AGENDA

Coordinating Committee Meeting
Pennsylvania Cooperative Fish and Wildlife Research Unit

Thursday, June 11, 2020
1:00 PM
Held via video conference

1. **Approval of minutes from July 11, 2019 meeting**

2. **Completed Projects (Summaries in Appendix A)**
   2.1. Wagner
      2.1.1. Spatio-temporal drivers of fish growth
   2.2. Walter
      2.2.1. Muskrat (*Ondatra zibethicus*) ecology, population estimation, and health
      2.2.2. Assessment of fence-line interactions at the captive-wild deer interface

3. **New & Continuing Projects (* Requires approval by Committee; See Appendix B)**
   3.1. Diefenbach
      3.1.1. Harvest and survival rates of hen wild turkeys in Pennsylvania
      3.1.2. Genetics of an insular population of bobcats and coyotes
      3.1.3. Deer abundance and its relationship to factors that affect forest vegetation conditions
      3.1.4. Distribution of predators and their relation to fawn survival
      3.1.5. *Monitoring movements and habitat use of snowshoe hare
      3.1.6. *Changes in forest composition through time due to charcoal production for the iron industry, tree harvest, and deer browse

   3.2. Wagner
      3.2.1. An investigation into the role of groundwater as a point source of emerging contaminants to smallmouth bass in the Susquehanna River
      3.2.2. Spatial and temporal analysis of endocrine disrupting compounds in surface waters of the Chesapeake Bay Watershed
      3.2.3. A macrosystems ecology framework for continental-scale prediction and understanding of lakes
      3.2.4. Fish habitat restoration to promote adaptation: resilience of sport fish in lakes of the Upper Midwest
      3.2.5. ***** Determining the consequences of land management actions on primary drivers influencing smallmouth bass populations

      3.2.6. ***** Changes in stream fish distribution and occurrence in seven National Park Service units of the Eastern Rivers and Mountains Network

      3.2.7. * Diet composition of invasive flathead catfish in the Susquehanna River Basin: quantifying impacts on native and migratory fishes and recreational fisheries

3.2.8. ***** Quantifying the roles of changing watershed conditions and biotic interactions in structuring Pennsylvania stream fish communities

3.2.9. ***** Forecasting aquatic invasions in rivers: using riverscapes genetics to inform invasive fish species management at regional scales

3.3. Walter
- 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
- 3.3.2. Epidemiology of West Nile virus in ruffed grouse (*Bonasa umbellus*)
- 3.3.3. Phase II: Genetic assignment of white-tailed deer to population of origin
- 3.3.4. *Optimizing CWD Surveillance: Regional Synthesis of Demographic, Spatial, and Transmission-Risk Factors
- 3.3.5. *Parturition timing and calf survival in Pennsylvania elk
- 3.3.6. *Minnesota white-tailed deer genetics within chronic wasting disease areas
- 3.3.7. *Linking Genetics to Movements of White-tailed deer to Assist Surveillance for Chronic Wasting Disease

4. Proposed Budget – (provided at meeting)

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

5.1. Diefenbach
- 5.1.1. Asia Murphy, PhD Ecology
- 5.1.2. Amanda Van Buskirk, MS Ecology

5.2. Wagner
- 5.2.1. Shannon White, Postdoc
- 5.2.2. Catherine McClure, MS Ecology
- 5.2.3. Danielle Massie, MS WFS
- 5.2.4. Tyler Thompson, MS Wildlife and Fisheries

5.3. Walter
- 5.3.1. Diego Montecino-Latorre, Postdoc
- 5.3.2. Avery Corondi, MS WFS
- 5.3.3. Joe Moran, PhD Ecology

6. Service on Graduate Committees (other than advisees)

6.1. Diefenbach
- 6.1.1. Laken Ganoe, MS Wildlife and Fisheries
- 6.1.2. Danielle Massey, MS WFS
- 6.1.3. Arun Regmi, PhD Forest Science
- 6.1.4. Michael Perkins, MS Forest Science
- 6.1.5. Samuel Bayuzick, MS Soils

6.2. Wagner
- 6.2.1. Courtney Davis, PhD Ecology
- 6.2.2. Nathan Wikel, PhD Statistics
- 6.2.3. Amanda Van Buskirk, MS Ecology

