Meeting Minutes

Coordinating Committee Meeting
Pennsylvania Cooperative Fish and Wildlife Research Unit

Wednesday, August 17, 2022
1:00 PM
Via Zoom

1. **Minutes from June 18, 2021 meeting approved**

2. **Completed Projects (Summaries in Appendix A)**
   2.1. Diefenbach
      2.1.1. Monitoring movements and habitat use of snowshoe hare
      2.1.2. Changes in forest composition through time due to charcoal production for the iron industry
   2.2. Wagner
      2.2.1. The spatiotemporal dynamics of contaminants
   2.3. Walter
      2.3.1. The effects of targeted removal of deer groups on the epidemiology of chronic wasting disease in wild white-tailed deer in Pennsylvania
      2.3.2. Epidemiology of West Nile virus in ruffed grouse (*Bonasa umbellus*)

3. **New & Continuing Projects (* Requires approval by Committee; See Appendix B)**
   3.1. Diefenbach
      3.1.1. Genetics of an insular population of bobcats
      3.1.2. Deer abundance and its relationship to factors that affect forest vegetation conditions
      3.1.3. Decision model for fall turkey hunting regulations
      3.1.4. *Snowshoe hare distribution and landscape genetics
      3.1.5. *Estimating crippling loss in wild turkeys

   3.2. Wagner
      3.2.1. A macrosystems ecology framework for continental-scale prediction and understanding of lakes
      3.2.2. Fish habitat restoration to promote adaptation: resilience of sport fish in lakes of the Upper Midwest
      3.2.3. Determining the consequences of land management actions on primary drivers influencing smallmouth bass populations
      3.2.4. Changes in stream fish distribution and occurrence in seven National Park Service units of the Eastern Rivers and Mountains Network
      3.2.5. Diet composition of invasive flathead catfish in the Susquehanna River Basin: quantifying impacts on native and migratory fishes and recreational fisheries
      3.2.6. Quantifying the roles of changing watershed conditions and biotic interactions in structuring Pennsylvania stream fish communities
      3.2.7. Forecasting aquatic invasions in rivers: using riverscapes genetics to inform invasive fish species management at regional scales

3.2.8. Quantifying the impacts of climate change on fish growth and production to enable sustainable management of diverse inland fisheries
3.2.9. Scale, Space, and Time: A Unifying Approach to Aquatic Invasions
3.2.10. *Collaborative Research: RAPID: lake ecosystem responses to fire along gradients of burn characteristics and hydrologic connectivity
3.2.11. *Aquatic food web changes to invasive Flathead Catfish along an invasion gradient
3.2.12. *Putting the sampling design to work: enhancing monitoring programs for improved management and inference of ecological responses to changes in climate

3.3. Walter
3.3.1. Phase II: Genetic assignment of white-tailed deer to population of origin
3.3.2. Optimizing CWD Surveillance: Regional Synthesis of Demographic, Spatial, and Transmission-Risk Factors
3.3.3. Parturition timing and calf survival in Pennsylvania elk
3.3.4. Linking Genetics to Movements of White-tailed deer to Assist Surveillance for Chronic Wasting Disease
3.3.5. Management Strategies and genetics of deer in Minnesota
3.3.6. Establishing a national tissue and reagents repository for chronic wasting disease
3.3.7. Assessment of movement of prions across the captive-wild interface
3.3.8. *Agent-based models to inform management of white-tailed deer for chronic wasting disease

4. Proposed Budget

5. Roster of Current Graduate Students and Post-Doctoral Researchers

5.1. Diefenbach
5.1.1. Eva Barr, MS Ecology
5.1.2. Amanda Zak, MS Ecology
5.1.3. Veronica Winter, PhD Ecology
5.1.4. Phillip Jones, Post-doc

5.2. Wagner
5.2.1. Paul McLaughlin, Post-doc
5.2.2. Christopher Custer, PhD Ecology
5.2.3. Morgan Strum, MS WFS
5.2.4. Sarah Batchelor, PhD Ecology

5.3. Walter
5.3.1. Avery Corondi, MS WFS
5.3.2. Kristin Bondo, Post-doc
5.3.3. Alberto Fameli, Post-doc
5.3.4. Tyler Walters, MS Ecology
5.3.5. Chia-Hua Lue, Post-doc
5.3.6. Kelly Russo-Petrick, Post-doc

6. Service on Graduate Committees (other than advisees)

6.1. Diefenbach

6.1.1. Arun Regmi, PhD Forest Science

6.1.2. Katherine Gunderman, MS WFS

6.1.3. Chyvonne Jessick, PhD Ecology

6.1.4. Nicole Palmer, MS Ecology

6.2. Wagner

6.2.1. Francesca Ferguson, PhD Ecology

6.2.2. Sydney Stark, MS WFS

6.2.3. Logan Stenger, MS Entomology

7. Courses and Workshops Taught by Unit Staff

7.1. Wagner

7.1.1. Applied Hierarchical Bayesian Modeling, spring 2022

7.2. Walter

7.2.1. Applied Spatial Ecology in R Workshop, Fall 2021

7.2.2. WFS 585 - Applied Spatial Ecology Course, Spring 2022

8. Comments from Cooperators

8.1. U.S. Geological Survey

8.1.1. Budget and staffing

8.1.1.1. Proposed budget increases funding by ~$2 million

8.1.1.2. Unit system has filled about 35 vacancies and ~15 are currently being filled

8.1.1.3. Michigan is a new unit

8.1.2. In 2023 an All-Hands Meeting of all Unit scientists will be held – the last meeting was held in 2016. About a 1/3 of the Unit workforce is new since 2016.

8.2. U.S. Fish and Wildlife Service

8.2.1. The proposed 2023 budget looks good. The NE Region is focusing on at-risk species, coastal resilience, and landscapes

8.2.2. The local Ecological Services office is focused on endangered species, assessing species status, recovery projects, and at-risk species.

8.2.2.1. Specifically, work involves wetland and stream restoration, environmental contaminants reclamation, hydropower review, pollinator conservation, migratory bird collisions

8.2.2.2. The office has 3 new/pending positions

8.3. Department of Ecosystem Science and Management, Penn State University

8.3.1. The Unit adds to the department with its scientific productivity, graduate education, and assistance to junior faculty

8.3.2. The department is dealing with staff shortages and has experienced about an 18% budget cut over the past 10 years

8.3.3. The department is seeing declining trends in students seeking PhD degrees

8.4. Pennsylvania Game Commission

8.4.1. Agency is in good fiscal shape and is investing in infrastructure, science, and beginning a new strategic plan

8.4.2. Full Board of Commissioners

8.4.3. Agency has created a new CWD section, developing a reintroduction of American marten proposal, and conducting quail reintroduction at Letterkenny Army Depot

8.5. Pennsylvania Fish and Boat Commission

8.5.1. Fiscally the agency is in good shape and investing in infrastructure and current strategic plan ends next year

8.5.2. Agency will be implementing incremental license fee increase as approved by Board of Commissioners

8.5.3. Freshwater mussel propagation is doing well; habitat staff are doing a lot of stream restoration; collaborating with USFWS on illegal trade in fish/amphibians

8.5.4. Soliciting public comment on fish stocking and working on regulations on bilge water to prevent transport of invasive species

8.5.5.

