West Virginia Cooperative Fish and Wildlife Research Unit

FY 2014
ANNUAL REPORT
1 October 2013 - 30 September 2014

COOPERATING AGENCIES:

U.S. Geological Survey
West Virginia Division of Natural Resources
West Virginia University
U.S. Fish and Wildlife Service
Wildlife Management Institute

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Cover Graphics: Cheat Lake, Morgantown, WV – Dustin Smith
WVCFWRU logo by Marianne Dewey

Introduction and History: The West Virginia Cooperative Fish and Wildlife Research Unit

The West Virginia Cooperative Fish and Wildlife Research Unit was formed at West Virginia University on July 1, 1986. The Coop Unit is housed in Percival Hall within the Division of Forestry and Natural Resources, Davis College of Agriculture, Natural Resources and Design. It is an integral part of the Wildlife and Fisheries program within the Division of Forestry and Natural Resources.

One mission of the West Virginia Coop Unit is to address the research and technical needs of the West Virginia Division of Natural Resources, U. S. Geological Survey, U. S. Fish and Wildlife Service, and other natural resource agencies and organizations. Research and technical needs goals are met by pursuing funding for research projects, collaborating with cooperators on research projects, publishing and presenting research results, and participating in short courses and workshops for cooperators when appropriate.

The Coop Unit's research program is focused on environmental impacts at the species and ecosystem levels. Wildlife research projects focus on the effects of anthropogenic disturbances (timber harvesting, mountaintop mining, and Marcellus shale gas development) in forested systems on wildlife populations. Fisheries research projects focus on contaminants in West Virginia watersheds, brook trout restoration, rainbow trout aquaculture, and systematics and ecology of West Virginia fishes.

Graduate education is also an important mission of the Coop Unit. Cooperating with West Virginia University, the Coop Unit contributes to the quality education and training of graduate students in fisheries and wildlife at West Virginia University. Coop Unit scientists achieve educational goals by chairing graduate committees, serving on graduate committees, teaching graduate level courses and delivering guest lectures and seminars. As of September 30, 2014, 105 students have completed their degree requirements: 85 Masters and 20 Ph. D. The Unit scientists are currently supervising 5 Master's students and 13 Ph.D. students.

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UNIT LEADER

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ASSISTANT LEADERS

Petra Bohall Wood, Adjunct Professor of Wildlife
Ph.D., University of Florida, 1992. Wildlife/habitat relationships, raptor ecology and management.

Stuart A. Welsh, Adjunct Professor of Fisheries
Ph.D., West Virginia University, 1997. Fisheries ecology, zoogeography and systematics.

STAFF

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PROJECT COOPERATORS

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Michael Schwartz, Freshwater Institute
J.R. Shute, Conservation Fisheries, Inc.
Steve Summerfelt, Freshwater Institute
T. Bentley Wigley, NCASI

STUDENTS

STUDENT	DEGREE	GRADUATION DATE	ADVISOR
Joni Aldinger	M.S.	Expected May 2015	Stuart Welsh
Kyle Aldinger	Ph.D.	Expected May 2014	Petra Wood
Ryan Braham	Ph.D.	Expected Dec 2016	Pat Mazik
Ryan Davis	M.S.	Completed May 2014	Petra Wood
Sheila Eyler (NCTC)	Ph.D.	Expected Dec 2014	Stuart Welsh
Laura Farwell	Ph.D.	Expected Aug 2016	Petra Wood
Steve Foster (NCTC)	Ph.D.	Expected Dec 2017	Stuart Welsh
Mack Frantz	Ph. D.	Expected May 2016	Petra Wood
Cassidy Hahn	Ph.D.	Expected Dec 2015	Pat Mazik
Corbin Hilling	M.S.	Expected May 2015	Stuart Welsh
Carlos Martinez (NCTC)	M.S.	Expected Dec 2015	Pat Mazik
Gretchen Nareff	Ph. D.	Expected May 2016	Petra Wood
Austin Rizzo	Ph. D.	Expected Dec 2017	Stuart Welsh
Jim Sheehan	Ph.D.	Expected May 2015	Petra Wood
Dustin Smith	Ph.D.	Expected Dec 2015	Stuart Welsh
Daniel Sparks (NCTC)	Ph.D.	Expected Dec 2015	Pat Mazik
Jeff Thomas (NCTC)	Ph.D.	Expected Dec 2017	Stuart Welsh
Patricia Thompson	M.S.	Expected May 2016	Stuart Welsh
Thomas Waldrop (NCTC)	M.S.	Expected Dec 2015	Pat Mazik
Heather Walsh	Ph. D.	Expected Dec 2018	Pat Mazik

UNIT STAFF COURSES TAUGHT

Patricia M. Mazik, Adjunct Professor of Fisheries
Aquatic Toxicology Fall 2014 3 credits

Stuart A. Welsh, Adjunct Professor of Fisheries
Advanced Ichthyology Fall 2014 3 credits

Petra B. Wood, Adjunct Professor of Wildlife
Wildlife and Fisheries Graduate Seminar Spring 2014 1 credit

PROGRAM DIRECTION STATEMENT

The West Virginia Cooperative Fish and Wildlife Research Unit was established at West Virginia University on 1 July 1986. The Unit Leader began on 13 April 1987, and both Assistant Leaders were in place by 14 September 1987. The Unit is housed within the Division of Forestry and Natural Resources, College of Agriculture, Natural Resources, and Design. Offices and laboratories are located in Percival Hall.

The purpose of this document is to identify those general areas of fish and wildlife research that are most appropriate for study by the Unit. It is not a proposal for specific projects, but rather a definition of the types of areas of research most appropriate for the Unit given the expertise and facilities available.

The research mission of the Unit is to address fish and wildlife problems of mutual interest to all cooperators. Graduate education is also a mission. Studies will be accomplished by graduate research associates, research associates, technicians, non-thesis graduate students, graduate students working on separate thesis topics, or cooperating faculty members.

Most broadly interpreted, the cooperative agreement establishing the Unit provides access to expertise from among all segments of the University and other cooperators. However, most research will be directed by the Unit staff (Leader and Assistants) and those cooperating faculty members conducting research related to fish or wildlife resources.

There is a long-standing wildlife program in the Division of Forestry and Natural Resources, studying a broad range of terrestrial ecology problems, ranging from traditional population studies of wildlife species, to effects of forestry practices on wild animals, to social aspects of wildlife management. The Unit will enhance the wildlife and fisheries program by emphasizing research on wildlife/forestry issues inherent to West Virginia.

Research conducted through the Unit should stress functional responses of terrestrial and aquatic communities to management actions or environmental impacts. That is, we will attempt to determine how and why populations respond rather than simply to document or quantify responses. A study that evaluates management actions or examines ecological processes usually results in increased understanding of fish and wildlife community ecology and, thus has broader application than the immediate problem of concern.

Most of the Unit's research should be conducted within West Virginia or the bordering states. We will consider those occasional research opportunities that arise in areas remote to the state if they are of broad importance, or if they are logically undertaken most effectively by the West Virginia Unit.

COMPLETED PROJECTS

WILDLIFE

IMPACTS OF MOUNTAINTOP MINING ON TERRESTRIAL ECOSYSTEM INTEGRITY: IDENTIFYING LANDSCAPE THRESHOLDS FOR AVIAN SPECIES

Postdoctoral Research Associate: Doug Becker
Principal Investigators: Petra Wood and Michael Strager
Cooperator: Christine Mazzarella
Years Ongoing: 2012-2014
Completion: January 2014
Funding Source: Environmental Protection Agency

Objective:
Identify avian community abundance landscape thresholds in response to changing landcover from mountaintop mining.

Results:

Introduction

The Central Appalachian landscape is naturally dominated by interior forest but the expansion of mountaintop removal/valley fill (MTR/VF) mining has been a major driver of landscape change to this system. The potential long-term effects of these landscape-scale changes are not accounted for in current assessments of mountaintop mining especially within terrestrial ecosystems. Breeding birds, as effective indicators of biotic integrity, can be used to quantify the impacts of mountaintop mining on terrestrial ecosystems. Herein, our objective was to quantify avian community and individual taxa thresholds in response to changing landscape dynamics due to mountaintop mining within the MTR/VF region and to improve management decision-making.

Methods

Within mature forest habitat, we conducted 50-m fixed radius avian point count surveys (n=707) adjacent to minelands in 2012-2013 and obtained data for additional survey points (n=905) sampled using comparable methodologies during 2008-2013 (Fig. 1). Removal model detectability results among datasets found differences were not systematic or large for most species, so datasets were combined for analysis. The landcover around each point was classified into five groups (mature forest, mining barren, mining shrub/grass, other barren, other grass/shrub). We derived five landscape metrics within a 1 km radius of each count (forest edge density, 100 - % core mature forest, 100 - % mature forest, % total mineland, and % total grassland and shrubland) and quantified positive and negative community, guild, and species thresholds using *Threshold Indicator Taxa Analysis (TITAN)* for each metric. Metric importance values were ranked based on a random forest analysis.

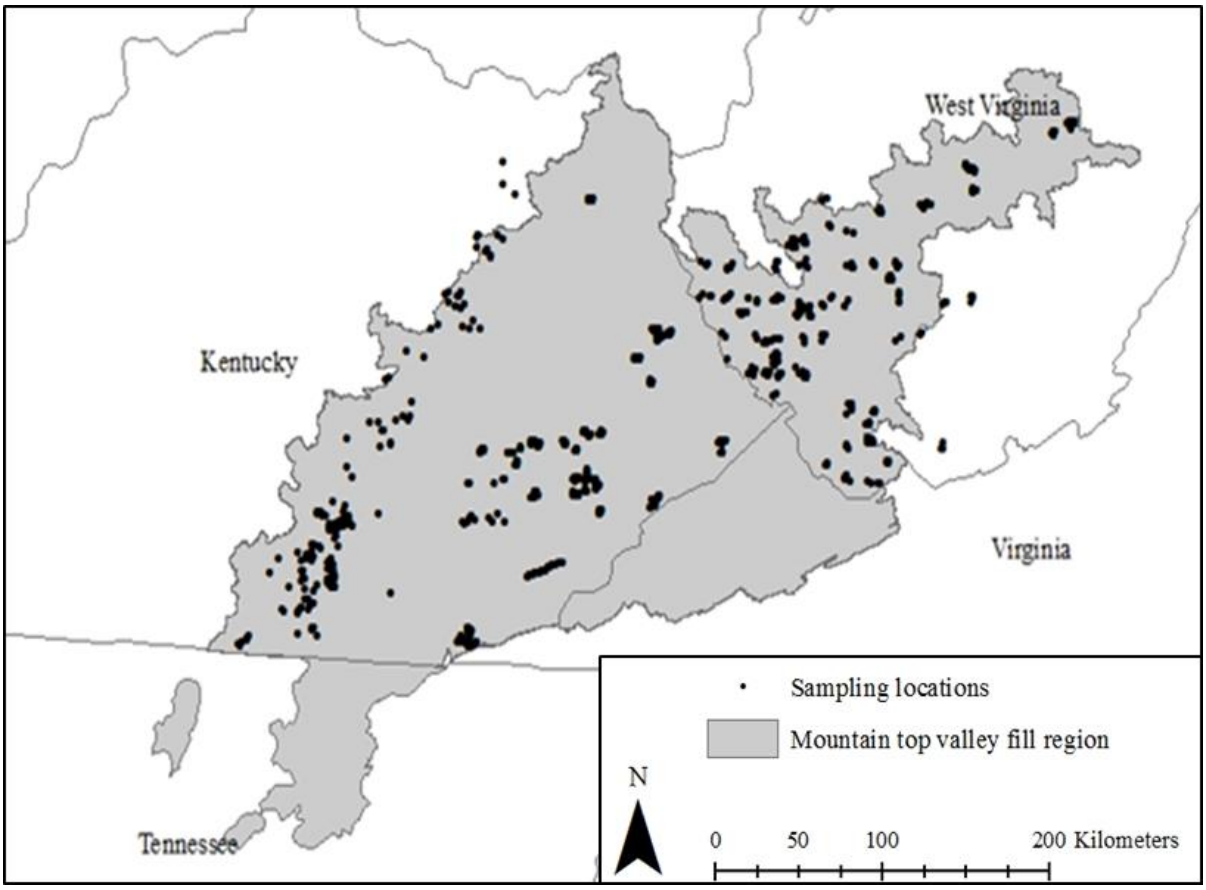

Figure. 1. Geographic distribution of all 1,612 bird survey sampling locations within MTR/VF region sampled 2008-2013

Results/Discussion

Community thresholds were quantified though less useful for management decisions due to the large variation in threshold responses of individual species with diverse habitat requirements combined within the overall community thresholds. Partitioning the avian community into habitat guilds clarified the responses while thresholds for significant individual species were most precise (Figure 2).

Reclaimed mine-dominated landscapes (less mature forest cover and more grassland or shrubland cover) elicited more negative (28 species, 57 %) than positive (19 species, 39 %) species responses within the avian community. The introduction of minelands and grassland/shrubland habitats to a landscape produced immediate negative response thresholds occurring within 1-2% habitat change within community thresholds and <10% change for most negatively responding species. In contrast, negative responses to core mature forest loss, mature forest loss, and increased edge density, were more delayed occurring at 10% loss of mature forest cover and 25% loss of core mature forest, indicating some resilience to mature forest loss and introduced edges within the forest songbird community but within limits. Forest interior birds generally responded negatively to landscape thresholds, interior edge species responses were mixed, and early successional birds responded positively.

Landscape conversion from MTR/VF mining was not detrimental to all species. But the majority of positive responses of relative abundance by guilds and individual species occurred at greater amounts of land-cover change than the negative responses, meaning that the negative responses occur before any beneficial responses and often included a large range in landscape condition of the metrics between

negative and positive response. Exceptions were increased edge for the forest interior guild (4-23 m/ha), increased non-forest mineland (3-7%) and grassland/shrubland (0-9%) for the interior edge guild, and increased edge (280-368 m/ha) for the early successional guild. Guild responses based on positive thresholds were similar to negative responses only for edge density and grassland/shrubland. In contrast, the interior edge guild responded more immediately to small changes, 1-3%, in mineland and grassland/shrubland and to less mature forest loss (16%). Early succession guild positive responses were more delayed (>50% forest loss, >88% core forest loss, >47% grass/shrub, and >77% non-forest mineland).

For forest landscape management, the decision is whether to maintain interior forest given the importance of biodiversity and the large extent of mature forest relative to other regions in the eastern United States or to create early successional habitat, which is limited in the region. In choosing which goal to emphasize, little middle ground exists because any landscape change to promote benefits to early successional species will surpass all negative thresholds for forest interior species. We note, however, that these thresholds are only in response to changes in relative abundance and do not consider whether increased abundance also leads to increased reproductive success or survival.

Based on random forest importance ranks, total amount of grassland/shrubland in a landscape had the most influence, although this varied by guild. Mature forest loss and core mature forest loss ranked closely across guilds with a slight edge to core mature forest, representing the need to maintain some intact interior forest. These results support an emphasis of the shrubland/grassland, mature forest, and core mature forest thresholds during management decisions.

Overall Conclusions

The transition to a more mine-dominated landscape elicited more negative than positive avian responses with negative thresholds occurring at primarily <10% landscape change. Positive responses occurred at greater amounts of land-cover change than the negative responses leaving little middle ground in the management decision whether to maintain interior forest or to create early successional habitat. Importance rankings emphasize support for the use of shrubland/grassland, mature forest, and core mature forest metrics. Our avian thresholds identify single avian community management targets accounting for scarce species and thresholds for guilds or individual species that allow for species-specific management.

Forest patch on a mountaintop mine in Kentucky.

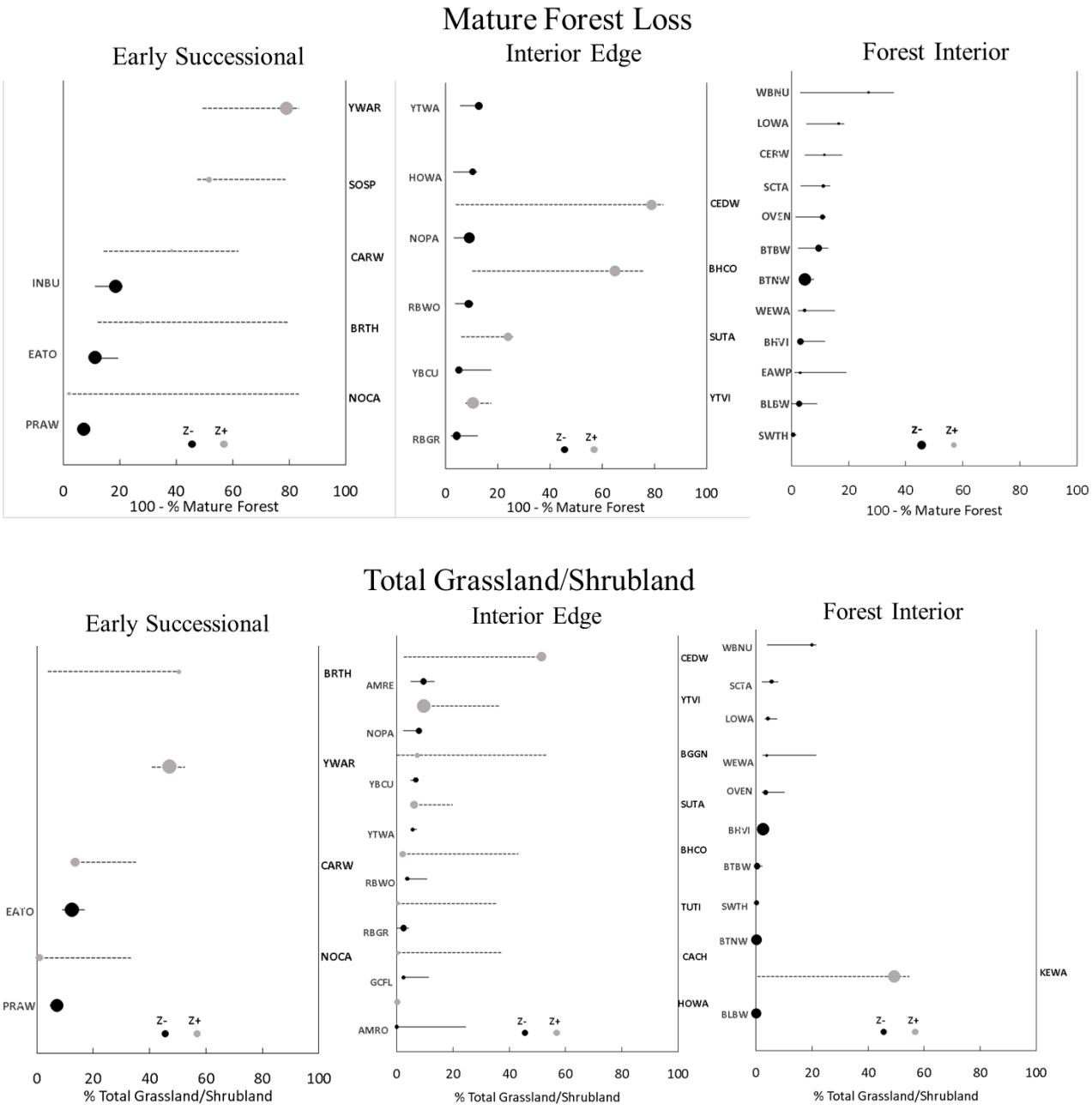

Figure. 2. TITAN plots for mature forest loss and total grassland/shrubland by avian habitat guild (early successional, interior edge, forest interior) showing each species with a significant threshold. Z+ species had a positive response to exceeding their threshold while Z- species had a negative response. Species with larger circles are more significant. The length of the line overlapping each circle represents the range from the 5-95 % bootstrap change point quantiles.

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IMPACT OF MARCELLUS SHALE DEVELOPMENT ON SHRUBLAND SONGBIRD NEST SUCCESS AND ABUNDANCE

Student Investigator: Ryan Davis
Principal Investigator: Petra Wood
Cooperators: Rick Hammack, Harry Edenborn
Years Ongoing: 2012-2014
Degree Program: M.S.
Completion Date: May 2014
Funding Sources: U.S. Department of Energy

Objectives:

1) Quantify avian abundance, community composition, and nest success rates on shrubland sites with and without unconventional gas deveopment.

2) Gather data on luminance and ambient noise levels at impacted and unimpacted sites.

3) Determine if avian abundance, community composition, or nest success differ between impacted and unimpacted sites.

4) Examine the relationship of these changes to the accompanying changes in luminance, ambient noise levels, and vegetative composition.

Results:

Extraction of gas from the Marcellus shale formation has increased in recent years due to technological advancements, namely hydraulic fracturing ("fracking"), that enable companies to reach these previously untapped deposits. These new techniques leave a much larger footprint than conventional oil and gas infrastructure does, and there is growing concern over the potential environmental impacts of hydraulic fracturing methods. Avian concerns mostly relate to habitat fragmentation and loss due to the large area of land that is converted from forest to well pads, gas lines, and roads. Consequently, most research examines the changes in avian communities on forested landscapes. We assessed the local-scale impacts on shrubland birds in an already highly-fragmented landscape context. Shrubland songbirds are a highly imperiled guild across much of North America due to reductions in forest disturbance and thus rapidly-diminishing habitat. We accordingly focused on this suite of species, quantifying abundance, community composition, and nest success.

Data on avian abundance, community composition, nest success, vegetative characteristics, and luminance and noise levels were gathered in the 2012 and 2013 breeding seasons. Our study areas were on shrublands located in southwestern Pennsylvania and the northern panhandle of West Virginia. In 2012 data were gathered on two non-developed sites and in 2013 on two non-developed sites and on a third site which had Marcellus infrastructure (wellpad, pipeline, road) and natural gas production.

We used 10-minute unfixed-radius point counts to measure avian abundance and composition. We excluded flyovers and detections greater than 70 meters from the observer. In 2012, this resulted in 1042 total detections of 55 unique species, 792 detections at one site (of 49 unique species) and 250 at the other (48 unique species). The 2013 results were 1087 detections of 55 unique species total, 323 detections of 40 unique species at the site being developed for natural gas, 397 detections of 39 unique species at one non-impacted site, and 367 detections of 34 unique species at the other.