6.3. Walter

6.3.1. Ellen Brandell, PhD Ecology
6.3.2. Walter Espindola, PhD Ecology

7. Courses and Workshops Taught by Unit Staff

7.1. Diefenbach

7.1.1. Population Estimation and Modeling, spring 2020

7.2. Wagner

7.2.1. Quantitative Methods in Ecology, spring 2019

7.3. Walter

7.3.1. Applied Spatial Ecology in R (workshop), March 2020

8. Comments from Cooperators

9. Adjourn

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

10.1. Approval of New (noted by asterisk) and Proposed Projects

Appendix A – Abstracts of Completed Projects

Appendix B – Summaries of New and Continuing Projects

Appendix C – Awards, Publications, and Presentations

Proposed Budget: July 1, 2020 to June 30, 2021

	Amount	Indirect costs		
		Rate	Paid	Waived
Base Funding				
USGS - Cooperative Research Units				
Scientist support (anticipated FY2020)	$0			
Salaries and benefits (Diefenbach, Wagner, Walter)	$489,402			
USGS TOTAL	**$489,402**			
PA Game Commission				
Diefenbach				
Carry-over from FY2019-20	$8,111			
Database manager (Tess Gingery)	$14,845			
Post-doc for Deer-Forest Study	$22,405			
Publications and Travel	$4,000			
Bobcat research	$6,000			
Rollover to next FY	$10,861			
SUBTOTAL	*$50,000*			
Walter				
Carry-over from FY2019-20	$8,706			
Deer/Elk genetics	$5,000			
Operating expenses (travel, publications)	$10,000			
Joe Moran (rollover, saving for PhD support)	*$43,706*			
SUBTOTAL	*$50,000*			
PGC TOTAL	**$100,000**	0.0%	$0	$58,050
PA Fish and Boat Commission				
PA stream fish ecology				
Chris Custer (rollover, saving for PhD support)	$50,000			
Flathead catfish research				
Sydney Stark (MS student, summer wages)	$5,000			
Field supplies	$3,000			
Genetics lab supplies	$5,000			
Travel	$2,000			
Operating expenses	$10,000			
PFBC TOTAL	**$75,000**	0.0%	$0	$43,538
PSU Ecosystem Science and Management				
Administrative assistant (salary and benefits)	$46,824			
Office expenses and support	$16,032			
SUBTOTAL	$62,856			
Waived indirect	$658,074			
PSU TOTAL	**$720,930**			
Base Funding Total (includes waived indirect)	**$1,385,332**			

Proposed Budget: July 1, 2020 to June 30, 2021
(federal funds are for federal FY 2021)

	Amount	Indirect costs Rate	Paid	Waived
Gifts, Grants, Contracts				
Deer-Forest Study - Diefenbach - PGC project 30	$120,698	0.0%	$0	$44,331
Deer-Forest Study - DCNR - Diefenbach	$116,686	0.0%	$0	$42,857
Snowshoe hare - Diefenbach - PGC project	$88,048	0.0%	$0	$32,339
CWD targeted removal - Walter - PGC project 31	$51,232	15.0%	$6,682	$12,135
West Nile Virus Grouse - Walter - PGC project 34	$42,459	0.0%	$0	$15,595
Genetic assignment - Walter - PGC project 39	$73,914	0.0%	$0	$27,148
Wood Thrush - Brittingham - PGC project 32	$221,786	15.0%	$28,929	$52,531
Flathead catfish - Wagner - PFBC project 37	$55,314	0.0%	$0	$20,316
Amphibian research - Miller - RWO 93 - USGS	$58,483	15.0%	$7,628	$13,852
Amphibian research - Miller - RWO 92 - USGS	$84,400	15.0%	$11,009	$19,990
Decision support - Miller - RWO 98 - USGS	$105,000	15.0%	$13,696	$24,870
Ches Bay project - Wagner - RWO 94 - USGS	$115,000	15.0%	$15,000	$27,238
Flathead catfish genetics - Wagner - RWO 95 - USGS	$125,000	15%	$16,304	$29,607
Stream fish - Wagner - PA Sea Grant	$50,000	0.0%	$0	$18,364
NPS streams - Wagner - NPS	$72,947	17.5%	$10,864	$15,928
Macrosystems Ecology - Wagner - NSF	$150,000	58.1%	$55,093	$0
Optimizing CWD surveillance - Walter - Cornell Universit	$33,483	0.0%	0.0%	$12,298
Elk parturition and calf survival - Walter PGC project 40	$298,303	0.0%	0.0%	$109,563
Minnesota white-tailed deer genetics - Walter - Minnesot	$30,000	0.0%	0.0%	$11,019
Linking Genetics to Movements - Walter - USGS	$111,907	15.0%	$14,597	$26,506
Gifts, Grants, and Contracts Total	**$2,004,660**		**$179,802**	**$556,487**
Grand Total (less waived overhead)	**$2,731,918**			

APPENDIX A - Completed Projects

2.2.1. Spatio-temporal drivers of fish growth

Tyler Wagner (PI)