9. Adjourn

10. An Executive Session of the Coordinating Committee followed immediately after adjournment

10.1. All new Projects (noted by asterisk) were approved

Appendix A – Abstracts of Completed Projects

Appendix B – Summaries of New and Continuing Projects

Appendix C – Awards, Publications, and Presentations

APPENDIX A - Completed Projects

2.1.1 **Monitoring movements and habitat use of snowshoe hare**, Emily Boyd, Duane Diefenbach

The Unit provided technical support to this project by hiring 2 full-time technicians and providing assistance with study design, data collection, and analysis. A Microsoft Access® database of all captures and mortalities was maintained by Unit personnel and all animal locations were uploaded to Movebank as a permanent repository. In addition, as a class project, the graduate students in WFS 560 analyzed hare survival over 2 years of the study. Below is the executive summary of their report to the PGC.

"The objective of this report is to identify which factors are related to snowshoe hare (*Lepus americanus*) survival in northeastern Pennsylvania. While their current conservation status in Pennsylvania is considered Secure, informed management practices would reduce the risk of this species becoming vulnerable to extinction in the face of climate change and habitat loss.

"A sample size of 85 snowshoe hares were used in this survival analysis study. They were caught in two State Game Lands (SGL 127 and SGL 038) in northeastern Pennsylvania from March 2020 to February 2022. Their survival and mortality were monitored using GPS collars. We used Akaike's information criterion corrected for small sample size (AICc) to identify the best Kaplan-Meier known-fate model in program MARK. The covariates considered in this survival analysis were sex, body mass, site, season, and percentage of an individual's locations in each of 6 habitat types.

"The best-performing model (i.e., lowest AICc) was the additive model including sex and percentage of locations spent in wetland or burned habitats. The survival probability of males was higher than the survival probability of females in wetland or burned habitats. However, this model was within 2 AICc units of a model where survival was constant.

"In contrast to prior snowshoe hare studies throughout its range, this analysis indicates that sex influenced survival while season and mass did not influence survival. Analysis and conclusions from this study are limited by a relatively small sample size but the results suggest that wetlands and burned areas increase snowshoe hare survival rates."

2.1.2 **Changes in forest composition through time due to charcoal production for the iron industry, tree harvest, and deer browse**. Sam Bayuzack, Patrick Drohan, Marc McDill, Duane Diefenbach

Throughout the northeastern United States (U.S.) and Europe, relict charcoal hearths (RCHs) are regularly being discovered in proximity to furnaces once used for the extraction of metal from ore or quick-lime production; charcoal produced in hearths was used as a furnace fuel. Given previous research has shown that topographic and subsurface disturbance can be great when a hearth is constructed, we hypothesize that hearth construction alters surface hydrology and soil chemistry in environments in and near hearths. We used a landscape classification process to identify 6,758 hearths near furnaces at Greenwood and Pine Grove Furnace State Park, central

and southcentral Pennsylvania, U.S. Two types of digital elevation model wetness indexes were used to quantify surface hydrology effects in and around hearths. Modeled wetness conditions were compared to field soil volumetric water content in RCHs near Greenwood Furnace State Park. Modeled wetness indexes indicate that RCH interiors are significantly wetter than RCH rim areas; RCHs are acting as a landscape moisture sink. Results also indicate that RCHs on slopes result in downslope drier conditions below RCHs. Field measured volumetric water content indicates that as distance from the center of the hearth increases, soil moisture significantly decreases. Geomorphic position was found to not be related to RCH wetness. Soil from RCHs, compared to nearby native soils, has significantly higher total C, a lower Mehlich 3 extractable acidity, higher Ca and P. No trend was evident with RCH soil chemistry and geomorphic position. The high frequency of RCH occurrence, in proximity to the furnace's RCHs supported, suggests that RCHs today could locally be an important niche for understory flora and fauna. Further research could explore how RCHs might be affecting surrounding plant populations and how within RCH patterns, especially on hillslopes, might represent a distinctly different scale of physical and chemical variability.

2.2.1. The spatiotemporal dynamics of contaminants in surface water and their potential accumulation in smallmouth bass in rivers of the Chesapeake Bay Watershed Tyler Wagner (PI), Vicki Blazer (co-PI, USGS), Kelly Smalling (co-PI, USGS)

Citation: McClure, C.M., K.L. Smalling, V.S. Blazer, A.J. Sperry, M.K. Schall, D.W. Kolpin, P.J. Phillips, M.L. Hladik, and T. Wagner. 2020. Spatiotemporal variation in occurrence and co-occurrence of pesticides, hormones, and other organic contaminants in rivers in the Chesapeake Bay Watershed, United States. Science of The Total Environment 728:138765.

There are many contaminant exposure pathways to fish including surface water, sediment, and groundwater, though less is known about the potential for the transfer of contaminants from female to young during egg development. Therefore, to investigate the role of contaminants in the decline of fish health in the region and to understand which exposure pathways contribute contaminants of concern, a multi-year study was established to investigate contaminants in surface water, sediment, and fish tissue, as well as document any signs of immunosuppression in the sampled fish. The first objective was to investigate the occurrence and co-occurrence dynamics of 28 contaminants and total estrogenicity in surface water across six river sampling sites over a three-year period. Bayesian hierarchical joint-contaminant models were used to describe any potential predictors in occurrence such as proportion of agricultural land-use in the immediate catchment, stream discharge or seasonality for a suite of contaminants in surface water. The second objective was to investigate the occurrence and concentration of contaminants in smallmouth bass adult ovary and juvenile full-body tissue to evaluate maternal transfer of contaminants as a potential exposure pathway. Results provide a necessary baseline of spatial and temporal contaminant occurrence dynamics in streams and rivers of the Chesapeake Bay Watershed. Understanding temporal and spatial contaminant dynamics as well as the potential for complex contaminant mixtures in surface water will provide necessary information on contaminant exposure to fish in the region. Additionally, this information coupled with the results that there is low, baseline levels of contaminants in juvenile

smallmouth bass tissue is important for understanding contaminant exposure pathways and the recent health declines in regional populations of the Chesapeake Bay Watershed.

3.3.1 The effects of targeted removal of deer groups on the epidemiology of chronic wasting disease in wild white-tailed deer in Pennsylvania

Joe Moran, David Walter, Chris Rosenberry (PGC)

Pennsylvania's CWD infection is currently in a relatively early stage of development. This provides some hope that an effective control strategy might protect the state's white-tailed deer resource. Potential elimination of CWD in free-ranging deer has occurred (e.g., New York) so it might be possible to focus targeted removal efforts on locations where CWD positive animals are found at or beyond the fringe of an infected area. We will implement a study designed to test and evaluate a systematic approach to controlling occurrence and distribution of CWD in Pennsylvania utilizing various harvest strategies (targeted removal of deer groups, altering hunting season) in areas CWD positive deer have been found. By employing a systematic program aimed at simultaneously trying to control the prevalence level within an area while attempting to eradicate new infections along the margin of the area, investigation of potential methods for effective control of CWD outbreaks is needed by state agencies or federal parks if CWD is discovered. This research will have management implications for various agencies by: (1) removing antler-point restrictions on harvest regulations of male deer, (2) controlled localized culling of deer to potentially reduce prevalence and transmission, and (3) a combination of 1 and 2 above as well as a control area with no management actions to assess the most suitable method to decrease prevalence and minimize/eliminate transmission out of the disease management area.

