Kentucky Department of Fish and Wildlife Resources

Annual Research Highlights 2016-2017

Volume X, Jan. 2019

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Our Mission:

To conserve and enhance fish and wildlife resources and provide opportunity for hunting, fishing, trapping, boating and other wildlife related activities.

COVER: *American bullfrog / John MacGregor*

Foreword

Bear den research / Kevin Kelly

Research and monitoring are key steps towards conserving and enhancing fish, wildlife, and habitat resources throughout the Commonwealth. To effectively manage a species it is vital to fully understand its ecology and behavior along with its responses to management activities. As stewards of Kentucky's fish and wildlife, it is our job to ensure seasons and bag limits are sustainable and to determine if management actions are achieving desired goals. The following project summaries serve as a testament to KDFWR's vigilance in the conservation of the fish and wildlife resources that we hold in trust for the public. The 2016-2017 KDFWR Research Highlights document represents targeted efforts by KDFWR and partners to fulfill statewide conservation goals.

Funding Sources and Guide to Federal Programs

KDFWR relies on hunting and fishing license fees, boat registration fees, and federal programs to fund the seven divisions within KDFWR. Nearly all of the projects included in this document are partially or fully funded by federal programs including the Wildlife Restoration Act (Pittman-Robertson), the Sport Fish Restoration Program (Dingell-Johnson), the State Wildlife Grant Program (SWG), and the Cooperative Endangered Species Conservation Fund (Section 6).

These federal programs serve a variety of purposes; however, each has an underlying goal of fish, wildlife, and/or habitat conservation. Brief descriptions of each of these programs are as

Federal Funding Source	Program Goal
Wildlife Restoration Act (Pittman-Robertson)	To restore, conserve, manage and enhance wild birds and mammals and their habitats
Sport Fish Restoration Program (Dingell-Johnson)	To fund fishery management projects, boating access, and aquatic education
Cooperative Endangered Species Conservation Fund (Section 6)	To fund conservation projects for candidate, proposed, or listed species
State Wildlife Grant Program (SWG)	To develop and implement programs that benefit wildlife and their habitats; specifically, species and habitats of conservation concern

Raising freshwater mussels at the Center for Mollusk Conservation / Obie Williams

follows:

These federal programs provided approximately 19.9 million dollars to KDFWR in 2017, while the sale of hunting and fishing licenses provided more than 28.5 million dollars- over half of KDFWR's budget (see Figure 1). For reference, we have included the state and federal funding sources for each project; however, these projects may be additionally supplemented by outside funding provided by non-profit organizations or universities. For each project summary, we also identify the specific goals addressed by either Kentucky's Strategic Plan or Kentucky's State Wildlife Action Plan, the two guiding documents for our agency.

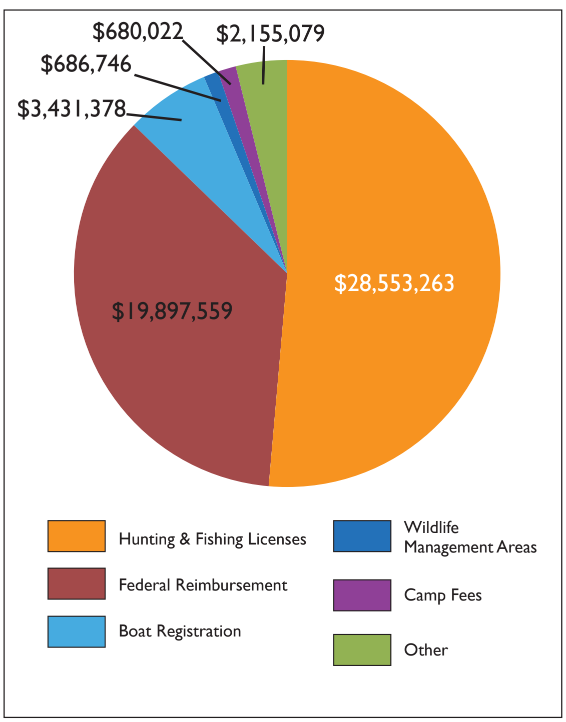

Figure 1. Kentucky Department of Fish and Wildlife Resources Funding Sources 2017. Total revenues for 2017 were $55,404,046.

How to Use This Document

This document is divided into four main sections: published research, completed projects, new projects, and project updates.

Citations for all published research with Kentucky Department of Fish and Wildlife involvement are included in the Table of Contents. For projects that have been completed and not yet published, a detailed summary will be included in the first portion ("completed projects") of the document. For projects that began in 2016-2017, a brief 1-page overview of the project is included in the second portion ("new projects") of the document. A comprehensive project reference guide lists all projects included in Research Highlights documents, beginning with publication year 2007.

Please use the following citation when referencing this document:

Kentucky Department of Fish and Wildlife Resources Annual Research Highlights, 2016-2017. Volume X. Publication of the Wildlife and Fisheries Divisions. January, 2019, 93 pp.

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Published Research

Contact Program Coordinator Laura Burford (laura.burford@ky.gov) for reprints of these publications.

Long, J.M., D. Stewart, J. Shiflet, D. Balsman, and D. Shoup. 2017. Bait type influences on catch and by catch in tandem hoop nets set in reservoirs. Fisheries Research 186(2017)102-108.

Slankard, K. and G. Sprandel. 2017. Monitoring bird response to forest stand improvement on Kentucky Wildlife Management Areas. *The Kentucky Warbler* 93(3):59-69.

Taylor, L., K. Slankard, and P. Hahs. 2017. The recovery and current distribution of nesting ospreys (*Pandion haliaetus*) in Kentucky. *The Kentucky Warbler* 93(4):87-93.

Completed Projects and Monitoring Summaries

Wildlife

Fisheries

New Projects

These projects began in 2016-2017.

Fisheries

Project Updates

This section includes brief updates for selected projects that began prior to 2016-2017.

WILDLIFE

FISHERIES

Osprey with trout / John Williams

Biologists prepare electrofishing equipment for population sampling / Obie Williams

Completed Projects

Winter Distribution of Golden Eagles *(Aquila chrysaetos)* in Kentucky

Loren Taylor and Kate Slankard
Kentucky Department of Fish and Wildlife Resources

Two Golden Eagles visit a camera trap at Bernheim Forest in 2013.

Abstract

The winter distribution and abundance of Golden Eagles in the eastern United States is poorly understood. To address this knowledge gap, we participated in the "Appalachian Eagle Monitoring Program," where we monitored wintering Golden Eagles across Kentucky, utilizing a network of camera traps from 2012-2017. We verified the occurrence of Golden Eagles by reviewing trail camera images and calculated the frequency of Golden Eagle presence and maximum count of individuals for each area. Through this study, we were able to better map the winter distribution of Golden Eagles in Kentucky and suggest areas of importance for the species across the state.

Introduction

The North American Golden Eagle (*Aquila chrysaetos)* population is estimated at 57,000, the bulk of which occurs in the west (Rosenberg et al. 2016). The Golden Eagle population in the western U.S. appears to be declining (USFWS 2016). Less is known about the population in the east. Recent estimates place the eastern Golden Eagle population at 5,000 individuals, although the extent of the species' breeding range in eastern Canada is not well understood, suggesting this number may be an underestimate (Morneau et al. 2015).

Historically, Golden Eagles nested in eastern Canada and the northeastern U.S., but no nesting activity has been confirmed in the eastern U.S. since the 1990s (Morneau et al. 2015). However, the species is a regularly occurring migrant and winter resident across the Appalachian mountain region (Jachowski et al. 2015). Long-term migration counts in the northeastern U.S. indicate a steady increase for Golden Eagles since 1974 (Farmer et al. 2008).

Prior to this study, information on the winter distribution of Golden Eagles in Kentucky was scant. Mengel (1965) considered the Golden Eagle to be a very rare winter resident or vagrant occurring most numerously in the Cumberland Plateau. Since the 1990s, most Annual Midwinter Eagle Surveys have recorded a few Golden Eagles at Bernheim Arboretum and Research Forest in Bullitt County (Heyden 2012, Burford 1999). Palmer-Ball (2003) described the species as an extremely rare to rare transient and winter resident, occurring regularly at the following locations: Ballard Wildlife Management Area (WMA), Land Between the Lakes (LBL) National Recreation Area, and Bernheim Forest. To learn more about the winter distribution of Golden Eagles in Kentucky, in 2012 the Kentucky Department of Fish and Wildlife Resources (KDFWR) began participating in the Appalachian Eagle Monitoring Program (AEMP), coordinated by the Eastern Golden Eagle Working Group (EGEWG). Although the AEMP is a region-wide monitoring program, in this summary we report results for Kentucky only.

Methods

Camera Trapping

Camera trap sites and setup followed the protocol established by the AEMP and outlined in Jachowski et al. (2015). The AEMP is a network of baited "camera traps" distributed

Two Golden Eagles spar over bait at an LBL camera trap in 2015.

across the Appalachian Mountain region. Camera trapping is an efficient, affordable, noninvasive surveying technique that can be implemented in hard-to-access areas across a large spatial scale. Camera traps "captured" Golden Eagles by photographing them while scavenging on bait, thereby documenting their presence at a site (Jachowski et al. 2015).

Telemetry data has shown that the majority of tracked Golden Eagles wintering in the eastern mountains use large blocks of forest or forest edges (Palmer-Ball 2010, Katzner et al. 2012). Therefore, we placed camera traps in small openings within forests or forest edges on public or private lands where volunteers or agency personnel were available to monitor the sites. We prioritized sites with higher elevation and previous records of Golden Eagles. When needed, we obtained state permits to collect road-killed White-tailed Deer (*Odocoileus virginianus*) and Elk (*Cervus canadensis*) carcasses for use as bait. Surveys were conducted November-March and categorized by the calendar year of the latest trap date. We planned to conduct camera trapping for a minimum of two weeks per survey year at each site. However, weather conditions and limited bait availability did not always make this possible. We have included surveys with less than two weeks of data in this paper.

Data Analysis

All camera trap photos (unaltered) were submitted to the KDFWR Wildlife Diversity Avian Monitoring Program. Each image was reviewed, and the number of individual Golden Eagles photographed on each date was recorded for corresponding camera sites. Individuals were differentiated by plumage differences – an approach which may result in a conservative estimate for maximum counts, since individuals of the same age can be difficult to distinguish.

Golden Eagle home ranges are large. Katzner et al. (2012) reported the average home range size of wintering Golden Eagles in the Appalachian region to be 553 km^2. To avoid inflated counts due to the possibility of individual eagles visiting multiple sites in a single day, data from camera sites within 553 km^2 were combined into camera trap "areas". The presence or absence of Golden Eagles each day was recorded and used to determine the frequency of Golden Eagle visitation at camera trap areas (Jachowski et al. 2015). Program R (R Core Team 2017) was used to calculate the frequency of Golden Eagle presence at camera trap areas. Frequency was defined as the percent of survey days with one or more Golden Eagles present. Frequency was calculated for each area annually and overall (all years pooled).

Results

A total of 33 cameras sites were monitored at 14 trap areas throughout the course of this study. The number of areas monitored annually varied from three in 2017 to eleven during 2014. Golden Eagles were not photographed at any point in the study at Clarks River NWR, Begley WMA, or Locust Hill (Table 1, Figure 1). Of the remaining areas, Golden Eagle frequencies demonstrated annual variation within and between trap areas. For instance, annual frequencies at Yellowbank WMA ranged from 0% to 70%; meanwhile, between areas, annual frequencies ranged from 5% (Peabody, 2014) to 81% (Robinson Forest, 2015). Overall frequency (all years pooled) was 32%; sites with Golden Eagles ranged from 4% (Northeast Lakes) to 48% (Bernheim Forest). Yellowbank WMA and Robinson Forest, also had high overall frequencies (43% and 41%, respectively). The most individual Golden Eagles identified at any site in a year was three at Bernheim Forest.

Discussion

The goal of this study was to increase our understanding of the winter distribution of Golden Eagles in Kentucky. We documented Golden Eagles at 11 areas distributed across the state. However, some areas exhibited fluctuating Golden Eagle frequencies between years. A limitation of the AEMP method is that it targets scavenging eagles (Jachowski et al. 2015), and this species is not entirely dependent on scavenging. Thus, factors affecting annual Golden Eagle frequency at particular sites may be complex and likely include competition with other species, weather patterns, and local food limitation (Jachowski et al. 2015). We counted between one and three different individuals at each area annually. Although these counts are conservative, the likely low abundance of this species in our state may lead to fluctuating frequencies due to individual movement patterns. For example, Palmer-Ball (2010) reported a tracked Golden Eagle returning to the same winter home range in Kentucky during 2006-2008; however, the individual did travel outside of this core area, up to 256 km away. In addition, Miller 2016 found that golden eagles spent nearly 50% of their fall migration at stop-overs, feeding, exploring, and waiting for optimal flying conditions. Camera sites with oscillating annual frequencies might have been used as stop-overs during migration, or were perhaps located outside of core winter ranges. Northeastern Lakes area, for example, had no eagles in 2012 and 2014. However, a Golden Eagle did visit the area briefly (4 days) in 2015. Bernheim Forest and LBL, previously known winter hotspots for Golden Eagles, proved to be reliable wintering areas throughout this study, with annual Golden Eagle frequencies ranging from 24% to 73%, and 23% to 63% respectively. However, other areas exhibited high frequencies as well. The Robinson Forest vicinity had the highest annual Golden Eagle frequency recorded for the study with 81% in 2015, and Yellowbank WMA had two of the highest annual frequencies observed: 71% in 2014 and 59% in 2017 (Table 1).