The goal of this research was to improve our understanding of how changes in macroscale water temperatures may impact the growth of fishes. Specifically, this research (1) provided a quantitative framework that can be used to help design studies for detecting macroscale effects on growth and (2) provided insights into how the growth of a cool-water species may be influenced by warming water temperatures. The quantitative framework for assessing fish macroscale effects on fish growth was developed to help identify the sample size needed to detect an effect of a given magnitude, as well as, diagnosing what effect sizes are detectable given the amount of among-fish and among-lake variability in a system of interest. This framework was illustrated by assessing the ability to detect a macroscale water temperature effect on the growth of flathead catfish (Pylodictis olivaris) and yellow perch (Perca flavescens) across a range of sampling scenarios. Despite differing amounts of spatial variability between the two case study species, confidently detecting effects will likely require sampling hundreds of waterbodies.

The second aspect of this research aimed at understanding how annual trends in walleye (Sander vitreus) growth were related to warming water temperatures. Walleye are a crucial component to the culture and economy of many regions in the Upper Midwest, USA. We quantified the spatiotemporal variability of walleye growth from 1983-2015 in 61 inland lakes in Minnesota and Wisconsin. We then determined the relationship between annual growth coefficients (K) and water temperature growing degree days (GDD) and identified physical lake characteristics influencing the K-GDD relationships. Lake water temperatures, on average, significantly increased overtime for these lakes. Annual growth coefficients, on average, significantly increased with increasing GDD. However, this relationship varied in direction and magnitude among lakes, suggesting that lake characteristics may be influencing this relationship. Lake-specific slopes of the K-GDD relationship were negatively correlated with Secchi disk depth. This suggests that water clarity may help mediate the effect of warming water temperature in these lakes.

2.2.2. Individual based model for smallmouth bass risk assessment

Tyler Wagner (PI)

Ecological risk assessments play an important role in environmental management and decision-making. Although empirical measurements of the effects of habitat changes and chemical exposure are often made at molecular and individual levels, environmental decision-making often requires the quantification of management-relevant, population-level outcomes. In this study, we established a modeling framework to evaluate population-level ecological risk of environmental stress and bioactive chemicals. The modeling framework includes (1) a biological model module that incorporates complex and interacting biological and ecological processes, and environmental stochasticity, (2) an effect module that links the impacts of environmental changes and chemical exposure to individual characteristics, and (3) a population module that upscales individual responses to population-level outcomes. To demonstrate this framework, we used a socioeconomically important riverine fish species, smallmouth bass Micropterus dolomieu, as the model species. We developed an individual-based model as the biological model module. We evaluated the impacts of changing water temperature and flow regimes, and the impacts of exposure to estrogenic endocrine disrupting compounds (EEDC) on smallmouth bass populations in the Chesapeake Bay Watershed, USA. Warm summer water temperatures and year-round high flows had the most severe impacts on the smallmouth bass population. An increase in exposure level to EEDC, both year-round and in summer months, substantially reduced population size, spawner and recruit abundance, and the proportion of quality-length individuals. Acute exposure to EEDC was more detrimental to the population than chronic exposure. Acute exposure during spawning season had the most severe impacts. This modeling framework can be extended to other species, environmental factors and chemicals, and can be used to inform management and conservation decisions.

2.3.1 Assessment of PRNP genotypes and stress levels to determine potential susceptibility of elk to chronic wasting disease. Will Miller, David Ensminger, Tess Gingery, Cate Pritchard, David Walter, Jeremy Banfield (PGC). Funding by the Pennsylvania Game Commission

Reintroduction of elk in Pennsylvania in the early 1900s has resulted in a sustained population that is experiencing low recruitment in recent decades. Although human habituation has occurred in some areas, elk continue to occupy various landscapes likely experiencing varying levels of human disturbance or stress. Little is known on the subpopulation-level effects on elk that occupy these disparate landscapes within their limited range in Pennsylvania. Furthermore, chronic wasting disease (CWD) was recently been found within 25 km of the border of elk range in a captive cervid facility that could potentially impact the elk population. A detailed assessment of subpopulation differences in elk physiology and genetics is needed to assist managers in refining elk management within their range in Pennsylvania. Use of stress hormones and genetic susceptibility to disease would assist management of this elk population that is currently being managed solely based on elk density within each sub-unit. Currently, 200 samples of elk tissue and feces have been collected from checkstations from elk harvested during the hunting season by the Pennsylvania Game Commission (PGC). Additional samples will be collected during the fall 2016 harvest and laboratory analysis and results will be summarized.