We transformed the 2013 count data into a Bray-Curtis dissimilarity matrix and assessed avian community composition with Adonis tests. Community structure did not differ significantly (P=0.01) by type (gas impacted v not impacted) once accounting for site. An NMDS ordination showed that the developed and unimpacted sites had avian communities that differed, but did not discriminate fully. The adonis test of vegetative communities at counts also found significant differences by type (P = 0.001) and site (P = 0.001). Overlaying highly correlated vegetation variables and displaying avian species used in the ordination showed that the site-level discrimination in species was largely explained by vegetation rather than Marcellus infrastructure. There were no differences in noise (P = 0.21) or light (P = 0.29) emissions between impacted and non-impacted shrublands, or at a developed site with increasing distance to the wellpad (noise P = 0.69 and light P = 0.91).

Figure 1. Focal species from left: Field Sparrow, Eastern Towhee (male), Blue-winged Warbler (male).

Nests were found and monitored for 3 focal species: Field Sparrow (*Spizella pusilla)*, Eastern Towhee (*Pipilo erythrophthalmus*), and Blue-winged Warbler (*Vermivora cyanoptera*) (Figure 1). We analyzed nest survival in an information-theoretic framework in Program MARK for 96 nests monitored in 2013; 31 at the site being developed, 42 at one non-developed site, and 23 at the other. The presence of gas wells and related infrastructure were important influences on Field Sparrow nest success; survival was reduced close to the wellpad but increased around pipelines and roads (Figure 2). However, nest survival was higher site-wide for the Field Sparrow and other early successional species on the impacted site than on non-impacted shrublands in the region. Nest predators were important in explaining variation in nest survival at the site-level. Within the developed site, nest abandonment was a more likely force around wells and the paved external road, while predation better explained variation in survival by distance to the pipeline and unpaved access road.

Our results suggest that presence of unconventional gas development infrastructure on our study site in an already-fragmented landscape context did not reduce shrubland songbird nesting success on a site overall, but it decreased with distance from the wellpad within a site. Further, large amounts of shrubland habitat are removed when gas infrastructure is developed and habitat loss is a pressing issue for shrubland species.

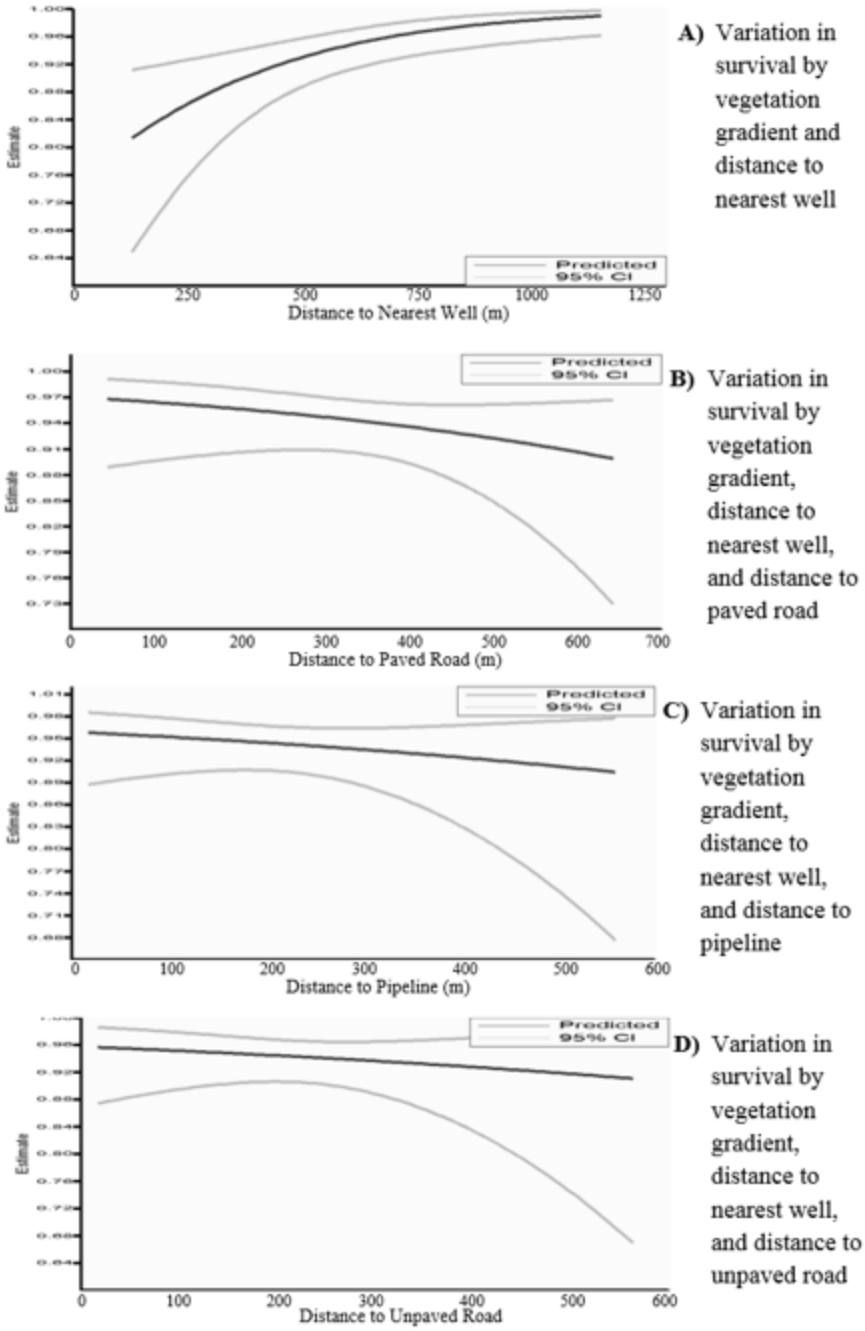


Figure 2. The predicted nest survival curves of Field Sparrows at the gas-impacted site for variables in the top four models, holding all other variables in each model constant: (A) distance to nearest well, (B) distance to the paved road, (C) distance to the pipeline, and (D) distance to the unpaved road.

CONTINUING PROJECTS

AQUATIC
CHEAT LAKE AND CHEAT RIVER PROJECTS

INVESTIGATION OF DIET, AGE AND GROWTH OF CHANNEL CATFISH IN CHEAT LAKE, WV

Student Investigator: Corbin Hilling
Principal Investigator: Stuart A. Welsh
Years Ongoing: 2013-2014
Degree Program: MS
Expected completion: May 2015
Funding Source: West Virginia Division of Natural Resources, NAES Corporation

Objectives:
Research objectives include examination of age/size structure, growth rates and food habits of Channel Catfish *Ictalurus punctatus* in Cheat Lake, WV. Also, Channel Catfish diets will be compared between time periods of relatively constant lake elevation and those of wide fluctuations.

Progress:
Cheat Lake, a hydropower reservoir also known as Lake Lynn, was created in the lower Cheat River drainage in 1926. Acid mine drainage within the Cheat River watershed has been linked to decades of poor water quality, but water quality and fisheries within the reservoir have improved drastically owing to mitigation efforts and regulations controlling operation of the Lake Lynn dam. Hydropower reservoirs often experience water level fluctuations, and water level fluctuations have been regulated for Cheat Lake, in part, to manage fish populations. Cheat Lake contains a large population of Channel Catfish and provides anglers with an excellent Channel Catfish fishery. Analyzing the size structure, growth rates and food habits of Channel Catfish in Cheat Lake will provide useful information toward further management of this fishery.

Figure1. Corbin Hilling holding a Cheat Lake Channel Catfish during a night electrofishing survey.

Channel Catfish collections for age and growth analysis have begun using baited hoop-nets, experimental gill nets and boat electrofishing. For this study, catfish are measured (mm), weighed (g) and sexed. Also, otoliths (lapilli) are removed and used for age determination. Age and growth data will allow us to examine growth rates and population dynamics of Cheat Lake's channel catfish population.

Channel Catfish food habits will be analyzed as a function of lake level fluctuation. The current lake elevation schedule dictates that the lake elevation can fluctuate a maximum of 13 feet (857-870 feet above sea level) from November to March. Channel Catfish diets during this lake fluctuation period will be compared between periods of relatively constant lake elevation and those with wide fluctuations. This component of my research will examine the influence of lake level fluctuation on diet of Channel Catfish.

BIOLOGICAL MONITORING OF AQUATIC COMMUNITIES OF CHEAT LAKE AND CHEAT RIVER DOWNSTREAM OF THE LAKE LYNN HYDRO STATION

Student Investigator: Dustin M. Smith
Principal Investigator: Stuart A. Welsh
Years Ongoing: 2011 – 2014
Degree Program: PhD
Expected completion: Dec 2015
Funding Source: WVDNR, NAES Corporation

Objectives:
A five-year biomonitoring project was initiated March 2011 for Cheat Lake and its tailwaters. The project (partitioned into nine tasks) is a continuation of previous work by West Virginia Division of Natural Resources. Three tasks of the proposed work focus on Cheat River and Cheat Lake tailwaters (Tasks 1 – 3), and 6 tasks focus on Cheat Lake (main lake and embayments). Currently, objectives 1-8 are ongoing, and objective 9 is complete. Quarterly progress reports are provided to the funding agencies

1. Fish biomonitoring downstream of Cheat Lake
2. Benthic macroinvertebrate resource biomonitoring downstream of Cheat Lake
3. Water quality biomonitoring downstream of Cheat Lake
4. Fish biomonitoring of Cheat Lake and embayments
5. Walleye population monitoring and stock assessment
6. Monitoring of adult walleye movement
7. Physical and chemical water quality characteristics of Cheat Lake
8. Aquatic vegetation mapping of Cheat Lake
9. Bathymetric mapping of Cheat Lake

Progress:
For this study, Cheat Lake was divided into three major study areas: the Cheat embayments (Rubles Run – 56 acres, and Morgan Run – 37 acres); lower Cheat Lake, downstream of I-68 bridge to Lake Lynn hydro station; and upper Cheat Lake upstream of the I-68 bridge to the head of the lake. The 3.7-mile section of Cheat River downstream from the hydro station was defined as the Cheat tailwater area located in the first 1.1 miles, and Cheat River between the Cheat tailwater area and the confluence of Cheat River with the Monongahela River (lower 2.6 miles).

The water quality of the Cheat Lake tailwaters and Cheat River have been monitored bi-monthly to assess any impacts from hydropower operations and/or existing acid mine drainage inputs on downstream water quality. The Cheat Lake tailwater section has consistently maintained water quality that is supportive of aquatic organisms with an average pH of 6.6, average dissolved oxygen of 8.5 mg/l, and average specific conductivity of 102 µs/cm. In contrast, water quality in Grassy Run, an acidic tributary to the Cheat River, as expected has had poor water quality with an average pH of 3.0 and conductivity of 1176 µs/cm. In general, Cheat River water quality downstream of Grassy Run reflects the impacts of acid mine drainage (AMD) from Grassy Run with an average pH of 5.4 and an average conductivity of 258 µs/cm. Physical and chemical water quality profiles have been conducted monthly (except during periods of ice cover) from 2011-2014. The primary focus of these limnological profiles is to monitor the pH of Cheat Lake which is still impacted by upstream AMD sources, and to monitor the stratification of water temperature and dissolved oxygen within the lake. Depressions in pH (less than 6.0) within the lake occurred occasionally in 2011, primarily in the early spring when the combined effects of AMD and acidic snowmelt impact the lake. This trend of early spring pH depression has been ongoing since the initiation of lake profiles by WVDNR in 2005. However, in 2012, 2013 and 2014 Cheat Lake did not experience pH depressions below 6.0, possibly due to increases in AMD remediation upstream in the Cheat River watershed. Otherwise, lake pH has been satisfactory, remaining above 6.0 the majority of the time. Stratification of water temperature and dissolved oxygen has historically occurred in lower Cheat Lake from approximately June-September. In general, the upper 6-8 meters of the water column is characterized by warmer water with suitable dissolved oxygen levels (above 5.0 mg/L), while the lower portion of the water column is characterized by much colder water with increasingly less dissolved oxygen (less than 5.0 mg/L). This phenomenon occurs primarily in the lower portion of Cheat Lake which is characterized by much greater depths. However, given the increases in precipitation and cooler air temperatures in 2013 and 2014, Cheat Lake has not recently experienced the severity of stratification that normally occurs during summer months.

Night boat electrofishing and gill netting have been conducted during May (2011, 2012, 2013, and 2014) and October (2011, 2012 and 2013) in Cheat Lake. The primary focus of these surveys is to monitor the health of the fish communities of Cheat Lake. In total, 640 fishes have been captured with gill nets, while 3,950 have been collected using electrofishing. The upper lake, which retains many riverine characteristics, has consistently produced a greater abundance of fish compared to both the lower lake and embayment areas. The embayment areas have produced the lowest fish abundances. Largemouth bass and spotted bass have been most abundant in embayment areas, while smallmouth bass are more abundant in the upper lake. Green sunfish, bluegill, and pumpkinseed are most abundant in the lower lake. Walleye, yellow perch, white bass, and channel catfish are typically most abundant in the upper lake. Smaller forage species also differ dependent on lake area. Mimic and emerald shiners are very abundant in the upper lake and fairly abundant in the lower lake, but are uncommon in embayments. Conversely, logperch and brook silversides are most abundant in the embayments and lower lake.

Night boat electrofishing, tow barge (pram) day electrofishing, and gill netting have been conducted during July, September (pram only), and October 2011 and have been completed for June 2014 in the tailwaters and river downstream of Cheat Lake. In total, 1335 fishes have been captured with boat electrofishing, 150 with gill nets, and 778 with pram electrofishing. An abundance of small forage fish primarily represented by mimic shiners, emerald shiners, and bluntnose minnows were collected in both the tailwater and river sections. In the tailwaters, mimic shiner was the most abundant forage fish, while in the river emerald shiners were more abundant. Smallmouth bass and channel catfish were the most abundant game fishes collected, although largemouth bass and sauger were quite abundant near the mouth of the Cheat River. In addition, benthic macroinvertebrate sampling was completed in July and November 2011 and most recently in June of 2014. The tailwater area just below the dam has a relatively low abundance of macroinvertebrates, likely stemming from the variation in outflow from the upstream dam. The family Chironomidae (midges) accounts for most of the invertebrates in the tailwaters just

downstream of the dam. Two sites are sampled for macroinvertebrates approximately one mile downstream of the dam, and support a much greater abundance of macroinvertebrates. However, the macroinvertebrate community at these sites has low diversity mainly comprised of tolerant taxa. Macroinvertebrates from the families Chironomidae and Hydropsychidae (net-spinnning caddisflies) account for most of the macroinvertebrates at these downstream stations.

Research on adult walleye movement was started in early December 2011. We implanted 49 adult walleyes (33 males; 16 females) with acoustic transmitters. Currently, 24 tagged walleye are active within the lake. Fish locations have been determined using both submerged, stationary receivers and active tracking. During winter months, tagged fish have normally remained near their original capture locations until late February (2012)/mid-March (2013/2014) when fish start to make upstream movements, likely in order to reach spawning habitat. By early March (2012) to early April (2013/2014), most tagged fish have moved to the head of Cheat Lake to spawn. Preliminary analysis of the data suggests that upstream movements correspond to a combination of increased water temperature, increases in lake elevation, and increases in incoming river flow. A minimum of 13 tagged fish have proceeded to move upstream of the first riffle and into the Cheat River, possibly to spawn in the next riffle/run area upstream of the lake approximately 1 mile. Several tagged fish continue to use this area upstream of the first riffle during the spring and summer months. Also, during non-spawning periods, increases in incoming river flow and water temperature appear to trigger upstream movements of many tagged fish. There is currently some evidence to suggest that walleye usage of the upstream riverine reaches increases during summer when main lake water temperature increases and dissolved oxygen decreases. Tagged walleyes can potentially alleviate stressful temperature and oxygen conditions by using the cooler, more oxygenated riverine area. An overview of monthly lake area use by tagged walleyes is provided in Figure 2.

Figure 1. Dustin Smith with a walleye captured during walleye population surveys.

Walleye population monitoring and stocking assessment surveys have been conducted in Cheat Lake during March/April (2012, 2013, and 2014) and November (2012 and 2013). Gill nets are used to capture walleyes throughout the lake to assess the status of the population and the success of walleye stocking efforts. Catch per unit effort (CPUE) of walleyes was only 0.5-0.6 fish per net night during spring (2012-2014). However, it is most likely that the walleye population was greatly underrepresented during our surveys. Most adult walleye were likely upstream of our netting areas near the head of the lake. Information from our acoustic tagged walleyes indicated that most fish were occupying this area in

preparation for spawning each spring during netting. Supporting this assumption, our CPUE during fall 2012 and 2013 was much higher with 1.4 fish per net night.

Currently, an aquatic vegetation map of Cheat Lake is being created. Areas of Cheat Lake that harbor aquatic vegetation have been visually assessed to determine species composition and relative abundance. This information is currently being incorporated into a lakewide map using GIS, and will depict species presence/abundance information. This information will help determine areas that likely represent import nursery habitat for larval/juvenile fishes of Cheat Lake.

A bathymetric map of Cheat Lake was created in 2011 using sonar, GPS technology, and GIS-based interpolation techniques. Depth data with GPS coordinates were recorded from transects using boat-mounted sonar gear. These data were imported into a GIS, where interpolation and contour line mapping techniques were used to produce a bathymetric map of Cheat Lake. This component of the study is being used to help determine habitat preferences of walleye and also areas that are vulnerable to water level fluctuations.

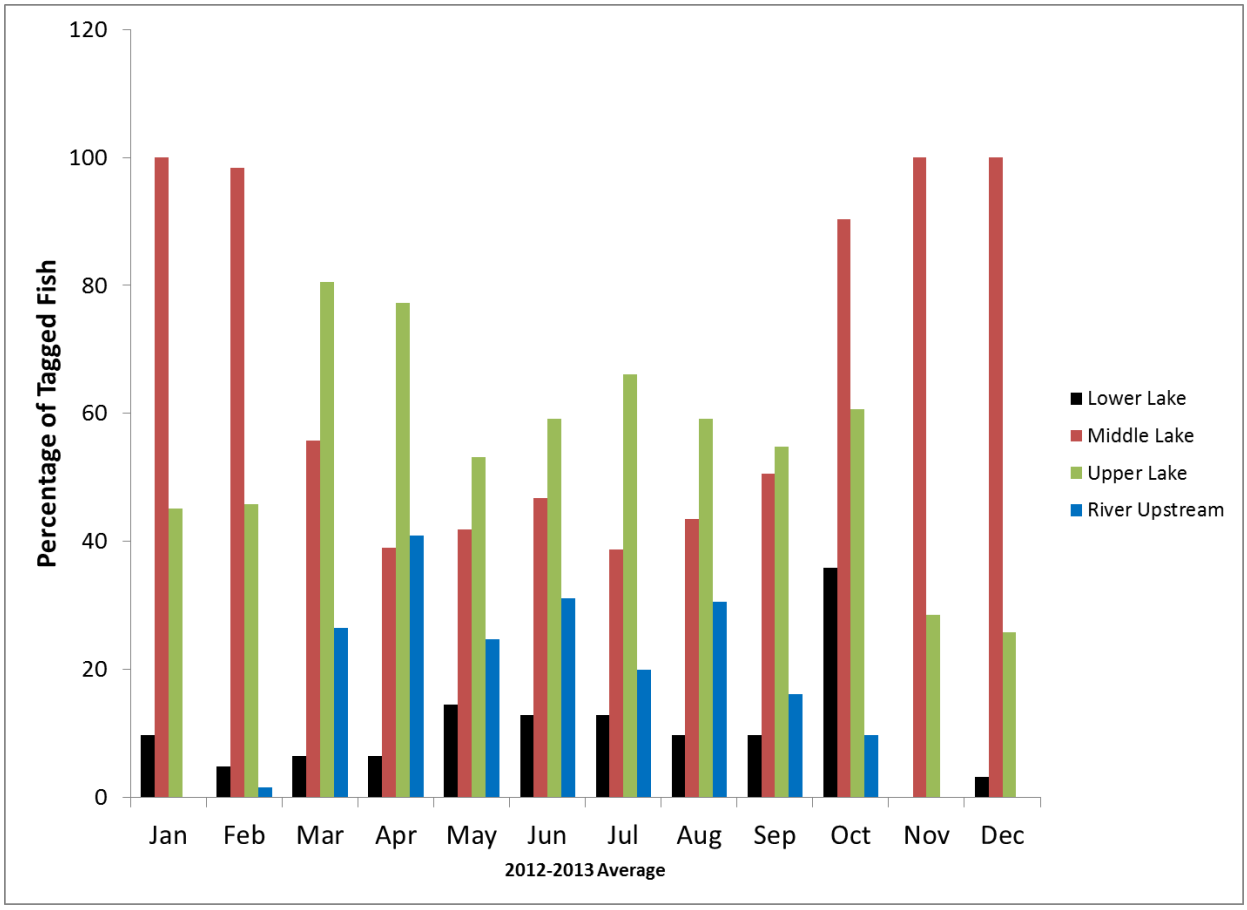


Figure 2. Mean monthly use of lake area by tagged walleyes. Use of lake area is represented by mean percentage of tagged walleyes using each lake area in each month. Data are averaged over the years 2012 and 2013. Percentages over 100 are due to some walleyes using multiple lake areas in a given month.

AQUATIC
EEL PROJECTS

RELATIONSHIPS BETWEEN BODY SIZE, TIMING OF PASSAGE, AND ENVIRONMENTAL VARIABLES FOR UPSTREAM MIGRANT AMERICAN EELS AT THE MILLVILLE DAM EEL LADDER, SHENANDOAH RIVER

Student Investigator: Joni Aldinger
Principal Investigator: Stuart A. Welsh
Years Ongoing: 2013-2014
Degree Program: MS
Expected completion: May 2015
Funding Source: WVDNR, PE Hydro Generation LLC

Objectives:
This study will examine relationships among eel lengths, timing of eel ladder passage, and environmental variables for upstream migrant American Eels at an eel ladder on the lower Shenandoah River.