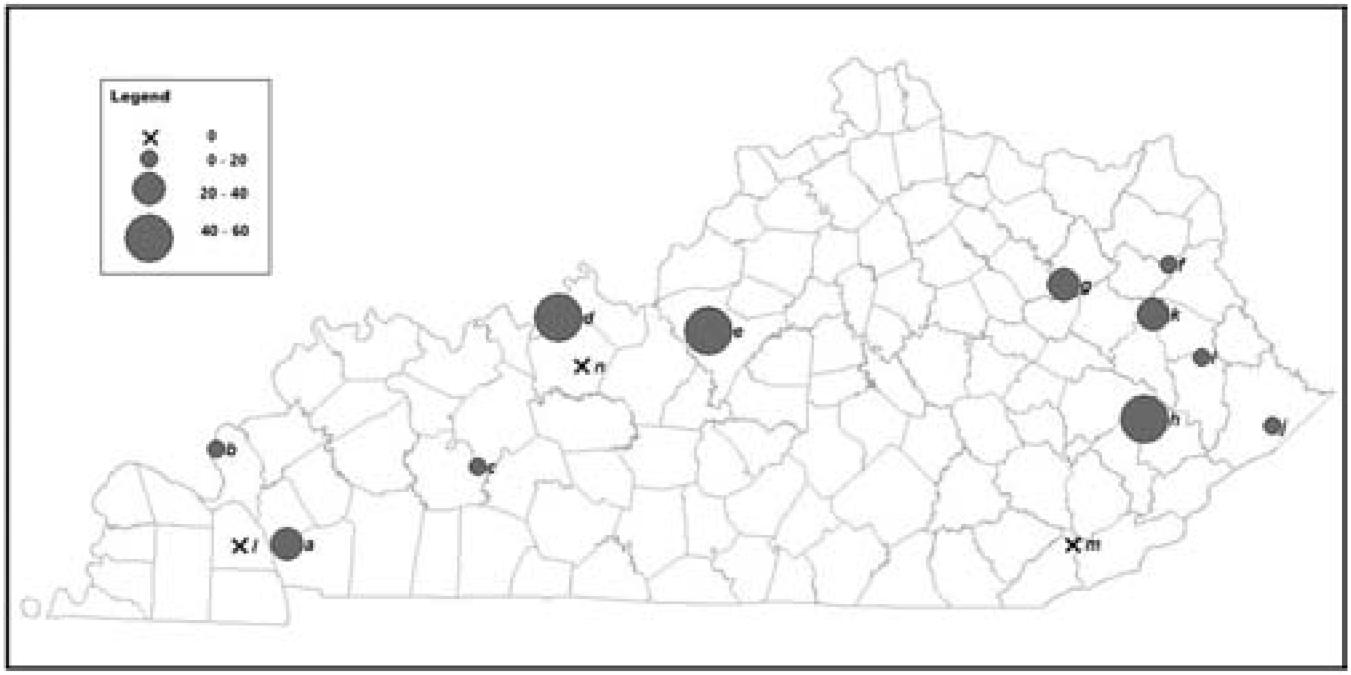
The abundance and quality of bait, as well as the duration and number of years in which it was supplied, may also influence eagle frequencies at a site. Miller et al (2017) suggests that the most important factors driving Golden Eagle ranging behavior is prey availability and updrafts. Baiting a site for a longer period and for multiple years may improve winter survival and increase the chances that individual eagles will return in subsequent years. All five of the areas with overall

Table 1: *Golden Eagle observations at camera trap areas in Kentucky during 2012-2017.*

	2012 12/8/2011-3/12/2012			2013 12/18/2012-3/31/2013			2014 11/21/2013-3/30/2014			2015 11/20/2014-3/11/2015			2016 12/21/2015-3/152016			2017 1/1/2017-3/9/2017			Overall 2012-2017		
Area [# of camera; Counties]	max	days	%	max	days	%	max	days	%	max	days	%	max	days	%	max	days	%	max	days	%
Northeast Lakes (Grayson/ Yatesville) [3; Carter, Lawrence]	0	24	0	1	39	10	0	33	0										1	96	4
Yellowbank WMA vicinity [5; Breckinridge]	0	10	0	2	21	24	2	31	71	0	16	0	2	38	47	2	29	59	2	145	43
Daniel Boone National Forest [2; Bath, Rowan]	1	34	53	1	31	52	0	25	0										1	90	38
Fishtrap WMA [1; Pike]	1	22	18	1	26	15													1	48	17
Bernheim Forest [9; Bullit]	3	95	37	2	103	51	1	95	73	3	95	52	2	38	24	2	68	29	3	494	48
Land Between the Lakes NRA [3; Lyon, Trigg]				1	28	32	1	48	23	2	16	63	2	21	52				2	113	36
Dewey Lake WMA [1, Floyd]							0	17	0	2	15	13							2	32	6
Clarks River NWR [1; Marshall]							0	21	0	0	70	0							0	91	0
Begley WMA [1, Bell]							0	6	0										0	6	0
Smithland [2; Livingston]							1	31	26	0	23	0	1	40	28				1	94	20
Peabody WMA [1; Muhlenberg]							1	38	5										1	38	5
Robinson Forest vicinity [2; Knott]							1	51	25	2	21	81	2	39	41				2	111	41
Paintsville Lake WMA [1; Morgan]													1	21	33	1	57	21	1	78	24
Locust Hill [1; Breckinridge]													0	24	0				0	24	0

max=maximum # of individual eagles; days=days camera trap in operation; %=% of days with a Golden Eagle photographed

Figure 1: Percentage of days with Golden Eagle at camera trap areas during 2012-2017. The size of points is proportional to the overall frequency of Golden Eagle presence at each camera trap area.



a – Land Between the Lakes NRA, b – Smithland, c – Peabody WMA, d – Yellowbank WMA vicinity, e – Bernheim Forest, f – Northeast Lakes (Grayson/Yatesville), g – Daniel Boone National Forest, h – Robinson Forest vicinity, i – Dewey Lake WMA, j – Fishtrap WMA, k – Paintsville Lake WMA, l – Clarks River NWR, m – Begley WMA, n – Locust Hill.

frequencies over 25% were baited and surveyed at least 3 years in a row. Bernheim Forest, for example, had 9 camera sites and a total of 494 days during this study, and consistently had eagles present. While Yellowbank WMA, had two years where no Golden Eagles were documented (2012, 2015). During these two years, the site was only active for 10 days in 2012, and 16 days in 2015. However, in 2013, 2014, 2016, and 2017 this area was baited for longer (21, 31, 38, and 29 days) and higher frequencies were observed for those years (24%, 71%, 47%, and 59%). Hence, surveying for a longer survey window for multiple years may provide a better idea of how many birds visit an area.

Our counts suggest that at least 10 individuals visited our camera sites in 2016; however, we assume this is an underestimate of the birds using the surveyed areas. During photo review, individuals were differentiated by plumage differences, often due to age. (This results in a very prudent estimate for maximum counts, since individuals of the same age can be difficult to distinguish). We also pooled data for sites within 553 km^2 to avoid double-counting birds. Tagging of birds at hotspots may help better estimate abundance and allow for the use of mark-recapture analysis.

We confirmed Golden Eagle presence at all but three survey areas (Begley WMA, Locust Hill and Clarks River NWR). In fact, Bernheim Forest, Yellowbank WMA, and Robinson Forest had Golden Eagles on over 40% of the days surveyed (Figure 1). Thus, although this species seems to occur in low numbers, it also seems to occur widely and regularly. Our results demonstrate that the distribution of this species is more widespread in Kentucky than once thought and that Golden Eagles occur regularly in eastern Kentucky's mountains and in forested regions in the western part of the state.

Prior to this study, little information on the wintering distribution of Golden Eagles in Kentucky existed. Through our efforts, we have begun to fill this knowledge gap and identified important wintering areas for Golden Eagles throughout the state. The confusion of this species with immature bald eagles and other raptors may lead to it being overlooked by many observers. Further exacerbating the paucity of incidental observations, Golden Eagles that occur in Appalachia are often in remote locations where recreational birders rarely visit. Future monitoring might best focus on these remote areas and regions of the state not covered in our effort (northern and south-central Kentucky).

Acknowledgements

This study was conducted in cooperation with the Eastern Golden Eagle Working Group and Appalachian Eagles Monitoring Program (www.appalachianeagles.org). We would like to acknowledge the following agencies and organizations for their contributions to this study: Bernheim Forest Arboretum and Research Forest (BFARF), U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS), U.S. Geological Survey (USGS) and West Virginia University. In addition, we acknowledge the following volunteers and staff for their dedication in operating camera trapping stations: Andrew Berry (BFARF), Elizabeth Raikes (USFS), Scott Simmons (USFWS), Ray Stainfield (Volunteer), and the following KDFWR staff: Dan Crank, Eric Williams, Evan DeHamer, Rick Mauro, Ryan Taylor, Scott Freidhof, and Steve Bonney. We also want to thank Andrew Stump for his assistance with Program R, and the follow KDFWR technicians who reviewed photographs: Ben Bowman, Brehan Furfey, Caleb Switzer, and Michael Arnold.

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Funding Source: *State Wildlife Grants (SWG)*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Summary of West Nile Virus Surveillance in Kentucky Ruffed Grouse

Zak Danks, Kentucky Department of Fish and Wildlife Resources

Grouse on log

Introduction

West Nile virus (WNV) has affected many avian species in North America since its arrival in 1999 and subsequent spread across the continent (LaDeau et al. 2007, George et al. 2015). Naugle et al. (2004, 2005) and Clark et al. (2006) identified WNV as a significant cause of mortality in greater sage-grouse (*Centrocercus urophasianus*) in the western U.S. More recently, Nemeth et al. (2017) found WNV to be lethal to experimentally infected ruffed grouse (*Bonasa umbellus*) chicks.

The possibility of a population-level impact from WNV on ruffed grouse is disconcerting to wildlife managers, particularly in the Appalachian Mountains states where grouse populations have shown persistent, long-term declines (L. Williams, Pennsylvania Game Commission, unpublished data). Grouse declines in the region are related to landscape-scale habitat loss due to forest maturation (Porter and Jarzyna 2013, Stauffer et al. 2017, Dessacker et al. 2006). Forest inventory data for eastern Kentucky counties where grouse occur show significant loss of young forest growth stages that constitute habitat for ruffed grouse since the 1970s (Danks 2017). Based on an analysis of grouse population data, forest inventory data, and WNV data in Pennsylvania, Stauffer et al. (2017) suggested that while habitat loss was the primary driver of grouse population decline, WNV has been an additional factor.

Data on WNV in KY are limited. From 2002-2008, the Kentucky Departments of Public Health and Agriculture conducted WNV surveillance for WNV activity in humans, birds, horses, and mosquitos (KDPH 2018). In 2002, 85% of counties in eastern Kentucky had WNV-positive samples from those species, yet WNV activity appeared to decline considerably in subsequent years (Table 1, Figure 1). The lack of WNV data for the past 11 years complicates our ability to relate grouse population trends with this disease. However, grouse declined markedly during the years for which WNV data are available (2002-2008; Figure 2) and at a steeper rate after 1999 compared to preceding years (Figure 3). Still, caution is warranted in interpreting potential linkages between grouse decline and WNV because spatial and temporal limitations inherent in flush rate, FIA, and WNV data may not permit valid comparison.

The Pennsylvania Game Commission (PGC) began a WNV surveillance effort in 2015 in which

Year	Grouse Hunter Flush Rate (Nov-Feb)	# WNV-Positive Birds (# above bar is % of all bird submissions that year)	% WNV-Positive Bird Samples (# Positives / # Total Submissions That Year)	# Grouse Counties with WNV-Positive Bird Samples	% of 53 Grouse Hunt Zone Counties with WNV-Positive Bird Samples	# Grouse Counties with WNV-Positive Samples, All Species*	% of 53 Grouse Hunt Zone Counties with WNV-Positive Samples, All Species*
2002	0.76	693	26%	38	72%	45	85%
2003	0.91	111	19%	15	28%	23	43%
2004	1.00	22	8%	2	4%	5	9%
2005	0.78	2	4%	1	2%	4	8%
2006	0.71	7	NA	0	0%	0	0%
2007	0.48	6	NA	0	0%	2	4%
2008	0.66	2	NA	0	0%	1	2%

Table 1. *Ruffed grouse population trend and West Nile Virus (WNV) activity in Kentucky, 2002-2008. Grouse trend is a population index calculated as the number of grouse flushed per hour by hunters during the grouse hunting season, Nov-Feb, in 53 eastern counties. Data compiled from Kentucky Department of Public Health reports posted online.*All species = human, horse, bird (many species), and mosquito samples testing positive for WNV.*

blood serum samples from hunter-harvested ruffed grouse were tested for WNV antibodies (Brown et al. 2016). WNV sero-prevalence in their samples ranged from 7% to 29% across the state (L. Williams, cited in Stauffer et al. 2017). For the 2016-2017 grouse hunting season, the Kentucky Department of Fish and Wildlife Resources (KDFWR) and the Virginia Department of Game and Inland Fisheries (VDGIF) adopted PA's survey methodology in their respective states to permit comparison of results over time. Both KY and VA continued the survey during the 2017-18 hunting season. Beginning with the 2018-19 hunting season, Michigan, Minnesota, and Wisconsin began a collaborative study using similar methods to investigate WNV prevalence in the core portion of the ruffed grouse's distribution.

