, Winzeler ME, Lankton JS, Raverty S, Snyman HN, Schwantje H, Thacker C, Knowles S, Cai HY, and Grear DA. 2023. *Paranannizziopsis* spp. infections in wild snakes and a qPCR assay for detection of the fungus. Frontiers in Microbiology 14. https://doi.org/10.3389/fmicb.2023.1302586

Recent NWHC publications, continued

Loyva K, Hofmeister EK, Georgousi F, Roderick C, and Cole RA. 2023. Considerations for colorblind individuals on selecting colorimetric or fluorescent dye assay outcomes. BioTechniques 75: 240-244. https://doi.org/10.2144/btn-2023-0041

Miller JL, Erickson L, Fork S, Roderick CL, Grear DA, and Cole RA. 2024. Morbidity in California giant salamander (*Dicamptodon ensatus* Eschscholtz, 1833) caused by *Euryhelmis* sp. Poche, 1926 (Trematoda: Heterophyiidae). International Journal for Parasitology: Parasites and Wildlife 23: 100908. https://doi.org/10.1016/j.ijppaw.2024.100908

Miller KJG, Parmley EJ, Ballmann A, Buckner J, Jones M, Lankton JS, and Zimmer M. 2024. Case definitions for wildlife diseases. U.S. Geological Survey Techniques and Methods, book 19, Reston, VA. https://doi.org/10.3133/tm19

Oh G, Aravamuthan S, Ma TF, Mandujano Reyes JF, Ballmann A, Hefley T, Mcgahan I, Russell R, Walsh DP, and Zhu J. 2023. Model-based surveillance system design under practical constraints with application to white-nose syndrome. Environmental and Ecological Statistics 30: 649-667. https://doi.org/10.1007/s10651-023-00578-3

Rocke TE. 2023. Plague and distemper: Threats to black-footed ferret conservation. Wildlife disease and health in conservation: 217-235. https://doi.org/10.56021/9781421446745

Russell RE, Dusek RJ, Prevost S, Clifford DL, Moriarty ME, and Takahashi F. 2024. Modeling the response of an endangered rabbit population to RHDV2 and vaccination. Conservation Science and Practice: e13072. https://doi.org/10.1111/csp2.13072

Thurman LL, Alger K, Ledee O, Thompson LM, Hofmeister E, Hudson JM, Martin AM, Melvin TA, Olson SH, Pruvot M, Rohr JR, Szymanksi JA, Aleuy OA, and Zuckerberg B. 2024. Disease-smart climate adaptation for wildlife management and conservation. Frontiers in Ecology and the Environment: e2716. https://doi.org/https://doi.org/10.1002/fee.2716

Tornabene BJ, Hossack BR, Halstead BJ, Eagles-Smith C, Adams MJ, Backlin AR, Brand A, Emery C, Fisher RN, Fleming JE, Glorioso B, Grear DA, Campbell Grant EH, Kleeman PM, Miller D, Muths EL, Pearl C, Rowe J, Rumrill CT, Waddle JH, Winzeler M, and Smalling KL. 2023. Broad-scale assessment of methylmercury in adult amphibians. Environmental Science and Technology 57: 17511-17521. https://doi.org/10.1021/acs.est.3c05549

Publications cited in this report

Carlson CM, Thomas S, Keating MW, Gibbs NM, Chang H, Wiepz JK, Austin AG, Schneider JR, Johnson CJ, and Pedersen JA. 2023. Plants as vectors for environmental prion transmission. iScience 26. https://doi.org/10.1016/j.isci.2023.108428

Lorch JM, Winzeler ME, Lankton JS, Raverty S, Snyman HN, Schwantje H, Thacker C, Knowles S, Cai HY, and Grear DA. 2023. *Paranannizziopsis* spp. infections in wild snakes and a qPCR assay for detection of the fungus. Frontiers in Microbiology 14. https://doi.org/10.3389/fmicb.2023.1302586

Miller KJG, Parmley EJ, Ballmann A, Buckner J, Jones M, Lankton JS, and Zimmer M. 2024. Case definitions for wildlife diseases. U.S. Geological Survey Techniques and Methods, book 19, Reston, VA. https://doi.org/10.3133/tm19

Oh G, Aravamuthan S, Ma TF, Mandujano Reyes JF, Ballmann A, Hefley T, Mcgahan I, Russell R, Walsh DP, and Zhu J. 2023. Model-based surveillance system design under practical constraints with application to white-nose syndrome. Environmental and Ecological Statistics 30: 649-667. https://doi.org/10.1007/s10651-023-00578-3

Pritzkow S, Morales R, Moda F, Khan U, Telling Glenn c, Hoover E, and Soto C. 2015. Grass Plants Bind, Retain, Uptake, and Transport Infectious Prions. Cell Reports 11: 1168-1175. https://doi.org/10.1016/j.celrep.2015.04.036

Russell RE, Dusek RJ, Prevost S, Clifford DL, Moriarty ME, and Takahashi F. 2024. Modeling the response of an endangered rabbit population to RHDV2 and vaccination. Conservation Science and Practice: e13072. https://doi.org/10.1111/csp2.13072

More Information from the NWHC

Visit our website at www.usgs.gov/nwhc and follow us on X @USGSWILDLIFE
To sign up to receive Newsletters and Wildlife Health Bulletins from the NWHC, please email nwhcoutreachdb@usgs.gov.