2.3.2 Feasibility of using non-invasive genetic sampling and spatial capture-recapture models for population estimation of fisher (*Martes pennanti*) Laken Ganoe, David Walter, Matt Lovallo (PGC), Jeff Larkin (Indiana University of Pennsylvania)

The fisher (*Martes pennanti*), a member of the weasel family, was reintroduced into Pennsylvania in the 1990s due to extirpation in the early 1900's. Since then, the fisher population in Pennsylvania has experienced considerable increases in size and distribution across the state. Original population estimates involved sightings by Wildlife Conservation Officers, accidental captures by trappers, and telemetry techniques. This study was designed to test the feasibility of using spatial capture-recapture models from non-invasive genetic sampling of hair snares on fishers to estimate population size. Hair snares are much less expensive and less invasive than traditional capture techniques. Using microsatellites from samples retrieved from hair snares, individuals will be identified genetically. Repeated sampling of individuals will then allow spatial capture-recapture models to be used to estimate population size. The study will be completed at locations to initially test the feasibility of this technique with hopes of applying it statewide in the future. It is important to estimate the population of fishers in Pennsylvania accurately for management purposes and use by the Pennsylvania Game Commission to create bag limits for the species during the trapping season.

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), Barry Grand (USGS), Amy Silvano (AL DNR). Funded by PGC, Pennsylvania Chapter NWTF, Alabama Chapter NWTF.

Over the past year we have finalized the decision model for making recommendations for the fall turkey season. We are currently writing a manuscript that we intend to submit to Wildlife Monographs that will summarize the results of the hen turkey study, the integrated population model we developed, and the decision model. We hope to have the manuscript completed in summer 2020.

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

To date we have conducted surveys to estimate abundance and monitor genetics in 2012, 2016, 2018, and 2019. We have observed populations increase from 10-14 in 2012-2016 to 23 in 2019. A comparison of the genetic structure of the current population to the founding individuals released on the island in 1989-1990 indicates a measurable loss in genetic diversity but limited evidence of inbreeding. Some of our findings were presented at the 2018 conference of The Wildlife Society and a manuscript is in preparation.

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

The Pennsylvania Game Commission (PGC) has developed a decision model for antlerless deer harvest allocations based on deer browsing impact as measured by the FIA in addition to estimates of tree seedling density. Similarly, the Pennsylvania DCNR Bureau of Forestry uses a vegetation monitoring protocol and the Deer Management Assistance Program to manage deer on state forests. This research proposes to stabilize deer populations at different densities on four study areas and quantify changes in vegetation with respect to other forest conditions (seed production, advanced tree regeneration, etc.) and management actions (e.g., herbicide to remove competing vegetation).

We continue to capture adult male and female deer to fit with satellite GPS collars. We have developed a distance sampling protocol that accounts for the fact that using roads as transects are not representative of the study area. The protocol accounts for the fact that deer avoid roads by using GPS data to model the distribution of deer within 150 m of a road. Also, we account for the distribution of deer across the study area by using GPS locations of deer and a resource selection model.

Vegetation data collection was cancelled for the 2020 field season due to the COVID-19 pandemic.

Amanda will be defending her thesis research this summer and has accepted a Ph.D. position at the University of Georgia. Her thesis will have 2 chapters: (1) modeling the effect of size and shape on the ability to reduce deer densities via the Deer Management Asssistance Program, and (2) estimating deer abundance using distance sampling and accounting for using roads as transects. Michael Perkins is working on a M.S. degree in Forest Science related to the vegetation and soil data that have been collected.

3.1.4 Distribution of predators and their relation to fawn survival Asia Murphy, D. Diefenbach, D. Miller (ESM faculty), M. Ternent (PGC), M. Lovallo (PGC), Chris Rosenberry (PGC). Funding provided by PGC.

Game cameras can be used to model occupancy of species on the landscape as well as how two species influence the distribution of each other. This project is using capture-recapture data from game cameras to estimate the distribution and of predators and how that distribution relates to fawn survival. Asia Murphy (Ph.D. in Ecology) has one manuscript submitted to a journal, is preparing a second manuscript. Asia was awarded a teaching PhD assistantship where she will develop and teach a course in spring 2021. She plans to complete her degree in 2021.

3.1.5* Snowshoe hare movements and habitat use. D. Diefenbach, A. Church, T. Gingery, E. Boyd (PGC).

Two technicians were hired in January 2020 to trap snowshoe hare, fit with GPS collars, and collect vegetation data. The Unit was funded by the PGC to support technician salary and vehicles and will provide databases of snowshoe hare locations and vegetation sampling.