Methods

For the KY survey, in both 2016 and 2017 we mailed WNV sampling packets (n = 170) to current and past hunters who participated in the KDFWR's annual small game survey and opportunistically to other hunters. Packets contained a Nobuto filter paper strip, plastic 15-ml vial, self-addressed return envelope, and instructions for collecting samples of blood for serum testing and specific body and primary wing feathers for sexing and aging of samples (Figure 6). Our goal was to test blood serum samples from both sexes and age classes (adult and juvenile) for WNV antibodies. The U. S. Geological Survey's Wildlife Health Center in Madison, WI, tested serum samples *pro bono* from both Kentucky and Virginia. Without this voluntary assistance,

	2016-17	2017-18
n total	29	9
n adult	21	6
n juvenile	7	1
unk age	1	2
n female	10	3
n male	18	5
unk sex	1	1
n counties	9	5
n (%) WNV positives	1 (3%)	2 (22%)

Table 1. *Results of West Nile virus sampling of hunter-harvested ruffed grouse in Kentucky, 2016-2018.*

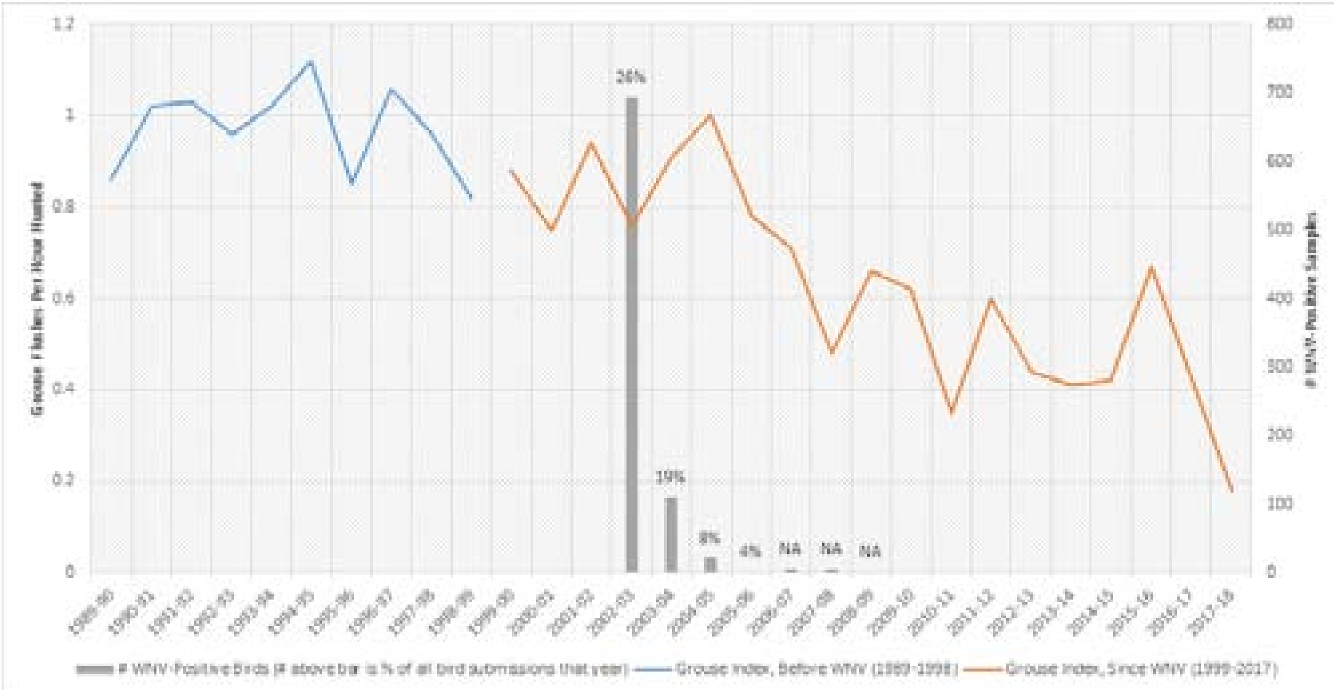

Figure 1. Long-term ruffed grouse population index and West Nile virus (WNV) activity in Kentucky, 1989-2017. Break in grouse index denotes periods before and after WNV detection in North America in 1999. Grouse index is grouse flushes per hour by hunters during the Nov-Feb hunting season (open in 53 counties). West Nile virus data compiled from reports posted online by the Kentucky Department of Public Health; shown are number and percentage of bird samples testing positive for WNV. Total number of bird samples not available (reported) for 2005-2008, so percentage could not be determined, but positive samples <10 in those years.

KDFWR could not have covered costs of testing.

Results

Following the 2016-2017 hunting season, KY received 29 blood samples of ruffed grouse harvested in 9 counties in eastern Kentucky (Figure 4). All but two samples included feathers that permitted aging and sexing of samples (Table 3, Figure 8). Only one sample (3%) tested positive for WNV antibodies; this was an adult male grouse harvested in Estill County, KY. Interestingly, only 3% of Virginia's ~40 samples tested positive.

Following the 2017-2018 hunting season, we received 9 blood samples from 5 counties (Figure 4). Of the 9, 2 samples were confirmed positive for WNV antibodies (22%). Two additional samples showed equivocal and suspected positive results, respectively. The majority of samples received in both years were from adult grouse.

Discussion

Interpretation of our results is difficult given uncertainty about WNV prevalence and dynamics across Kentucky and over multiple years, and due to only 2 years of data so far. Our low sero-prevalence in 2016-17 (3%) may indicate low prevalence of WNV that year, and thus, that low exposure to the disease produced little impact on grouse populations. Conversely, such a low sero-prevalence in hunter-harvested grouse may indicate high activity of WNV, meaning that high exposure to the disease lead to greater grouse mortality (i.e, that very few grouse survived to be harvested during the hunting season).

Pennsylvania data, while limited to just 2 years, support the latter theory (L. Williams, PA Game Commission, unpublished data). Sero-prevalence in their hunter-harvested grouse samples was 14% in 2015-16 and 24% in 2016-17. A WNV Vector Index, calculated from mosquito abundance and WNV infection rate in mosquito samples, dropped by 42% from summer 2015 to summer 2016. So, assuming sero-prevalence indicates grouse survivorship from WNV and their Vector Index indicates WNV activity, these data indicate higher grouse survival when WNV activity is lower. Also, PA samples show higher WNV sero-prevalence in areas of the state characterized by high-quality, abundant habitat (northwest and northcentral regions vs. southern tier). This could indicate a potential link between habitat quality and quantity with grouse surviving WNV (L. Williams, Pennsylvania Game Commission grouse biologist, personal communication). Based on FIA data, which indicate a relative lack of young forest in eastern Kentucky compared to past years and northern regions of grouse range, and our low sero-prevalence of WNV in grouse, habitat may hinder survival from WNV in KY's grouse population.

Counter to the above logic, our data showed higher WNV sero-prevalence (22%) during year 2 of our surveillance (2017-18), which had lower flush rates (0.18 flushes/hour) compared to year 1 (2016-17) when WNV sero-prevalence was lower (3%) and flush rate was higher (0.43 flushes/hour). However, with such a low sample size (n=9) our results may not have reflected actual conditions. Larger sample sizes are needed to infer potential grouse survival from WNV and how that may differ across eastern KY grouse range, such across elevation gradients (e.g., Cumberland Plateau vs. Mountains).

Interestingly, in 6 of 7 Appalachian states for which data are available flush rate dropped noticeably from 2016-17 to 2017-18 seasons. This could indicate that factors detrimental to grouse reproductive success were operating in a fairly consistent fashion among states. WNV activity in PA was severe in summer 2017 (L. Williams, PA Game Commission, personal communication). Whether last season's drop among several states was a product of similar weather conditions, or whether disease conditions is unknown at present. Synchrony in weather conditions across townships has been demonstrated in wild turkey populations (Fleming and Porter 2007), and conceivably could affect ruffed grouse in a similar manner.

Notably, the majority of samples received in both years were from adult grouse. The reproductive capacity of grouse in the Appalachians is known to be lower than in the core of the species' distribution (Devers et al. 2007). Thus, having mostly adult birds is unsurprising. The extent to which this apparent lack of juveniles in the grouse population (i.e., low juvenile:adult ratio) may indicate reproductive impacts from WNV versus other known impacts (e.g., weather, predation) is unknown. However, the potential for additive mortality to grouse chicks is, again, worrisome for grouse abundance and even population persistence.

Despite the potential influence of WNV on grouse populations, improvement of forest habitat and adjustments to hunting-season length are the only factors wildlife managers can control. KDFWR is implementing a strategic plan that focuses primarily on increasing the quality and quantity of ruffed grouse habitat across Kentucky

Figure 2. Ruffed grouse population index and West Nile virus (WNV) activity in Kentucky, 2002-2008. Grouse index is grouse flushes per hour by hunters during the Nov-Feb hunting season (open in 53 counties). West Nile virus data compiled from reports posted online by the Kentucky Department of Public Health. Shown are number of counties with samples (human, horse, bird, or mosquito) testing positive for WNV. WNV data limited to years presented.

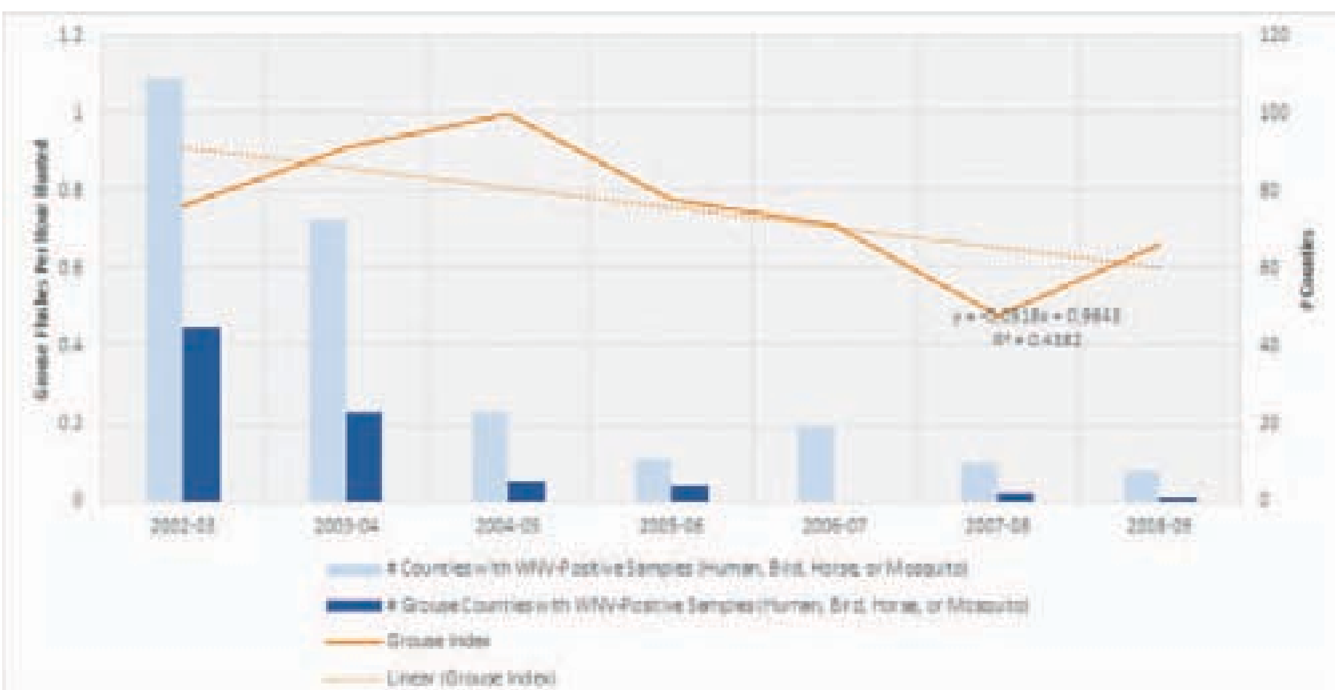

Figure 3. Ruffed grouse population index trends before (1989-1998) and after (since 1999) arrival of West Nile virus (WNV) in North America. Grouse index is grouse flushes per hour by hunters during the Nov-Feb hunting season (open in 53 counties). Steeper negative trend in the grouse index post-WNV indicates a potential population-level effect of disease.

(Danks 2017). Hunting pressure is considered too low to be of influence (Devers et al. 2007), evidenced by low participation in grouse hunting. Nevertheless, continued surveillance of WNV in Kentucky grouse will be important for assessing success of habitat efforts relative to what possibly is an emergent disease influence. Thus, we propose to continue collaboration with other state wildlife agencies and wildlife health professionals on WNV sero-surveillance.

We lack knowledge of WNV activity in forested ruffed grouse habitat compared to human environments, including presence and abundance of mosquitos capable of transmitting WNV (e.g., *Culex* spp.). In summer 2017, we partnered with the Kentucky Department of Public Health to collect mosquito samples in two locations in southeastern and northeastern Kentucky, neither of which yielded WNV positives. We were not able to repeat this sampling in summer 2018 but hope to restart this effort in coming years to improve knowledge about potential impacts to grouse from WNV. KDFWR collaboration on inter- and intra-state WNV surveillance addresses strategic plan objectives of monitoring grouse population health and forming partnerships to combat grouse decline (Danks 2017).

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The KDFWR Grouse Program thanks the many dedicated ruffed grouse hunters who submitted blood and feather samples for testing, wildlife veterinarian Dr. Iga Stasiak for assistance with planning and implementation, Lisa Williams and Gary Norman of the Pennsylvania Game Commission and Virginia Department of Game and Inland Fisheries, respectively, for cross-state collaboration, and the U.S. Geological Survey National Wildlife Health Center for processing samples.

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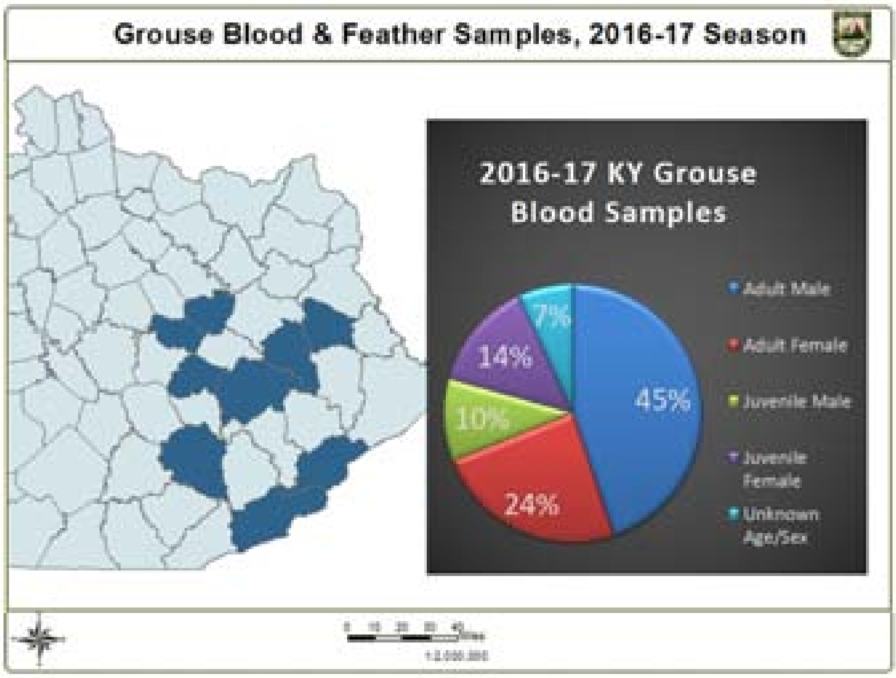

Figure 4. Results of a West Nile virus surveillance effort in Kentucky during the 2016-17 hunting season.