3.3.2 Epidemiology of West Nile virus in ruffed grouse

Kristin Bondo, David Walter, Lisa Williams (PGC), Justin Brown (PGC)

Since its arrival in North America in 1999, West Nile virus (WNV) has had unprecedented adverse effects on the health of native bird species. In Pennsylvania, WNV was first documented statewide in 2002, soon after which population declines were observed in Pennsylvania ruffed grouse (*Bonasa umbellus*) and since then grouse populations have not recovered. Subsequent outbreaks of WNV are correlated with reductions in population indices of hunter flush rates and summer sighting survey (brood) data. In Spring 2015, the Unit assisted the Pennsylania Game Commision by purchasing radiotransmitters to monitor wild grouse hens and collect eggs for a challenge study of naïve individuals inoculated with the WNV virus. Forty percent of chicks died within a week post-inoculation, and long term survival was questionable for an additional 30–50% of chicks. Recent research indicates there may be an interaction between habitat quality/quantity and the effect of WNV on grouse populations. More information is needed on the epidemiology of WNV with respect to ruffed grouse because nearly all research and monitoring has focused on WNV risk in human environments. Our objectives are to identify the mosquito species that coexist with ruffed grouse in early successional habitat, which mosquito species are important vectors of WNV for ruffed grouse, and which environmental factors increase the risk of WNV exposure to ruffed grouse. This information will result in background

data to model the epidemiology of WNV across Pennsylvania to determine the ruffed grouse populations most at risk from the virus.

APPENDIX B – New (*) and Continuing Projects

3.1.1 Harvest and survival rates of hen wild turkeys in Pennsylvania. Duane R. Diefenbach, Mary Jo Casalena (PGC), Paul Fackler (NCSU), Funded by PGC, Pennsylvania Chapter NWTF, Alabama Chapter NWTF.

We have been working to incorporate the decision model for making recommendations for the fall turkey season into the PGC's decision making process. A manuscript that we intend to submit to Wildlife Monographs summarizes the results of the hen turkey study, the integrated population model we developed, and the decision model. The manuscript is nearly completed for internal approvals before being submitted to the journal.

3.1.2 Genetics of an insular population of bobcats and coyotes. D. Diefenbach. L. Hansen (LANL), C. Miller-Butterworth (Penn State–Beaver)

We continue to collect DNA from scats to monitor abundance and genetic diversity of the population. Discussions regarding translocating bobcats to the island to restore genetic diversity of the population have continued but dealing with state (FL and GA), federal (NPS), and university bureaucracies has been challenging.

3.1.3 Deer abundance and its relationship to factors that affect forest vegetation conditions. Eva Barr, D. Diefenbach, M. McDill, P. Drohan, C. Rosenberry (PGC), E. Just (DCNR). Funding provided by PGC and DCNR Bureau of Forestry.

Eva Barr (MS Ecology) is studying how environmental factors (soil conditions, slope/aspect, deer herbivory, etc.) explain the distribution of plants used to monitor the effects of deer herbivory. Eva is completing her first field season in August 2022.

We have analyzed results of the experiment that Danielle Begley-Miller established in 2014 and have found that soil pH plays an important role in the outcomes of fence and herbicide treatments to address deer herbivory and competing vegetation. A manuscript is in preparation.

Continued work on this project over the next 4 years is going to focus on 1) completing soil sampling in the oak-hickory study areas, 2) investigating how to better design a monitoring program to detect the effects of deer herbivory on understory vegetation. This fall we will have 3 graduate students and a post-doc on the project. We are working on hiring soil technicians.

3.1.4. Decision model for fall turkey hunting regulations D. Diefenbach, F. Buderman (PSU), Andrew Mowen (PSU)

Veronica Winter (PhD Ecology) will begin her graduate program in August and will be focusing on developing a Bayesian population model and further developing the decision model for setting fall seasons.

Support for fieldwork that began this winter is operational. Kevin Lamp maintains the capture/mortality/censor database, provides field techs with weekly graphs of activity to identify mortalities and nesting attempts, coordinates with Alyssia Church on uploading locations to Movebank, and maintains the SQL database of GPS locations and accelerometer data.

To accommodate the huge amount of data collected on this project we have set up a virtual machine through Penn State (vmhosting.psu.edu) to manage the SQL Server database. This database currently has over 8 million accelerometer records and 400,000 GPS locations.

3.1.5 *Estimating wild turkey movements and crippling loss D. Diefenbach, A. Mowen (PSU), F. Buderman (PSU)

This project is will support a MS student to study turkey movements as related to habitat and disease. A PhD student (supported in part by Department of Parks, Recreation, and Tourism) will investigate crippling loss via simulated hunting scenarios and hunter surveys, in conjunction with field data being collected on turkeys fitted with transmitters.

3.2.1 A macrosystems ecology framework for continental-scale prediction and understanding of lakes Tyler Wagner (co-PI), Patricia Soranno (PI, MSU), Kendra Cheruvelil (co-PI, MSU), Emily Stanley (co-PI, Univ. WI), Noah Lottig (co-PI, Univ. WI), Ephraim Hanks (co-PI, PSU), Erin Schliep (co-PI, Univ. MO), Pang-Ning Tan (co-PI, Univ. MSU), Jiayu Zhou (co-PI, Univ. MSU)

In the past decade, our understanding of how inland waters influence regional, continental, and global biogeochemical cycles has fundamentally changed. We have moved from discounting their contributions, to now recognizing these ecosystems as significant hotspots for the storage and transformation of nitrogen, phosphorus, and carbon. This realization has come about through careful and labor-intensive collection, integration, and synthesis of often-scattered data sources, combined with a variety of different approaches to extrapolate site-level measures to unsampled sites across regions and continents. Today, although this view of the role of inland waters in large-scale cycling is supported by numerous studies, substantial gaps in our understanding remain. Estimates for the same flux (e.g., organic carbon burial in lakes) often differ substantially among studies. Further, most attempts to quantify continental or global fluxes or pools come with caveats regarding the often high– and often unknown– uncertainty associated with these estimates. To better understand the role of inland waters in macroscale nutrient cycling, new approaches are needed to reduce uncertainty in extrapolating site-level estimates to larger geographical scales. The overarching goal of this research is to understand and predict nutrient patterns for ALL continental US lakes to inform estimates of lake contributions to continental and global cycles of nitrogen (N), phosphorus (P), and carbon (C), while also providing locally valuable information about conditions in unsampled lakes.