Progress:
The Millville hydroelectric dam on the lower Shenandoah River is located approximately 9 rkm upstream of the confluence with the Potomac River, and 285 rkm upstream of the mouth of the Potomac River estuary. An eel ladder on this dam, which aids upstream migration of American Eels, has been monitored since 2003, and a semi-automated eel ladder camera has been used to monitor eel passage since 2008. Previously, monitoring was conducted by placing a net bag on the terminal end of the ladder, and captured eels were counted and measured (Figure 1). More recently, the eel ladder camera has been used for monitoring, and allows for data collection of passage counts, eel lengths, and timing of passage. The eel ladder camera photographs each eel that passes through the ladder, and each photograph has a time and date stamp. Using photogrammetric methods, total lengths of eels using the ladder are estimated from photographs (Figure 2).

Figure 1. Joni Aldinger holding a net bag of American Eels collected at the terminal end of the eel ladder at Millville Dam.

Figure 2. Photograph of an American Eel passing through the Millville Dam eel ladder

This study is part of a larger study researching upstream migration of American Eels in the Shenandoah River. I will examine whether there is a pattern to the time of night that an eel migrates upstream, termed nocturnal periodicity. Further, I will examine the pattern of nocturnal movements associated with ecological and environmental variables, such as body length, water temperature, river flow, lunar phase, and time of year. The primary data used in this study are date, time of passage, and total length measurements of American Eels passing through the Millville Dam ladder. These data will provide novel insights into the migration ecology of American Eels.

To date, I have photogrammetric lengths and time of passage data for over 6,500 American Eels. I will continue to collect and analyze data from the eel ladder throughout the remaining 2014 migration season. I have also compiled astronomical data for categorizing periods of migration, including dusk, dawn, and nocturnal time periods. Preliminary results for 1,184 individuals that passed through the ladder from July 12-16, 2013 suggest nocturnal periodicity (Figure 3). Most movement occurred around dusk and dawn and also peaked slightly around 00:00-01:00.

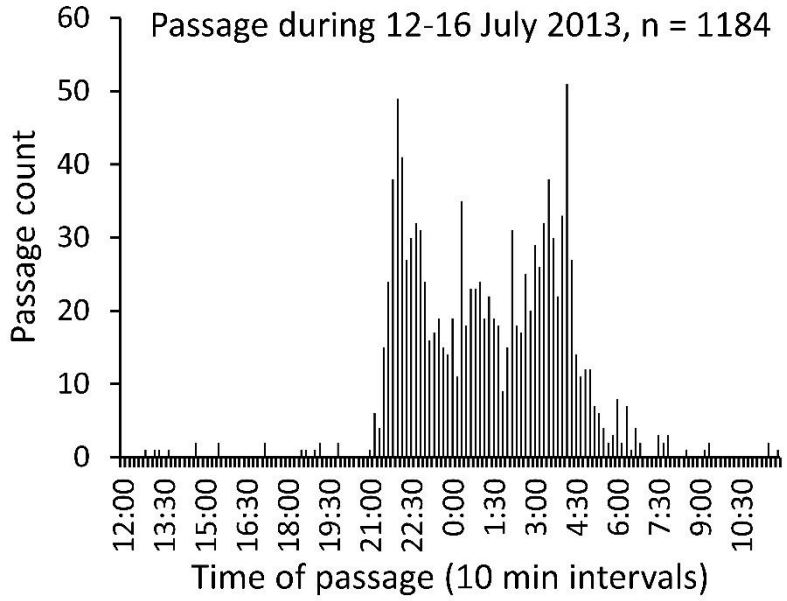


Figure 3. Length-frequency histogram of the timing of passage of 1184 American Eels during 12–16 July 2013 at the Millville Dam eel ladder on the Shenandoah River. The figure depicts a trimodal distribution of passage reflecting crepuscular and nocturnal movements.

DOWNSTREAM MIGRATION AND MORTALITY OF SILVER AMERICAN EELS ASSOCIATED WITH HYDROELECTRIC DAMS ON THE SHENANDOAH RIVER

Student Investigator: Sheila Eyler
Principal Investigators: Stuart A. Welsh and David R. Smith
Years Ongoing: 2007 – 2014
Degree Program: PhD
Expected Completion: December 2014
Funding Source: WVDNR, PE Hydro Generation LLC

Objectives:
Examine out-migration of silver American eels relative to five hydroelectric dams on the lower Shenandoah River. Document eel passage relative to use of dam spillways versus canals and associated intakes to hydroelectric turbines, and document the timing and environmental cues of out-migration.

Progress:
Hydroelectric dams can impact downstream migrating American Eels (*Anguilla rostrata*) through migratory delays and turbine mortality. The cumulative impacts of multiple dams in a river can have significant impacts on American Eels migrating out of the upstream reaches of freshwater rivers. I used radio telemetry to determine the timing and survival of American Eels migrating downstream past five hydroelectric dams on the Shenandoah River in Virginia and West Virginia. The five hydroelectric dams operated a seasonal nighttime turbine shutdown period to protect downstream migrants. The shutdown period was conducted from September 15 to December 15 annually, operating from 18:00 to 06:00 daily. During the fall months from 2007 to 2009, large American Eels were collected primarily by electrofishing above the Luray, Newport, and Shenandoah dams. A total of 145 American Eels were radio-tagged and released near their capture location. All five hydroelectric dams were outfitted with telemetry monitoring equipment to determine the time of arrival to the dam, the time of passage at the dam, the method of passage at a dam, and immediate mortality of tagged fish. Telemetry equipment at the dams was deployed during the fall of 2007 and monitored continuously through the summer of 2010.

A total of 96 tagged American Eels migrated downstream past at least one dam during the study. Downstream passage events occurred during every month of the year except July, with peak migrations in the fall and spring months. A total of 67% of the downstream migration events occurred during the nighttime turbine shutdown period (September 15 to December 15) and 26% of downstream migration events occurred from February to May. Most (87%) downstream migration events occurred between 17:00-05:00. Downstream migration for an individual American Eel usually occurred during one study year (August 1 to July 31) and multi-year downstream migratory activity for an individual was rarely observed.

Migration out of the Shenandoah River occurred relatively quickly. Median migration time was 18 days for American Eels to pass all five dams at a distance of 195km. The majority (81%) of migratory delay experienced at each dam was less than 24 hours in the Shenandoah River. Travel speed was similar between the Shenandoah River (with five hydroelectric dams) and the Potomac River (with only one low head non-hydroelectric dam), suggesting that hydroelectric dams on the Shenandoah River did not cause a substantial migratory delay.

A total of 28 American Eels experienced immediate turbine mortality during the study. Turbine mortality occurred at all dams, with individual dam mortality rates ranging from 14-36% during hydroelectric generation. Turbine mortality rates were reduced to 0-6% during the turbine shutdown periods. Overall mortality rates at each dam, including the turbine shutdown periods, ranged from 3-14%, with a

cumulative mortality for eels passing all five dams of 37%. The seasonal nighttime turbine shutdown period was effective in reducing mortality to downstream migrating eels.

Environmental variables were associated with downstream migration events of American Eel. River discharge, proportional increases in river discharge, and water temperature were significant factors in describing when downstream migration events occurred during the study. A logistic regression model was able to accurately describe when downstream migration events occurred 85% of the time. Lunar phase, time of year, and dam location were not significant variables in describing downstream migration events.

Stuart Welsh holding a large silver American Eel from the upper Shenandoah River. The eel was surgically implanted with a radio tag prior to its release.

Shenandoah River dams likely have little impact on migration delay for American Eel, however, cumulative mortality for eels migrating while turbines are operating is significant. Turbine shutdowns are an effective method to reduce or eliminate mortality during downstream migration events. The current time period for implementation of nighttime turbine shutdowns (September 15-December 15) encompassed two-thirds of downstream migration events, however American Eel passage only occurred on a small portion of days during the shutdown period on any given year. On the Shenandoah River, the nighttime turbine shutdown period could be more protective for downstream migrating American Eel if it were implemented based on environmental variable triggers.

UPSTREAM MIGRATION AND USE OF FISHWAYS BY AMERICAN EELS IN THE SHENANDOAH RIVER

Principal Investigator: Stuart A. Welsh
Years Ongoing: 2009 – 2014
Expected Completion: 2014
Funding Source: WVDNR, PE Hydro Generation, LLC

Objectives:
Examine upstream migration of American eels through monitoring of eel-specific fishways on hydroelectric dams of the lower Shenandoah River.

Progress:
The American eel is a migratory species with extensive upstream migrations in rivers during the yellow phase of its life cycle. Given recent concerns of population declines, studies have focused on obstructions to migration, specifically in relation to dams and associated influences on upstream migration. Improving technologies for upstream eel passage has been listed as a high research priority. Managers of fisheries

and those of hydroelectric facilities have installed eel-specific fishways (commonly called eel ladders) on some rivers to assist eels in passing dams during upstream migration. However, little is known about eel movements and behaviors near dams and eel ladders, and few dams have been evaluated for ladder effectiveness.

There are five hydroelectric facilities on the Shenandoah River. All reservoirs are run-of-the-river. The dams and associated hydropower facilities are operated by PE Hydro Generation, LLC. An eel ladder was installed in 2003 on Millville Dam within the lower Shenandoah River (Figures 1, 2). This ladder has passed over 22,000 eels during the period of 2003 to present. Eel ladders have also been installed upstream at Warren and Luray dams, but these ladders have passed relatively few eels.

The Millville Dam eel ladder is currently monitored with a semi-automated eel ladder camera. This method allows for daily counts, estimation of lengths, and documentation of the time of passage of each eel. Based on data collected at the Millville ladder, upstream migrant eels range from 3 to 11 years in age and average 30 cm in length (primarily ranging from 19 cm to 50 cm, Figure 3). Eels often use the ladder during time periods near the new moon or periods of increasing river discharges. Eels are crepuscular and nocturnal and primarily use the ladder at night. The largest numbers of eels have passed the Millville ladder during high river discharges of spring and fall, and relatively few eels move upstream during low flow periods of summer.

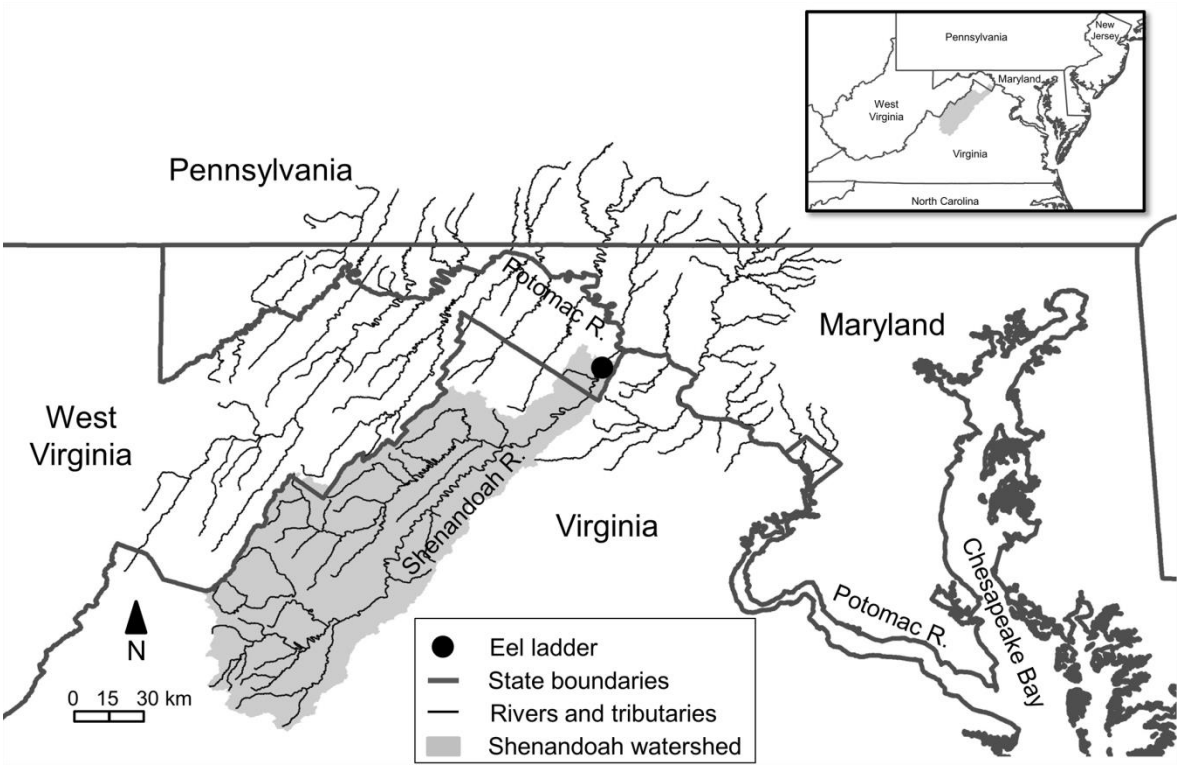


Figure 1. Map of the Potomac River drainage and the location of the Millville Dam eel ladder on the Shenandoah River.

Figure 2. Millville Dam eel ladder on the lower Shenandoah River.

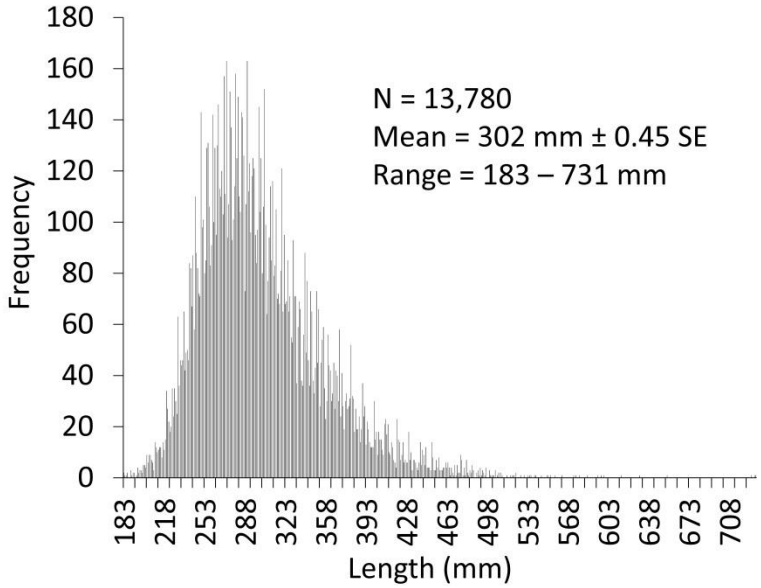


Figure 3. Length-frequency histogram of 13,780 American Eels from the Millville Dam eel ladder on the Shenandoah River. The mean length of American Eels using the ladder is 302 mm with a range of 183–731 mm, although individuals >500 mm rarely use the ladder.

AQUATIC
FISH HEALTH PROJECTS

AN EXAMINATION OF CYANOTOXINS IN THE UPPER AND MIDDLE POTOMAC RIVER DRAINAGE, USA

Student Investigator: Ryan Braham, M. S.
Principal Investigators: Dr. Patricia Mazik
Collaborators: Dr. Vicki Blazer - USGS Leetown Science Center, Jim Hedrick - WVDNR
Years Ongoing: 2013 - 2016
Degree Program: PhD
Expected Completion: December 2016
Funding Source: West Virginia Division of Natural Resources

Objectives:

The primary objective of this study is to take an investigative approach to quantifying the extent of cyanotoxins, as well as their possible effects on the aquatic community in the upper and middle Potomac River drainage. The specific research objectives are to:

1. Investigate potential correlations between the cyanotoxins (specifically microcystins) present in the water column with the potential toxin available in both the water column and the periphyton community at selected sites in West Virginia, Maryland, and Virginia

2. Investigate potential correlations between the total estrogenicity and phytoestrogens present in the water column with the potential toxin available in both the water column and the periphyton community at selected sites in West Virginia, Maryland, and Virginia

3. Examine the effects of microcystin-LR exposure on juvenile golden redhorse sucker (*Moxostoma erythrurum*) using differential gene expression in the liver, disruption of immune function in the anterior kidney and total microcystin toxin present in the liver as endpoints for disruption

4. Examine gene expression markers in the liver and change in immune function in the anterior kidney as indicators of disruption possibly resulting from exposure to microcystins in wild fish at selected sites in West Virginia, Maryland, and Virginia

5. Investigate possible accumulation of cyanotoxins in the liver of fishes as a function of the amount of cyanotoxins present in the aquatic environment at selected sites in West Virginia and Maryland; and 6. Investigate the presence of histological endpoints associated with exposure to microcystins (such as necrosis) in fish at selected sites West Virginia and Maryland.

Progress:

Objective 1: A total of 175 water and periphyton samples were collected between June 26, 2013 and June 18, 2014 from the 15 selected in West Virginia, Maryland, and Virginia for analysis. Samples were collected and analyzed for total microcystin toxin present in the filtered water column, unfiltered water column and periphyton. Analysis is ongoing. During FY 2015, 3 sites were identified to have filtered water, unfiltered water, and periphyton samples collected bimonthly for total microcystin quantification for an additional calendar year. Collection and analysis is ongoing. In addition, samples

will be collected for total nitrogen, total phosphorous, and total dissolved phosphorous in the water column and total nitrogen and total phosphorous in the sediment at these sites. Collection and analysis is ongoing.

Objective 2: A total of 175filtered water samples were collected to quantify the total estrogenicity from the 15 selected in West Virginia, Maryland, and Virginia. Preliminary analysis suggests the presence of estrogens in the water column at many sites during the fall of 2013 and at a few sites in the spring of 2014. Analysis is ongoing. A total of 18 filtered water samples were collected for phytoestrogen analysis at 2 selected sites in West Virginia. Analysis is ongoing. During FY 2015, 3 sites were identified to have filtered water samples collected bimonthly for total estrogenicity for an additional calendar year. One of these sites will continue to have filtered water collected once monthly for phytoestrogen analysis. Collection and analysis is ongoing.

Objective 3: A target area in the South Branch of the Potomac River in West Virginia has been identified for the collection of individuals. This objective will not move forward until FY 2015.

Objective 4: A total of 160 smallmouth bass were collected among 4 sites between March 29, 2013 and May 7, 2014. A total of 174 golden redhorse suckers were collected among 2 sites between April 4, 2013 and June 3, 2014. Samples of liver and anterior kidney were retained for gene expression and immune function analysis. Analysis is ongoing.

Objective 5: A total of 160 smallmouth bass were collected among 4 sites between March 29, 2013 and May 7, 2014. A total of 174 golden redhorse suckers were collected among 2 sites between April 4, 2013 and June 3, 2014. Samples of liver were retained for quantification of microcystin present. Analysis is ongoing.

Objective 6: A total of 160 smallmouth bass were collected among 4 sites between March 29, 2013 and May 7, 2014. A total of 174 golden redhorse suckers were collected among 2 sites between April 4, 2013 and June 3, 2014. Samples of liver were retained for histological analysis. Analysis is ongoing.

Ryan Braham conducting a fish necropsy to examine presence of cyanotoxins in fish on the South Branch River, WV

EVALUATION OF MOLECULAR BIOMARKERS FOR USE IN THE ASSESSMENT OF FISH HEALTH IN GREAT LAKES AREAS OF CONCERN

Student Investigator: Cassidy Hahn, M.S.
Principal Investigators: Dr. Patricia Mazik
Collaborators: Dr. Vicki Blazer, Dr. Luke Iwanowicz - USGS Leetown Science Center
Years Ongoing: 2011 - 2015
Degree Program: PhD
Expected Completion: December 2015
Funding Source: U. S. Fish and Wildlife Service (RWO 55, 61)

Objectives:

The primary objectives of this study are the creation and evaluation of molecular endpoints to assist in the assessment of wild fish health from Areas of Concern (AOCs) throughout the Great Lakes region. These AOCs are thought to contain both legacy and emerging environmental contaminants for which the biological effects are unknown. To address this issue, a suite of biological endpoints from the molecular to histological level were collected and analyzed. At each site samples were collected from 20 mature fish of two species, brown bullhead (*Ameiurus nebulosus*) or white sucker (*Catostomus commersoni*) and largemouth bass (*Micropterus salmoides*) or smallmouth bass (*Micropterus dolomieu*). Liver samples from these collections were then used to evaluate gene expression changes using the Nanostring Technologies nCounter Assay.

Progress:
Sample Collection and Processing

Sampling for this project is now complete. Samples were collected in the fall of 2010, spring of 2011, and spring of 2012 from a total of 8 AOCs throughout the Great Lakes region. Whole transcriptome databases were created for each species of interest. Initial databases for smallmouth bass and brown bullhead were created at CoFactor Genomics (St. Louis, MO) on an Illumnia Hi-Seq. Assembly and annotation of these databases was also provided. An additional smallmouth bass run was then performed at Duke Institute for Genome Science and Policy (Durham, NC) using 454 sequencing on a GS Junior. A hybrid assembly was then completed at the Leetown Science Center (Kearneysville, WV) to integrate data from both runs into a single database for the smallmouth bass. An initial database for the white sucker was created at Leetown Science Center on a GS Junior. Additional sequencing for the white sucker was later performed at the Institute for Genome Science (Baltimore, MD) on an Illumnia Hi-Seq. Genes from these runs were identified through BLASTn and BLASTx searches on a local database and assembled using CLC workbench.

Upon completion of the whole transcriptome databases, genes of interest for this study were identified for each species (Tables 1, 2 and 3). Sequence data for each gene was then used by Nanostring Technologies to create probe sets. Tissue lysate from liver samples was created and shipped to The University of Pittsburgh Genomics and Proteomics Core Laboratory (Pittsburg, PA) for analysis using the nCounter Gene Expression Assay. This method of evaluating gene expression is similar in sensitivity and specificity to real time PCR but allows for the examination of multiple genes and therefore a reduction in cost per gene. To date, samples for smallmouth bass (n=192), largemouth bass (n=384), and white sucker (n=288) have been processed using this method. Samples for brown bullhead (n=413) were shipped in August of 2014 and should be completed by October of 2014.

Statistical Analysis

Quantitative data has been received for smallmouth bass, largemouth bass and white sucker. These datasets were normalized using the NanostringNorm R statistical software package and variation in gene expression was evaluated using the edgeR statistical software package in R. In addition, graphical analysis was completed using nSolver 2.0 (Nanostring Technologies). Initial comparisons for the smallmouth bass and largemouth bass species are complete. These include comparisons of gene expression endpoints between males and females, seasons and species.