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KDFWR Strategic Plan. Goal 1. Strategic Objective 5

Monitoring Songbird Response to Forest Stand Improvement On Kentucky Wildlife Management Areas

Kate Slankard and Gary Sprandel KDFWR

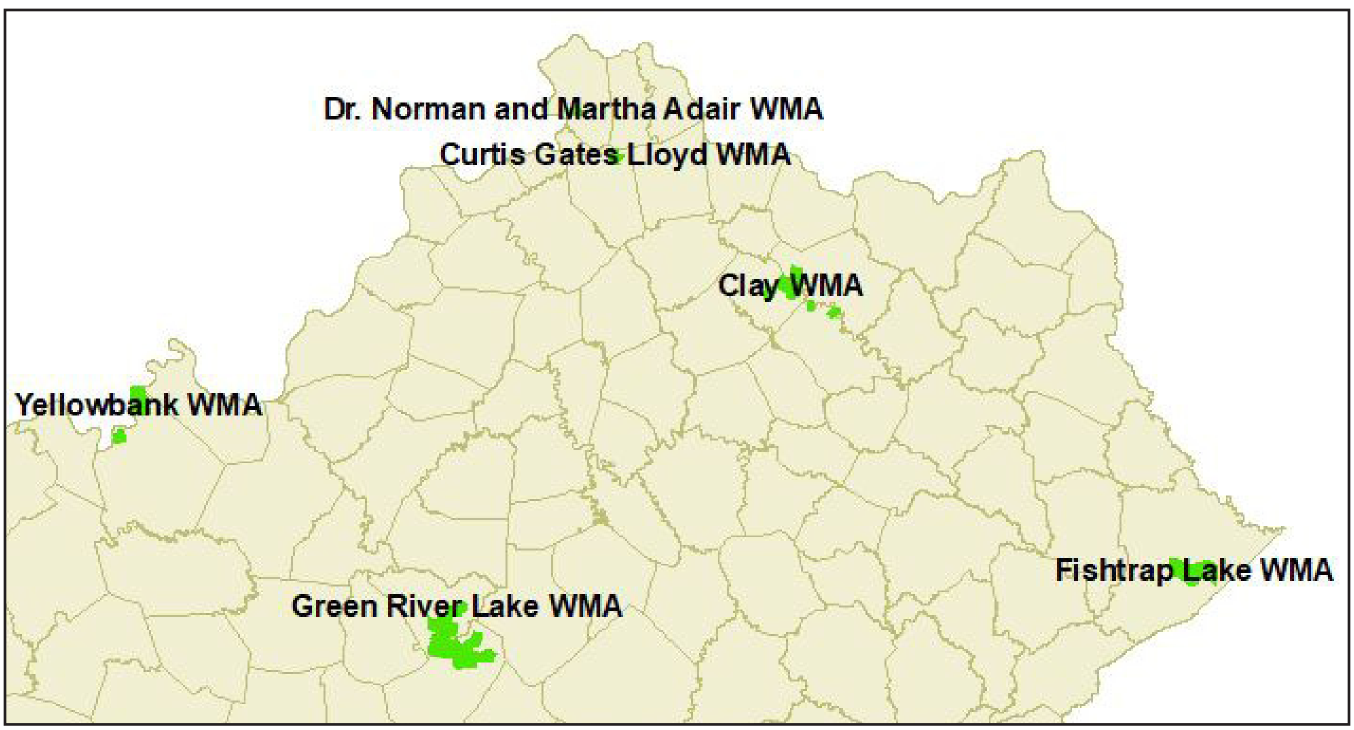
Introduction

In 2009, the Kentucky Department of Fish and Wildlife Resources (KDFWR) created an internal initiative to increase forest management on Wildlife Management Areas (WMAs). Soon after, WMA managers drafted and began implementation of forest plans that encouraged historical conditions, focusing on the restoration of oak-hickory dominant forests. Most areas accomplished forest stand improvement (FSI) without the involvement of commercial timber sales, and overall treatments were fairly conservative when it came to timber removal. Nonetheless, KDFWR's Avian Monitoring Program initiated point count surveys on several Kentucky WMAs in order to investigate songbird response to FSI. The objectives of this project were to estimate abundance of priority songbird species on WMAs and to compare songbird abundance before and after localized management for FSI. In this summary, we present the results from six WMAs at which FSI occurred during 2010-2014.

Methods

The Central Hardwoods Joint Venture (CHJV) developed the point count methodology used for this project in 2009 (Tirpak et al. 2009). Selected Kentucky WMAs, which were slated for FSI, were surveyed for the project and the same survey transects were surveyed for songbirds before and after forest treatments. WMA managers provided GIS layers for planned FSI. Random grids of potential survey points (250 m apart) were generated for each potential treatment area and points that fell within planned treatment units were selected for survey transects. Survey transects consisted of 10-12 points that one observer could walk to in a single morning.

Surveys were conducted between 15 May and 15 June to target breeding songbirds when they are most vocal. Most surveys were conducted annually between 2009 and 2016, in order to collect 2-3 years of data prior to treatment and 2-3 years of data post-treatment. Surveys commenced just before local sunrise and ended no later than 10:00 AM. Most transects were surveyed by the same observer



WMAs where FSI songbird surveys occurred during 2009-2016.

each year; however, several different observers conducted transects throughout the state.

Surveys focused on 30 priority songbirds, including 13 Species of Greatest Conservation Need (SGCN), listed in Kentucky's State Wildlife Action Plan (KDFWR 2013). Observers recorded the first observation of each bird at each point within the 5-minute survey period. Time interval and distance from the observer (in distance bands) was recorded along with each detection. Habitat and weather measurements were also collected at each point count location (Husch et al. 2003).

WMA managers tracked implementation of forest plans via GIS and provided feedback on progress, timing and location of treatments. Practices varied from thinning and girdling to invasive species removal and treatments generally spanned 60-250 acres. Treatments did not occur during the songbird survey season.

We used the program, *AbundanceR* to calculate species relative abundance, with confidence intervals (Mordecai 2012). This program accounts for detection probability using time-removal methods (Alldredge et al. 2007). Each survey date was classified as "before" or "after" management, and data from all years before and after treatment were pooled for comparisons. Confidence intervals (95% and 90%) were used to determine significant differences in abundance before and after treatments. Unless notable, we do not report results for species which did not demonstrate a change in abundance in the pre/post-treatment analysis.

Results

Dr. Norman and Martha Adair WMA

Management Practices: Oak-hickory restoration. Thinning and girdling of non-desirable species (maple and ash).

Bird Response: Kentucky Warbler showed a significant increase in abundance after management (pre-treatment = 0.30 birds/survey; post-treatment = 0.68 birds/survey; *P* = 0.05). The data suggested a higher abundance post-treatment for Great Crested Flycatcher, but this difference was not significant (pre-treatment = 0.14 birds/survey; post-treatment = 0.34 birds/survey; *P* = 0.10).

Clay WMA

Management Practices: Open woodland restoration. Removal of eastern red cedar.

Bird Response: Management resulted in a significant increase in Prairie Warbler abundance (pre-treatment = 0.05 birds/survey; post-treatment = 0.41 birds/survey; *P* = 0.05). Great Crested Flycatchers also exhibited a probable increase to treatment (pre-treatment = 0.05 birds/survey; post-treatment = 0.21 birds/survey; *P* = 0.10).

Fishtrap Lake WMA

Management Practices: Invasive species removal. Treatment of Japanese knotweed, formerly the dominant understory plant.

Bird Response: Post-management surveys suggested a higher abundance for Acadian Flycatcher (pre-treatment = 0.59 birds/survey; post-treatment = 0.98 birds/survey; *P* = 0.10) and Pileated Woodpecker (pre-treatment = 0.20 birds/survey; post-treatment = 0.48 birds/survey; *P* = 0.10), but these differences were not significant. On the contrary, a lower post-treatment abundance was suggested, but not significant for Northern Parula (pre-treatment = 0.29 birds/survey; post-treatment = 0.13 birds/survey; *P* = 0.10) and White-eyed Vireo (pre-treatment = 0.29 birds/survey; post-treatment = 0.15 birds/survey; *P* = 0.10).

Green River Lake WMA- Casey Creek Transect

Management Practices: Oak-hickory restoration and midstory removal.

Bird Response: Post-treatment surveys suggested a higher abundance in Northern Parula than pre-treatment, but this difference was not significant (pre-treatment = 0.10 birds/survey; post-treatment = 0.26 birds/survey; *P* = 0.10). However, abundance for White-

Focal Species
Acadian Flycatcher*
Bell's Vireo*
Black-throated Green Warbler*
Black-&-white Warbler
Blue-gray Gnatcatcher
Blue-winged Warbler*
Brown Thrasher
Carolina Chickadee
Cerulean Warbler*
Eastern Wood-Pewee
Field Sparrow
Great Crested Flycatcher
Hooded Warbler
Kentucky Warbler*
Louisiana Waterthrush*
Northern Bobwhite*
Northern Parula
Orchard Oriole
Pileated Woodpecker
Prairie Warbler*
Prothonotary Warbler*
Red-headed Woodpecker*
White-eyed Vireo
Wood Thrush*
Worm-eating Warbler*
Yellow-breasted Chat
Yellow-throated Vireo

*SGCN

eyed Vireo was significantly lower post-treatment (pre-treatment = 0.77 birds/survey; post-treatment = 0.41 birds/survey; $P = 0.05$).

Green River Lake WMA- Green River Lake Transect

Management Practices: Oak-hickory restoration. Heavy thinning (midstory removal), invasive species removal, oak planting, and alder rejuvenation (thinning thick stands of alder).

Bird Response: More species demonstrated response to management at this site than any others. Post-treatment surveys measured a significantly higher abundance in Northern Parula (pre-treatment = 0.17 birds/survey; post-treatment = 0.33 birds/survey; $P = 0.05$) and Yellow-breasted Chat (pre-treatment = 0.68 birds/survey; post-treatment = 1.04 birds/survey; $P = 0.05$) than pre-treatment surveys. The data also suggested a higher post-treatment abundance for Blue-gray Gnatcatcher (pre-treatment = 0.56 birds/survey; post-treatment = 0.73 birds/survey; $P = 0.10$). Conversely, abundance for Acadian Flycatcher (pre-treatment = 0.64 birds/survey; post-treatment = 0.34 birds/survey; $P = 0.05$), Yellow-throated Vireo (pre-treatment = 0.26 birds/survey; post-treatment = 0.14 birds/survey; $P = 0.05$), White-eyed Vireo (pre-treatment = 0.91 birds/survey; post-treatment = 0.75 birds/survey; $P = 0.05$) and were significantly lower post-treatment.

Curtis Gates Lloyd WMA

Management Practices: Edge feathering and invasive species (honeysuckle) removal.

Bird Response: The abundance of Acadian Flycatchers (pre-treatment = 0.30 birds/survey; post-treatment = 0.84 birds/survey; $P = 0.05$) and Northern Parulas (pre-treatment = 0.04 birds/survey; post-treatment = 0.30 birds/survey; $P = 0.05$) was significantly higher post-treatment, than pre-treatment. The data suggested a higher abundance of Eastern Wood-Pewee post- treatment, but these findings were not significant (pre-treatment = 0.26 birds/survey; post-treatment = 0.62 birds/survey; $P = 0.10$).

Yellowbank WMA

Management Practices: Oak-hickory restoration, including girdling of non-desirable species.

Bird Response: Post-treatment surveys documented a significantly higher abundance of Blue-gray Gnatcatcher (pre-treatment = 1.77 birds/survey; post-treatment = 2.56 birds/survey; $P = 0.05$), Northern Parula (pre-treatment = 0.49 birds/survey; post-treatment = 0.82 birds/survey; $P = 0.05$), and Wood Thrush (pre-treatment = 1.20 birds/survey; post-treatment = 1.54 birds/survey; $P = 0.05$) than pre-treatment surveys.

Discussion

Although forest treatments for this project were generally conservative and basal area was often not drastically reduced, at least a few changes in focal species abundance were observed at each managed area. Increases and decreases in some of the focal species were expected. For instance, a relatively aggressive reduction in basal area at Adair WMA resulted in an anticipated significant increase in Kentucky Warbler. Similarly, thinning and restoration of open woodland conditions at Clay WMA resulted in a significant increase in Prairie Warbler. Conversely, some unanticipated changes in abundance were observed for the mature forest species, Northern Parula, which increased in abundance at most areas with FSI. In addition, the positive response of Acadian Flycatcher at Lloyd WMA and Fishtrap Lake WMA, in both cases after the removal of invasive species, was not only consistent with other studies (Bakermans et al. 2006), but confirms that this management tactic should be a priority for this SGCN in Kentucky.

Habitat change inevitably results in tradeoffs in songbird species composition, with a decrease in species that preferred pre-treatment habitat conditions. Forest treatments in our case were implemented in hopes to restore historical forest conditions (oak and hickory dominant forests) and benefit SGCN. Several treatments resulted in a decrease in White-eyed Vireos. This was not surprising as many treatments involved reducing the midstory and understory, which is crucial for this species. Although this species is not a SGCN, at first glance, this may seem concerning. However, this species has been found to have a positive trend of 2.33% (95% CI 0.05, 4.20), with high credibility in 2003-2013 Kentucky Breeding Bird Survey data (Sauer et al. 2014). Recognizing that we cannot benefit all species with a single practice, in general, forest treatments resulted in significant increases in SGCN including Kentucky Warbler, Prairie Warbler, Wood Thrush and Acadian Flycatcher (increased at two sites, declined at one site).

The survey period for this project was rather short, in terms of forest change. It may be worthwhile to repeat surveys, for a 2-3 year sampling period, 10-15 years post-treatment to evaluate long-term effects on bird communities and vegetation composition. This project also encompassed a relatively small portion of FSI practices and as the opportunity arises to evaluate additional practices or replicate the aforementioned practices in other areas of the state, additional bird monitoring will lead to a better understanding of the effects of FSI on SGCN.

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Funding Source: *State Wildlife Grants (SWG)*

KDFWR Strategic Plan: Goal 1. Strategic Objective 5.

Survey and Assessment of the Fish Fauna of the Clarks River National Wildlife Refuge in Marshall, McCracken, and Graves Counties, Kentucky

Matthew Thomas and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources

Introduction

The lower Tennessee River basin is one of the most biologically diverse river systems in the U.S., with nearly 200 species of fish, 75 freshwater mussels, 50 aquatic snails, and 20 crayfish (Woodside et al. 2004). The Clarks River, a major tributary system in the lower Tennessee River basin, occupies nearly a quarter of the Jackson Purchase Region in western Kentucky. It is a low-gradient system consisting of two major forks that meander through a broad floodplain containing areas of contiguous bottomland hardwood forest, wetland complexes, overflow ponds, and meander cut-offs formed by the Clarks River. These natural palustrine systems provide excellent fish and wildlife habitat for both game and non-game species. Because of the significant resource value of this area, the U.S. Fish and Wildlife Service (USFWS) established the Clarks River National Wildlife Refuge (NWR) in 1997. The approximately 9,000 acre refuge is located in portions of Marshall, McCracken, and Graves counties. In addition to the land acquired in 1997, the USFWS has proposed an expansion area that includes 40 river miles and adds approximately 34,000 acres to the existing acquisition boundary. A comprehensive conservation and land protection plan for the Clarks River NWR was completed in 2012 (U.S. Fish and Wildlife Service 2012).