3.1.6* Changes in forest composition through time due to charcoal production for the iron industry, tree harvest, and deer browse. P. Drohan, M. McDill, D. Diefenbach. S. Bayuick

Historic charcoal production is an example of abrupt change across northern Appalachian forest ecosystems that we hypothesize has had a lasting effect on forests; forest managers can be better prepared to adapt to future abrupt change by studying this model system of past abrupt change.

Abrupt changes in a forest ecosystem, whether natural or anthropogenic, are changes that occur over short time periods; such disturbance has the potential to drive state changes and alter forest resilience. Understanding how present-day abrupt forest change may alter ecosystem services is becoming more important due to ever-growing anthropogenic stresses.

Forest managers trying the adapt to anthropogenic stress can benefit from the study and quantification of past abrupt changes in forests, especially when the legacy of past disturbance is still evident.

3.2.1 An investigation into the role of groundwater as a point source of emerging contaminants to smallmouth bass in the Susquehanna River basin

Tyler Wagner (PI), Vicki Blazer (co-PI, USGS), Megan Kepler (co-PI, PSU), Jon Niles (co-PI, Susq. Univ.)

There is currently a large effort underway to quantify endocrine disrupting compounds (EDCs) in the Susquehanna River basin and their effects on smallmouth bass populations. During this ongoing research, a large amount of effort has been, and currently is, devoted to quantifying potential EDC exposure pathways, including from the surrounding landscape through surface waters, stream sediments, and adult female smallmouth bass, as a pathway of in-utero contamination from vertical transmission. However, there is currently a paucity of information on the role of groundwater discharge into surface waters as point sources of contaminants from polluted aquifers. This is critical to understand because the use of groundwater seeps are important for smallmouth bass, particularly during spawning season, and there use is related to increased hatch success and survival of age 0 fish. In addition, previous work has shown smallmouth bass utilizing areas of groundwater upwelling for spawning in the Susquehanna River basin. Exposure to EDCs during this critical life-stage of egg development could have detrimental short- and long-term consequences on immune function and fish health. Therefore, the objective of this research is to investigate the role of groundwater as a point source of emerging contaminants to smallmouth bass in the Susquehanna River basin.

3.3.2 Spatial and temporal analysis of endocrine disrupting compounds in surface waters of the Chesapeake Bay Watershed

Tyler Wagner (PI), Vicki Blazer (co-PI, USGS), Kelly Smalling (co-PI, USGS)

This project that investigate the spatial and temporal variation of contaminants of emerging concern (CEC's) within the surface waters of rivers in the Chesapeake Bay watershed. The project will synthesize and analyze over four years of existing data that were collected by the United State Geological Survey (USGS) throughout the Chesapeake Bay watershed. Specifically, this project will focus on the role that extreme flow and storm events may have on the prevalence and concentration of CEC's in surface water, as well as any possible connections between nutrient levels and CEC's in surface water. Finally, we will conduct a spatial analysis to explore the role that different land cover types have on river CEC composition and concentrations. The proposed project will use Bayesian statistical modelling to meet the study objectives. The goals of this research are to increase the knowledge of the spatiotemporal dynamics of CEC's to better inform management of the Chesapeake Bay watershed. Specifically, this information will help inform land management, restoration and protection of the Chesapeake Bay.

3.2.3 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.

3.2.4 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.

3.2.5 * 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.

3.2.6 * 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.

3.2.7 * 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.

3.2.8 * 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.

3.2.9 * 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.

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

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 Diego Montecino-Latorre, 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.

3.3.3 Phase II: Genetic assignment of white-tailed deer to population of origin. David Walter, 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.

3.3.4 *Optimizing CWD Surveillance: Regional Synthesis of Demographic, Spatial, and Transmission-Risk Factors. David Walter, 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.

3.3.5 *Parturition timing and calf survival in Pennsylvania elk. Avery Corondi (MS, PSU), David Walter, 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.

3.3.6 *Minnesota white-tailed deer genetics within chronic wasting disease areas. David Walter, Chris Jennelle (Minnesota DNR), Michelle Carstensen (Minnesota DNR). Funding by the Minnesota Department of Natural Resources

Minnesota has been experiencing various occurrences of chronic wasting disease in white-tailed deer for last decade in wild and captive white-tailed deer. The origin of the disease in the state is largely unknown, however, there are concerns for spread and transmission north into previously disease-free areas from the core areas in southeastern Minnesota. Landscape genetics has become a powerful tool to assess movement of deer by inferring shared ancestry implies some form of movement of deer between subpopulations. This information is not known for the core of chronic wasting disease in Minnesota and also not known across the state with diverse habitats and landscape composition that deer occupy. The objectives of this project are to conduct genetic analysis testing on up to 625 wild white-tailed deer muscle samples received from Minnesota during routine disease monitoring protocols. Testing will include a microsatellite (msats) panel on the 11 optimal white-tailed deer msats as determined by a recent study. Also, testing will include forward and reverse DNA sequencing of mitochondrial DNA (mtDNA), and prion protein gene (PRNP) analysis for codons 95, 96, and 116. The results will provide details on separate components of shared ancestry (11 microsatellite marker genotypes and mtDNA haplotypes) and susceptibility to chronic wasting disease (PRNP genotypes at codons 95, 96,116) for all 625 deer.