Preliminary Results

In order to accurately assess gene expression changes, fish were grouped by sex, species and season collected for all analysis. Analysis of males versus females found significant down-regulation of estrogen receptor α (ERα), cysteine rich protein (CRP), and vitellogenin (VTG) in fall smallmouth bass. Similarly, in spring smallmouth bass, down-regulation of VTG, ERα and choriogenin (CHG) was seen. Fold changes in these genes were larger in spring samples than those collected in the fall. These patterns also held true for largemouth bass where VTG, ERα and CHG were down-regulated in males versus females in both the fall and the spring. Comparisons were also made in expression between seasons. In female smallmouth bass, heat shock protein 70 (HSP70) and warm temperature acclimation protein 65 (WAP65) were significantly up-regulated while glucokinase was significantly down-regulated in the spring in relation to the fall. In male smallmouth bass, down-regulation was seen in VTG with up-regulation in HSP70 and WAP65 in the spring relative to the fall. Different expression patterns were seen seasonally in the largemouth bass. In female largemouth bass, HSP70 and WAP65 were down-regulated while VTG was up-regulated. In male largemouth bass, VTG, HSP70, and AR were all up-regulated in the spring relative to the fall. A visual example of gene expression changes between male and female smallmouth bass in the spring versus the fall is shown in Figure 1.

Species differences were also assessed at one sampling site where both bass species were collected simultaneously. Genes with differential expression fell into a variety of categories including reproductive genes, cellular control genes, thermal response genes, and contaminant response genes (Figure 2). These results emphasize the differences in sensitivity of two closely related species and the importance of indicator species when assessing biological effects.

Future work

Additional statistical analysis will be performed. Similar sex and season comparisons will be made for the white sucker and brown bullhead. Species comparisons between these species and between bass and these species will also be completed. Histological and water quality data will also be incorporated in an effort to assess the biological effects of these gene expression changes.

Table 1. Genes of interest and their function for smallmouth bass and largemouth bass.

Micropterus Species	
Gene	**Function**
03β-Hydroxysteroid Dehydrogenase	Catalyzes synthesis of progesterone
17β-Hydroxysteroid Dehydrogenase	Catalyzes synthesis of progesterone
Actin β	Housekeeping Gene
Androgen Receptor	Binds androgenic hormones, testosterone
Apolipoprotein A1	Lipid metabolism
Arginase	Regulates last step in urea cycle to removed excess nitrogen
Aryl Hyrdrocarbon Receptor	Regulates response to aromatic hydrocarbons (PAHs)
Catalase	Antioxidant
Catenin β	Regulates cell to cell adhesion (associated with many cancers)
Choriogenin	Precursor to egg yolk development
CYP17	Steroid synthesis
CYP19A1A (Aromatase)	Synthesis of estrogens
CYP1A	Drug and steroid metabolism
CYP3A	Drug and steroid metabolism
Cystenin-Rich Protein	Zinc absorption
Elongation Factor 1α	Housekeeping Gene
Epidermal Growth Factor Receptor	Adhesion and proliferation of epidermal cells
Epoxide Hydrolase 1	Detoxification during drug metabolism
Estrogen Receptors (ER) α, β1, β2	Bind estrogen
Eukaryotic Translation Initation Factor 3D	Housekeeping Gene
Ferritin	Stores and releases iron
Fibroblast Growth Factor	Wound healing, endothelial cell proliferation, endocrine effects
Follicle Stimulating Hormone Receptor	Stimulates granulose cells to produce estrogen
Glucocorticoid Receptor	Binds cortisol and other glucocoritcoids
Glucokinase	Glycolysis
Glutathione Peroxidase 1	Antioxidant
Glutathione S-Transferase	Detoxify xenobiotics
Heat Shock Proteins 70, 71, 90 α	Stress response
Hepcidins 1 and 2	Iron regulation
Hypoxanthine Phosphoribosyltransferase 1	Housekeeping Gene
Insulin-like Growth Factor 1	Mediates effects of growth hormone
Metallothionein	Metal binding including zinc, mercury, copper, arsenic, silver
Phosphoenolpyruvate Carboxykinase	Essential in glucose homeostasis
RBMX2	Housekeeping Gene
Ribosomal Protein L8	Housekeeping Gene
Superoxide Dismutase	Antioxidant
Tata Box Binding Protein	Housekeeping Gene
Thyroid Hormone Receptors α, β	Mediates functions of thyroid hormones
Transforming Growth Factor β	Controls cellular proliferation and differentiation
Transforming Growth Factor β Receptor 1	Controls cellular proliferation and differentiation
Type 1 and II Deiodinases	Activation/Deactivation of thyroid hormone
Vitellogenin	Precursor to egg yolk development
Warm Temperature Acclimation Protein	Stress response

Table 2. Genes of interest and their function for white sucker.

Catostomus commersonii	
Gene	**Function**
11β Hydroxysteroid Dehydrogenase	Catalyzes synthesis of progesterone
17β Hydroxysteroid Dehydrogenase	Catalyzes synthesis of progesterone
Androgen Receptor	Binds androgenic hormones, testosterone
Apolipoprotein A1	Lipid metabolism
Aryl Hydrocarbon Receptor	Regulates response to aromatic hydrocarbons (PAHs)
Catenin β	Regulates cell to cell adhesion (associated with many cancers)
Catalase	Antioxidant
CYP11C1	Steroid synthesis
CYP1B2	Drug and steroid metabolism, BaP toxification
CYP3A	Drug and steroid metabolism
Elongation Factor 1α	Housekeeping Gene
Epidermal Growth Factor	Adhesion and proliferation of epidermal cells
Epoxide Hydrolase	Detoxification during drug metabolism
Estrogen Receptor 1	Bind estrogen
Estrogen Receptor 2	Bind estrogen
Eukaryotic Translation Initiation Factor	Housekeeping Gene
Ferritin	Stores and releases iron
Fibroblast Growth Factor	Wound healing, endothelial cell proliferation, endocrine effects
Follicle Stimulating Hormone Receptor	Stimulates granulose cells to produce estrogen
Glucocorticoid Receptor	Binds cortisol and other glucocoritcoids
Glutathione Peroxidase 1	Antioxidant
Glutathione-S-Transferase	Detoxify xenobiotics
Granulin	Bile duct tumors
Heat Shock Proteins 70, 90	Stress response
Hepatitis B PreC Antigen	Hepatitis viral infection
Hepcidin	Iron regulation
Hypoxanthine phosphoribosyltransferase	Housekeeping Gene
Hypoxia-inducible factor	Promotes formation of blood vessels (cancer tumors)
Insulin-Like Growth Factor	Mediates effects of growth hormone
Keratin 8	Carcinomas
Metallothionein	Metal binding including zinc, mercury, copper, arsenic, silver
Peroxisome proliferator-activated receptor	Regulation of cellular differentiation, development, metabolism and tumorgensis
Phosphoenolpyruvate Carboxykinase	Essential in glucose homeostasis
Proliferating cell nuclear antigen	Repair of DNA damage
RBMX	Housekeeping Gene
Retinoblastoma	Tumor suppressor protein
Ribosomal Protein L8	Housekeeping Gene
Steroidogenic acute regulatory protein	Production of steroid hormones
Superoxide Dismutase	Antioxidant
TGFb 1A	Controls cellular proliferation and differentiation
TGFB Receptor 2	Controls cellular proliferation and differentiation
Thyroid Hormone Receptor α, β	Mediates functions of thyroid hormones
Trypsin	Protein breakdown
Tumor Necrosis Factor	Systemic inflammation, regulation of immune cells
Tumor Protein p53	Controls production of tumor suppression protein
Type II Deiodinase	Activation/Deactivation of thyroid hormone
Vitellogenin	Precursor to egg yolk development
V-Ki-Ras2	Mutated in many cancers

Table 3. Genes of interest and their function for brown bullhead.

Ameiurus nebulosus	
Gene	**Function**
Elongation Factor 1α	Housekeeping Gene
03β Hydroxysteroid Dehydrogenase	Catalyzes synthesis of progesterone
17β Hydroxysteroid Dehydrogenase	Catalyzes synthesis of progesterone
Androgen Receptor	Binds androgenic hormones, testosterone
Apolipoprotein	Lipid metabolism
Arginase	Regulates last step in urea cycle to removed excess nitrogen
Aryl Hydrocarbon Receptor	Regulates response to aromatic hydrocarbons (PAHs)
Catalase	Antioxidant
Catenin β	Regulates cell to cell adhesion (associated with many cancers)
Cytochrome C Oxidase	Associated with liver inflammation/carcinogenesis
CYP17	Steroid synthesis
CYP19A1A (Aromatase)	Synthesis of estrogens
CYP1A	Drug and steroid metabolism
CYP3A	Drug and steroid metabolism
Epidermal Growth Factor Receptor	Adhesion and proliferation of epidermal cells
Epoxide Hydrolase	Detoxification during drug metabolism
Estrogen Receptor α, β	Bind estrogen
Eukaryotic Translation Initiation Factor	Housekeeping Gene
Ferritin	Stores and releases iron
Fibroblast Growth Factor	Wound healing, endothelial cell proliferation, endocrine effects
Follicle Stimulating Hormone Receptor	Stimulates granulose cells to produce estrogen
Gluathione S-Transferase	Detoxify xenobiotics
Glucocorticoid Receptor	Binds cortisol and other glucocoritcoids
Glucokinase	Glycolysis
Glutathione Peroxidase	Antioxidant
Granulin 1	Bile duct tumors
Granulin Precursor b	Bile duct tumors
Heat Shock Protein 70, 90	Stress response
Hepcidin	Iron regulation
Hypoxanthine phosphoribosyltransferase	Housekeeping Gene
Hypoxia-inducible factor	Promotes formation of blood vessels (cancer tumors)
Insulin-like growth factor	Mediates effects of growth hormone
Interferon	Released in response to pathogens
Interleukin	Immune and inflammatory response
MYXO Parasite	Myxobolus liver parasite detection
Peroxisome proliferator-activated receptor	Regulation of cellular differentiation, development, metabolism and tumorgensis
Proliferation cell nuclear antigen	Repair of DNA damage
RBMX2	Housekeeping Gene
Ribosomal Protein L8	Housekeeping Gene
Superoxide Dismutase	Antioxidant
Thyroid Hormone Receptor α, β	Mediates functions of thyroid hormones
Transforming Growth Factor β1	Controls cellular proliferation and differentiation
Tumor protein p53, p73	Controls production of tumor suppression protein
Vitellogenin	Precursor to egg yolk development
V-K-ras	Mutated in many cancers
Warm Temperature Acclimation Protein	Stress response

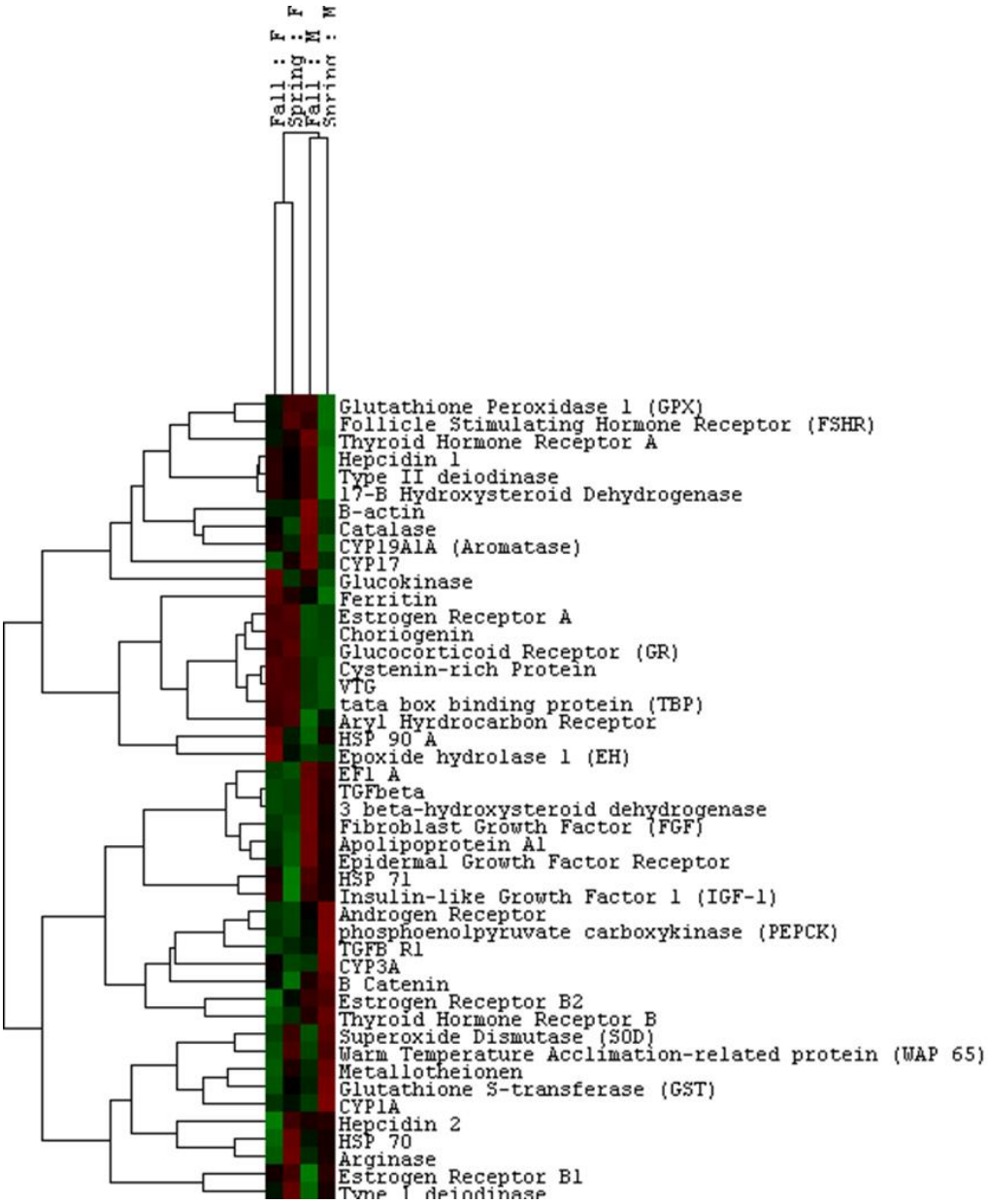


Figure 1. Heatmap comparing gene expression in female smallmouth bass from the spring and the fall versus male smallmouth bass in the spring and the fall. Red boxes represent down-regulation, black boxes represent no change, green boxes represent up-regulation.

Smallmouth Bass vs Largemouth Bass (Raisin River - Spring 2012)

Gene	General Function	Log Fold Change	P-Value
EGFR	Epidermal Cell Proliferation	-8.5869	5.56E-33
THRA	Thyroid Hormone Regulation	-5.3913	2.89E-14
T2DI	Thyroid Hormone Regulation	-4.344	1.06E-12
HSP70	Thermal Stress Response	-4.3412	1.80E-12
3BHD	Progesterone Synthesis	-4.3003	2.12E-10
FSHR	Estrogen Production	5.1206	5.64E-08
AR	Androgen Regulation	-2.7296	2.84E-06
TGFBR1	Cellular Proliferation	-2.5451	1.17E-05
HPC1	Iron Regulation/Parasites	-2.456	3.49E-05
TBP	Housekeeping Gene?	-2.3281	5.70E-05
CYP1A	Drug/Steroid Metabolism	-2.0641	3.40E-04
CGR	Egg Yolk Development	2.3199	5.81E-04
BCAT	Cellular Adhesion	-1.881	1.09E-03
WAP65	Thermal Stress Response	-1.7961	1.77E-03
TGFB	Cellular Proliferation	-1.7247	2.74E-03
ERA	Estrogen Regulation	1.9544	3.14E-03
AHR	PAH Regulation	-1.6998	3.16E-03
PEPCK	Glucose homeostasis	-1.6243	4.64E-03

Figure 2. Differential gene expression in smallmouth bass in relation to largemouth bass from the same sampling site. The gene abbreviation and function are shown as well as the log of the fold change and p-value for each comparison.

Largemouth bass (*Micropterus salmoides*)

THE USE OF IN SITU HYBRIDIZATION FOR THE DETECTION OF BILE DUCT MYXOZOANS, THE HEPATITIS-B VIRUS, AND HEPCIDIN IN BROWN BULLHEAD (*Ameiurus nebulosus*) OR WHITE SUCKERS (*Catostomus commersoni*) FROM THE GREAT LAKES AOCS AND FOR THE DETECTION OF *Myxobolus inornatus* IN YOUNG-OF-THE-YEAR SMALLMOUTH BASS (*Micropterus dolomieu*) FROM THE SUSQUEHANNA RIVER BASIN IN GREAT LAKES AREAS OF CONCERN

Student Investigator: Heather L. Walsh, M.S.
Principal Investigators: Dr. Patricia Mazik
Collaborators: Dr. Vicki Blazer, Dr. Luke Iwanowicz - USGS Leetown Science Center
Years Ongoing: 2014 - 2017
Degree Program: PhD
Expected Completion: December 2017
Funding Source: U.S. Fish and Wildlife Service (RWO 55, 61), U.S. Geological Survey (RWO 60)

Objectives:

The primary objective of this study is to use in situ hybridization (ISH) techniques for the detection of parasites, viruses, and hepcidin in white sucker, brown bullhead, smallmouth bass, or largemouth bass. The use of ISH for these biomarkers will assist in an overall evaluation of fish health from selected sites in the Great Lakes Areas of Concern (AOC) in a study on the beneficial use impairment for fish tumors and other deformities. In situ hybridization will be beneficial for determining whether a myxozoan parasite observed in the bile ducts of brown bullhead is the same as the one observed in the bile ducts of white sucker, smallmouth, and largemouth bass and whether it's associated with bile duct proliferation. It will also be used to determine whether bile duct proliferation and tumors in white suckers and brown bullhead are associated the hepatitis B virus and whether lip and skin tumors have a viral etiology. Finally, hepcidin levels will be measured using quantitative polymerase chain reaction (qPCR) and ISH will be used to visualize locations in the liver of brown bullhead where hepcidin is expressed. In a separate study, young-of-the-year smallmouth bass from the Susquehanna River Basin were found to exhibit infections of a myxozoan parasite, *Myxobolus inornatus*, in the connective tissue of the muscle below the epidermis. In some of the histology samples, observations of areas of inflammation are only observed and ISH will be used to determine if these areas are actually early stage infections of *M. inornatus*. It will also be used to try and determine the portal of entry into the fish for *M. inornatus*.

Progress:

Fish were collected in the fall or spring between 2010-2012 for the Great Lakes AOC study and in the summer of 2013 for the young-of-the-year smallmouth bass study. Primers previously made for *M. inornatus* for PCR were labeled with digoxigenin and are being used with a heat denaturation ISH and a non-heat denaturation ISH method. The protocol for ISH is being optimized on young-of-the-year smallmouth bass samples from the Susquehanna River Basin. Fish preserved in Z-fix and PAXgene are being used to determine which preservative is optimal for hybridization.

AQUATIC
OTHER PROJECTS

CONSERVATION ASSESSMENT OF WEST VIRGINIA CRAYFISHES

Principle Investigators: Zac Loughman and Stuart Welsh
Years Ongoing: 2007-2014
Expected completion: 2016
Funding Source: WVDNR

Objectives:

1. Identify species in need of conservation
2. Document distribution ranges of invasive species
3. Document range expansion and conservation standing of "common" species
4. Conduct surveys for new state records and undescribed forms
5. Generate an interactive WV crayfish key and web site for public involvement and awareness

Progress:

Crayfishes have received moderate attention within the state of West Virginia. The first major work on decapods was performed by Faxon (1885), who listed only two taxa in WV. Since this initial research, several more species have been added to the crayfishes of West Virginia, with 22 known taxa residing within the state's borders as of 2006. Several of these species additions were the result of crayfish surveys throughout various ecological regions within the state. Survey efforts within the state reached their peak during the 1980's, with the last formal statewide survey of West Virginia's crayfish fauna performed by Jezerinac during the summers of 1987 and 1988.

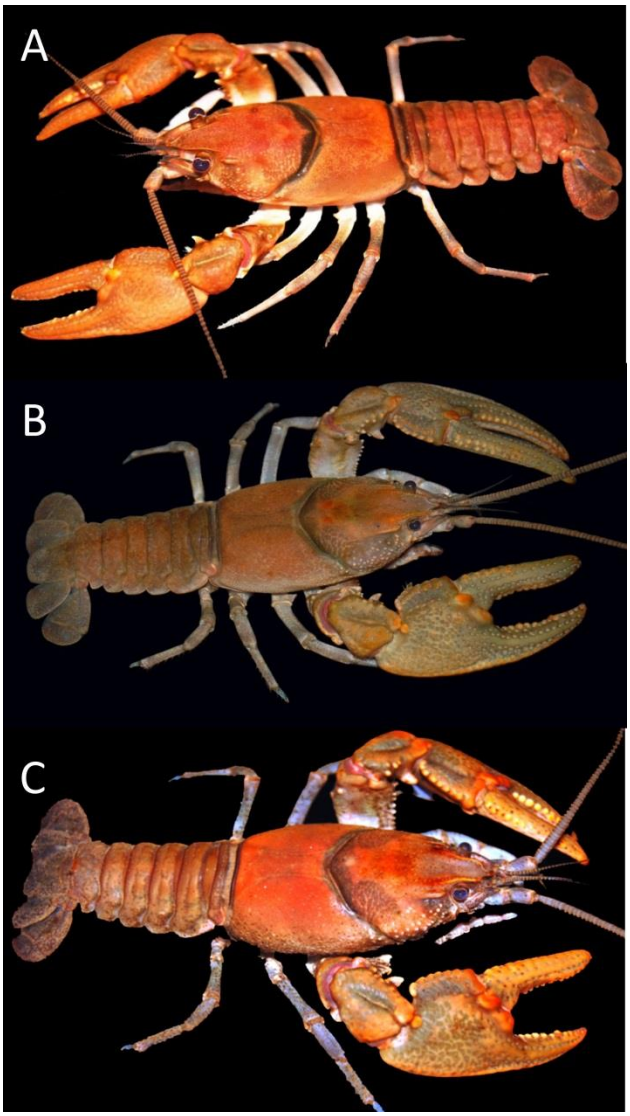
Efforts within the state to identify conservation threats, potential state records, and conservation concerns since the publication of Jezerinac et al. have been disjunct in nature. Key species (*Cambarus* (*H.*) *elkensis*, *Cambarus* (*P.*) *veteranus*), have received attention since Jezerinac's effort, while the majority of taxa have remained understudied. Conservation concerns have arisen since the publication of Jezerinac et al. that were not of major consequence in the 1980s to crayfish populations. Land use issues, stream alteration, invasive species, and habitat loss have occurred throughout the state in areas with diverse crayfish populations, and the ultimate impact of these activities on crayfishes remains poorly understood.