3.2.2 Fish habitat restoration to promote adaptation: resilience of sport fish in lakes of the Upper Midwest

Tyler Wagner (co-PI), Gretchen Hansen (PI, Univ. MN), Jordan Read (co-PI, USGS), Erin Schiep (co-PI, Mizzou), Zach Feiner (co-PI, WI DNR), Catherine Hein (co-PI, WI DNR), Pete Jacobson (co-PI, MN DNR), Joe Nohner (co-PI, MGLP, MN DNR), Samantha Oliver (co-PI, USGS), Kevin Wehrly (co-PI, MI DNR), Abigail Lynch (co-PI, USGS NCAC)

Fish responses to climate change are heterogeneous across the landscape of lakes. Local habitat conditions and the abundance of other species can influence fish responses, and by manipulating these factors, fish managers may increase resilience of certain populations to warming. We propose to quantify fish responses to climate change in lakes throughout the Midwestern United States, and to identify factors that explain heterogeneity in how fish populations respond. Our objectives are to: (1) Develop statistical models of the relative abundance of multiple species of fish in lakes throughout the Upper Midwest; (2) Quantify relationships between environmental conditions, species interactions, and the abundance and recruitment of managed fish; (3) Predict abundance and recruitment of multiple fish species under future scenarios of climate change; and (4) Identify and communicate priority lakes for implementing habitat protection and restoration actions. We will develop joint species distribution models that quantify dependencies between multiple fish species and their environment. We will collate fish relative abundance and habitat data from the 8 state fisheries management agencies of our study region (Illinois, Indiana, Iowa, Michigan, Minnesota, North Dakota, South Dakota, and Wisconsin). Target species will include walleye, yellow perch, black bass, northern pike, cisco, and bluegill to span a range of thermal preferences and management strategies. We will simulate water temperature conditions under contemporary (1979-2019) and future (late 21st century) climate conditions. We will quantify relationships between multiple fish species abundance and recruitment, lake characteristics, and climate. The models will be used to assess how multiple fish species respond to water temperature and how that response depends on other variables. We will assess the role of harvest and stocking in influencing walleye abundance and the entire fish community on a subset of lakes where suitable data are available. We will develop a prioritization scheme for managing fish communities under climate change and communicate results via data visualization and communication tools co-produced with fisheries management agencies. By generating lake-level predictions for multiple species in tens of thousands of lakes across multiple states, our results will be relevant for prioritizing climate adaptation management decisions at lake, watershed, county, state, and regional scales.

3.2.3 Determining the consequences of land management actions on primary drivers influencing smallmouth bass populations

Tyler Wagner (PI)

Better understanding the drivers and stressors affecting fish health, fish habitat and aquatic conditions remains a significant management need in cool and warmwater rivers. Quantifying the effects of land management activities on aquatic ecosystems plays an important role in environmental management and decision-making. This research will address stakeholder needs

related to understanding the effects of land management actions on stream and river habitat conditions – habitat that is critical for supporting socioeconomically and ecologically important fish communities throughout the Chesapeake Bay Watershed. The project is a collaboration of researchers across multiple agencies and includes the USGS and state fisheries management agencies across the Chesapeake Bay Watershed. Through the development of several modeling frameworks, this research will focus on quantifying the effects of land management actions on population-level outcomes that are relevant to managers, including effects on abundance, recruitment, the number of spawners, and size structure.

3.2.4 Changes in stream fish distribution and occurrence in seven National Park Service units of the Eastern Rivers and Mountains Network Tyler Wagner (co-PI)

The National Park Service (NPS) mission to preserve, protect, and maintain the integrity of park ecosystems for the enjoyment of future generations relies upon access to science-based information regarding the status and trends of ecosystem condition. The Eastern Rivers and Mountains Network (ERMN) includes nine parks located in four states: New York, New Jersey, Pennsylvania, and West Virginia ranging in size from approximately 66 to 30,000 hectares with over 690 km of rivers and streams. The ERMN documents long-term change in the ecological integrity of one of the most abundant surface water ecosystems types in the network (high gradient, wadeable streams) by monitoring stream fish communities. Assessment of changes in fish community composition, occupancy and abundance is necessary in order to ensure the NPS mission is achieved. The project is a collaboration of researchers from USGS, NPS, and Pennsylvania State University. The statistical models developed during this project will inform decision making processes for the management of park ecosystems.

3.2.5 Diet composition of invasive flathead catfish in the Susquehanna River Basin: quantifying impacts on native and migratory fishes and recreational fisheries Tyler Wagner (co-PI)

Flathead Catfish are an indiscriminate predator of other fish and an expanding invader to large river systems outside of its native range, including the Susquehanna River Basin in Pennsylvania. Research efforts are beginning to provide insight on the distribution of this invader in the Susquehanna River Basin, however, there is considerable uncertainty about the potential ecological impacts of Flathead Catfish. In particular, there are concerns about their impacts on native and migratory fish species and on economically important recreational fisheries. To begin understanding the ecological effects of Flathead Catfish invasion, we propose a comprehensive diet study on Flathead Catfish in the Susquehanna River Basin. We will quantify Flathead Catfish diet composition using morphology and molecular identification of ingested prey items. Our study will help inform future fisheries management in the Susquehanna River Basin by increasing our understanding about the predatory effects and potential ecological consequences of invasive Flathead Catfish. The project is in collaboration with the Pennsylvania Fish and Boat Commission and Penn State University.

3.2.6 Quantifying the roles of changing watershed conditions and biotic interactions in structuring Pennsylvania stream fish communities Tyler Wagner (PI)

Understanding and predicting fish community interactions and their response to environmental stressors is of utmost importance for fisheries and water resource management. For example, state agencies and other water resource agencies rely on knowledge of stream and river fish communities for assessment programs, many of which have regulatory ramifications and implications for water and fisheries management and aquatic resource use activities. However, traditional fish community studies fail to accommodate potential interactions that exist among the entire fish assemblage and thus represent an overly simplistic view of community dynamics. This is important because treating species independently when quantifying and predicting their responses to changing watershed conditions ignores potential dependencies between species due to biotic interactions and can lead to erroneous predictions. Therefore, the overarching goal of this research is to help inform fisheries and water resource management and conservation by improving our understanding of the relative roles of fish species interactions, environmental factors, and how species traits influence a species' response to changing watershed conditions in Pennsylvania streams and rivers. The project is in collaboration with the Pennsylvania Fish and Boat Commission, the Pennsylvania Department of Environmental Protection, the Susquehanna River Basin Commission, and Penn State University.

3.2.7 Forecasting aquatic invasions in rivers: using riverscapes genetics to inform invasive fish species management at regional scales Tyler Wagner (PI)

To date, research on aquatic invasive species has focused primarily on predicting species occurrence using niche or habitat suitability models. While these models provide some indication of where in the basin an invasive species may already occur, they do not provide information about the dispersal potential through the river network, nor do they identify river or landscape (i.e., riverscape) characteristics that facilitate or restrict movement. This is a critical shortcoming, because migration through the river network is the primary means by which invasive species establish new populations. Understanding the factors that increase migration, rather than just occurrence, is important for developing regional invasive species management plans to prevent future range expansions. The goal of this study is to apply a novel quantitative framework for riverscape genetics recently developed by the PIs to better understand and predict the invasion potential of invasive fish species. The specific objectives are to (1) identify river and landscape covariates that increase dispersal and colonization rates of an invasive, apex fish predator, (2) predict the future range expansion of the invasive fish species to unsampled river reaches, (3) identify management scenarios that can be used to limit future invasion, and (4) develop a web viewer to communicate the efficacy of different management scenarios to end-users.