The fish fauna of the Clarks River drainage was poorly known prior to a survey by Sisk (1969) who documented 61 species from the drainage. Kuhajda and Warren (1985) conducted an extensive review of published and unpublished collection records made prior to and subsequent to Sisk's (1969) survey, including additional collections made personally, which resulted in 87 total species for the Clarks River drainage. In their review of collection records for the Distributional Atlas of Kentucky Fishes, Burr and Warren (1986) confirmed reports of at least 79 species of fish from the Clarks River drainage based on voucher specimens maintained in various museum collections and unquestionable literature records.

Although most of the Clarks River fish fauna is extant, 15 species are considered species of greatest conservation need (Kentucky's Wildlife Conservation Strategy 2013; Kentucky State Nature Preserves Commission 2012). These species include Chestnut Lamprey (*Ichthyomyzon castaneus*), Southern Brook Lamprey (*Ichthyomyzon gagei*), Paddlefish (*Polyodon spathula*), American Eel (*Anguilla rostrata*), Cypress Minnow (*Hybognathus hayi*), Pallid Shiner (*Hybopsis amnis*), Taillight Shiner (*Notropis maculatus*), Black Buffalo (*Ictiobus niger*), Chain Pickerel (*Esox niger*), Central Mudminnow (*Umbra limi*), Mississippi Silverside (*Menidia audens*), Dollar Sunfish (*Lepomis marginatus*), Goldstripe Darter (*Etheostoma parvipinne*), and Cypress Darter (*Etheostoma proeliare*). The Alligator Gar (*Atractoseus spatula*), a species once native to big river floodplain habitats in the Jackson Purchase, has been introduced in the lower mainstem Clarks River by the Kentucky Department of Fish and Wildlife Resources since 2009.

Since 1986, numerous fish collections have been made in the Clarks River drainage by various state and federal natural resource agencies and universities. In 2000 and 2002, a fish survey was conducted within the Clarks River NWR in conjunction with an environmental contaminants investigation (Alexander 2005). A large volume of data collected during the past three decades, including Alexander's (2005) work, has not been reviewed and compiled to produce an accurate, up-to-date list of fishes currently existing in the Clarks River drainage.

The objectives of this project are: 1) compile and verify existing fish collection data on the Clarks River drainage from all available sources; 2) conduct fish surveys to determine species composition, abundance, and distributions at sites sampled during 2000-2002 and assess changes to the fauna during the past 15 years; 3) further expand the area sampled in 2000-2002 to cover any unique or significant habitats and associated species potentially missed or not present during the previous survey; 4) establish a credible species list, expand upon the current data set, and provide recommendations for future monitoring of the fish community within the Clarks River NWR; and 5) assess fish community structure, habitat conditions, and status of species of greatest conservation need.

Methods

Study Area

The focal area of our survey is

the Clarks River NWR, including riverine, tributary, and wetland habitats within the existing refuge and expansion area (**Figure 1**). This area includes a 40-mile section of the Clarks River from KY 3075 (Sheehan Bridge), McCracken County, upstream to Hardin, Marshall County. It also includes an 18-mile section of the West Fork Clarks River from its mouth near Oaks, McCracken County, upstream to the Purchase Parkway, Graves County. Kaler Bottoms Wildlife Management area, a 1,832 acre tract containing wetland and cypress swamp habitat is also located within this section of the refuge expansion area.

Data Acquisition and Field Methods

To assess prior fish sampling effort within the Clarks River drainage, we obtained fish collection data from the Kentucky Fish and Wildlife Information System (KFWIS), Ecological Data Application System (EDAS), and online searchable natural history museum databases. Fish sampling sites were chosen within the study area based, in part, on refuge-specific fish collection records by Alexander (2005). Additional sites were chosen arbitrarily based on accessibility, stream or water body size, location in the drainage, and proximity to one another.

Field sampling was conducted during August and September 2015, and in June 2016. Fish collection methods were selected to capture the greatest number of species in all representative habitat types within the study area. Small to large wadeable stream habitats, including sites sampled by Alexander (2005), were sampled following protocols established by KY Division of Water (KDOW 2002). Fishes were collected using a backpack electrofisher, dip nets, and 6’ X 10’ or 6’ X 15’ (1/8” mesh) seines. At each stream site, all habitats within a 100-200m reach were worked thoroughly to ensure a representative sample.

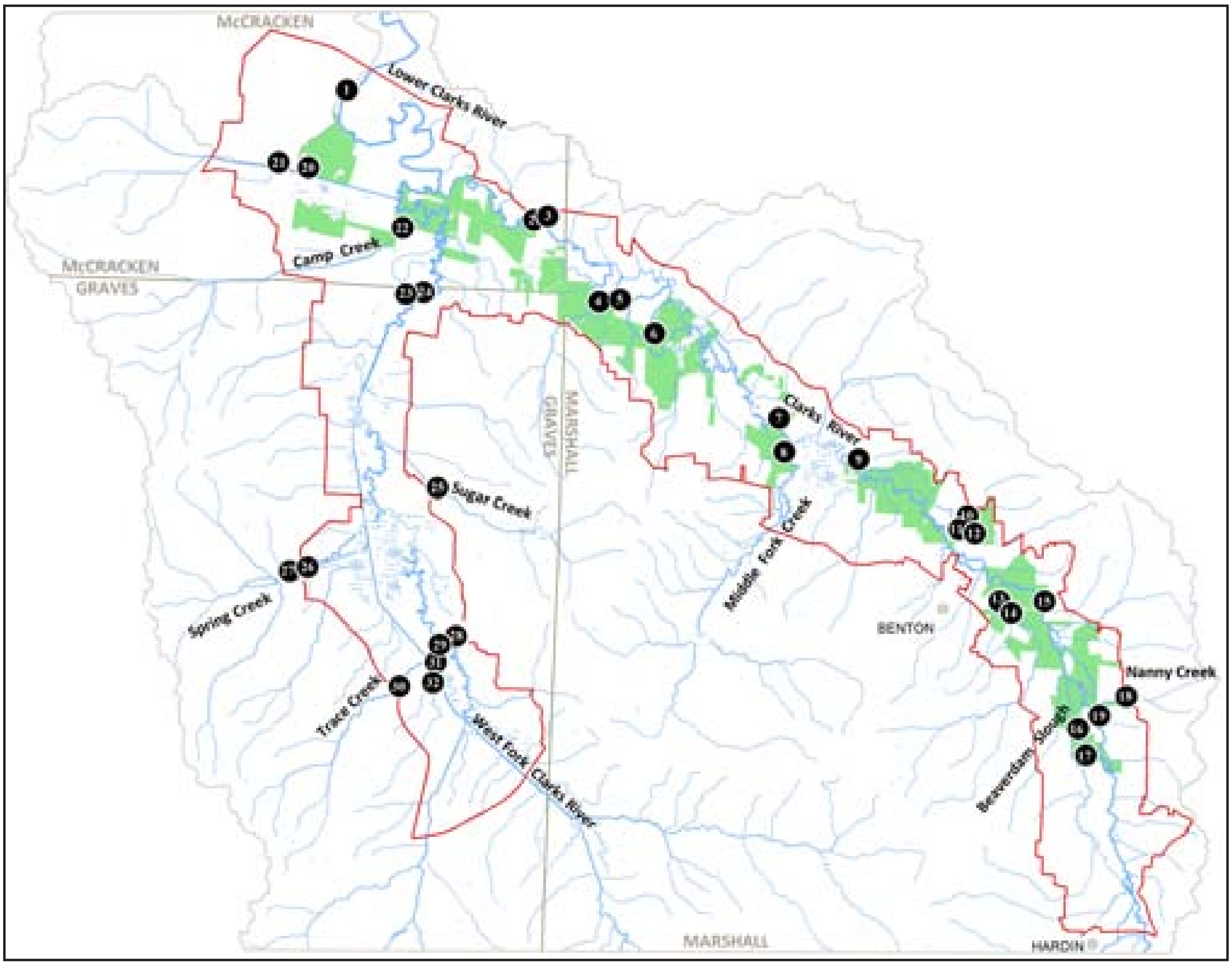

Figure 1. Sites sampled for fishes in the Clarks River drainage within or near the refuge (light green) and expansion area (red line) during 2015-2016.

Electrofishing was performed for 500-2000 seconds, depending on the size of the stream or water body and available habitat. In larger streams, sloughs, ponds, and wetlands, electrofishing was followed by 10-20 seine hauls/sets to effectively work the same area and available habitat. Deep channel and pooled sections of the lower mainstem Clarks River (site 1) and the pond behind the Clarks River NWR headquarters (site 11) were sampled using boat electrofishing. Fish community health at three sites sampled during September-October 2000 by Alexander (2005) was evaluated using the Kentucky Index of Biotic Integrity (KIBI; Compton et al. 2003).

Most fish captured were identified on site, enumerated, photo-vouchered, and released. A limited number of representative specimens were retained as vouchers that were fixed in 10% formalin, and then transferred to 70% ethanol. These specimens were deposited in the David H. Snyder Museum of Zoology at Austin Peay State University and at KDFWR. For each rare or exotic species collected, gender (when possible), total lengths (when >20 individuals), and habitat conditions were recorded. Digital photographs were also taken to document species and habitats at all sample sites.

Data Source	Records	Years	Vouchers
KYTC DEA stream surveys	70	1980-1982	unknown
EDAS (KDOW, KDFWR, USFWS, Murray St. Univ.)	894	1988-2012	unknown
KDFWR stream surveys	461	1980-1986	unknown
KSNPC (multiple sources)	27	1965-2007	unknown
Scientific collection permit (multiple sources)	440	2004-2014	unknown
SIUC database (SIUC, INHS, MOSU, UMMZ)	873	1942-2005	all vouchered
VertNet (UAIC, CUMV, KU, NCSM, TU, YPM)	191	1953-2010	all vouchered
UTK David A. Etnier Ichthyological Collection	72	1978-2010	all vouchered

Table 1. *Fish collection records by source compiled and reviewed to produce the list in Table 2. Data sources: KY Transportation Cabinent Division of Environmental Analysis (KYTC DEA), KY Division of Water (KDOW), KY Department of Fish and Wildlife Resources (KDFWR), U.S. Fish and Wildlife Service (USFWS), KY State Nature Preserves Commission (KSNPC), Southern Illinois University Carbondale (SIUC), Illinois Natural History Survey (INHS), University of Michigan Museum of Zoology (UMMZ), Morehead State University (MOSU), University of Alabama Ichthyological Collection (UAIC), Cornell University Museum of Vertebrate Zoology (CUMV), University of Kansas (KU), North Carolina State Museum of Natural History (NCSM), Tulane University (TU), Yale Peabody Museum (YPM), and University of Tennessee (UTK).*

Results and Discussion

Composition and Distribution of Fishes

We compiled and reviewed 3,028 fish collection records from the Clarks River drainage spanning a period from 1942-2014 (**Table 1**). These records revealed a total of 107 species known to occur or have occurred in the Clarks River drainage (**Table 2**). This diversity is distributed among the Clarks River (including East and Middle forks; 86 species), West Fork (79 species), and lower mainstem Clarks River below the mouth of the West Fork (52 species). Specimen vouchers were available for 1,136 records, which were verified by Burr and Warren (1986) or personal examination. An additional 1,892 records, for which voucher specimens were unavailable, were reviewed and judged to be reasonable. We were able to substantiate records for some species in our 2015 field survey effort; however, voucher specimens or photos of other species are still needed for verification.

During August and September 2015, and in June 2016, fish community collections were made from 32 sites within the study area (**Figure 1**). Prior fish community data collected by Alexander (2005) were available for three of these sites for comparison. Each site was classified by habitat type (i.e., Palustrine and Riverine) based on the framework and definitions described by Cowardin et al. (1979), Burr and Warren (1986), and Alexander (2005). Each site was sampled once using KDOW (2002) protocols (17 riverine sites) or qualitatively using methods to capture all species within a given area (15 palustrine sites). The lower mainstem Clarks River (site 1) was sampled using boat electrofishing only; the refuge office pond (site 11) was sampled using boat electrofishing and seining along the margins in two separate events. All fish sample data from boat electrofishing are treated as qualitative (presence/absence).