This research will provide a manual or guide to the crayfishes of West Virginia. Given recent developments in electronic media, an interactive key to the crayfishes of West Virginia with multiple pictures of a species, list of key characters, and current range maps is a possibility that did not exist during the initial statewide crayfish survey. This product would be one output of a current statewide crayfish census, and would make it possible for field biologists across West Virginia to ID specimens in the field via an electronic and interactive identification key.

Using a probabilistic-random sampling of stream sites, we have sampled crayfishes from approximately 10 sites from each 10 digit sub-basin within the Cheat, Elk, Potomac, Youghiogheny, Greenbrier, Guyandotte, James, and Tug Fork river drainages, as well as drainages from the northern panhandle of WV. Analyses of these data are underway, and the remainder of the state will be sampled in future efforts. Separate efforts will also target burrowing crayfishes.

In addition to the overall distributional information on the WV crayfish fauna, some interesting findings of this work include rediscovery of *Cambarus veteranus*, and the discovery and description of three new species of *Cambarus: Cambarus smilax, Cambarus theepiensis*, and *Cambarus hatfieldi*.

Cambarus veteranus (Big Sandy Crayfish) has been a focal species of this work due to its rarity when the state received its initial statewide census in the mid 1980's. Jezerinac et al. determined that *C. veteranus* likely would be extirpated due to land use practices and stream degradation in the West Virginia coal fields. Several investigators have focused on determining the conservation status of *C. veteranus* in the last decade in West Virginia; during these efforts zero *C. veteranus* were observed. In the summer of 2009, all historic locations (n = 17) and additional locations determined through a probabilistic site selection design, were surveyed in the Guyandotte, Bluestone, and Tug Fork river basins to determine if the West Virginia population had been extirpated. Resultant of this effort, *C. veteranus* was discovered at 1 historic station for the species, in Pinnacle Creek, Wyoming County. In addition to the rediscovery of the Pinnacle Creek population, another population was discovered in Dry Fork, a tributary to the Tug Fork River. This population represents a new basin record for the species in West Virginia and appears to be more stable than the Pinnacle Creek population.



The first species description, resultant of specimens collected during this study, was published in the *Proceedings of the Biological Society of Washington*. The new species, *Cambarus smilax* (Greenbrier Crayfish; Figure 1A), is endemic to streams occurring in the Greenbrier River system, and reaches its highest population densities in the headwaters of the Greenbrier River, specifically the East and West Forks of the Greenbrier, Thorny Creek, and Deer Creek. Populations of this animal are stable but are limited to the Greenbrier River system.

Secondly, *Cambarus theepiensis* (Coalfields Crayfish) was described as a new species in the journal *Zootaxa* in 2013 (Figure 1B). This species is a stream-dwelling crayfish that appears to be endemic to the junction of the Cumberland Mountains with the Appalachian Plateau in West Virginia and Kentucky. Within this region, it is prevalent in the Guyandotte and Twelvepole basins of West Virginia, the Little Sandy River and Levisa Fork basins of Kentucky, and tributaries of the Big Sandy River shared by both states. The specific name is the latinized form of the Shawnee word for river, theepi. The Shawnee were among the first settlers of the Big Sandy, Lower Ohio and Guyandotte watersheds.

Figure 1. Three crayfish species described during this study: A. *Cambarus smilax*, B. *Cambarus theepiensis*, and C. *Cambarus hatfieldi*

Finally, *Cambarus hatfieldi* (Tug Valley Crayfish) was described as a new species in the journal *Zootaxa* in 2013 (Figure 1C). This stream-dwelling crayfish appears to be endemic to the Tug Fork River system of West Virginia, Virginia, and Kentucky. Within this region, it is prevalent in all major tributaries in the basin as well as the Tug Fork River's mainstem. The specific name is the latinized form of Hatfield in honor of the Hatfield and McCoy feud which occurred in the Tug Fork River Valley of Kentucky and West Virginia in the late 1800s.

SOURCE POPULATION ASSIGNMENT OF LAKE SUPERIOR LAKE STURGEON

Stuadent Investigator: Christi Raines
Principle Investigator: Dr. Amy B. Welsh, WVU
Years of Project: 2013 - 2016
Degree Program: M.S.
Expected Completion: May 2016
Funding Source: U.S. Fish and Wildlife Service (RWO 63)

Objective:

The objective of this project is to determine the source spawning population of juvenile lake sturgeon (*Acipenser fulvescens*) captured throughout Lake Superior.

Progress as of August 2014:

Knowledge of lake sturgeon movements and habitat use during non-spawning times is limited. Available information suggests that lake sturgeon are capable of long-distance migrations and tend to densely aggregate in relatively small areas. Movement patterns can vary depending on life-stage. Traditional mark-recapture methods or radio telemetry studies of tagged fish provide limited data about lake sturgeon movement because relatively few individuals from any breeding population are tagged or marked. Genetic techniques can overcome these obstacles and can identify which spawning populations are represented in non-spawning groups of lake sturgeon.

Genetic analysis will be conducted on samples from 690 sampled juveniles. Estimates of proportional contributions of sturgeon from all potentially represented spawning populations to samples collected in all assessments during non-spawning periods will be made based on established statistical methods. For collections with a large sample size ($\geq$40), the relative contribution of each potential spawning lake sturgeon population will be estimated by comparing the distribution of expected genotype frequencies of each spawning population with genotype frequencies observed from lake sturgeon of unknown origin captured during non-breeding time periods. Mixed stock analysis (MSA) uses the relative differences in allele frequencies between baseline spawning populations to estimate the composition of a mixed sample. In locations where fewer than 40 individuals were sampled or the identity of an individual is valuable, individual assignment tests (IA) will be used to assign unknown individuals to their most likely spawning population of origin. The assignment test uses Bayesian or frequency-based methods to calculate the likelihood of a non-spawning individual originating from each of the spawning populations represented in the genetic baseline. The likelihood calculations are based on comparing the individual's genotype to the genotype and/or allele frequencies of the spawning populations. An individual is then classified as belonging to the population with the highest relative likelihood of origin. The power of the genetic baseline of spawning populations will also be tested in order to better understand the level of confidence associated with the assignment of the unknown individuals.

An M.S. student was selected for the project and began August 2013. DNA was extracted from all samples and genotypes based on 12 microsatellite loci have been determined. All initial genotyping has been completed and the student is now conducting laboratory work on samples that do not have complete genotypes. All laboratory work is expected to be complete by December 2014. The student is currently working on the MSA for completed samples from Goulais Bay and will be giving an on-campus presentation of the preliminary results at the end of August 2014.

DISTRIBUTION AND HABITAT USE OF THE DIAMOND DARTER

Student Investigator: Austin Rizzo
Principal Investigator: Stuart Welsh
Years Ongoing: 2014
Degree Program: PhD
Expected completion: March 2017
Funding Sources: NiSource, WVDNR

Objectives:
Research objectives include documenting Diamond Darter presence and abundance in glide vs. pool habitats relative to gas pipeline crossings, and documenting upstream and downstream distribution limits of the species within the Elk River, West Virginia

Progress:
The diamond darter *Crystallaria cincotta* is a federally-endangered fish of the Ohio River drainage. The species occurred previously over a wider range within the Ohio River drainage, but populations are thought to be extirpated from Kentucky, Ohio, and Tennessee. We previously documented presence of this species in the lower 37 km of Elk River, Kanawha County, WV. Information on the diamond darter is relatively limited compared to that for most fish species, in part, owing to the recent discovery of the species, species rarity, and to a low rate of species detection when using conventional sampling gears. Information is needed on species presence and abundance in macrohabitats, such as shoal vs. pool habitats. This information would increase our knowledge of the species, and would aid planning and decisions regarding anthropogenic riverine uses of the lower Elk River. Also, further research is needed to understand the distribution range of the diamond darter in Elk River, as well as document abundances of the diamond darter.

Data are lacking on distribution and abundance of the diamond darter, primarily because the species has been difficult to collect with conventional sampling gears. Sampling efforts throughout the lower Elk River drainage have largely been unsuccessful at finding diamond darters. However, by using a spotlight sampling approach at night, we observed a total of 82 diamond darters at 10 of 11 sampling sites within the lower 37 km of Elk River. This spotlight sampling method, given its high success rate, provides a promising new approach to further document the distribution and abundances of diamond darters within Elk River. Also, a new sampling method of using underwater cameras will be evaluated for deeper pool habitats.

The research objectives for the proposed study are to document distribution and abundance of diamond darters in Elk River. Based on previous sampling efforts, the spotlight method has a high detection rate for diamond darters. This method will allow for collection of distribution and abundance data within the previously-sampled lower 37 km of the river, as well as upstream and downstream sites in order to document the upper and lower range of the diamond darter within Elk River. Data on distribution

and habitat use obtained during this study will be useful toward conservation and management efforts for this rare species. Specifically, data will aid planning and decision makers regarding uses of specific sections of the lower Elk River relative to gas pipeline crossings.

Figure 1. A diamond darter photographed at night with underwater camera within Elk River, near Elk View, WV during July 2012.

EFFECTS OF CORRIDOR H HIGHWAY CONSTRUCTION ON BENTHIC MACROINVERTEBRATE AND FISH COMMUNITIES

Principal Investigators: Stuart Welsh and Jim Anderson
Co-Investigator: Lara Hedrick
Years Ongoing: 2002-2014
Expected Completion: May 2015
Funding Sources: West Virginia Division of Highways

Objective:

To identify and compare changes in the benthic macroinvertebrate communities within watersheds impacted by construction of Corridor H, a four lane highway.

Progress:

This study was initiated in response to commitments made by the West Virginia Division of Highways established during the environmental impact assessment update for Corridor H. As part of the conditions for constructing the highway, the WVDOH must establish a long-term investigation focused on providing community level information on stream ecosystems. The current list of streams that will be impacted by construction is as follows: Beaver Creek, Patterson Creek, tributaries of Elk Lick, Middle Fork of Patterson, Walnut Bottom Run and Waites Run. The sites located in the Beaver Creek watershed are in "during construction" phase. Sites located in the Patterson Creek and Walnut Bottom watersheds are in "post construction" phase.

New sites located in watersheds that will be impacted in the Parsons to Kerens alignment have been established and monitoring began in Spring 2013 (Figure 1). Sites are located on the following streams: PK-1 Smokey Hollow, Pk-2 Sugar Camp Run, PK-3 South Branch of Haddix Run, PK-4 Goodwin Run, PK-5 and PK-6 Haddix Run, PK-7 Baldlick Run, PK-8 and PK-9 Wilmoth Run, PK-10 and PK-11 Lazy Run, and PK-12 and PK-13 on Pleasant Run.

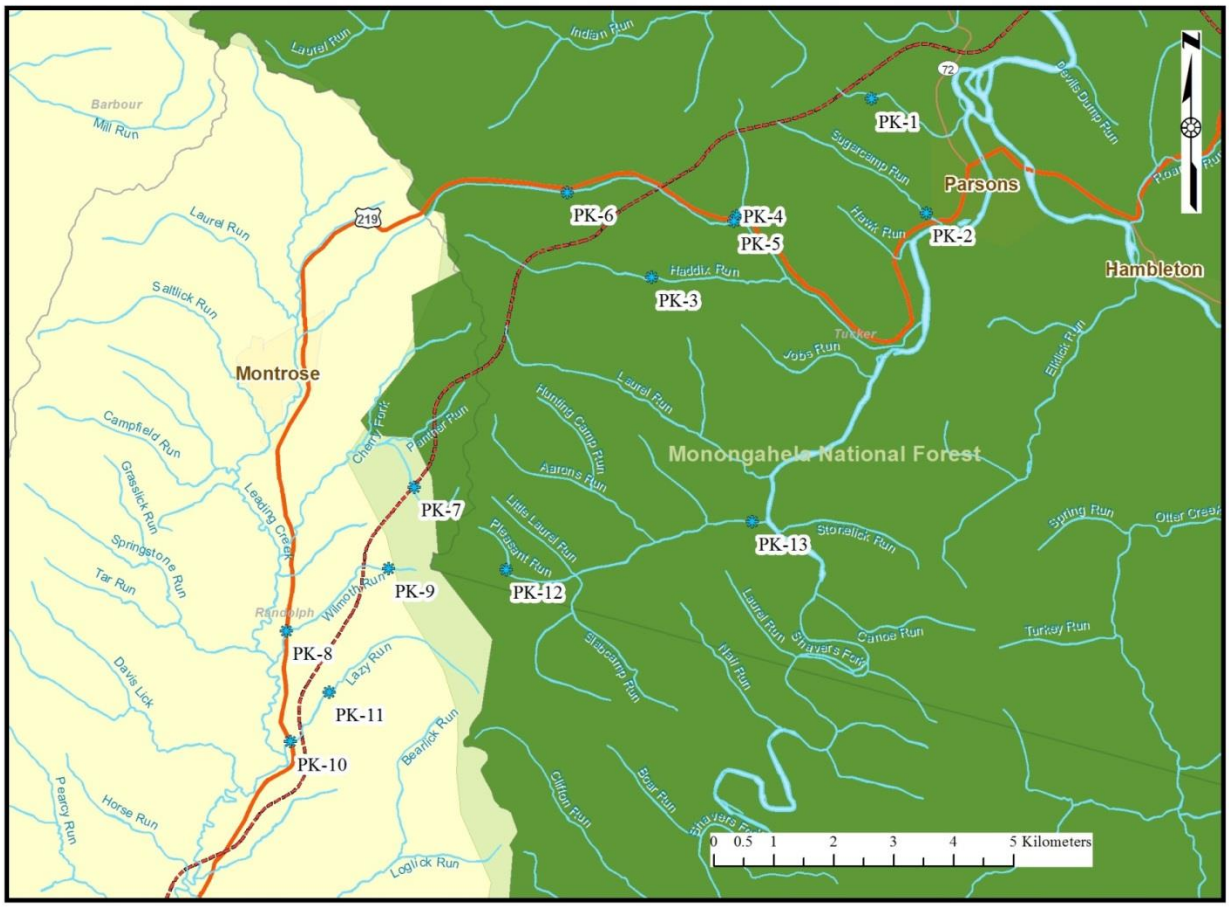


Figure 1. Location of sampling sites along the Parsons to Kerens, WV proposed Corridor H alignment.

In fall 2013 and spring 2014, benthic macroinvertebrate samples were collected in four areas, Patterson Creek, Walnut Bottom, Beaver Creek, and Parsons to Kerens. Benthic macroinvertebrate samples from 2013-2014 are currently being picked and identified in the laboratory. Samples collected in 2012- 2013 from the watersheds were sub-sampled, identified, and analyzed. The data were entered into a database and used to calculate a multi-metric index. Six metrics (EPT taxa, total taxa, % EPT, % chironomidae, % top 2 dominant taxa, and Hilsenhoff Family Biotic Index, [HBI]) were used to calculate the West Virginia Stream Condition Index (WV SCI). The WV SCI scores are as follows: 78.1 to 100 = Very Good; 68.1 to 78 = Good; 45.1 to 68 = Fair; 22.1 to 45 = Poor; and 0 to 22 = Very Poor.

Work to be completed in 2014-2015 includes identification of benthic macroinvertebrate samples collected during 2012-2013. Benthic macroinvertebrate collections will be made in the fall of 2013 and the spring of 2014 at all sites. An annual report will be submitted to the WVDOH.

TAXONOMY OF FRESHWATER EEL-TAILED CATFISH OF AUSTRALIA WITH A DESCRIPTION OF A NEW SPECIES FROM THE WET TROPICS REGION OF EASTERN AUSTRALIA

Principal Investigator: Stuart A. Welsh
Co-investigators: Dean R. Jerry, Damien W. Burrows
Years Ongoing: 2010–2014
Completed: January 2014
Funding Source: U.S. Geological Survey

Objective: This research examined the taxonomy of eel-tailed catfishes of the genus *Tandanus* within Australia, with a focus on biodiversity recognition and the description of new species.

Results:

The family Plotosidae has an Indo-Pacific distribution, and includes 10 genera and close to 40 species. In Australia, plotosid catfishes are represented by eight genera; *Anodontiglanis, Cnidoglanis, Euristhmus, Neosiluroides, Neosilurus, Paraplotus, Plotosus*, and *Tandanus*. The genus *Tandanus* is represented in eastern Australia by *T. tandanus* and in Western Australia by *T. bostocki*. *Tandanus tandanus* was described from the Murray-Darling drainage basin of southeastern Australia, but a much wider range distribution has been recognized in eastern Australia's coastal rivers of New South Wales (NSW) and Queensland.

The taxonomy of *Tandanus* in eastern Australia has long been questioned, but has remained unresolved owing partly to conservative morphology in this genus. Taxonomic resolution of *Tandanus* is also troubled by translocations, because *T. tandanus* has been introduced widely as a sportfish into rivers and reservoirs in eastern Australia. However, based on genetic or morphologic data, researchers have suggested that *T. tandanus* represents two or more species. For example, DRJ separated *T. tandanus* into three monophyletic clades based on genetic analysis of a 399-bp fragment of the mitochondrial DNA control region. The first clade comprised individuals from the Murray–Darling drainage basin, southern NSW coastal, northern NSW, and central-southern Queensland populations. The second clade confirmed high levels of genetic divergence in catfish from the Bellinger, Macleay, Hastings, and Manning rivers of mid-northern NSW, while the third clade represented populations from the wet tropics region of northeastern Queensland. Given these genetically distinct lineages, the second clade from mid-northern NSW and third clade from the wet tropics region were hypothesized to be undescribed species.

Our morphologic study of individuals from the wet tropics region of northeastern Queensland corroborated genetic data and supported the hypothesis that those individuals represented a new species of *Tandanus*. We described the species and named it *Tandanus tropicanus* (Wet Tropics Tandan). The species description was published in the January 2014 issue of the journal Copeia.

Photo of *Tandanus tropicanus*, holotype female

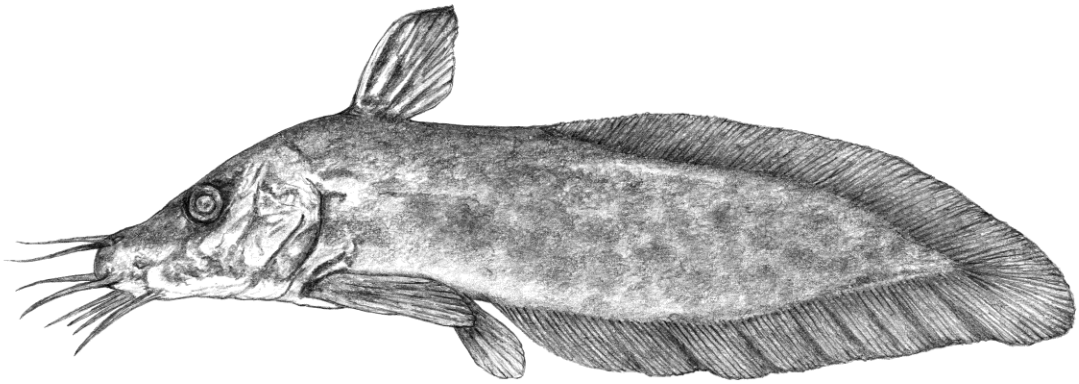


Figure 1. *Tandanus tropicanus*, holotype female, AMS I.45550-001, 356 mm SL, Tully River, Approx. 5 km ESE of Cardstone, Queensland (illustration by SAW).

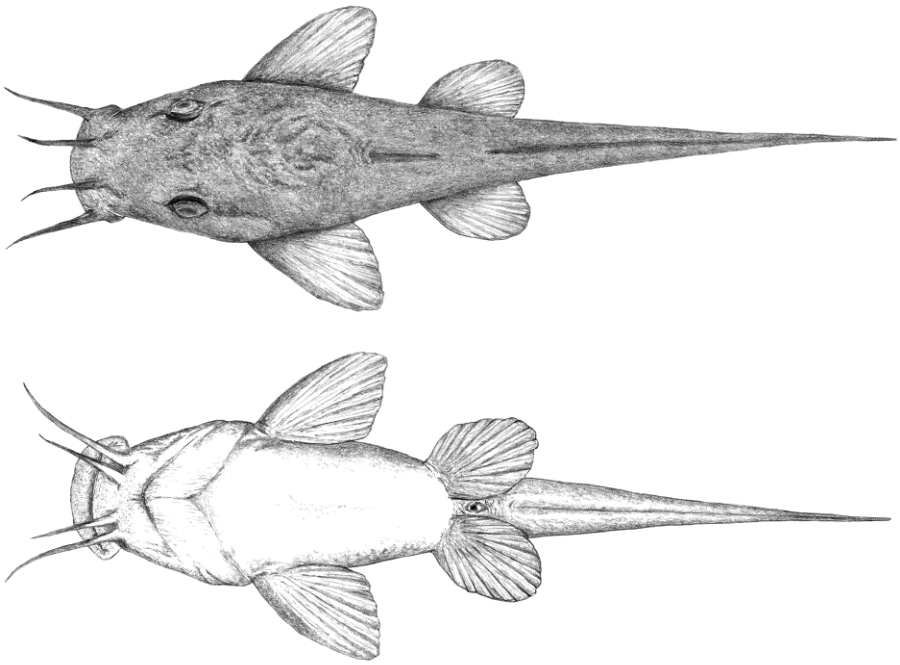


Figure 2. Dorsal and ventral body views of *Tandanus tropicanus*, holotype female, 356 mm SL (illustrations by SAW).