3.3.7 *Linking Genetics to Movements of White-tailed deer to Assist Surveillance for Chronic Wasting Disease. Post Doc (TBD), David Walter, Krysten Schuler (Cornell University). 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 (O'Rourke et al. 2004, Robinson et al. 2012). 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. We intend to genotype the prion gene of individuals sampled from distinct populations of wild white-tailed deer that have experienced CWD for 10–20 years (Maryland/Pennsylvania/Virginia) and an area with no current infection as of 2019 (New York) to determine the level of CWD susceptible deer in various subpopulations throughout the region to help managers understand the potential genetic risk factors for CWD in these populations. We will also conduct landscape genetics on 11 microsatellites from deer in the region using a previously developed panel of microsatellites. 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 project aligns with FY20 EMA annual guidance, and the RFP priority: Chronic Wasting Disease: Research to investigate the impact of genetics on CWD dynamics in cervid populations.

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

Honors and Awards

Tyler Wagner was awarded the U.S. Geological Survey Scientific Excellence Award - Awarded for excellence in furthering the mission of the Cooperative Research Units Program.

David Walter was awarded the U.S. Geological Survey Scientific Excellence Award - Awarded for excellence in furthering the mission of the Cooperative Research Units Program.

Duane Diefenbach, Gordon Kirkland Lifetime Achievement Award by the Pennsylvania Chapter of The Wildlife Society. The award is meant to recognize mid-career and beyond professionals with demonstrated accomplishments in and dedication to the wildlife field. This is a peer-nominated award.

Danielle Massie (MS student, Wagner) was selected as a recipient of the 2020 Distinguished Master's Thesis Award - considered to be among the most prestigious of the awards given to Penn State graduate students.

Danielle Massie (MS student, Wagner) was awarded the Cooper Award by the Pennsylvania Chapter of the American Fisheries Society. The Cooper Award provides travel support for students to present at the chapter's annual meeting.

Danielle Massie (MS student, Wagner) was awarded the Roger M. Latham Award. The award is given annually to an outstanding graduate student advised by Wildlife and Fisheries Science faculty in the Department of Ecosystem Science and Management.

Peer-reviewed Publications

Diefenbach

Miller, W.M., C.M. Miller-Butterworth, **D.R. Diefenbach**, and **W.D. Walter**. 2020. Assessment of spatial genetic structure to identify populations at risk for infection of an emerging epizootic disease. Ecology and Evolution 10(9):3977–3990; https://doi.org/10.1002/ece3.6161

Gigliotti, L. C., N. D. Berg, R. Boonstra, S. M. Cleveland., **D. R. Diefenbach**, E. M. Gese, J. S. Ivan, K. Kielland, C. J. Krebs, A. V. Kumar, L. S. Mills, J. N. Pauli, H B. Underwood, E. C. Wilson, M. J. Sheriff. 2020. Latitudinal variation in snowshoe hare (Lepus americanus) body mass: A test of Bergmann's Rule. Canadian Journal of Zoology 98:88-95. https://doi.org/10.1139/cjz-2019-0184

<u>*Wagner*</u>

White, S.L., E.M. Hanks, and **T. Wagner**. A novel quantitative framework for riverscape genetics. Ecological Applications.

Brennan, J.C., R.W. Gale, D.A. Alvarez, J.K. Leet, **Y. Li**, **T. Wagner**, D.E. Tillitt. Accepted. Factors affecting sampling strategies for design of an effects-directed analysis for endocrine-active chemicals. Environmental Toxicology and Chemistry.

Soranno, P.A., K.S. Cheruvelil, B. Liu, Q. Wang, P-N. Tan, J. Zhou, K.B.S. King, I.M. McCullough, J. Stachelek, M. Bartley, C.T. Filstrup, E.M. Hanks, J-F. Lapierre, N.R. Lottig, E.M. Schliep, **T. Wagner**, K.E. Webster. Accepted. Ecological prediction at macroscales using big data: Does sampling design matter? Ecological Applications.