3.2.8 Quantifying the impacts of climate change on fish growth and production to enable sustainable management of diverse inland fisheries Tyler Wagner (co-PI), Gretchen Hansen

(PI, UM), Olaf Jensen (co-PI, University of Wisconsin-Madison), Jordan Read (co-PI, USGS Water Mission Area), Craig Paukert (co-PI USGS)

Fisheries managers in Midwestern lakes and reservoirs are tasked with balancing multiple management objectives related to the abundance and growth of several priority fish species across a landscape of diverse lakes. Growth rates of fish are indicators of population status, and directly influence the effectiveness of regulations designed to protect spawning fish or to promote trophy fishing opportunities. Growth, combined with reproduction and survival, also determines the amount of fish biomass available for harvest, known as population production. Changing water temperatures can influence growth and production of managed fish species in multiple and complex ways, increasing the opportunity for harvest in certain locations and decreasing it in others. In this project, we will quantify how climate change influences growth and productivity of priority fish species in lakes and reservoirs throughout the Midwest. This information will enable managers to adapt management objectives to take advantage of increased growth and harvest potential in certain places, while implementing protective actions where climate change is likely to have negative effects. Such work is particularly important given that climate change impacts on fish populations are often indirect, influencing species interactions, growth rates, and recruitment in ways that are often counterintuitive and vary across the landscape of Midwestern Lakes and reservoirs. This study builds upon previous advances in lake temperature modeling and ongoing work to estimate water temperature and its effects on managed fish abundance in upper Midwestern lakes by expanding the work to southern Midwestern reservoirs, and by partnering with fishery managers in Minnesota, Wisconsin, Iowa, and Missouri, and the Laurentian Great Lakes to link changes in lake temperatures to key management metrics related to fish size and harvest.

3.2.9 Scale, Space, and Time: A Unifying Approach to Aquatic Invasions Tyler Wagner (Senior personnel), Brandon Peoples (PI, Clemson), et al.

Species invasions are a major catalyst in the global biodiversity crisis, with particularly acute effects in river ecosystems. Yet despite decades of research, ecology still faces a glaring paradox: Many invasion theories are at odds with one another, but each is supported by strong empirical evidence. The paradox exists because studies have been constrained in three key dimensions: scale, space, and time. Using riverine fishes as a model system, the project team will integrate invasion theories to develop a more unified framework of species invasions. Because this research will be broadly applicable to other systems and taxa, it will support our partners, including state and federal fish and wildlife agencies, in their management decision making processes designed to prevent, manage, and predict the spread of invasive species.

3.2.10* Collaborative Research: RAPID: lake ecosystem responses to fire along gradients of burn characteristics and hydrologic connectivity Tyler Wagner (co-PI), Ian McCullough (PI, MSU) et al.

High-quality water is needed for sustaining all life on Earth. Different types of pollution, however, can reduce water quality and harm the plants, animals and people that depend on water to live. Specifically, recent wildfires across the US may reduce water quality in several ways. For example, ash from wildfires can end up in lakes and rivers, potentially harming fish and drinking water supplies. In this project, a group of researchers will study water quality of northern Minnesota lakes after the 2021 Greenwood Fire. This wildfire burned a large part of Superior National Forest in fall 2021, including areas near 28 lakes. The researchers expect that after spring snowmelt or rain, ash and large pieces of burned plants will wash into these lakes and reduce water quality. They will visit lakes five times from spring to late summer of 2022 to document any water quality changes following the Greenwood Fire. Results of this study will help water managers in Minnesota and elsewhere predict how water quality in lakes and reservoirs may change after future wildfires. This project will also help people who live near lakes understand how the water activities they care about, such as fishing and boating, may be affected by future wildfires.

3.2.11* Aquatic food web changes to invasive Flathead Catfish along an invasion gradient Tyler Wagner (PI), Geff Smith (co-PI, PAFBC), Megan Schall (co-PI, PSU Hazelton)

Biological invasions have the potential to significantly alter the structure and function of aquatic communities. Invasive predatory fish species are known to restructure food webs – since predatory fishes have a dominant influence on community structure in freshwater systems. The Flathead Catfish Pylodictis olivaris is a large piscivorous catfish that is invasive in many parts of Pennsylvania, including the Susquehanna River Basin within the Chesapeake Bay Watershed. First detected in 2002 in the Susquehanna River Basin, the species is currently spreading northward and into tributaries. Although ongoing research is attempting to understand various aspects of invasion dynamics and ecology, there is currently no information on how this species may be altering food web structure – which is critical for informing conservation and management decisions. This research proposes to study the aquatic food web changes to invasive Flathead Catfish along a natural invasion gradient in the Susquehanna River Basin, PA.

3.2.12* Putting the sampling design to work: enhancing monitoring programs for improved management and inference of ecological responses to changes in climate Tyler Wagner (co-PI), Erin Schliep (NC State, PI), Chris Wikle (co-PI, Mizzou)

Climate-mediated shifts in seasonal activities (e.g., spawning, migration) have the potential to greatly influence a monitoring program's ability to distinguish changes in abundance or occupancy from shifts in phenology due to climate change. Since many existing monitoring

programs were not originally designed to elucidate climate effects, stochastic dependence often exists between climate processes and the monitoring design. For example, when sampling locations are nonrandom such that sites where the underlying climate processes that determine the data (e.g., abundance) are above or below average, inference and prediction can be biased. These biases may be exacerbated for species exhibiting synchrony with climate, such as birds or fish, since critical phases of their life cycles are closely linked to temporal cycles in climate. Thus, even with a well-established sampling design (e.g., one that has remained constant over many years of monitoring), reported changes in climatological seasonal cycles greatly limit a program's ability to (i) track changes in state variables of interest, (ii) understand system responses to climate variation, and (iii) make informed management decisions. The goal of this work is to develop statistical methods to enhance and/or modify existing monitoring programs' abilities to account for climate effects on fish and wildlife populations. We will quantify the effects of the sampling design in terms of our understanding of the relationship between climate and the species of interest and our ability to predict or forecast important measures of these species under current and future climate scenarios. Then, we give two options of deliverables for managers that will improve existing monitoring programs: Provide methods to account for the current sampling design to enhance the existing monitoring program's ability to address climate impacts and ecological responses. Given the current sampling design, develop an optimal supplemental sampling design that factors in spatial and temporal effects, precision, and cost tradeoffs to enhance the monitoring program's ability to track climate change and provide early indicators for fish and wildlife responses. Both of these options will enable improved detection or identification of system changes that are necessary for making informed management decisions in the face of climate change.