WILDLIFE

ECOLOGY AND MANAGEMENT OF GOLDEN-WINGED WARBLERS ON HIGH-ELEVATION PASTURELANDS ON THE MONONGAHELA NATIONAL FOREST, WEST VIRGINIA

Student Investigator: Kyle Aldinger
Principal Investigator: Petra Wood
Cooperators: Rich Bailey, Cathy Johnson, Jeff Larkin
Years Ongoing: 2008-Present
Degree Program: PhD
Expected Completion: May 2015
Funding Sources: US Natural Resources Conservation Service, US Geological Survey, US Fish and Wildlife Service, US Forest Service, WV Division of Natural Resources, National Fish and Wildlife Foundation

Objectives:
1. Evaluate the response of Golden-winged Warblers to habitat management.
2. Quantify site-fidelity, survival, and movements of banded males, females, and nestlings.
3. Monitor broad-scale Golden-winged Warbler and associated bird species populations on pastures with regards to vegetative characteristics and grazing intensity.

Progress:
Golden-winged Warbler (*Vermivora chrysoptera*, GWWA) populations declined by 8.8%/year in West Virginia during 1966-2011 according to Breeding Bird Survey data. As a result, the U.S. Fish and Wildlife Service is reviewing their status for Endangered Species Act listing. Limiting factors for this species include habitat availability on breeding and wintering grounds, migratory obstacles, Brown-headed Cowbird (*Molothrus ater*) brood parasitism, climate change, and interactions with the closely-related Blue-winged Warbler (*V. cyanoptera*, BWWA). Complicating conservation efforts, GWWA and BWWA produce fertile hybrids, the Brewster's (BRWA) and the rarer Lawrence's Warbler (LAWA). Our research has focused on active and abandoned pasturelands in and around the Monongahela National Forest in central West Virginia. The West Virginia study is part of two larger range-wide investigations of GWWA breeding ecology. GWWA breeding territories contain a mixture of grasses, herbaceous vegetation, raspberry/blackberry (*Rubus* spp.), shrubs, saplings, and a few trees in a forested landscape.

We discovered 196 *Vermivora* spp. nests (n=170 GWWA, n=26 other *Vermivora* spp.) during 2008-2013, of which, 142 GWWA and 22 other *Vermivora* spp. nests (Fig. 1) reached at least egg-laying. Daily survival rate (DSR) of nests did not differ by species (Fig. 2) or year (Fig. 3), but decreased sharply about 30 days into the nesting season (Fig. 4), which started 12 May (± 1.4 days [SE]) each year on average. Complete clutch size and number of young fledged per successful *Vermivora* spp. nests were 4.6 ± 0.1 eggs and 3.9 ± 0.2 fledglings, respectively. Three nests were parasitized by Brown-headed Cowbirds.

Figure 1. Golden-winged Warbler nest with nestlings (Kyle Aldinger).

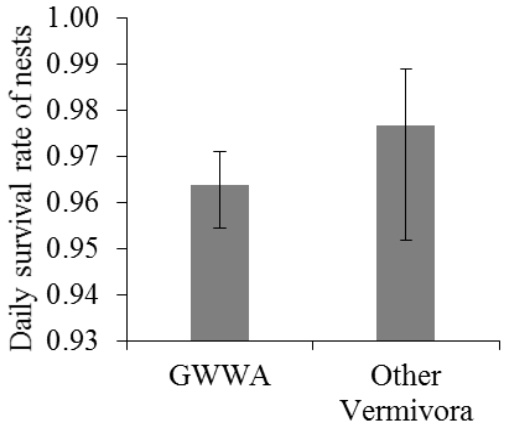


Figure 2. Daily survival rate (± 95% CI) of Vermivora spp. nests.

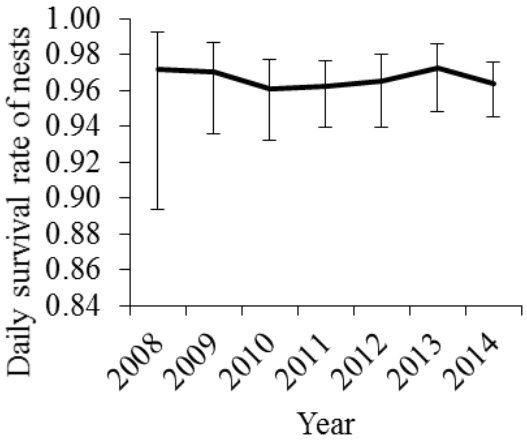


Figure 3. Annual daily survival rate (± 95% CI) of Vermivora spp. nests.

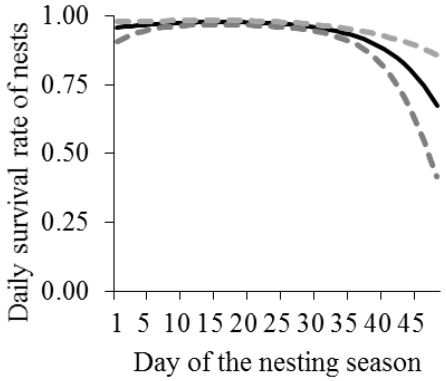


Figure 4. Daily survival rate (± 95% CI) of Vermivora spp. nests over time.

We measured detailed spatial arrangement of vegetation characteristics at 121 GWWA nests during 2011-2013 that reached at least egg-laying. GWWA selected areas with more forb and *Rubus* cover than random and their preference for these cover types varied spatially, such that forb and *Rubus* cover decreased as distance from the nest increased (Figs. 5-6).

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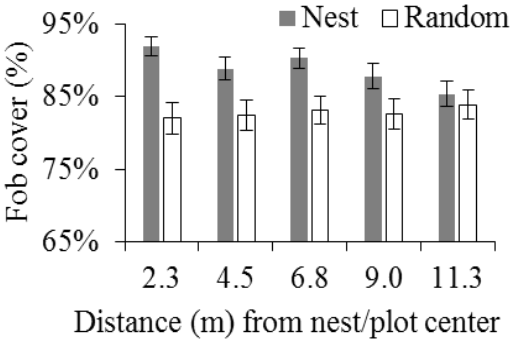

Figure 5. Forb cover (± SE) as a function of distance from GWWA nest or random plot center

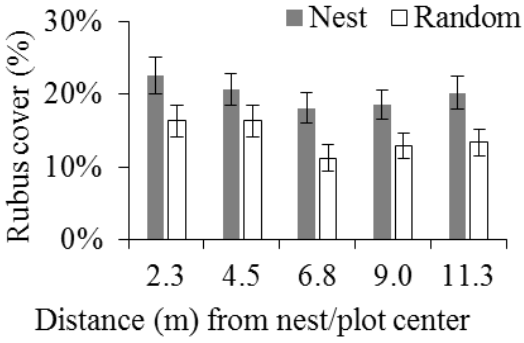

Figure 6. Rubus cover (± SE) as a function of distance from GWWA nest or random plot center.

We mapped 268 territories of GWWA (88%), BWWA (8%), and BRWA (4%) males during 2008-2014. Average territory sizes for GWWA, BWWA, and BRWA were 1.5 ± 0.1 ha, 3.3 ± 1.2 ha, and 3.0 ± 1.1 ha, respectively. Our Randolph County GWWA population experienced precipitous declines during 2008-2014, while our Pocahontas County GWWA population was relatively stable (Fig. 7). We suspect that the Randolph County population has declined because it is isolated from other GWWA populations and has experienced encroachment by BWWA and hybrids.

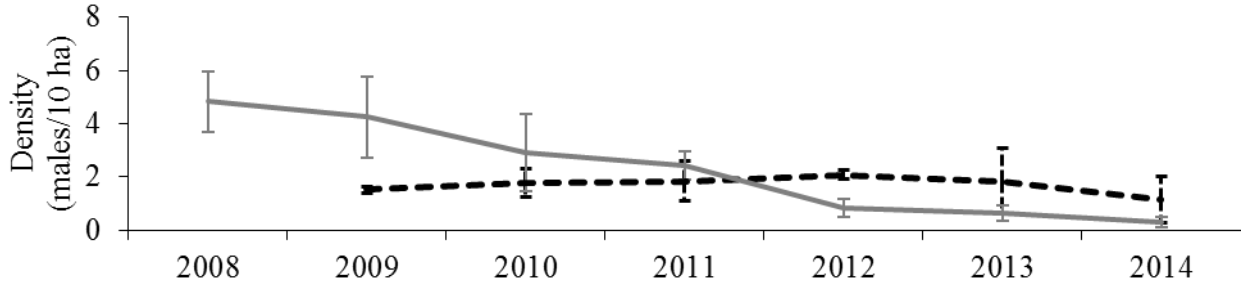

Figure 7. Annual GWWA breeding territory density in our study areas in Pocahontas and Randolph counties.

Our results and those from the range-wide study were used to develop the GWWA Conservation Plan and regional habitat management plans. Our current work is evaluating the effectiveness of the NRCS Working Lands for Wildlife program in providing quality habitat for GWWA.

CERULEAN WARBLER AND ASSOCIATED SPECIES RESPONSE TO SILVICULTURAL PRESCRIPTIONS IN THE CENTRAL APPALACHIAN REGION

Student Investigator: Gretchen E. Nareff
Principal Investigator: Petra Wood
Cooperators: Todd Fearer, Mark Ford, Jeff Larkin, Scott Stoleson
Years Ongoing: 2013-Present
Expected Completion: May 2016
Funding Sources: U.S. Geological Survey (WV RWO 62), WV Department of Natural Resources, Pennsylvania Game Commission

Objectives:

1. Quantify and compare broad-scale influence of timber harvests on relative avian abundance and community composition pre- and post-harvest across four cooperating states and territory density at two sites in West Virginia, pre- and post-harvest.

2. Examine how silvicultural practices impact habitat use of an interior-forest passerine, the Cerulean Warbler, in West Virginia, pre- and post-harvest.

3. Examine the response of six focal indicator species to silvicultural harvest mosaics and assess using the Cerulean Warbler as an umbrella species for songbird management across a spectrum of conditions.

Progress:

The Cerulean Warbler (*Setophaga cerulea*) is a severely declining, late successional songbird species whose core breeding range is in the hardwood forests of the Appalachian Mountains. The cerulean uses heavily forested landscapes with heterogeneous vegetation structure. Although not federally listed by the Endangered Species Act, it was petitioned for listing in 2000 and is considered a focal species of management concern by the U.S. Fish and Wildlife Service (USFWS) based on a range-wide population decline. Understanding habitat selection on multiple scales and managing for Cerulean Warbler preferences is critical in reversing this decline and conserving the species. This study is a region-wide, cooperative project with study sites in Kentucky, Pennsylvania, Virginia, and West Virginia. Fieldwork will be conducted within the host states by local teams and data management and analysis will be a cooperative effort. The West Virginia team will complete global analyses.

Our study will expand on the recently published *Cerulean Warbler Management Guidelines for Enhancing Breeding Habitat in Appalachian Hardwood Forests* by studying operational silviculture under a broad set of conditions and harvest types. Ideally, we will identify harvest regimes that benefit the ceruleans and associated Species of Greatest Conservation Need (SGCN) that can be integrated into existing harvest regimes. We will quantify cerulean warbler and SGCN selection for various vegetative characteristics (e.g. residual basal area, tree species composition) and for landscape characteristics (e.g. slope position, aspect, landform) at the point count and territory levels. We will examine how ceruleans select territories on a landscape-scale within a harvest mosaic that offers structural diversity to the birds and how other songbird species may be managed under the umbrella of cerulean breeding habitat management. Our results will be used to refine the existing habitat management guidelines.

All study sites are located in KY, PA, VA, and WV within the Appalachian Mountain Bird Conservation Region. Each state will conduct timber harvests incorporating the recommendations of the Guidelines. The five West Virginia study sites are at Coopers Rock State Forest (Scott's Run, 77.2 ha, and Pisgah, 151.8 ha) in Monongalia and Preston counties, Stonewall Jackson Wildlife Management Area (WMA; 32.0 ha) in Lewis County, and two sites (Dynamite, 39.8 ha and Wolf Creek, 26.6 ha) at the Elk River

WMA in Braxton County. Harvests occur as a mosaic at each WV site, including shelterwood harvests, clearcuts, singletree selection, and group selection, with unharvested areas throughout (Figure 1).

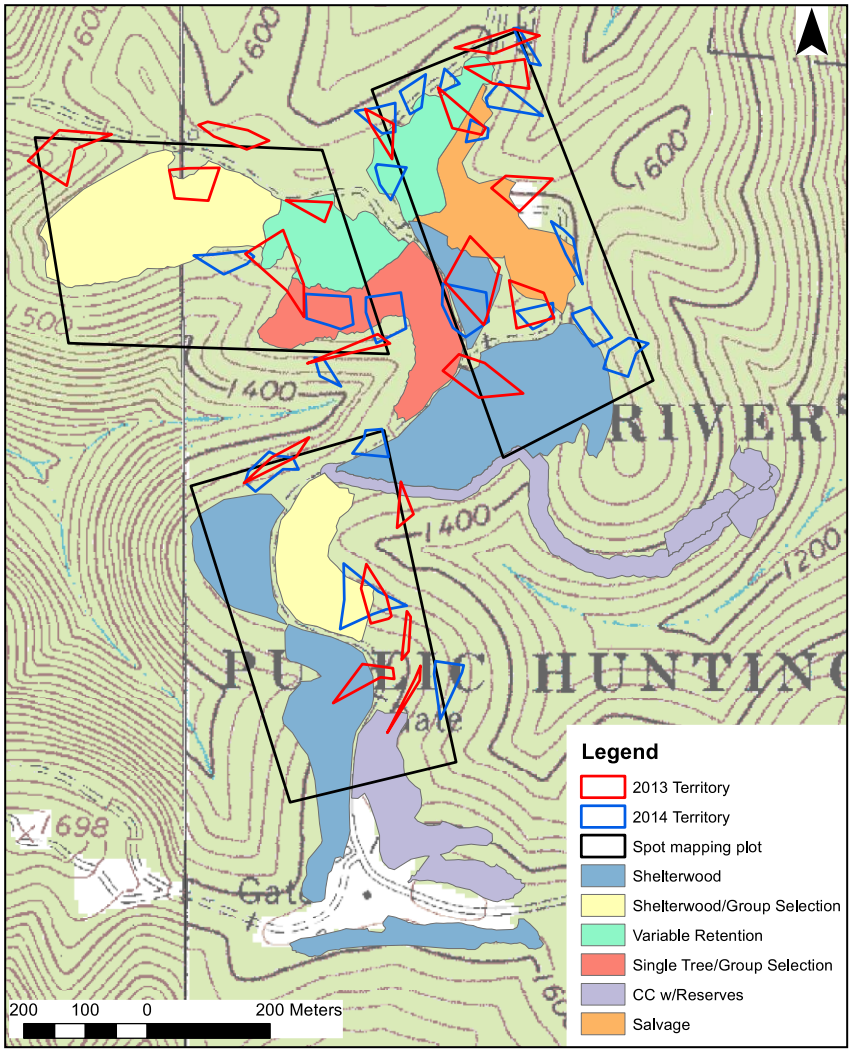

Figure 1. Cerulean Warbler territories from 2013 and 2014 at the Dynamite Harvest Mosaic within the Elk River Wildlife Management Area in Braxton County, WV.

We quantified songbird response to a range of forest management treatments in the four states during the 2013 and 2014 breeding seasons. We are using point counts to evaluate changes in songbird abundance pre- and post-harvest, and spot mapping techniques (only in WV) to evaluate changes in territory density pre- and post-harvest of six focal species (eastern towhee [*Pipilo erythrophthalmus*], indigo bunting [*Passerina cyanea*], hooded warbler [*S. citrina*], cerulean warbler, wood thrush [*Hylocichla mustelina*], and worm-eating warbler [*Helmitheros vermivorum*]) representing a range of preferred basal areas. We used standardized 10-minute point counts conducted three times at each point to determine avian abundance and community composition. Ten spot mapping plots 16-18 ha in size were placed over the harvest mosaics in WV and visited 7-8 times per season to determine territory locations of the six focal species.

Spot-mapping in WV revealed greater cerulean territory density at harvested than unharvested sites. In 2013, harvested sites had 0.23 territories/ha while unharvested sites had 0.17/ha. In 2014, harvested sites

had 0.33/ha and unharvested sites had 0.24/ha. Territories often included multiple types of harvests and edges within them (Figure 1).

For point count data summaries, we excluded flyovers and birds detected greater than 75m from the observer. Subsequent analyses will account for detection probability and time removal methods. Across the four states, at harvested sites in 2013 and 2014, ceruleans were detected at 34.6% of point count stations at harvest interior points, 16.0% of point count stations at harvest edge points, and 23.2% of point count stations in unharvested reference stands. The Kentucky site and 6.1 ha at Wolf Creek in WV were harvested after the 2013 breeding season; cerulean relative abundance changed little before and after harvest (Table 1). At the 5 WV sites in 2014, species richness was higher at the 2 harvested sites (52, 53) than at the 3 unharvested sites (35-39).

Table 1. Cerulean Warbler detections (mean ± SE) within 75m of point count stations pre- and post-harvest in Kentucky and at six points harvested prior to the 2014 breeding season at the Wolf Creek (WC) site in WV. Harvest, Edge, and Reference refer to point count locations.

	2013 Pre-harvest		
	Harvest	**Edge**	**Reference**
KY	0.86±0.34	0.86±0.46	0
WV (WC)	1.0±0.0	0.50±0.29	0.90±0.17
	2014 Post-harvest		
KY	0.86±0.26	0.71±0.36	0.14±0.14
WV (WC)	1.0±0.0	0.50±0.29	1.0±0.21

USE OF A HIGH RESOLUTION SATELLITE IMAGE AND DIGITAL ELEVATION MODEL TO PREDICT THE RIDGE FOREST BIRD COMMUNITY, AND FACTORS LEADING TO SONGBIRD SPECIES DISTRIBUTION PATTERNS AND CERULEAN WARBLER CLUSTERING AT THE LEWIS WETZEL WILDLIFE MANAGEMENT AREA, WV

Student Investigator: Jim Sheehan.
Principal Investigator: Petra Wood
Cooperators: Harry Edenborn, Randy Dettmers, T. Bentley Wigley
Years Ongoing: 2010-Present
Degree Program: Ph.D.
Expected Completion: May 2015
Funding Sources: Department of Energy, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation

Objectives:
1. Determine if remote sensing information from a satellite image and a digital elevation model can predict habitat characteristics and the avian community found on mature hardwood-forested ridges.
2. Use this remote sensing information along with habitat data to study the distribution patterns of territories of ridgetop cerulean warblers, ovenbirds, and hooded warblers.
3. Investigate how territories of cerulean warblers cluster in relation to topography, forest structure and composition, and conspecific presence.

Progress:
The heavily forested ridgetops of northwestern West Virginia harbor a rich avian community that is an important component of the native biodiversity of the Central Appalachians. These ridgetops also are the focus of much energy industry activity, particularly the development of Marcellus Shale natural gas. The Marcellus well pads and associated roads and pipelines, and the development of the region's abundant conventional gas and oil resources, have the potential to affect a significant portion of the region's ridgetops and associated breeding bird species, including the sharply declining Cerulean Warbler.

Remote sensing data has proven to be useful in the study of avian habitat relationships. One objective of this project is to examine how a high-resolution, leaf-on 2009 Quickbird satellite image and a 3-meter digital elevation model (DEM) relate to a 2010-11 ridgetop avian point count survey and habitat measurements at the Lewis Wetzel Wildlife Management Area, WV. Results to date include that image spectral brightness and several measures of image texture (the spatial variability of image pixel values) predicted a gradient in forest composition and structure, ranging from less complex, chestnut oak-dominated forest to more complex, sugar maple-dominated forest. The richness of a subset of bird species closely associated with the well-developed understory of canopy gaps was positively and most strongly related to a simple measure of image texture, the standard deviation of panchromatic image pixel values (Figure 1). These initial findings support the use of remote sensing data in lieu of intensive field surveys to provide valuable information on forest composition and structure at the site, and indicate habitat for bird species dependent on structurally heterogeneous forests. In turn, this information may be useful for considering the implications of where energy industry activities occur in this forest.

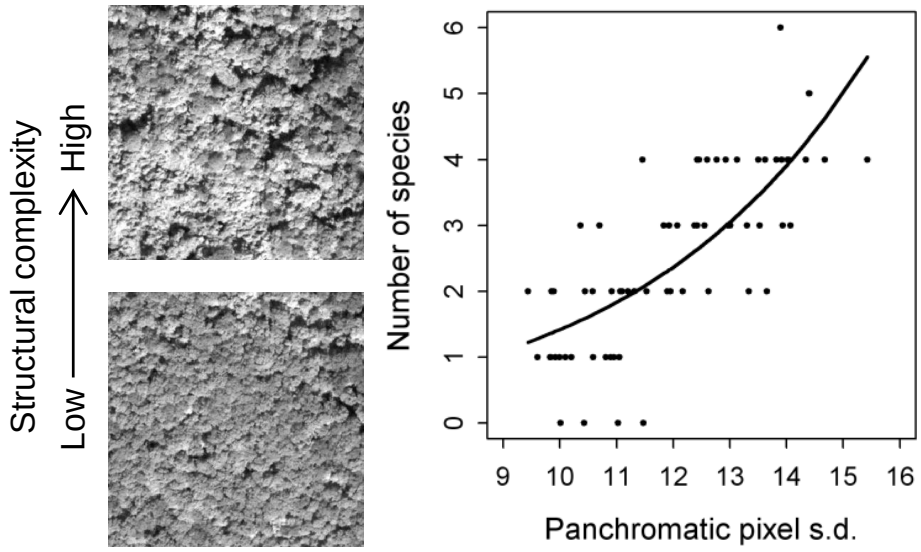

Figure 1. A gradient in forest structural complexity and the richness of six forest gap-associated bird species in relation to a Quickbird satellite image texture measure that appears to reflect this gradient.

The other two objectives of this project use the distribution patterns of three territorial songbirds, obtained from focal ridgetop transect surveys in 2010 and 2011. Ovenbirds, Hooded Warblers, and Cerulean Warblers (Figure 2) are widespread and abundant at the site, and differ in the forest habitat components they require for breeding. Analyses of their distribution patterns in relation to the Quickbird image data, the DEM, and habitat data are ongoing and will be used to examine potential underlying factors responsible for their occurrence. For the Cerulean Warbler, the final objective is to infer if habitat,

sociality, or both, may be the driving factors underlying where they occur, and in particular where they strongly cluster at the site. Understanding factors responsible for their observed distribution patterns could be of particular value for the management of this high conservation priority species. Results for all three species may suggest remote sensing-based approaches to understanding the distribution of these species on ridgetops throughout the region, and how their populations intersect with energy industry activities.