Fish community sampling at seven sites in the Clarks River (five within the refuge) in 2000 by Alexander (2005) produced a total of 54 species. In a mussel survey of the Clarks River, Levine (2013) compiled a list of 69 fish

Table 2. *Comprehensive list of fishes reported from the Clarks River drainage based on records from 1942-2014, as well as current (2015-2016) survey effort: 1) museum vouchers; 2) non-vouchered records needing verification; 3) verified through current survey. Status: N=native; I=introduced; EXO=exotic; EP=presumed extirpated. Rare species are in bold print.*

Scientific Name	Common Name	Lower Mainstem	Clarks River	West Fork	Status
Ichthyomyzon castaneus	**Chestnut Lamprey**			**2**	**N**
Ichthyomyzon gagei	**Southern Brook Lamprey**			**1**	**EP**
Lampetra aepyptera	Least Brook Lamprey			1	N
Polyodon spathula	**Paddlefish**	**1,2**			**N**
Atractosteus spatula	**Alligator Gar**	**1**			**N,I**
Lepisosteus oculatus	Spotted Gar	2,3	1,3	1,3	N
Lepisosteus osseus	Longnose Gar	1,2,3	1		N
Lepisosteus platostomus	Shortnose Gar	1,2,3	3	2,3	N
Amia calva	Bowfin	2,3	3	1,3	N
Hiodon alosoides	Goldeye	1,2,3			N
Anguilla rostrata	**American Eel**	**1**			**N**
Alosa chrysochloris	Skipjack Herring	1,2,3			N
Dorosoma cepedianum	Gizzard Shad	1,2,3	1,2,3	1	N
Dorosoma petenense	Threadfin Shad	1,2			N
Campostoma oligolepis	Largescale Stoneroller		1,2,3	1,3	N
Carassius auratus	Goldfish		1		EXO
Ctenopharyngodon idella	Grass Carp	2,3	3	3	EXO
Cyprinella lutrensis	Red Shiner		3	1,3	N
Cyprinella spiloptera	Spotfin Shiner	2	2	2	N
Cyprinella whipplei	Steelcolor Shiner	1	1,2,3	1,2,3	N
Cyprinus carpio	Common Carp	1,2,3	1,3	1,2,3	EXO
Hybognathus hayi	**Cypress Minnow**			**1**	**N**
Hybognathus nuchalis	Mississippi Silvery Minnow		1,2,3	1,3	N
Hybopsis amnis	**Pallid Shiner**		**1**		**EP**
Hypophthalmichthys molitrix	Silver Carp	2,3	3	3	EXO
Hypophthalmichthys nobilis	Bighead Carp	2			EXO
Luxilus chrysocephalus	Striped Shiner			3	N
Lythrurus fumeus	Ribbon Shiner		1,2,3	1,3	N
Lythrurus umbratilis	Redfin Shiner		1,2,3	1,2,3	N
Macrhybopsis storeriana	Silver Chub			1	N
Notemigonus crysoleucas	Golden Shiner	1	1,2,3	1,3	N
Notropis atherinoides	Emerald Shiner	1,3	1,2,3	1	N
Notropis boops	Bigeye Shiner		1,2,3	1,3	N
Notropis maculatus	**Taillight Shiner**		**3**	**1**	**N**
Notropis volucellus	Mimic Shiner		3	1,3	N
Opsopoeodus emiliae	Pugnose Minnow		1,2	1	N
Phenacobius mirabilis	Suckermouth Minnow		1,2	1	N
Pimephales notatus	Bluntnose Minnow		1,2,3	1,2,3	N
Pimephales promelas	Fathead Minnow		1		N
Pimephales vigilax	Bullhead Minnow	3	1,3	1,3	N
Semotilus atromaculatus	Creek Chub	1	1,3	1,3	N
Carpiodes carpio	River Carpsucker	1,2,3	1	2	N

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Table 2. *Comprehensive list of fishes reported from the Clarks River drainage based on records from 1942-2014, as well as current (2015-2016) survey effort: 1) museum vouchers; 2) non-vouchered records needing verification; 3) verified through current survey. Status: N=native; I=introduced; EXO=exotic; EP=presumed extirpated. Rare species are in bold print.*

Scientific Name	Common Name	Lower Mainstem	Clarks River	West Fork	Status
Carpiodes cyprinus	Quillback	2			N
Carpiodes velifer	Highfin Carpsucker	2			N
Catostomus commersonii	White Sucker		1	1,3	N
Cycleptus elongatus	Blue Sucker	1			N
Erimyzon claviformis	Western Creek Chubsucker	1	1,3	1,3	N
Hypentelium nigricans	Northern Hog Sucker		1,2,3	1,2,3	N
Ictiobus bubalus	Smallmouth Buffalo	1,2,3	2,3		N
Ictiobus cyprinellus	Bigmouth Buffalo	1,2,3	1,3		N
Ictiobus niger	**Black Buffalo**	**2,3**	**2,3**		**N**
Minytrema melanops	Spotted Sucker	1,3	1,2,3	1,2,3	N
Moxostoma erythrurum	Golden Redhorse		1,2,3	1,3	N
Ameiurus melas	Black Bullhead	1	1	1,3	N
Ameiurus natalis	Yellow Bullhead	1	1,2,3	1,2,3	N
Ameiurus nebulosus	Brown Bullhead		2		N
Ictalurus furcatus	Blue Catfish	1,2			N
Ictalurus punctatus	Channel Catfish	1,2,3	1,2,3	1,2,3	N
Noturus gyrinus	Tadpole Madtom	3	1	1,3	N
Noturus miurus	Brindled Madtom		1,2,3	1,3	N
Noturus nocturnus	Freckled Madtom		1,2,3	1	N
Pylodictis olivaris	Flathead Catfish	1,2,3	3	1	N
Esox americanus	Grass Pickerel		1,3	1,2,3	N
Esox niger	**Chain Pickerel**		**2**		**N**
Umbra limi	**Central Mudminnow**		**1,3**	**1,3**	**N**
Aphredoderus sayanus	Pirate Perch		1,2,3	1,3	N
Labidesthes sicculus	Brook Silverside	1,3	2,3	3	N
Menidia audens	**Mississippi Silverside**	**1**			**N**
Fundulus notatus	Blackstripe Topminnow		2		N
Fundulus olivaceus	Blackspotted Topminnow	3	1,3	1,3	N
Gambusia affinis	Western Mosquitofish		1,2,3	1,3	N
Morone chrysops	White Bass	1,2,3		1	N
Morone mississippiensis	Yellow Bass	2	3		N
Centrarchus macropterus	Flier		1,2,3	1,3	N
Lepomis cyanellus	Green Sunfish	1,3	1,2,3	1,3	N
Lepomis gulosus	Warmouth	1,3	1,3	1,2,3	N
Lepomis humilis	Orangespotted Sunfish		1,2,3	1,3	N
Lepomis macrochirus	Bluegill	1,2,3	1,2,3	1,3	N
Lepomis marginatus	**Dollar Sunfish**		**1,3**	**1,3**	**N**
Lepomis megalotis	Longear Sunfish	1,2,3	1,3	1,2,3	N
Lepomis microlophus	Redear Sunfish		1,3		N
Micropterus punctulatus	Spotted Bass	3	1,2,3	1,2,3	N
Micropterus salmoides	Largemouth Bass	2,3	1,2,3	1,2,3	N
Pomoxis annularis	White Crappie	1,2,3	1,3	1,2,3	N
Pomoxis nigromaculatus	Black Crappie	2,3	1,3	1,3	N

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Table 2. *Comprehensive list of fishes reported from the Clarks River drainage based on records from 1942-2014, as well as current (2015-2016) survey effort: 1) museum vouchers; 2) non-vouchered records needing verification; 3) verified through current survey. Status: N=native; I=introduced; EXO=exotic; EP=presumed extirpated. Rare species are in bold print.*

Scientific Name	Common Name	Lower Mainstem	Clarks River	West Fork	Status
Etheostoma asprigene	Mud Darter		1,3	1,3	N
Etheostoma chlorosoma	Bluntnose Darter	1	1,3	1,3	N
Etheostoma flabellare	Fantail Darter		1,2	1,3	N
Etheostoma gracile	Slough Darter		1,2,3	1,3	N
Etheostoma histrio	Harlequin Darter		1,2,3	1,3	N
Etheostoma kennicotti	Stripetail Darter		1		N
Etheostoma nigrum	Johnny Darter		1,3	1,3	N
Etheostoma oophylax	Guardian Darter		2,3	3	N
Etheostoma parvipinne	**Goldstripe Darter**			**2**	**N**
Etheostoma proeliare	**Cypress Darter**		**2,3**	**3**	**N**
Etheostoma rufilineatum	Redline Darter			1,3	N
Etheostoma stigmaeum	Speckled Darter		1,2,3	1,3	N
Etheostoma zonistium	Bandfin Darter		1,2,3	1,3	N
Perca flavescens	Yellow Perch		3		N
Percina caprodes	Logperch		1,3	1,3	N
Percina maculata	Blackside Darter		1,2,3	1,3	N
Percina sciera	Dusky Darter		1,2,3	1,3	N
Percina shumardi	River Darter		2		N
Percina vigil	Saddleback Darter		1,2,3	1,3	N
Sander canadensis	Sauger	1,2	1	1	N
Aplodinotus grunniens	Freshwater Drum	1,2,3	1,2,3	1	N
Elassoma zonatum	Banded Pygmy Sunfish		1,3	1,3	N
Total species (per watershed):		52	86	79	
Total species (entire drainage):	107 (102 native)				

species in the Clarks River (excluding West Fork) from Alexander (2005) and more recent unpublished data from Murray State University graduate students. Our sampling effort produced 32 species from the lower mainstem Clarks River (1 site), 69 species from the Clarks River drainage upstream of the West Fork confluence (18 sites), and 62 species from the West Fork Clarks River drainage within the refuge expansion boundary (13 sites).

We collected a total of 79 species in 18 families, representing approximately 74% of the 107 species reported from the Clarks River drainage and 40% of the approximately 200 species known from the lower Tennessee River basin. Most species (80%) in our collections were members of five families: Cyprinidae (18 species), Percidae (16), Centrarchidae (12), Catostomidae (9), and Ictaluridae (7 species). The remaining 16 species represented 13 families.

The diversity of habitat types in the survey area influences fish species richness and how it is distributed. Patterns of species diversity and distribution are evident when the study area is divided into habitat systems and subsystems. Most species were found predominantly in Riverine habitats (35 species or 44%) or both Riverine and Palustrine habitats (37 species or 47%); the remaining 9% (7 species) occurred predominantly or exclusively in Palustrine habitats. The largest number of species occurred in the Lowland Stream and River subsystem (69 or 32%), followed by Lowland Headwater Creek (52 or 24%), Pond (38 or 18%), Slough and Oxbow (33 or 16%), and Wetland (21 or 10%) subsystems (**Figure 4**). Often species characteristically inhabiting a river or creek were found in a slough or pond and vise versa, particularly when there was a nearby connection between the two habitat subsystems.

We report new distribution records for certain species that are tolerant of a wide range of environmental conditions and are capable of extensive dispersal. The Red Shiner (*Cyprinella lutrensis*) was collected for the first time in the Clarks River upstream of the West Fork confluence (site 18). This species is very tolerant of altered or drastically fluctuating habitats and has been increasing its range in the Mississippi River basin (Etnier and Starnes 1993). Our collection of two species, Striped Shiner (*Luxilus chrysocephalus*) and Yellow Perch (*Perca flavescens*), were new records for the Clarks River drainage.

Previously reported occurrences for the following seven species are in need verification, either because they lack voucher specimens/photos or specimens in museum collections potentially have been misidentified: Chestnut Lamprey (*Ichthyomyzon castaneus*) in West Fork, Spotfin Shiner (*Cyprinella spiloptera*) throughout drainage, Bighead Carp (*Hypophthalmicthys nobilis*) in lower mainstem, Highfin Carpsucker (*Carpiodes velifer*) in lower mainstem, Chain Pickerel (*Esox niger*) in Clarks River, and Goldstripe Darter (*Etheostoma parvipinne*) in Clarks River.

Three Clarks River sites within the NWR sampled during September-October 2000 by Alexander (2005) were re-sampled during August-September 2015 and subjected to the KIBI. Our sampling resulted in greater species richness and abundance at all three sites when compared with the 2000 sample data. We also collected three exotic species which were not present in 2000 samples (Common Carp, Grass Carp, and Silver Carp). Despite differences in species richness and abundance metrics between the two sample periods, sites 9 and 19 ranked as “Good”, suggesting stability in the fish community during the past 15 years. Site 3 (most downstream site) had the largest discrepancy in species richness, composition, and abundance. The differences in IBI scores (“Fair” in 2000 vs. “Excellent” in 2015) could be interpreted as improvement to fish community health during the past 15 years; however, it could also reflect greater habitat disturbance and instability over time resulting in temporal variability in fish assemblage structure. Another factor that could explain differences in species richness and abundance values, as well as IBI scores, is variation in sampling effort (i.e., time spent sampling and sampling distance) at each site between 2000 and 2015.

Species of Greatest Conservation Need

Within the study area, we collected five species of greatest conservation need (SGCN) recognized by KDFWR. The following accounts summarize occurrences based on the August-September 2015-2016 sampling effort at 32 sites. General distribution and habitat comments are based on published studies, personal communication with experts, and our field observations.

Notropis maculatus (Hay). Taillight Shiner.—In Kentucky, the Taillight Shiner is restricted to the Jackson Purchase where it is known to occupy oxbows, swamps, and low-gradient streams primarily along the lower Ohio and Mississippi river floodplains. It was first reported in the Clarks River drainage in 2004 in an old channel oxbow of the West Fork Clarks River (Compton et al. 2004); it was collected at the same locality again in 2007 (D. Eisenhour, Morehead State University, pers. comm.). In June 2010, KDFWR biologists collected the species at two locations in the Clarks River near Benton, within the NWR. In September 2015 and June 2016, we collected single individuals in the pond behind the refuge headquarters (site 11). It is probable that this species exists in additional Palustrine habitats (i.e., vegetated oxbows and drainage canals) in the middle and lower reaches of the Clarks River drainage.

Ictiobus niger (Rafinesque). Black Buffalo.— In Kentucky, the Black Buffalo is considered sporadic and rare in large rivers and reservoirs in the western half of the state (Burr and Warren 1986). Most accounts indicate that its distribution is similar to the Smallmouth Buffalo (*Ictiobus bubalus*), but much less common (e.g., Pearson and Krumholz 1984). Five records (one vouchered) are available for the lower mainstem and one (not vouchered) from the Clarks River upstream of the West Fork confluence; it has not been reported from the West Fork (**Table 2**). During boat electrofishing runs on 15 September 2015, we collected three individuals in the lower mainstem (site 1) and one individual in the refuge headquarters pond (site 11).

Umbra limi (Kirtland). Central Mudminnow.—This species reaches the southernmost edge of its range in western Kentucky, where it is usually associated with dense beds of submergent aquatic plants, organic debris, or piles of detritus. It is known to be occasional to locally common in the Clarks and Blood River drainages, Terrapin Creek, and Running Slough (Burr and Warren 1986). In 2015, we collected five individuals in Egners Branch (site 10) and one in a West Fork Clarks River oxbow (site 28). In 2016, one specimen was collected from the Lindsey impoundment (site 2) and one from the Middle Fork Creek wetland (site 8). Specimens collected at sites 10, 2, and 8 represent the first reported occurrences of this species in the Clarks River upstream of the West Fork confluence since 1979. As with the Taillight Shiner, the Central Mudminnow likely occupies additional Palustrine habitats in the middle and lower portions of the Clarks River drainage.