3.3.1 Phase II: Genetic assignment of white-tailed deer to population of origin.

David Walter (PI), Chris Rosenberry (PGC). Funding by the Pennsylvania Game Commission

Genetic assignment tests, using multi-locus genotypes, employ algorithms to cluster individuals together based on genetic similarity and can be used to identify migrants when individuals assign to a population not representative of the genetic cluster they were sampled. These assignment methods can be useful for identifying the source of novel disease outbreaks particular for disease such as chronic wasting disease that can be sourced to captive or wild origins. Research on surveillance strategies, that consider demographic and environmental factors, is lacking in most states CWD has not been found. Developing surveillance strategies to maximize efficiency of sampling white-tailed deer has been recommended but requires knowledge of deer behavior, movements, and spatial connectivity of populations. Landscape genetics can provide the necessary framework to understand landscape features, dispersal characteristics of deer, and transmission and spread of CWD through assessment of population structure throughout a region. Phase I of this research identified 11 subpopulations with the Disease Management Areas (DMA) 1–3 in Pennsylvania and in Maryland/Virginia (see publications by Miller and others in Appedix C). Statewide assessment of subpopulation structuring would provide integral detail on potential for CWD spread throughout the state as well as a method of identifying new focal areas of the disease should they arise.

3.3.2 Optimizing CWD Surveillance: Regional Synthesis of Demographic, Spatial, and Transmission-Risk Factors. David Walter (PI), Krysten Schuler (Cornell University), David Williams (Michigan State University), Sonja Christensen (Michigan State University), Aniruddha Belsare (Michigan State University), Dan Walsh (USGS), Chris Jennelle (Minnesota DNR), Brenda Hanley (Cornell University)

Chronic wasting disease (CWD) is a fatal disease of cervids with significant ecological and economic impacts. State wildlife agencies spend millions each year to test deer and elk for CWD, more so if they are one of 26 states that have previously detected the disease. Therefore, maximizing sampling efficiency and improving its effectiveness are critical. Several modeling efforts have already examined risk factors including sex, age, sample source, genetics, geophysical features, captive cervids, hunter-imported carcasses, and disposal methods to "sample smarter" and increase detection power; however, a rigorous integration of these various models has not happened. We will evaluate strengths and weaknesses of available analytical tools and determine which can be synthesized to derive a more powerful sampling strategy. The products of this synthesis will be a tool that integrates local harvest and disease prevalence data with data science, mathematical and statistical modeling techniques. This toolset will allow MI to more fully explore and optimize disease surveillance efforts. By identifying risk factors for CWD, states can tailor sampling protocols to maximize efficiency and confidence in disease prevalence. The strength of this project is to form a regional collaboration that will allow for standardization, comparison, and integration of CWD surveillance streams. All states involved will benefit from improved surveillance effectiveness, minimized cost of sampling, and maximize the probability of discovering new infections across state boundaries.

3.3.3 Parturition timing and calf survival in Pennsylvania elk. Avery Corondi (MS, PSU), David Walter (PI), Jeremy Banfield (PGC), Justin Brown (PSU), Chris Roseberry (PGC). Funding by the Pennsylvania Game Commission

Recent evaluation of pregnancy rates in Pennsylvania elk (Cervus elaphus) suggest some level of delayed or asynchronous breeding. From 2013 to 2018, paired serum and uteri samples were collected from 245 adult females (ages 3-12) harvested during the general hunting season. These samples were tested for pregnancy via a serum-based pregnancy specific protein B using an enzyme linked immunosorbent assay (PSPB) and gross examination, respectively. The PSPB was shown to be highly accurate at pregnancy detection in elk >15 days post conception (sensitivity: 95% and specificity: 91%) . In Pennsylvania, peak conception occurs from approximately 17 September to 9 September, with the general hunting season occurring around the first full week of November. Thus, pregnancy testing on harvested cows during the general hunting season captures at least one, and possibly two, estrus cycles. The average pregnancy rate during this period was 51.3% for adult aged females which prompted an additional blood collection during the late winters (January–April) of 2018 and 2019 with calculation of pregnancy rates again via PSPB. Late season pregnancy rates averaged 88.5% (Table 2), a notable increase from the early season average of 51.3%. The increase in pregnancy rates between autumn and late winter indicates asynchronous breeding, with a substantial proportion of reproductive aged females conceiving later than expected. Defining the calving season through use of vaginal implant transmitter (VIT) technology is a critical next step and will

provide the data needed to calculate a more accurate estimate of the elk breeding season in Pennsylvania and determine what proportion of females are conceiving early or late in the breeding season. In addition, monitoring calf survival as a function of birth date will enable managers to evaluate the effect of asynchronous breeding/parturition on Pennsylvania's elk population. Intuitively, identifying factors that affect recruitment is a prerequisite for developing appropriate management responses.

3.3.4 Minnesota white-tailed deer genetics within chronic wasting disease areas. Alberto Fameli (Post Doc), David Walter (PI), Chris Jennelle (Minnesota DNR), Michelle Carstensen (Minnesota DNR). Funding by the United States Department of Agriculture through Minnesota Department of Natural Resources

It has been nearly four years since the Minnesota Department of Natural Resources (MNDNR) discovered CWD during the 2016 regular hunting season in Fillmore County, Minnesota. The disease has since expanded to central and north-central Minnesota suggesting that spatial spread of CWD continues to radiate from the core areas around Preston, MN and a previously positive captive cervid facility in Winona County. Minnesota's CWD infection appears to be in a relatively early stage of development. This provides hope that an effective control strategy might protect the state's white-tailed deer resource. Empirical evidence from 2019 and 2020 CWD management efforts suggests that targeted culling efforts were about 3 to 7 times more likely, respectively, to result in a CWD positive sample compared to regular hunter harvest efforts within the CWD Management Zone. Clearly, targeted culling of deer in close proximity to locations of CWD positive deer harvest provides Minnesota the most effective means to remove CWD positive deer from the landscape and mitigate deposition of infectious prions into the environment; however, we are uncertain if this tool is effective in minimizing disease spread through related individuals in close proximity to detected CWD positive deer. The objectives of this project are to conduct genetic analysis testing on up to 800 wild white-tailed deer muscle samples received from Minnesota during routine disease monitoring protocols. Assessing the relatedness among culled deer in close proximity to known CWD positive deer locations will permit us to establish if familial network structure exists in the pool of infected animals. This will provide a basis for evaluating whether particular social groups are high risk for CWD exposure and the effectiveness of our culling program.