Figure 2. Three focal ridgetop songbirds: the ground nesting Ovenbird (left), shrub nesting Hooded Warbler (center), and upper canopy nesting Cerulean Warbler (right).

WILDLIFE
MARCELLUS SHALE PROJECTS

SONGBIRD RESPONSE TO GAS WELL AND INFRASTRUCTURE DEVELOPMENT IN THE MARCELLUS SHALE REGION

Student Investigator: Laura Farwell
Principal Investigator: Petra Wood
Cooperators: Randy Dettmers, Todd Fearer, Margaret Brittingham
Years Ongoing: 2013-present
Degree Program: PhD
Expected Completion: Sept 2016
Funding Source: US Fish and Wildlife Service

Objectives:

1. Quantify how the size, shape, age and placement of gas well pads and pipelines in the landscape impact abundance and diversity of forest songbirds through the following analyses:
    a. Compare relative abundance and diversity of breeding bird populations at Marcellus well pad sites and infrastructure with that of comparable reference sites not impacted by Marcellus development.
    b. Quantify effects of well pad site size, age and density on abundance and diversity of breeding bird population and identify thresholds for percent of landscape impacted by well pads and infrastructure beyond which birds are negatively impacted.
    c. Determine distance that edge effects on avian populations extend into adjacent forest from well pad sites.
2. Compare the results of this project with recent Pennsylvania land cover change analyses (USGS) and model projections of hot spots for shale gas development (TNC), to potentially identify forest areas of high conservation concern that stand to be heavily impacted, and which should be excluded from further shale gas development.

3. Describe management recommendations regarding pad shape, size, age and placement that minimize impacts to forest interior birds and restoration of pipelines to maximize habitat improvement for early successional species.

Progress:
Extraction of natural gas from Marcellus shale has increased exponentially in the central Appalachians. Our goal is to quantify how the size, shape, age and placement of gas well pads and pipelines in the landscape (Figure 1) impact abundance and diversity of forest songbirds across the Marcellus shale region. We seek to identify thresholds of habitat and landscape metrics beyond which birds are negatively impacted and quantify how far edge effects from well pads extend into the surrounding forest.

Figure 1.
Top: Well pads and infrastructure in mature, core forest in Tiadaghton State Forest, PA. Photo by Martha Rial, Marcellus Shale Documentary Project.
Bottom: Recently cleared Marcellus pipeline corridor, Conaway Run Lake Wildlife Management Area, WV. Photo by Laura Farwell.

We used stratified sampling to select well sites from landscapes across a range of forest cover and with high and low density shale gas well development. We selected reference sites using a similar stratification of forest cover and high and low density *non-shale gas* development. We used standard protocols to quantify avian, vegetation, and landscape metrics and are currently developing statistical models to relate bird abundance and diversity to habitat and landscape metrics. We hope these results will inform conservation professionals as well as industry regarding effects of Marcellus development on forest birds and will provide baseline data that can be used to monitor bird populations and assess effects over a longer period of time. The results will also inform management recommendations regarding pad

shape, size, and placement that minimize impacts to forest interior birds and will inform restoration of pipelines to maximize habitat improvement for the early successional suite of species.

During May through early July 2014, we surveyed 100 field sites (1 km radius circular plots) in three states: WV, OH, and PA (Figure 2). Of these 100 sites, 69 contained Marcellus gas development and 31 were reference sites; 72 sites were located on public lands and 28 were on private lands. We conducted a total of 1,356 point count and vegetation surveys, averaging 13 survey points per field site and ranging from 8-16 survey points per site depending on access and topography (Figure 3). Points within a site were >250-m apart.

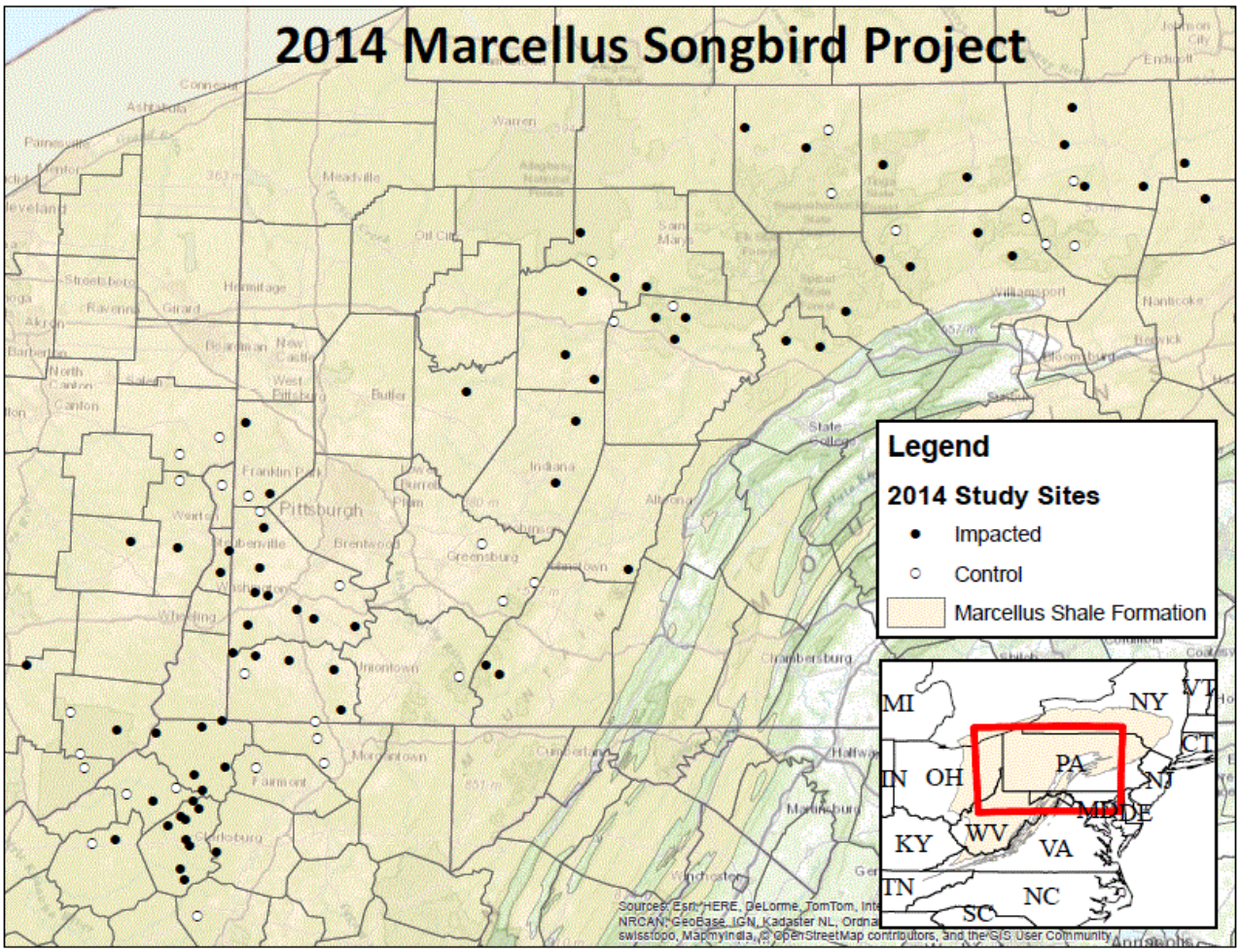

Figure 2. Field site locations in PA, OH, WV sampled in 2014: black dots represent shale gas impacted sites, white dots are control sites.

We are currently in the process of digitizing shale gas impacts and land cover classes at each of our 1 km radius field sites (Figure 3) using GIS, based on the most recent aerial and satellite imagery available as well as personal knowledge of the sites. We are categorizing different types of shale gas development (e.g., well pads, ponds, roads, pipelines), as well as other types of non-gas development and land cover classes of interest, including forests and agricultural lands. We will relate the avian data to the land cover and fragmentation metrics.

A priority for site selection for the 2015 field season will be to fill in gaps along the gradients of percent forest cover and well density, adding more sites on private lands, and adding more sites in OH and WV.

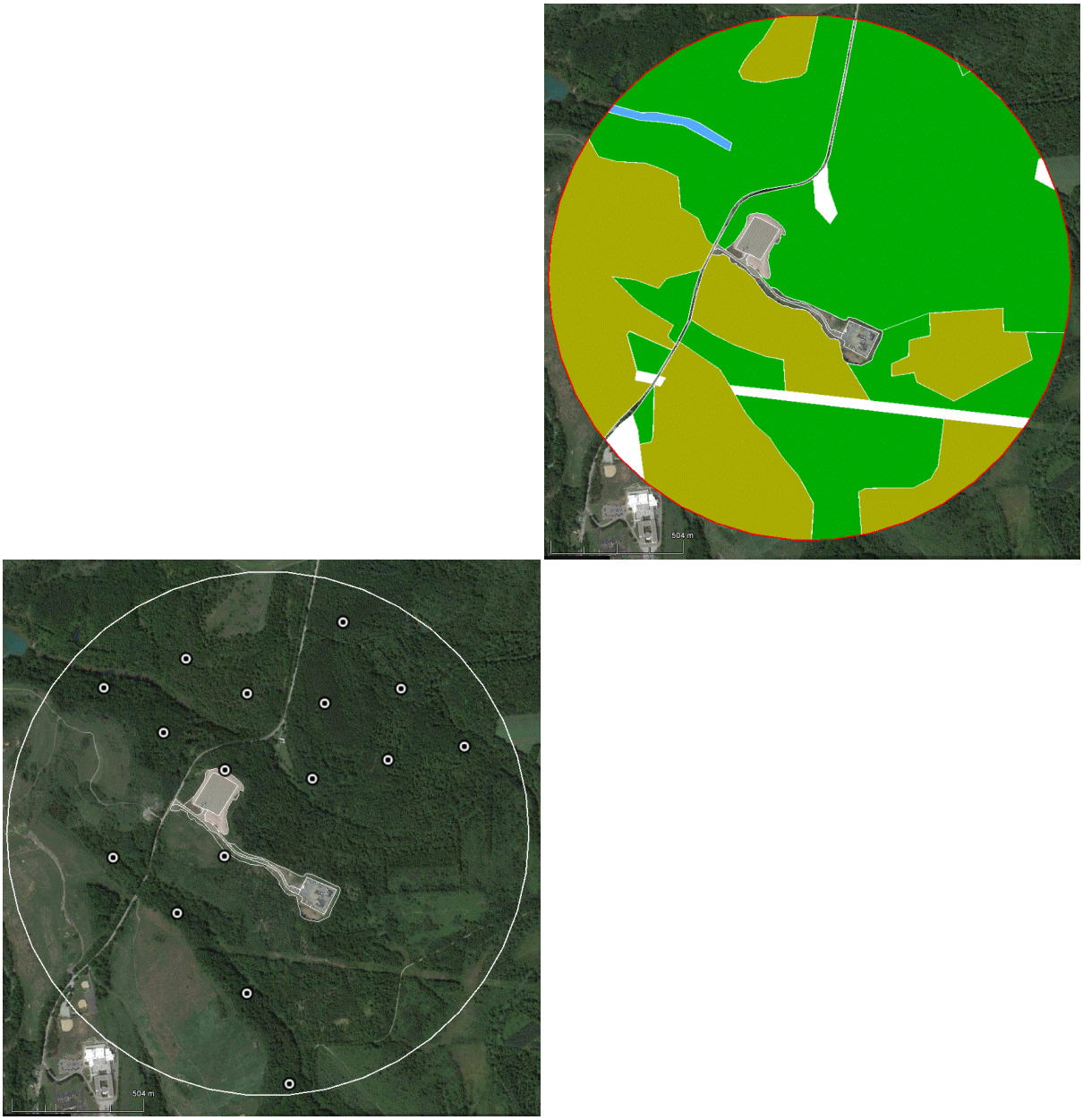

Figure 3. A 1 km radius field site in Washington Co, PA; (left) white dots indicate avian/vegetation survey locations; (right) digitization of shale gas impacts and land cover classes.

Student Investigator: Mack Frantz
Principal Investigator: Petra Wood
Cooperator: Steve Latta
Years Ongoing: 2013-present
Degree Program: PhD
Expected Completion: December 2015
Funding Sources: US Geological Survey (WV RWO 64), WV Department of Natural Resources, Pittsburgh National Aviary, Eastern Bird Banding Association, First Catholic Slovak Ladies Association, West Virginia University Provost Fellowship

Objectives:
1. Determine how gas well development activities spatially influence Louisiana Waterthrush territory density, foraging locations or behavior, nesting location and success, and site fidelity.
    1a. Develop spatially explicit habitat models from Louisiana Waterthrush data to aid land managers in mitigating habitat disturbance from oil and gas activities.

2. Determine how gas well and infrastructure development influence Louisiana Waterthrush epigenetic (DNA methylation) variation between areas of impacted and unimpacted streams, and to determine how DNA methylation varies among individuals.

Progress:
An emerging threat for wildlife is shale gas development in the Appalachian region. My research is examining how gas development activity and possible environmental stressors (such as stream contamination via heavy metals) influence Louisiana Waterthrush (*Parkesia motacilla*) DNA methylation between individuals nesting at impacted and unimpacted streams on the Lewis Wetzel Wildlife Management Area (LWWMA) in WV. In addition, stream and nesting features are being spatially assessed to determine if there is a spatial component to gas development activity that influences waterthrush demographics (e.g. nesting success).

This study follows up on a study during 2008-2011 of Louisiana Waterthrush on LWWMA. In the original work, we observed no demographic response of waterthrush to the low amount of habitat disturbance from shale gas development although habitat quality decreased at impacted sites. The amount of shale gas development has continued to increase leading to this follow-up study which is using methods similar to the original study. Given that LWWMA has a history of oil and gas development, we aim to assess impacts from all oil and gas activity and specifically shale gas development in influencing Louisiana Waterthrush demographics.

Annually, we captured and color-banded adult Louisiana Waterthrush to allow for recognition of individuals by sight. We banded nestlings to ID individuals and to monitor dispersal. We collected three flight feathers from each adult and 3-5 breast feathers from each nestling for analysis of contaminants. Blood (5-10 microliters) was sampled by venipuncture from the ulnar vein of the wing for analysis of epigenetic (DNA methylation) differences among individuals. We resighted color-banded individuals to assess survival rates across and within years. We assessed habitat quality by characterizing vegetation immediately surrounding each nest, with the EPA Rapid Bioassessment protocol for high gradient streams, and with a Louisiana Waterthrush Habitat Suitability Index (HSI). Macroinvertebrates occurring in riffle habitat of each individual's territory and at each nesting location were sampled with a Surber sampler.

Louisiana Waterthrush monitoring took place during March 28 – 31 July 2013 and 2014 by searching 50 km of headwater streams (n=12) on LWWMA. Over the two years, 184 nests were found through nest searching with nine known fledged nests that were not found. Forty-one nests were considered to be impacted by gas development by being near gas activity or infrastructure. Of these 41 impacted nests, 16

were successful and 25 failed or were abandoned. Forty-seven nests were considered potentially impacted by shale gas development because they were downstream of a well pad or activity. Overall Mayfield nest survival in 2013 was 33.3% ± 0.1 (n=64 nests). Nest survival analysis for the 2014 breeding season is still in progress. Impacted nests were three times closer to non-forest habitat edges (48 ± 17 m) than were unimpacted nests (167 ± 13 m).

We first recorded Brown-headed Cowbird nest parasitism (n=4; Figure 1) at LWWMA in 2013. Two of the parasitized nests were successful, yielding one and three fledglings in each nest. In 2014, three parasitized nests produced no waterthrush offspring.

Figure 1. Left: A Louisiana Waterthrush nest that was parasitized by Brown-headed Cowbirds and has a waterthrush egg with 2 cowbird nestlings. Right: a male waterthrush fitted with a geolocator. These geolocators will help us determine what routes waterthrush use to reach their wintering grounds.

We captured 112 nestlings and 72 adults in 2013 and 78 nestlings and 53 adults in 2014 (315 total). Thirty-two of these adults were recaptures from previous years with one originally banded in 2008. We confirmed our first two return nestlings to LWWMA, one of which was banded in 2013. In addition, 15 males were fitted with geolocators (Figure 1) to identify their migratory route to wintering grounds. From captured birds, we collected 309 feather and 314 blood samples for analysis of stream contaminants and epigenetic variation. Preliminary analyses of blood samples suggest that DNA methylation varies between individuals.

We resighted ~13% of all individuals banded during 2008-2011 in 2013 (14 of 108 total). About 18.2% of banded individuals from 2011 (6 of 33 total) were resighted in 2013 (no birds were banded in 2012). In 2014, we resighted 17.3% of banded individuals from 2013 (29 of 168 total). Of all individuals banded in 2008-2013, ~13.6% were resighted in 2014 (37 of 273 total).

In 2013, we collected 633 territorial observations among 60 males, with 51 of them holding a territory and making a nesting attempt. Average territory length was 657±34 m (range 183-1604 m). In 2014, we collected 315 territorial observations among 60 individuals; 55 were breeding pairs. Average territory length in 2014 was larger (768±42m; range 209-1775 m). Territory density (#terr/km) per stream and average number of territories per stream has declined annually (Table 1). Changes in territory length and density between years may be related to streams having more of their length impacted in 2014 (19.2%) than the previous year (16.3%).

Table 1. Louisiana Waterthrush territory densities and average number of territories on our study streams (n=12) at LWWMA across years. No waterthrush data was collected in 2012.

YEAR	Territory Densities	± SE	Avg. Number of Territories	± SE
2009	1.3	0.1	6	0.6
2010	1.5	0.1	7	0.8
2011	1.3	0.1	6	0.6
2013	1.2	0.1	5.5	0.7
2014	1.1	0.1	4.6	0.7

Habitat assessments (EPA and HSI) were completed at nest sites each year. EPA stream assessment scores were higher at unimpacted (159.2 ± 1.4) than impacted (144.8 ± 3.7) sites and were different based on 95% confidence intervals (CIs). HSI scores were lower at impacted (0.60 ± 0.01) than at unimpacted (0.63 ± 0.01) sites and also were different based on CIs. Both of these scores suggest lower habitat quality at impacted sites.

We collected 314 macroinvertebrate samples total in 2013 and 2014 at foraging and nesting locations that will be compared between impacted and unimpacted areas. Collectively, 26 of 65 foraging locations (40%) were considered impacted. So far, we have identified twenty genera in eight samples. Water chemistry was measured while collecting foraging and nest-site macroinvertebrate samples, and also during the EPA stream assessment. Conductivity, TDS, and ph are all higher at impacted nests (Table 3). Further data summaries and analyses will be completed this fall and winter.

Table 3. Water chemistry readings collected during EPA stream assessments at impacted and unimpacted nests in 2013 and 2014.

Conductivity (*uS*)		Total Dissolved Solids (TDS)		pH	
Unimpacted	Impacted	Unimpacted	Impacted	Unimpacted	Impacted
111.8 ± 3.2	178.8 ± 13.0	56.1 ± 1.6	90.2 ± 6.6	7.4 ± 0.0	7.7 ± 0.1

LONG-TERM SONGBIRD POPULATION RESPONSE TO GAS WELL DEVELOPMENT

Student Investigators: Jim Sheehan, Laura Farwell, Greg George
Principal Investigator: Petra Bohall Wood
Years Ongoing: 2008-2014
Expected Completion: May 2016
Funding Source: Department of Energy, US Fish and Wildlife Service

Objectives:
1. Determine how oil and gas activities influence distribution and relative abundance of songbirds.
2. Determine how oil and gas activities influence habitat and landcover metrics.

Progress:
The central Appalachian region is heavily forested and of high importance to forest songbirds. The region is also experiencing rapid growth in Marcellus shale gas development (Fig. 1). The Lewis Wetzel Wildlife Management Area in north-central WV had shale gas development beginning in 2008. This

project is quantifying effects of habitat impacts, both positive and negative, on avian populations and linking these effects with land cover changes to develop spatially explicit habitat models that will aid land managers in mitigating these disturbances.

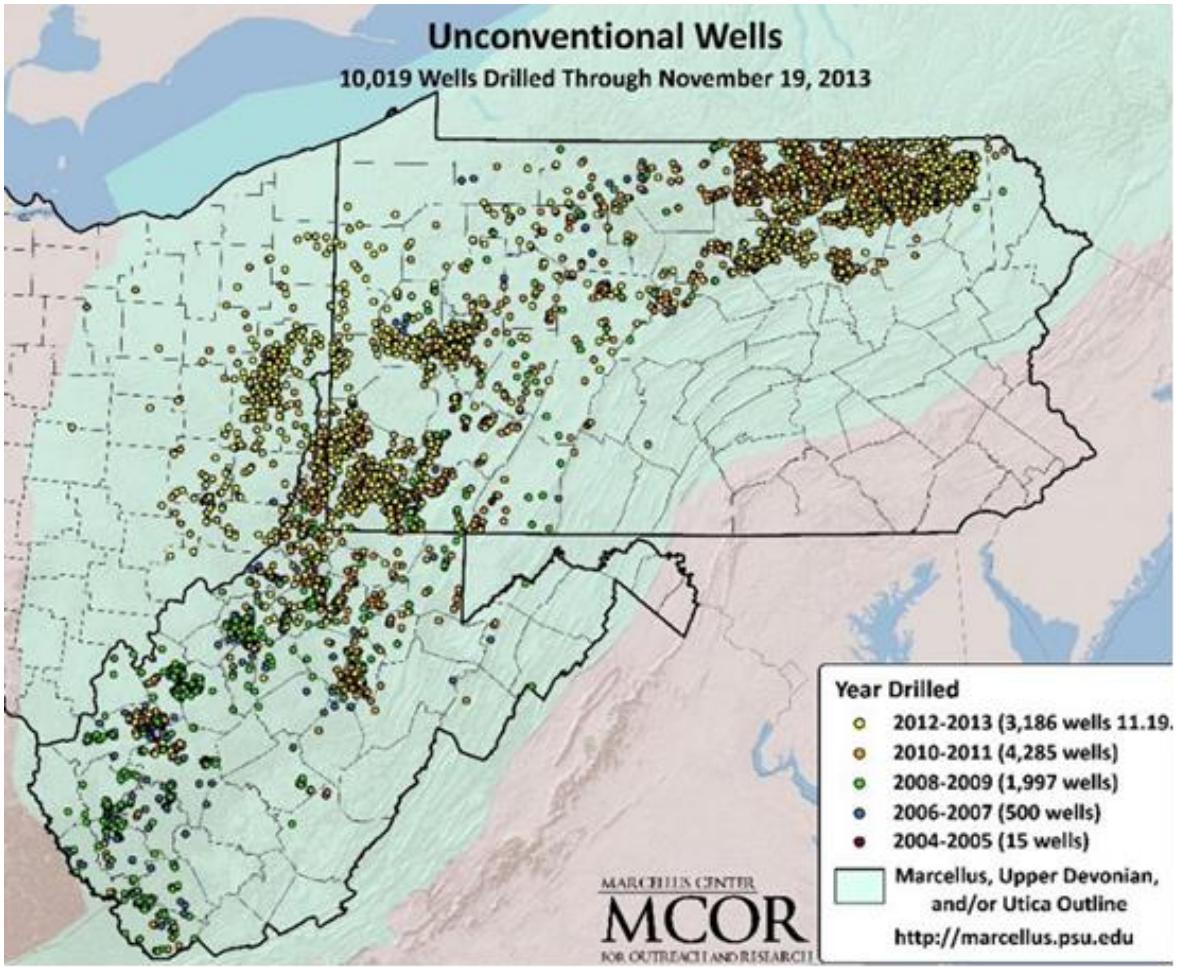

Figure. 1. Marcellus gas wells as of Nov. 2013.