Stachelek, J. W. Weng, C.C. Carey, A.R. Kemanian, K.M. Cobourn, **T. Wagner**, K.C. Weathers, P.A. Soranno. In press. Granular measures of agricultural land-use influence lake nitrogen and phosphorus differently at macroscales. Ecological Applications.

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.

White, S., **D. DeMario**, L. Iwanowicz, V. Blazer, and **T. Wagner**. 2020. Tissue distribution and immunomodulation in channel catfish (Ictalurus punctatus) following dietary exposure to polychlorinated biphenyl Aroclors and food deprivation. Int J Environ Res Public Health: 17(4).

White, S., E. Faulk, C. Tzilkowski, A.S. Weber, M. Marshall, and **T. Wagner**. 2020. Predicting fish species richness and habitat relationships using Bayesian hierarchical multispecies occupancy models. Canadian Journal of Fisheries and Aquatic Sciences 77:602-610.

Hansen, G.J.A., T.D. Ahrenstorff, B.J. Bethke, J. Dumke, J. Hirsch, K.E. Kovalenko, J.F. LeDuc, R.P. Maki, H. Rantala, and **T. Wagner**. Walleye growth declines following zebra mussel and Bythotrephes invasion. Biological Invasions.

Bartley, M.L., E.M. Hanks, E.M. Schliep, P.A. Soranno, and **T. Wagner**. Identifying and characterizing extrapolation in multivariate response data. PLOSE ONE.

Wagner, T., N.R. Lottig, M.L. Bartley, E.M. Hanks, E.M. Schliep, N.B. Wikle, K.B.S. King, I. McCullough, J. Stachelek, K.S. Cheruvelil, C.T. Filstrup, J.F. Lapierre, B. Liu, P.A. Soranno, P-N. Tan, Q. Wang, K. Webster, and J. Zhou. 2019. Increasing accuracy of lake nutrient predictions in thousands of lakes by leveraging water clarity data. Limnology and Oceanography Letters.

<u>*Walter*</u>

Ensminger, D.C., C. Pritchard, T. Langkilde, T. Gingery, J.E. Banfield, and **W.D. Walter**. The influence of hunting pressure and ecological factors on fecal glucocorticoid metabolites in wild elk. Wildlife Biology. *In press.*

Ganoe, L.S., J.D. Brown, M.J. Yabsley, M.J. Lovallo, and **W.D. Walter**. A review of pathogens, diseases, and contaminants of muskrats (*Ondatra zibethicus*) in North America. Frontiers in Veterinary Science 7:233. doi: 10.3389/fvets.2020.00233

Ahrestani, F.S,, M.A. Ternent, M.J. Lovallo, and **W. D. Walter**. Bear management in suburbia: a novel landholder step-selection approach. Human-Wildlife Interactions. *In press.*

Miller, W.M., C.M. Miller-Butterworth, **D.R. Diefenbach**, and **W.D. Walter**. Assessment of spatial genetic structure to identify populations at risk for infection of an emerging epizootic disease. Ecology and Evolution 10(9):3977–3990; **https://doi.org/10.1002/ece3.6161**

Miller, W.L. and **W. D. Walter**. Can genetic assignment tests provide insight on the influence of captive egression on the epizootiology of chronic wasting disease? Evolutionary Applications. 13:715–726; https://doi.org/10.1111/eva.12895.

Hopkins, M.C., Carlson, C.M., Cross, P.C., Johnson, C.J., Richards, B.J., Russell, R.E., Samuel, M.D., Sargeant, G.A., Walsh, D.P., and **Walter, W.D.** 2019. Chronic wasting disease—Research by the U.S. Geological Survey and partners: U.S. Geological Survey Open-File Report 2019–1109, 29 p.,

Presentations at Scientific Meetings

Diefenbach

Diefenbach, D. R., T. A. Marques, J. L. Laake, **T. M. Gingery**, **A. Van Buskirk**, C. S. Rosenberry, B. D. Wallingford, **W. D. Walter**. 2020. Accounting for animal density gradients in distance sampling surveys. International Statistical Ecology Conference, Sydney, Australia. Canceled due to COVID-19 Pandemic.

Arnold, D., **D. R. Diefenbach**, **T. Gingery**, C. S. Rosenberry, B. D. Wallingford. Winter snow storms and their influence on behavior of white-tailed deer. Pennsylvania Chapter of The Wildlife Society Annual Meeting, State College, PA, 28 March 2020. Canceled due to COVID-19 Pandemic.

Diefenbach, D. R., T. A. Marques, J. L. Laake, **T. M. Gingery**, **A. Van Buskirk**, C. S. Rosenberry, B. D. Wallingford, **W. D. Walter.** 2020. Accounting for animal density gradients in distance sampling surveys. Pennsylvania Chapter of The Wildlife Society Annual Meeting, State College, PA, 28 March 2020. Canceled due to COVID-19 Pandemic.