3.3.5 Linking genetics to movements of white-tailed deer to assist surveillance for chronic wasting disease. Kelly Russo-Petrick (Post Doc), Alberto Fameli (Post Doc), Jessie Edson (PSU), David Walter (PI). Funding by the U.S. Geological Survey

Chronic wasting disease (CWD) is a transmissible spongiform encephalopathy, and although the disease is always fatal once contracted, previous research suggests that certain rare prion gene variants are less susceptible to CWD and have delayed disease progression compared to other more common genotypes. Furthermore, understanding spatial patterns of CWD susceptibility and movements of deer would allow wildlife managers to develop more targeted mitigation strategies accounting for underlying genetic risk factors and fine-scale transmission dynamics (e.g., weighted surveillance strategies). Landscape genetics can provide the necessary framework to understand landscape features, dispersal characteristics of deer, and transmission and spread of CWD through assessment of population structure throughout a region. The purpose

of the proposed research is to identify the frequency and distribution of prion gene variants within white-tailed deer populations across multiple regions with varying histories of CWD infection. In addition, use of microsatellite genotypes collected from free-ranging white-tailed deer can provide details on the landscape genetics of white-tailed deer across multiple areas with differing CWD exposure histories. This project will increase understanding of the potential genetic basis of disease risk and potential disease transmission pathways at the landscape level for several areas of known or anticipated CWD occurrence. This study involves assessing PRNP genotypes and broad- and fine-scale landscape genetics using microsatellite markers statewide in Ohio, New York, and Pennsylvania in collaboration with 3.3.1.

3.3.6 Establishing a national tissue and reagents repository for chronic wasting disease. Chia-Hua Lue (Post Doc), David Walter (PI), Jason Bartz (Creighton University). Funding by the U.S. Geological Survey

The prevalence of CWD within cervid populations can approach 50% and, since CWD is always fatal, CWD can have detrimental effects on cervid populations (Edmunds et al. 2016, DeVivo et al. 2017). 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). Monitoring, characterizing, and tracking progression of CWD across the US has not been possible because identification of distinct strains of CWD has been lacking. Prion strains can differ considerably in their ability to cause disease in cervids and the potential to infect a new species. Although this understanding of the biology of prions has been well studied, prion researchers have been unable to study prion strains because in multiple regions of the US because of the lack of availability of samples positive for CWD. Unfortunately, a centralized collection of CWD tissues is not currently available. The overall goal of this program is to establish a virtual 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 uninfected sources 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.

3.3.7 Assessment of movement of prions across the captive-wild interface. Tyler Walters (MS PSU), David Walter (PI), Kurt VerCauteren (United States Department of Agriculture), Deep Tewari (Pennsylvania Department of Agriculture). Funding by the National Wildlife Research Center, USDA-APHIS-WS.

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, assessment 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 primary objective is 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. Our secondary objective is 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.

3.3.8 *Agent-based models to inform management of white-tailed deer for chronic wasting disease. Kristin Bondo (Post Doc), David Walter (PI), Chris Rosenberry (PSU). Funding by the Pennsylvania Game Commission

Early CWD work analyzed the spatial scale at which CWD spread and predictors of spread using Bayesian hierarchical models. The use of disease surveillance data combined with spatial information allows statistical models to ask the fundamental questions: what covariates drive disease incidence, and where will the disease spread. Subsequent studies have incorporated population and disease dynamics to inform potential management actions for disease prevention and offer insight into the mechanisms driving disease spread using agent-based models. Agent-based models were used to show that preemptive management of host populations, through reducing disease host densities or the manipulation of age and sex population distributions, could have a large impact on ability of chronic wasting disease (CWD) to successfully invade a population (Belsare and Stewart 2020). Using this framework, we will understand disease dynamics in an established disease area and how management actions may affect prevalence and population dynamics. The Pennsylvania Game Commission (PGC) first formed Disease Management Area (DMA) in response to detection of CWD in 2012 (Evans et al. 2014). Free-ranging white-tailed deer test positive annually each year with prevalence increasing that resulted in a study to understand the movements and population dynamics of white-tailed deer in the core of the DMA. Data from that research and additional research projects in the state are available to incorporate into agent-based models to determine ideal management scenarios in attempts to decrease prevalence of CWD in white-tailed deer. Objectives of this study are to compile a review of the deer behavior literature on contacts, associations, and observational data for white-tailed deer to compile sex/age-specific likelihood of contacts to inform transmission coefficients for agent-based models. We will also use hunter-behavior datasets (previously collected and provided by the Game Commission) and agent-based models to understand how harvest scenarios and endemic prevalence can influence disease dynamics and management of deer in various units within Pennsylvania where previous research was conducted and surrounding areas added during this project.

Appendix C – Awards, Publications, and Presentations
(Unit personnel and students in bold)

Honors and Awards

Chris Custer received 3rd place for best student presentation at the Keystone Coldwater Conference.

Peer-reviewed Publications

Diefenbach

Buderman, F. E., **T. M. Gingery**, **D. R. Diefenbach**, **L. C. Gigliotti**, **D. Begley-Miller**, M. E. McDill, B. D. Wallingford, C. S. Rosenberry, and P. J. Drohan. 2021. Caution is warranted when using animal space-use and movement to infer behavioral states . Animal Movement 9:30. https://doi.org/10.1186/s40462-021-00264-8

Wagner

McLaughlin, P., R. Alexander, J. Blomquist, O. Devereux, G. Noe, K. Smalling, and **T. Wagner**. 2022. Power Analysis for Detecting the Effects of Best Management Practices on Reducing Nitrogen and Phosphorus Fluxes to the Chesapeake Bay Watershed, USA. Ecological Indicators 136:108713.

Cheruvelil, K.S., K. Webster, K. King, A. Poisson, **T. Wagner**. 2022. Taking a macroscale perspective to improve understanding of shallow lake total phosphorus and chlorophyll a. Hydrobiologia.

Wagner, T., McLaughlin, P., Smalling, K., Breitmeyer, S., Gordon, S., and Noe, G.B., 2021. The statistical power to detect regional temporal trends in riverine contaminants in the Chesapeake Bay Watershed, USA. Science of the Total Environment 812:152435.

Sweka, J.A. and **T. Wagner**. 2022. Influence of seasonal extreme flows on Brook Trout recruitment. Transactions of the American Fisheries Society 151:231-244.

Qui, Q., Y. Xu, S.S. Matsuzaki, K. Komatsu, Z. Liang, **T. Wagner**. 2021. A framework to track temporal dependence of chlorophyll–nutrient relationships: implications for lake eutrophication management. Journal of Hydrology 603:127134.

White, S.L., M.S. Eackles, **T. Wagner**, M. Schall, G. Smith, J. Avery, and D.C. Kazyak. 2021. Optimization of a suite of flathead catfish (Pylodictis olivaris) microsatellite markers for understanding the population genetics of introduced populations in the northeast United States. BMC Research Notes 14:314.

Walter

Niedringhaus, K.D, **L.S. Ganoe**, M. Lovallo, **W.D. Walter**, M.J. Yabsley, J.D. Brown. 2021. Fatal infection by *Versteria* sp. in a muskrat (*Ondatra zibethicus*) with implications for human health. Journal of Veterinary Diagnostic Investigations 34(2): 314–318.

Ganoe, L.S., J.D. Brown, M.J. Lovallo, M.J. Yabsley, K.B. Garrett, A.T. Thompson, R.H. Poppenga, M.G. Ruder, and **W.D. Walter**. 2021. Surveillance for diseases, pathogens, and toxicants of muskrat (*Ondatra zibethicus*) in Pennsylvania and surrounding regions. PlosONE 16(12):e0260987.