We established 144 point count locations throughout the ~3,416 ha study area in northwestern West Virginia in both ridgetop and riparian habitat. Points were surveyed during the 2008-2014 breeding seasons to determine abundance, diversity, and distribution of songbirds. Point counts sampled areas with current Marcellus activity, areas with past O&G activity, and mature forest reference areas. Across the study area, habitat fragmentation and change has increased over the study period. The amount of mature forest cover has declined and has resulted in an increase in edge density (Fig. 2) primarily due to the construction of new access roads and pipelines.

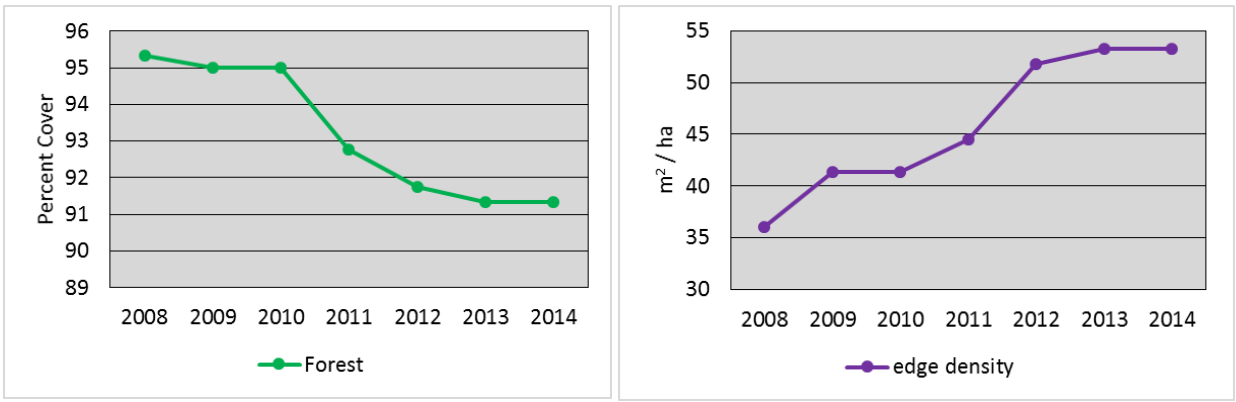

Figure. 2. Mature forest cover and amount of forest edge on the management area during 2008-14.

Relative abundance of avian species dependent on mature forest habitats have generally declined from 2008-2014 across the study area (Fig. 3). Cerulean Warblers (CERW) have had the largest decrease followed by Hooded Warblers (HOWA) and Ovenbirds (OVEN). The Worm-eating Warbler (WEWA) also declined initially then increased before decreasing again. Brown-headed Cowbirds, a nest parasite, and European Starlings increased in abundance and distribution particularly in association with new impacts on the study area. As Marcellus well pad and associated infrastructure (access roads and pipelines) construction continue on the study area, we expect the avian community to continue to change.

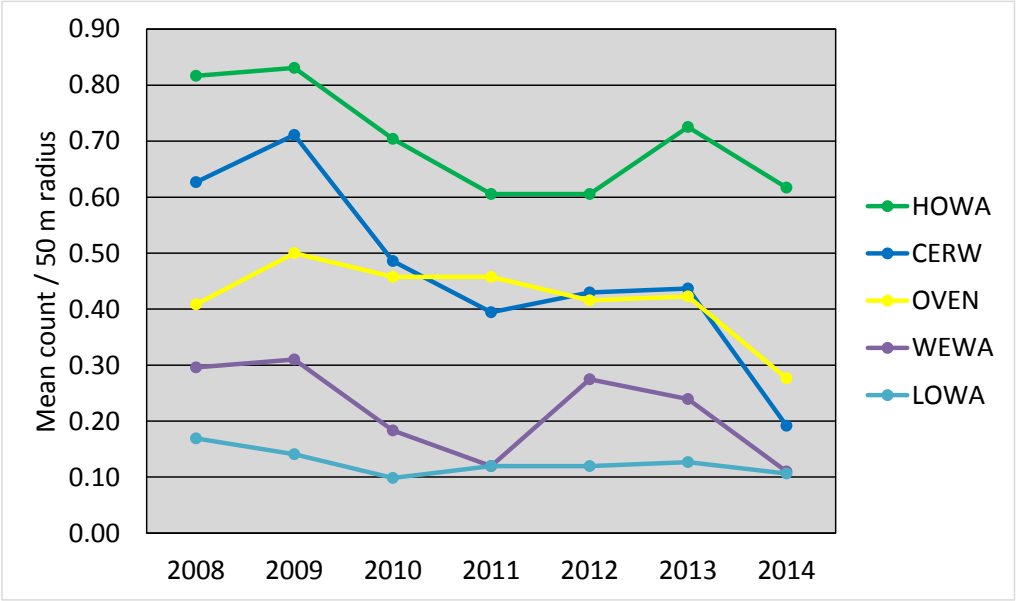

Figure. 3. Annual relative abundance of mature forest dependent avian species.

PUBLICATIONS, THESES, DISSERTATIONS, PRESENTATIONS, AND HONORS, AWARDS, AND APPOINTMENTS

SCIENTIFIC PUBLICATIONS

Aldinger, K. and P.B. Wood. 2014. Reproductive success and habitat characteristics of Golden-winged Warblers in high-elevation pasturelands. Wilson Journal of Ornithology 126(2):279-287.

Aunins, A.W., J.T. Petty, T.L. King, M. Schilz and P.M. Mazik. 2014. River mainstem thermal regimes influence population structuring within an Appalachian brook trout population. Conservation Genetics. DOI 10.1007/s10592-014-0636-6

Blazer, V.S., J. Hoffman, H.L. Walsh, R.P. Braham, C. Hahn, P. Collins, Z. Jorgenson, and T. Ledder. 2013. Health of white sucker within the St. Louis River area of concern associated with habitat usage as assessed using stable isotopes. Ecotoxicology 23: 236-251.

Blazer, V.S., D.D. Iwanowicz, H.L. Walsh, A.J. Sperry, L.R. Iwanowicz, D.A. Alvarez, R.A. Brightbill, G. Smith, W.T. Foreman, and R. Manning. 2014. Reproductive health indicators of fishes from Pennsylvania watersheds: association with chemicals of emerging concern. Environmental Monitoring and Assessment, online.

Blazer, V.S., P.M. Mazik, L.R. Iwanowicz, R.P. Braham, C.M. Hahn, H.L. Walsh, and A.J. Sperry. 2014. Assessment of the fish tumor beneficial use impairment in brown bullhead (*Ameiurus nebulosus*) at selected Great lakes Areas of Concern. U.S. Geological Survey Open-File Report 2014-1105. 17p., http://dx.doi.org/10.3133/ofr20141105.

Blazer, V.S., P.M. Mazik, L.R. Iwanowicz, R.P. Braham, C.M. Hahn, H.L. Walsh, and A.J. Sperry. 2014. Monitoring of wild fish at selected sites in the Great Lakes Basin - Methods and preliminary results. U.S. Geological Survey Open-File Report 2014-1027. 31p., http://dx.doi.org/10.3133/ofr20141027.

Boves, T.J., D.A. Buehler, P.B. Wood, A.D. Rodewald, J.L. Larkin, P.D. Keyser, and T.B. Wigley. Multiple plumage ornaments convey information about age and within-age-class qualities of a canopy-dwelling songbird, the Cerulean Warbler. Auk 131:20-31.

Cincotta, D.A., D.P. Wegmen, T.E. Oldham, S.A. Welsh, and L.B. Hedrick. In press. Fishes of the Blackwater River drainage, Tucker County, West Virginia. Northeastern Naturalist

Ekman, D.R., G.T. Ankley, V.S. Blazer, T.W. Collette, N. Garcia-Reyero, L.R. Iwanowicz, Z.G. Jorgenson, K.E. Lee, P.M. Mazik, D.H. Miller, E.J. Perkins, E.T. Smith, J.E. Tietge, and D.L. Villeneuve. 2013. Biological Effects-based Tools for Monitoring Impacted Surface Waters in the Great Lakes: A Multi-Agency Program in Support of the GLRI. Environmental Practice. 15(4):409-426.

Iwanowicz, L., C. Densmore, C. Hahn, P. McAllister and J. Odenkirk. 2013. Identification of Largemouth Bass Virus in the Introduced Northern snakehead (*Channa argus*) inhabiting the Chesapeake Bay Watershed. Journal of Aquatic Animal Health, 25:3, 191-196.

Loughman, Z.J., D. Foltz, and S.A. Welsh. 2013. Baited lines, an active nondestructive collection method for burrowing crayfish. *Southeastern Naturalist* 12:809-815.

Loughman, Z.J., R. Fagundo, S.A. Welsh, E. Lau, and R.F. Thoma. 2013. *Cambarus (C.) hatfieldi*, a new species of crayfish (Decapoda:Cambaridae) from the Tug Fork River Basin of Kentucky, Virginia and West Virginia, USA. Zootaxa 3750:223-236.

McDermott, M.E., M.B. Shumar, and P.B. Wood. 2013. Case study: prioritizing reforestation of minelands for cerulean warbler conservation. Journal of the American Society of Mining and Reclamation 2(2):80-98.

Perkins, K.A. and P.B. Wood. 2014. Selection of forest canopy gaps by male cerulean warblers in West Virginia. Wilson Journal of Ornithology 126(2):288-297.

Petty, J.T., D. Thorne, B.M. Huntsman, and P.M. Mazik. 2014. Effects of density and temperature regimeon brook trouth growth and consumption within a complex Appalachian riverscape. Hydrobiologia 727:151-166

Ruble, C.L., P.L. Rakes, J.R. Shute, and S.A. Welsh. 2014. Captive propagation, reproductive biology, and early life history of the Diamond Darter (*Crystallaria cincotta*). American Midland Naturalist 172:107–118.

Sheehan, J., P.B. Wood, Buehler, D.A., Keyser, P.D., Larkin, J.L., Rodewald, A.D., Wigley, T.B., Boves, T.J., George, G.A., Bakermans, M.H., Beachy, T.A., Evans, A., McDermott, M.E., Newell, F.L., Perkins, K.A., White, M. 2014. Avian response to timber harvesting applied experimentally to manage Cerulean Warbler breeding populations. Forest Ecology and Management 321:5-18.

Sheehan, K. and S. Welsh. 2013. Accuracy of stream habitat interpolations across spatial scales. Journal of Geographic Information System 5:602-612.

Smith, J., S.A. Welsh, J.T. Anderson, and R. Fortney. In press. Water quality trends in the Blackwater River watershed, West Virginia. Northeastern Naturalist.

Welsh, S.A., D.M. Smith, and N.D. Taylor. 2013. Microhabitat use of the diamond darter. Ecology of Freshwater Fish 22:587–595.

Welsh, S.A., D. A. Cincotta, and W.C. Starnes. 2013. First records of *Nocomis biguttatus* (Hornyhead Chub) from West Virginia discovered in museum voucher specimens. Northeastern Naturalist 20:N19–N22.

Welsh, S.A., D.R. Jerry, D.W. Burrows. 2014. A new species of freshwater eel-tailed catfish of the genus *Tandanus* (Teleostei: Plotosidae) from the wet tropics region of eastern Australia Copeia 2014:136-142.

Welsh, S.A. and J.L. Aldinger. 2014. A semi-automated method for monitoring dam passage of upstream migrant yellow-phase American Eels. North American Journal of Fisheries Management 34:702–709.

Welsh, S.A., D.A. Cincotta, and R.L. Raesly. In press. First record of the Bigeye Shiner (*Notropis boops*) from West Virginia. American Midland Naturalist.

Wood, P. J. Larkin, J. Mizel, C. Zipper, and P. Angel. 2013. Reforestation to enhance Appalachian mined lands as habitat for terrestrial wildlife. Forest Reclamation Advisory No. 10. U.S. Office of Surface Mining, ARRI. 8pp.

Wood, P.B. and J.M. Williams. 2013. Terrestrial salamander abundance on reclaimed mountaintop removal mines. Wildlife Society Bulletin 37(4):815-823.

THESES AND DISSERTATIONS

Davis, R.D. May 2014. Impacts of non-renewable resource extraction on shrubland songbird nest success and abundance. MS Thesis, West Virginia University, Morgantown. 164 pp.

PRESENTATIONS

Aldinger, K.R. and P.B. Wood. The need for shrublands and young forests: a case study using Golden-winged Warblers. West Virginia Forest Stewardship Training Workshop, Flatwoods, WV, 13 March 2014. [invited]

Braham, R.P., V.S. Blazer, H.L Walsh, C.M Hahn, and P.M Mazik. 2014. An Evaluation of Biological Markers as Indicators of Exposure to Genotoxic and Mutagenic Compounds in the Great Lakes Basin, United States. International Symposium on Aquatic Animal Health. Portland, Oregon. August 31-September 4, 2014.

Braham, R.P., P.M. Mazik, J. Hedrick, L. Iwanowicz, and V. Blazer. 2014. Investigations on algal (cyanobacterial) species and toxins and their associations with fish lesions, mortalities and estrogenic activity. International Symposium on Aquatic Animal Health. Portland, Oregon. August 31-September 4, 2014.

Eyler, S., S. Welsh, D. Smith, and M. Mandt. 2014. Passage method, turbine mortality, and migratory delay of silver American Eels (*Anguilla rostrata*) at five hydroelectric dams on the Shenandoah River. International Eel Symposium 2014: Are eels climbing back up the slippery slope? 144th Annual Meeting of the American Fisheries Society, 21 August 2014, Quebec City, Canada.

Frantz, M., P.B. Wood, J. Sheehan, and G. George. Response of Louisiana Waterthrush to shale gas development. American Ornithologists Union Annual Conference, Estes Park, CO, 24-27 Sept 2014. [invited]

Hahn, C.M., Iwanowicz, L.R., Blazer, V.S., Cornman, R.S. 2014. The First Report of a Hepadnavirus Isolated from Fishes: Evidence of Hepatitis B Virus infection in White Sucker (*Catostomus commersoni*) from the Great Lakes Region. International Symposium on Aquatic Animal Health. Portland, Oregon. August 31-September 4, 2014.

Hahn, C.M., Iwanowicz, L.R., Blazer, V.S., Walsh, H.L., Braham, R.P., Mazik, P.M. 2014. Biological Effects of Environmental Contaminants on Gene Expression Endpoints in Largemouth Bass (*Micropterus salmoides*) and Smallmouth Bass (*Micropterus dolomieu*) from Great Lakes Areas of Concern. International Symposium on Aquatic Animal Health. Portland, Oregon. August 31-September 4, 2014.

Hahn, C.M., Iwanowicz, L.R., Blazer, V.S., Walsh, H.L. 2014. Evaluating temporal variation and the effects of estrogenic endocrine disruption chemicals on gene expression on Smallmouth bass (*Micropterus dolomieu*) from the South Fork of the Shenandoah River. USGS Chesapeake Bay Science Workshop, Shepherdstown, West Virginia. May 12-14, 2014.

Iwanowicz, D.D., L.R. Iwanowicz, L.R., Ottinger, C.A., Hahn, C.M., Blazer, V.S. 2014. Application of RNA-seq for the Detection of Fish Pathogens and Biomarker Transcripts. Eastern Fish Health Workshop. Shepherdstown, West Virginia. April 28-May 2, 2014.

Rolek, B., C.S. Loftin, D. Harrison, and P.B. Wood. The influence of silviculture on New England bird communities in northern coniferous forests. Presentation at the 70th Annual Northeast Association of Fish and Wildlife Agencies, Portland, ME, 13-15 April 2014.

Sheehan, J. and P.B. Wood. Cerulean warbler and associated avian species response to forest management. NEAFWA Habitat Technical Committee Meeting, Charleston, WV, 13 August 2014. [invited]

Smith, D.M., S.A. Welsh, N.D. Taylor, C.D. Hilling. 2014. Use of acoustic telemetry to determine seasonal movements of walleye in a hydropower reservoir. Annual Meeting of the Southern Division American Fisheries Society, Charleston, SC, 26 January 2014.

Walsh, H.L., Blazer, V.S., and Iwanowicz, L.R. 2014. Overview of Myxozoan Parasites Commonly Observed in Largemouth (*Micropterus salmoides*) and Smallmouth Bass (*M. dolomieu*) Inhabiting the Chesapeake Bay Watershed. Presentation. 39th Eastern Fish Health Workshop, Shepherdstown, WV, April 28-May 2, 2014.

Walsh, H.L., M. Keplar, G. Smith, and V.S. Blazer. 2014. Parasite infections in smallmouth bass in the Chesapeake Bay Watershed: potential associations with fish mortalities and water quality. Poster. USGS Priority Ecosystem Chesapeake Bay Annual Meeting, Shepherdstown, WV, May 12-14, 2014.

Welsh, S.A. and J. Aldinger. 2014. A photographic counter for monitoring American Eels at an eel ladder. Annual Meeting of the Southern Division American Fisheries Society, Charleston, SC, 26 January 2014.

Welsh, S.A. and J. Aldinger. 2014. Semi-automated monitoring of an eel ladder on the Shenandoah River. Joint Annual Meeting of the West Virginia Chapters of the American Fisheries Society and The Wildlife Society, Elkins, WV, 27 February 2014.

Welsh, S, D. Jerry, and D. Burrows. 2014. A new species of freshwater eel-tailed catfish of the genus *Tandanus* (Teleostei: Plotosidae) from the wet tropics region of eastern Australia. Joint Meeting of Ichthyologists and Herpetologists, Chattanooga, TN, 3 August 2014.

Welsh, S., S. Hammond, H. Liller, J. Zimmerman, M. Braham, and J. Aldinger. 2014. An 11-year series of passage counts of upstream migrant American Eels at the Millville Dam eel ladder, lower Shenandoah River, USA. International Eel Symposium 2014: Are Eels Climbing Back up the Slippery Slope? 144th Annual Meeting of the American Fisheries Society, 21 August 2014, Quebec City, Canada.

Wood, P.B., M. Frantz, and J. Sheehan. Long-term avian response to forest fragmentation from shale gas development. Northeast Association of Fish and Wildlife Associations annual conference. Portland, ME. 13-15 April 2014.

Wood, P.B., M. Frantz, and J. Sheehan. Long-term avian response to forest fragmentation from shale gas development. Northeast Natural History Conference, Springfield, MA, 7-9 April 2014. [invited]

Wood, P.B. Cerulean warbler and associated avian species response to forest management. Seminar at University of Maine. 11 April 2014. [invited]

Wood, P.B., J.L. Larkin, T.J. Boves, J. Sheehan, D.A. Buehler, A.D. Rodewald, P.D. Keyser, T.B. Wigley, T.A. Beachy, M.H. Bakermans, A. Evans, G.A. George, M.E. McDermott, F. L. Newell, K.A. Perkins, and M. White. Avian diversity in response to forest management for cerulean warblers. The Wildlife Society Annual Conference, Milwaukee, WI. Oct 2013.[invited]

Wood, P.B., J. Sheehan, and L. Farwell. Long-term avian response to forest fragmentation from shale gas development. American Ornithologists Union Annual Conference, Estes Park, CO, 24-27 Sept 2014. [invited]

AWARDS

Stuart Welsh and Patricia Mazik were promoted to adjunct full professor.

MS student Ryan Davis and PhD student Jim Sheehan received awards for their oral presentations at the Student Research & Creative Scholarship Conference for the Davis College of Agriculture, Natural Resources & Design on April 9, 2014. Ryan received first place in the MS category and Jim received third place in PhD category.

PhD students Kyle Aldinger, Laura Farwell, Mack Frantz, and Gretchen Nareff, were awarded travel grants from the WVU Davis College and the Division of Forestry and Natural Resources to attend and present their research results at The Wildlife Society Conference in Pittsburgh, PA. Laura Farwell was awarded an additional travel grant from The Wildlife Society for this conference.

PhD student Mack Frantz was awarded a travel grant from the WVU Stitzel Graduate Student Enhancement Support Fund to attend and present his research results at the annual joint conference of the American Ornithologists Union and Cooper Ornithological Society.

PhD student Mack Frantz was awarded two research grants for his epigenetics study. They were the Eastern Bird Banding Association Memorial Research Grant and one from the First Catholic Slovak Ladies Association.

Research Associate Doug Becker received a competitive travel grant from Kutztown University to present WV Unit research results at The Wildlife Society Conference in Pittsburgh, PA.

PhD student Dustin Smith was awarded the STEM Mountains of Excellence Scholarship from the WVU Office of Graduate Education and Life.