Lepomis marginatus (Holbrook). Dollar Sunfish.—This small sunfish is restricted to the Jackson Purchase where it inhabits spring-fed wetlands, sluggish streams, and sloughs. It is known only from Murphy Pond, Hickman County, Terrapin Creek, Graves County, and the Clarks River

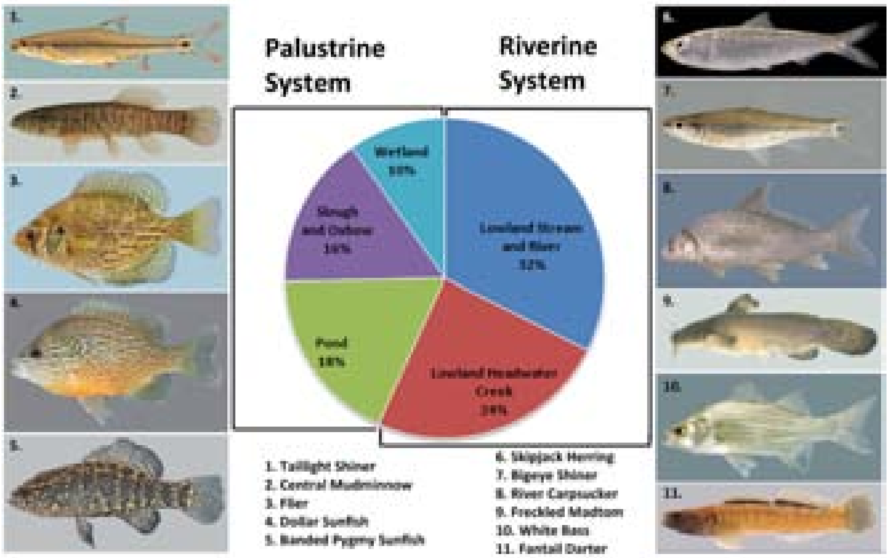

Figure 4. Habitat associations of fishes collected in the Clarks River drainage during 2015-2016. Examples of species characteristic of habitat systems and subsystems are shown on the left (Palustrine) and right (Riverine) panels.

drainage, Graves and Marshall counties. It was first documented in spring-fed perennial pools and wetlands in the West Fork drainage in 1982 (Rice et al. 1983; Warren and Cicerello 1983). It was later reported from the Clarks River by Kuhajda and Warren (1985). During 2015-2016, we collected Dollar Sunfish at six sites in the Clarks River upstream of the West Fork confluence (sites 6, 10, 12, 14, 16, and 17) and one site in the West Fork oxbow (site 28). Our collections from the Clarks River sites are the first to be reported since 1985 and represent an upstream extension of its known distribution in the drainage.

Etheostoma proeliare (Hay). Cypress Darter.— This small darter is sporadic and rare in small to medium-sized streams and margins of oxbows that border the Mississippi, and lower portions of the Ohio, Cumberland and Tennessee River drainages. It is associated with submerged vegetation and detritus near margins of streams, oxbow lakes and sloughs (Burr and Warren, 1986). Only five records for this species in Kentucky have been reported during the last 15 years. It was first collected in the Clarks River in 2000 and 2001 (Alexander 2005; EDAS database). The last record was from an oxbow of the West Fork (Thomas 2009). Our 2015-2016 sampling effort produced eight new occurrence records, including two (sites 21 and 24) in the West Fork drainage and six (sites 4, 5, 6, 10, 11, and 14) in the Clarks River upstream of the West Fork confluence.

Exotic Species

Our sampling effort in August-September 2015 produced three of the five exotic species known from the Clarks River drainage. The Goldfish (*Carassius auratus*) is known only from a single pre-1986 record in the Clarks River (Burr and Warren 1986). It has not been reported since and is likely not an established resident in the drainage. The Common Carp (*Cyprinus carpio*) is well-established throughout the state and is generally distributed throughout the Clarks River drainage. It was present at 11 of the 32 sites sampled and in both Riverine and Palustrine systems. Within the past 20 years, Grass Carp (*Ctenopharyngodon idella*), Silver Carp (*Hypophthalmichthys molitrix*), and Bighead Carp (*Hypophthalmichthys nobilis*) have been documented in the Clarks River drainage. These three species are collectively referred to as Asian carps; two of these (Silver and Bighead carps) are on the federal list of Injurious Wildlife (USFWS 2007, 2011). A single unconfirmed record of Bighead Carp from the lower mainstem Clarks River is available; however, our sampling did not detect its presence at any site. The following accounts discuss the current presence and distribution of Grass and Silver carps in the Clarks River drainage.

Ctenopharyngodon idella (Valenciennes). Grass Carp.—Native to rivers of eastern Asia, the Grass Carp was first brought to the U.S. in 1963. It has since been widely stocked in private water bodies for vegetation control (Schofield et al. 2005). The species is tolerant of a wide range of environmental conditions, and once released, is capable of extensive migrations in open systems (Guillory and Gasaway 1978). Prior to our sampling effort, only five records were documented from the Clarks River drainage: four from the lower mainstem (1995-2014) and one from the Clarks River upstream of the West Fork confluence (2006). We collected the species from eight sites in the lower mainstem (site 1), West Fork (sites 21, 25, 26, and 31), and Clarks River upstream of the West Fork confluence (sites 4, 6, 9, and 19). Young-of-year juveniles (less than 5 in. total length) were present at all sites except the lower mainstem (site 1), where a single large adult was captured. In shallow riffles and runs of river and creek sites, young-of-year were observed schooling with Common Carp and Silver Carp, some in high densities (e.g., at sites 25 and 31).

Hypophthalmichthys molitrix (Valenciennes). Silver Carp.—This large planktivorous species, native to large rivers of eastern Asia, was first imported to the U.S. in 1973 to control phytoplankton in eutrophic water bodies and as a food fish (Freeze and Henderson 1982). Since the mid-1990s, the species has rapidly expanded its distribution and is now self-sustaining in the Mississippi, Missouri, and Ohio River drainages (Conover et al. 2007). The first available record for Silver Carp in the Clarks River is in the lower mainstem in 2004 (TVA unpublished data). Two additional records were reported in 2006, one in the lower mainstem and one above the confluence of the West fork. An additional 17 records were reported between 2010 and 2014, all in the lower mainstem (unpublished data from TVA, KDFWR, and Murray State University). We report the presence of Silver Carp for the first time in the West Fork (sites 25 and 31), as well as multiple records in the Clarks River upstream of the West Fork confluence (sites 5, 8, 11, 18, and 19) and the lower mainstem (site 1). As with Grass Carp, large adults were observed during boat electrofishing in the lower mainstem; all other sites sampled using backpack electrofishing and seining produced only young-of-year juveniles (less than 5 in. total length). High densities were observed in shallow riffles and runs at sites 1 and 31 (n = 43-170), and site 5 (n = 40). Silver Carp were the dominant component in schools mixed with Grass Carp and Common Carp.

Conclusions and Management Recommendations

The high level of fish species diversity within the Clarks River NWR corresponds to the rich array of habitat types, including Riverine Systems (lowland rivers and creeks) and Palustrine Systems (ponds, oxbows, sloughs, and vegetated wetlands). Changes in fish species composition, abundance, and distribution documented in this assessment demonstrate the need for periodic surveys to monitor the distribution and population status of rare species, as well as the presence of exotic and invasive species. We recommend periodic (every 5-10 years) fish sampling in the Clarks River drainage at locations established herein to serve as a baseline for future assessment. Because our sampling involved only single visits to specific localities, there is an inherent amount of error in our ability to detect the full complement species at a given location. This is an important consideration when attempting to assess the status of rare species. Repeated sampling at sites established in this project as well as an additional array of randomly selected localities within the NWR and proposed expansion area could be used to estimate occupancy and detection probability for rare species.

The primary stressors impacting fishes and other aquatic organisms in the Clarks River drainage are clearing and drainage of wetlands and oxbows, channelization, siltation from poor agricultural practices, and domestic and industrial wastes (Burr and Warren 1986). We agree with and reiterate recommendations proposed by Alexander (2005) to enhance and maintain environmental quality in the Clarks River NWR: 1) improving cooperative farming practices on the refuge to reduce soil erosion and the associated transport of environmental contaminants to aquatic systems; 2) continue the implementation of the integrated pest management program on the refuge that couples the proper use of appropriate pesticides with other techniques; 3) installing and protecting vegetative buffer strips along stream channels, ditches, swales, and other water-conveyance conduits on the refuge; and 4) working actively with private landowners, other Federal and State agencies, and non-governmental organizations in the refuge watershed to improve land use practices. Finally, we emphasize the need for continued long-term research programs on fish communities aimed at inventories of abundance and distribution, ecosystem recovery, and riparian-riverine interactions (Warren and Burr 1994).

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KDFWR Strategic Plan: Goal 1. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi.

Status Survey of the Goldstripe Darter, *Etheostoma parvipinne*, in Kentucky

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Introduction

The Goldstripe Darter, *Etheostoma parvipinne* Gilbert and Swain, is a small darter (maximum total length 3 in.) that belongs to a unique and diverse community of aquatic species inhabiting small streams associated with vegetated wetlands and springs in the Tennessee River Plain and Eastern Gulf Coastal Plain regions of western Kentucky (Burr and Warren 1986). Many of these habitats have been lost or degraded and the species was known to exist at only four locations: Terrapin and Powell creeks, Graves County, and Sugar Creek and Billie Branch, Calloway County (Miller 1978; Burr and Mayden 1979; Burr and Warren 1986). Available collection records for the Goldstripe Darter in western Kentucky are sparse, taken from 1978-2015 (Table 1). It has a status of endangered on the current List of Rare and Extirpated Biota of Kentucky (KSNPC 2012) and is a Species of Greatest Conservation Need (SGCN) in the Kentucky Wildlife Action Plan (KDFWR 2013).

Although the Goldstripe Darter has a more extensive distribution in the Coastal Plain (Atlantic and Gulf slopes) south of Kentucky, occurrences in western Kentucky represent northern peripheral populations (Rohde 1980; Page and Burr 2011). Such populations may be somewhat or entirely separated from the rest of their taxon and subject to different evolutionary or ecological forces; therefore, they can contain unique genetic structure and have an important role in the evolutionary potential of the species (Garcia-Ramos and Kirkpatrick 1997; Nielsen et al. 2001). Monitoring peripheral species, such as the Goldstripe Darter and several others in Kentucky is necessary to achieve the larger goal of sustaining genetic variability. Also, shifts in the distributional boundaries of these species and changes in abundance trends may reflect changing environmental conditions, ranging from local habitat loss or disturbance to the pervasive effects of climate change.

The objectives of this project are 1): determine current distribution and abundance of the Goldstripe Darter in western Kentucky; and 2) assess spawning activity, general habitat usage, and current habitat conditions within the known range of the species; and 3) document fish community composition with emphasis on other fish SGCN in habitats supporting Goldstripe Darter populations. These objectives meet priority monitoring, research, and survey needs detailed in the Kentucky Wildlife Action Plan. This study will provide information needed to develop effective conservation actions and long-term monitoring strategies aimed at preventing declines in fish SGCN and need for Endangered Species Act protection.

Methods

Data Review and Study Area

The Goldstripe Darter's distribution in Kentucky includes parts of two major ecoregions: Interior Plateau (Western Highland Rim) and the Mississippi Loess Plains (Woods et al. 2002). The Western Highland Rim includes the lower Tennessee River tributaries draining into Kentucky Lake (e.g., Jonathan Creek, Blood River, and Cypress Creek). These watersheds are more wooded and rugged than the largely agricultural plains to the west in the Jackson Purchase. The area is underlain by shale, siltstone, and sandstone. Streams have moderate gradients, are cool and clear, and have cherty gravel and sand substrates. By contrast, the northern tributaries of the North Fork Obion River (i.e., Terrapin Creek, Powell Creek, and Blackamore Creek drainages) lie within the Mississippi Valley Loess Plains, which is composed of gently rolling uplands, broad bottomlands, and terraces. The area is covered by thick loess and alluvium, which are underlain by weak, unconsolidated coastal plain sediments. It is marked by extensive agricultural development, including row crop, livestock, and poultry farming. Many streams have been channelized and agricultural runoff has degraded surface water quality (Woods et al. 2002).

We compiled and reviewed available collection records for Goldstripe Darter from the Kentucky Department of Fish and Wildlife Resources (KDFWR), Kentucky Division of Water, Kentucky State Nature Preserves Commission (KSNPC), Tennessee Valley Authority (TVA), Murray State University (MSU), and Southern Illinois University at Carbondale (SIUC). These included early published records (Miller 1978; Burr and Mayden 1979; Burr and Warren 1986) and subsequent records submitted to KDFWR by various entities as required under scientific and educational permit guidelines.

Sample sites were established in the Blood River drainage and northern tributaries of the Obion River (i.e., Terrapin, Powell, and Old Knob creeks) based on known presence of Goldstripe Darter populations (**Figure 1**). We also included the upper Clarks

River drainage and Jonathan Creek, where recent unsubstantiated reports of the species had been documented (Alexander 2005; TVA unpublished data). Our approach was to first revisit historic localities followed by additional sites judged to have suitable habitat that could potentially result in new occurrence records. Special emphasis was placed on small, gravel and sand-bottomed creeks that were spring-fed or connected to wetlands.