Bauder, J.M., C.S. Anderson, H.L. Gibbs, M.J. Tonkovich, and **W.D. Walter**. 2021. Landscape features fail to explain spatial genetic structure in white-tailed deer across Ohio, USA. Journal of Wildlife Management 85(8):1669-1684. DOI: 10.1002/jwmg.22120.

Presentations at Scientific Meetings

Diefenbach

Knox, W. M., and **D. R. Diefenbach**. Rearranging the deck chairs on the Titanic. Midwest Deer and Wild Turkey Study Group and Southeast Cervid and Wild Turkey Working Groups, August 15-18, 2022, Junction City, KS (Contributed Oral)

Drohan, P., S. Bayuzick, D. Guarin, R. Raab, A. Bonhage, **D. Diefenbach**, and M. McDill. Appalachian relict charcoal hearths have complex landscape and pedologic patterns that are unique from surrounding forest ecosystems. May 22-17, 2022, Vienna, Austria (Contributed Oral)

Wagner

Batchelor, S., J. Avery, M.S. Eackles, D.C. Kazyak, M. Schall, K. Smalling, G. Smith, S.L. White, and **T. Wagner**. 2022. Understanding the spread and impact of invasive flathead catfish in the Chesapeake Bay Watershed, USA. USGS Chesapeake Bay Workshop. June 27-30th. National Conservation Training Center. (Invited Poster)

McLaughlin, P., R. Alexander, J. Blomquist, O. Devereux, G. Noe, K. Smalling, and **T. Wagner**. 2022. Power analysis for detecting the effects of BMPs on nutrient flux reductions in the Chesapeake Bay Watershed. USGS Chesapeake Bay Workshop. June 27-30th. National Conservation Training Center. (Invited Poster)

Schall, M.K., V.S. Blazer, H.L. Walsh, G.D. Smith, T. Wertz, and **T. Wagner**. 2022. Investigating Spatiotemporal Variability in Visual Health Assessments for Adult Smallmouth Bass. Chesapeake Community Research Symposium. Annapolis, MD. (Invited Oral)

Kundel, H., **T. Wagner**, and G.J.A. Hansen. 2022. Historical Data and Novel Invaders: Impacts of Zebra Mussels on Walleye Recruitment in MN Lakes. Joint Aquatic Sciences Meeting, Grand Rapids, MI. (Contributed Oral)

Lapierre, J-F, **T. Wagner**, and 29 coauthors. 2022. Classification of US lakes as continuous mixtures of geographic archetypes. Joint Aquatic Sciences Meeting, Grand Rapids, MI. (Contributed Oral)

Peoples, B., W. Annis, G. Hansen, S. Midway, J. Olden, L. Thompson, **T. Wagner**, and M. Zink. 2022. FishScales: A contemporary stream fish community database for the conterminous United States. Joint Aquatic Sciences Meeting, Grand Rapids, MI. (Contributed Oral)

Peoples, B., W. Annis, G. Hansen, S. Midway, J. Olden, L. Thompson, **T. Wagner**, and M. Zink. 2022. FishScales: A contemporary stream fish community database for the conterminous United States. American Fisheries Society Annual Meeting, Spokane, WA. (Contributed Oral)

Stark, S.K., M.K. Schall, G.D. Smith, J.D. Avery, and T. Wagner. 2022. Comparison of collection methods for diet studies of invasive flathead catfish. Northeast Fish & Wildlife Conference. (Invited Oral)

Custer, C. Fischer, D., Henning, A., Hintz, D., Schall, M.K., Shank, M., Smith, G., Wertz, T., and **Wagner, T**. Quantifying the roles of biotic and abiotic factors structuring stream fish communities. Keystone Coldwater Conference & PA Chapter of the American Fisheries Society. February 25-26, 2022. (Contributed Oral)

McLaughlin, P., Alexander, R., Blomquist, J., Devereux, O., Noe, G., Smalling, K., and **Wagner, T**., 2022. Keystone Coldwater Conference & PA Chapter of the American Fisheries Society. February 25-26, 2022. (Contributed Oral)

Stark, S.K., Schall, M.K., Smith, G.D., Avery, J.D., Wagner, T. 2022. Preliminary diet analysis of the invasive Flathead Catfish in the Susquehanna River Basin. Keystone Coldwater Conference & PA Chapter of the American Fisheries Society. February 25-26, 2022. (Contributed Oral)

Hansen, JA., Custer, C., Kundel, H., North, J., Read, J.S., Schliep, E., and **T. Wagner**. 2022. The importance of water temperature in governing lake fish abundance across a landscape of diverse lakes. Midwest Fish and Wildlife Conference. (Contributed Oral)

Wagner, T., McLaughlin, P., Smalling, K., Breitmeyer, S., Gordon, S., and Noe, G.B., 2022. The statistical power to detect regional temporal trends in riverine contaminants in the Chesapeake Bay Watershed, USA. Chesapeake Bay Water Quality Goal Implementation Team, Toxic Contaminants Workgroup. (Invited Oral)

Wagner, T. **Y. Li,** V.S. Blazer, L.R. Iwanowicz, M.K. Schall, K. Smalling, D. Tillitt. 2021. Ecological risk assessment of environmental stress and bioactive chemicals to riverine fish populations: an individual-based model of smallmouth bass Micropterus dolomieu. Annual Meeting of the American Fisheries Society. (Invited Oral)

Schall, M.K., V.S. Blazer, H.L. Walsh, G.D. Smith, T. Wertz, and **T. Wagner**. 2021. Where do we go from here?: Quantifying spatiotemporal variability in fish health observations from Smallmouth Bass Micropterus dolomieu after disease and population declines. The Annual Meeting of the American Fisheries Society. (Invited Oral)

Stark, S.K., M.K. Schall, J.D. Avery, G.D. Smith, and **T. Wagner**. 2021. Preliminary Diet Analysis of the invasive Flathead Catfish (Pylodictis olivaris) in the Susquehanna River Basin, PA. The Annual Meeting of the American Fisheries Society. (Contributed Oral)

Walter

Corondi, A.M., J.E. Banfield, J.D. Brown, and **W.D. Walter**. 2022. Unexpected findings through the use of vaginal implant transmitters in elk in Pennsylvania. 16-19 May, 2022, 24th Eastern Elk Management Workshop. Bemidji, MN, USA. (Contributed Oral).

Corondi, A.M., J.E. Banfield, J.D. Brown, and **W.D. Walter**. 2021. G.U.T.-check – GPS, Ultrasound, and Transmitters to properly evaluate reproduction in elk. 1-5 November, 2021, The Wildlife Society Annual Conference, Baltimore, MD. (Contributed Oral).

Gunderman, K. P., **D. R. Diefenbach**, **W. D. Walter**, **A.M. Corondi**, J. Banfield, C. Rosenberry, and F. E. Buderman. 2021. Efficacy of positional and behavioral change-point models to determine ungulate parturition events. 1 - 5 November 2021, The Wildlife Society Annual Meeting, Baltimore, MD. (Contributed Oral).