Gingery, T. M., **D. R. Diefenbach**, C. Pritchard, B. D. Wallingford, and C. S. Rosenberry. Survival negatively associated with glucocorticoids in a wild, large herbivore ungulate. Pennsylvania Chapter of The Wildlife Society Annual Meeting, State College, PA, 28 March 2020. Canceled due to COVID-19 Pandemic.

Van Buskirk, A., **D. R. Diefenbach**, C. S. Rosenberry, E. Domoto, B. Wallingford. Modeling ability to achieve localized areas of reduced white-tailed deer density. Pennsylvania Chapter of The Wildlife Society Annual Meeting, State College, PA, 28 March 2020. Canceled due to COVID-19 Pandemic.

Robinson, K., A. Fuller, M. Schiavone, **D. Diefenbach**, and W. Siemer. A structured decision making approach to addressing wild turkey population declines. Informs Annual Meeting, 22-23 October 2019, Seattle, Washington, USA.

Wagner

Massie, D.L., Hansen, G., Li. Y., and **T. Wagner**. 2020. Do lake-specific characteristics mediate the temporal relationship between Walleye growth and warming water temperatures? Pennsylvania Chapter of the American Fisheries Society. (Contributed Oral)

McClure, C., K. Smalling, V.Blazer, and **T. Wagner**. 2020. Maternal sourcing of contaminants from ovary to juvenile Smallmouth Bass in the Chesapeake Bay Watershed. Pennsylvania Chapter of the American Fisheries Society. (Contributed Oral)

Li, Y. and **T. Wagner.** 2019. Ecological risk assessment of environmental stress and bioactive chemicals to riverine fish populations: an individual-based model of smallmouth bass. American Geophysical Union Annual Conference. (Contributed Oral)

Massie, D.L., G. Hansen, Y. Li. and **T. Wagner.** 2019. Do lake-specific characteristics mediate the temporal relationship between Walleye growth and warming water temperature? Annual Meeting of the American Fisheries Society. (Contributed Oral)

McClure, C. K. Smalling, V. Blazer, and **T. Wagner**. 2019. The spatiotemporal dynamics of contaminants in streams of the Chesapeake Bay Watershed. Annual Meeting of the American Fisheries Society. (Contributed Oral)

White, S.L., E.M. Hanks, and **T. Wagner.** 2019. A novel quantitative framework for riverscape genetics highlights the importance of mainstem channels for brook trout population connectivity. Annual Meeting of the American Fisheries Society. (Contributed Oral)

Stachelek, J., C.C. Carey, K.M. Cobourn, S.M. Collins, A.R. Kemanian, **T. Wagner**, K.C. Weathers, W. Weng, and P.A. Soranno. 2019. Analysis of 500 lake catchments reveals the relationship between crop type, fertilizer and manure inputs and lake nutrient concentrations. 2019. Ecological Society of America Annual Meeting. (Contributed Oral)

Schall, M.K., V.S. Blazer, H.L. Walsh, G. Smith, T. Wertz, and **T. Wagner**. 2019. Quantifying spatial variability in young of year smallmouth bass disease infections in the Chesapeake Bay Watershed. International Association for Great Lakes Research (IAGLR), Brockport, NY, June 10 – 14. (Contributed Oral)

Smith, G.D., M.K. Schall, V.S. Blazer, H.L. Walsh, and **T. Wagner**. 2019. The role of disease in altering the population structure of Smallmouth Bass in the Susquehanna River Basin. International Association for Great Lakes Research (IAGLR). (Contributed Oral)

Walter

Ganoe, L, J. Brown, M. Lovallo, M. Yabsley, M. Ruder, **D.R. Diefenbach**, and **W.D. Walter**. 2019. Mischievous muskrats; survey techniques for survival and health investigations in Pennsylvania. The Wildlife Society Annual Meeting, Reno, NV. (Invited Oral).

Walter, W.D., F.S. Ahrestani, and **W.L. Miller**. Synergy of genetics and diffusion dynamics in white-tailed deer to understand epidemiology of chronic wasting disease. 68th Annual International Conference of the Wildlife Disease Association, Tahoe City, CA. (Contributed Oral)

Ganoe, L., J. Brown, M. Lovallo, M. Yabsley, M. Ruder, and **W.D. Walter**. 2019. Defining Pathogens and Disease of Muskrats (Ondatra zibethicus) in Pennsylvania. Wildlife Disease Association, Tahoe City, CA. (Contributed Poster)