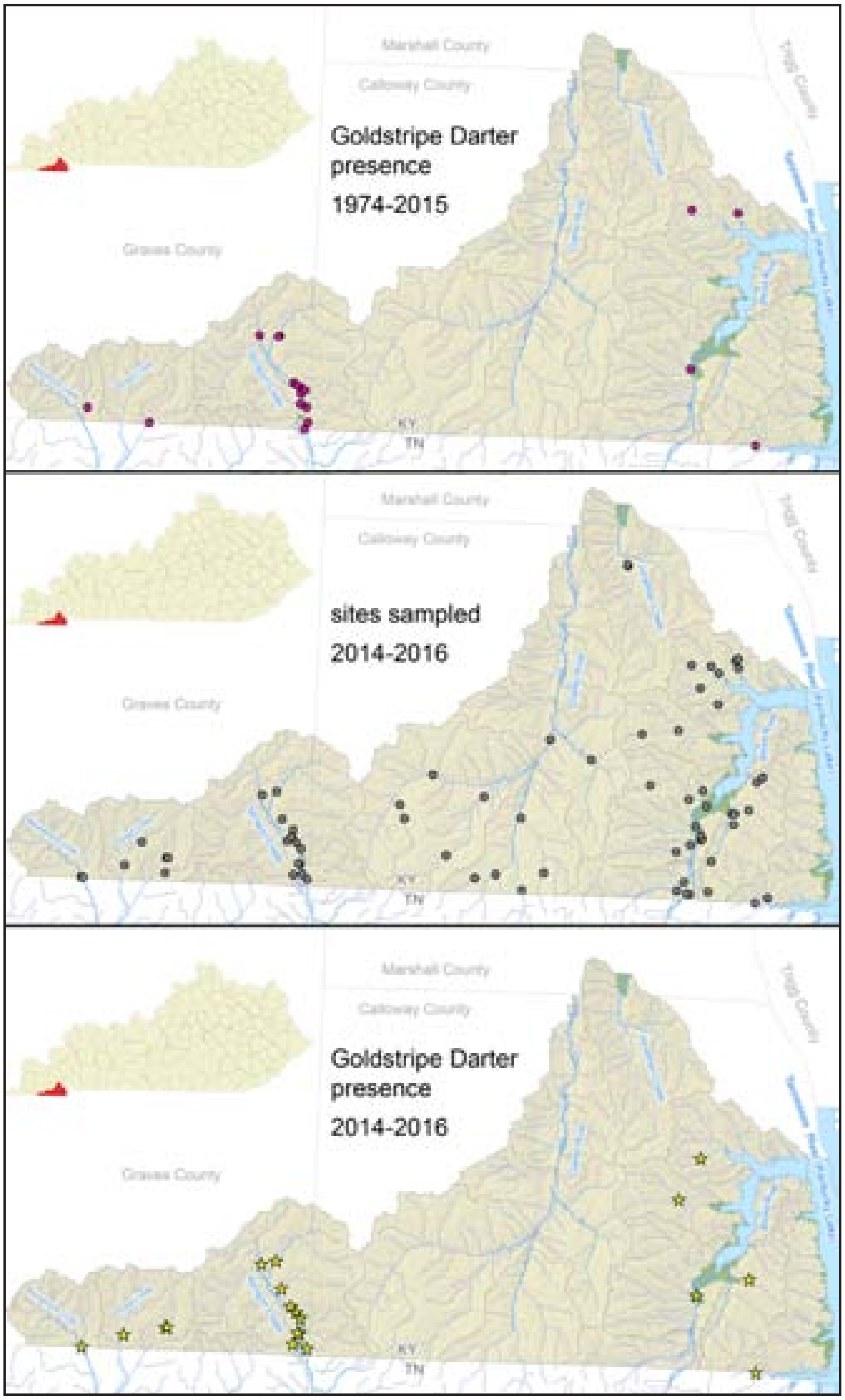

Figure 1. Distribution of Goldstripe Darter in Kentucky based on historic and current collection records.

Field Methods

Field sampling was conducted between 17 April 2014 and 25 May 2016 to determine the current distribution and abundance of Goldstripe Darter populations in western Kentucky. Fish sampling methods generally followed wadeable stream sampling protocols (KDOW 2002). Fishes were captured using a backpack electrofisher and dip net, or a 6 X 10' (1/8" mesh) seine. Within Kentucky State Nature Preserves (i.e., Blood River Seeps and Terrapin Creek), sites were sampled using only a seine and dip nets. At most sites, all habitats within a 100-200 m reach were worked thoroughly to ensure a representative fish community sample. Additional emphasis was placed on specific habitats known or considered likely to harbor the Goldstripe Darter and other fish SGCN. Most fish captured were identified on site, enumerated, and released. A limited number of representative specimens were photo-vouchered or retained in 10% formalin, then transferred to 70% ethanol and archived at KDFWR. For each Goldstripe Darter or other SGCN captured, gender (when possible), total length, and habitat conditions were recorded. At each site, basic water quality parameters including temperature, conductivity, and pH were recorded. Habitat type and condition were assessed qualitatively and documented through field notes and digital photographs.

Results and Discussion

Composition, Abundance, and Distribution of Fishes

During April-June 2014 and 2015, and May 2016, we completed fish community sampling at a total of 69 sites in Calloway and Graves counties. Effort was distributed across the Blood

River (32 sites), Jonathan Creek-Kentucky Lake (2 sites), Standing Rock Creek-Kentucky Lake (2 sites), Upper Clarks River (12 sites), and Upper North Fork Obion River (21 sites) drainages (**Figure 1**). We collected a total of 62 fish species, including 11 SGCN. All species were native except for Grass Carp (*Ctenopharyngodon idella*) which was captured at one site in the Upper Clarks River drainage. Because the primary target species was the Goldstripe Darter, sampling was biased towards smaller streams and seepages associated with springs or wetlands. Using the stream classification framework of Olivero-Sheldon and Anderson (2013), most of the sites sampled (52/69 or 75%) are classified as headwater with a catchment area of less than 3.8 sq. mi.; of the remaing sites, 16 are classified

Figure 2. Live coloration and appearance of Goldstripe Darter on mixed sand/gravel substrate in Powell Creek, Graves County.

Figure 3. Goldstripe Darter adults in spawning condition from different drainages in western Kentucky.

as creek (less than 39 sq. mi.) and one small river (Clarks River, 93.2 sq. mi.). Therefore, fishes we encountered were more representative of headwater and creek assemblages in each of the respective drainages surveyed.

Our fish community data reflect faunal differences between the Tennessee River and North Fork Obion River drainages, sampling bias towards smaller streams notwithstanding. Twelve species were only captured in the North Fork Obion River tributaries (e.g., Terrapin Creek, Powell Creek, and Knob Creek), including seven fish SGCN: Bluntface Shiner (*Cyprinella camura*), Blacktail Redhorse (*Moxostoma poecilurum*), Brown Madtom (*Noturus phaeus*), Brighteye Darter (*Etheostoma lynceum*), Firebelly Darter (*Etheostoma pyrrhogaster*), and Gulf Darter (*Etheostoma swaini*).

Twenty-seven species captured in the lower Tennessee River drainage were not detected in the North Fork Obion River drainage. A nearly two-fold increase in darter diversity was observed in Tennessee River drainage tributaries, which were distinctively more upland with clear water and rocky substrates compared with the generally more lowland, sand and clay bottomed Coastal Plain streams in the North Fork Obion River drainage. Also noteworthy was the presence of Rosyside Dace (*Clinostomus funduloides*) and Southern Redbelly Dace (*Chrosomus erythrogaster*) from headwater creek sites in Blood River drainage (both species) and Cypress Creek drainage (just Rosyside Dace). We report the Dollar Sunfish (*Lepomis marginatus*) for the first time in the Blood River drainage and add new steam occurrences for the Bluntface shiner, Brown Madtom, Central Mudminnow (*Umbra limi*), Goldstripe Darter, Cypress Darter (*Etheostoma proeliare*), and Gulf Darter.

Generally distributed and often dominant species (present in all watersheds sampled) were the Creek Chub (*Semotilus atromaculatus*; 64 sites), Green Sunfish (*Lepomis cyanellus*; 47 sites), Blackspotted Topminnow (*Fundulus olivaceus*; 43 sites), Western Creek Chubsucker (*Erimyzon claviformis*; 41 sites), Yellow Bullhead (*Ameiurus natalis*; 29 sites), and Bluegill (*Lepomis macrochirus*; 27 sites). The species most commonly associated with the Goldstripe Darter was the Creek Chub. Species occurring at over half of Goldtripe Darter sites were Least Brook Lamprey (*Lampetra aeypyptera*), Blackspotted Topminnow, and Western Creek Chubsucker. At five Tennessee River drainage sites where the Goldstripe Darter was present, the Guardian Darter (*Etheostoma oophylax*) and Largescale Stoneroller (*Campostoma oligolepis*) were also common associates.

Goldstripe Darter Distribution and Status

During 2014-2016, we confirmed the continued existence of Goldstripe Darter populations previously documented in the Blood River and Cypress Creek drainages (Tennessee River basin), and in Terrapin and Powell Creek drainages (Obion River-Mississippi River basin). We captured the species at a total of 19 sites including most previously documented locations and 11 new sites. We observed the species to be most densely distributed and abundant in the Terrapin Creek drainage, where it was captured at 10 sites. In the Powell and Blackamore Creek drainages, individuals were captured at 4 of 7 sites. The species is present, but sparsely distributed in the Blood River and Cypress Creek drainages, where it was captured at only 5 of 34 sites sampled.

Two unsubstantiated records in the Clarks River prompted us to sample an array of sites with potentially suitable habitat in the Upper Clarks River drainage. We did not detect the species at any of the 12 sites sampled, including one of the two sites on the mainstem Clarks River near Murray, where the species was reported in 2000 (Alexander 2005). Here the Clarks River is much larger than streams typically inhabited by the Goldstripe Darter. An intensive survey of the Clarks River drainage downstream of Murray in the Clarks River National Wildlife Refuge by Thomas and Brandt (2016) also failed to detect the species. Our sampling in Jonathan Creek did not detect the species; a single record at this location reported by the TVA in 2013 was determined to be a mis-identification of the Guardian Darter (Dave Matthews, TVA, pers. comm.). We consider the Goldstripe Darter's presence in the Clarks River and Jonathan Creek drainages unlikely.

The Goldstripe Darter has rather specialized habitat requirements. Characteristics of habitat currently supporting the species in western Kentucky are largely consistent with what has been reported in other parts of its range (e.g., Robison 1977; Etnier and Starnes 1993; Pflieger 1997; Ross 2001; Boschung and Mayden 2004). Robison (1977) described its habitat in Arkansas as "small, spring-fed, shallow (6 in. to 2 ft.) feeder streams or spring branches of low to moderate gradient. Such streams are typically about 2 to 8 ft. wide with a sand bottom and generally lack rooted aquatic vegetation because of heavy tree canopies overhead. Specimens were most often collected in sandy areas where fallen twigs, decaying leaves, and other detritus formed protected areas in long, shallow pools having slight to moderate current." This is a good description of the physical characteristics of habitats in which the species was found during our surveys. We found the species predominantly in headwater creeks, although our sampling was biased towards smaller streams. These streams were generally clear or stained with tannins. The appearance of live individuals captured over sand and small gravel substrates is shown in **Figure 2**.

The peak spawning period for the Goldstripe Darter is March and April, possibly extending into May (Etnier and Starnes 1993; Pflieger 1997; Ross 2001; Boschung and Mayden 2004). The species is considered an egg-attacher; small, adhesive eggs are deposited individually on plant stems, roots, or on top of gravel near the base of plants. This strategy is predicted for species living in lentic habitats where the substrate is often mud and silt and potentially poorly oxygenated. Probably more than one clutch is spawned per year, but fecundity estimates are low, about 66 eggs per year (Johnston 1994). Although we did not observe spawning activity, we did capture adults during May 2014 and 2015 that appeared to be in nuptial condition or perhaps having just exceeded the peak spawning period (**Figure 3**). Evidence of successful recruitment was observed from late May to mid-June at sites in the Terrapin Creek and Powell Creek drainages where young-of-year (20-30 mm TL) and at least one adult group (45-55 mm TL) were present; in one case, 30 young-of-year were captured from a vegetated roadside ditch (**Figure 4**).

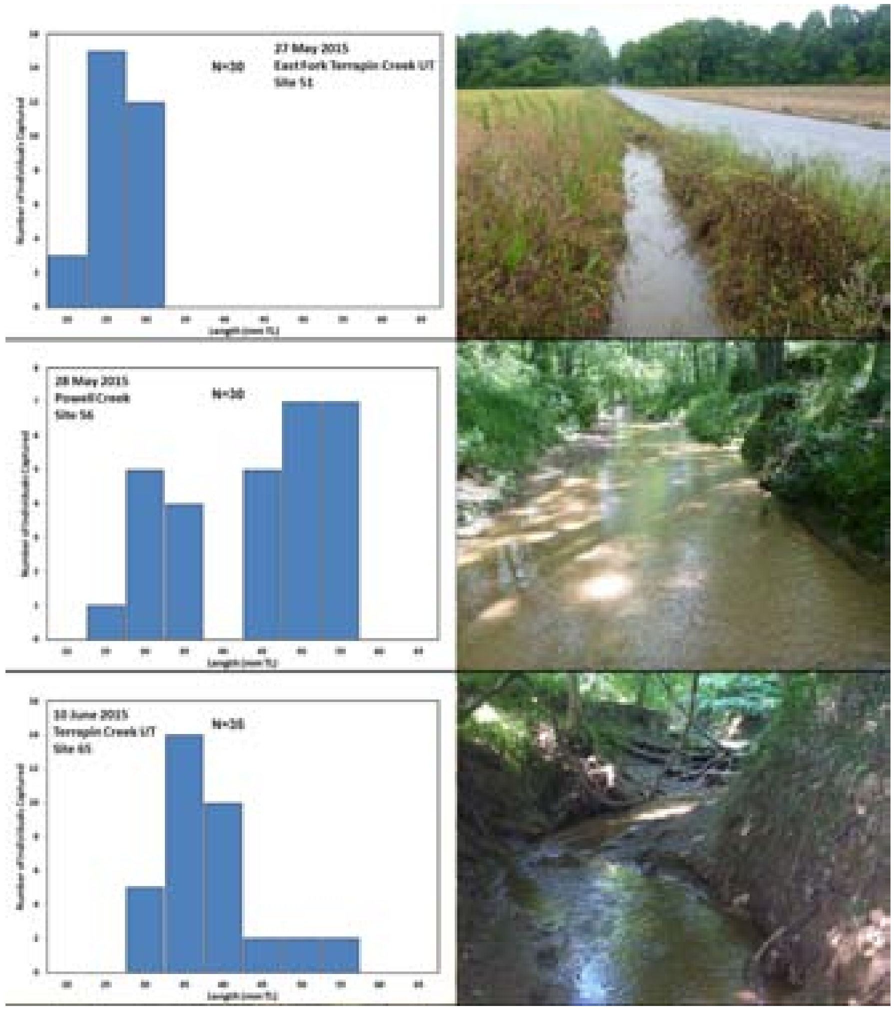

Figure 4. Length frequency distributions of Goldstripe Darters captured in different streams and habitat types in western Kentucky during May-June, 2015.

Backpack electrofishing was more effective in capturing Goldstripe Darters than seining, especially around marginal cover (e.g., root mats or other forms of vegetation) in streams with little or no current. We did not find individuals in Blood River Seeps State Nature Preserves using a seine and dip nets, despite what appeared to be an abundance of suitable habitat with numerous seeps and small channels coursing through the well-forested Blood River floodplain. Future discovery of the Goldstripe Darter somewhere in this 193-acre preserve would not be surprising.

Goldstripe Darter abundance can be variable among streams and sampling periods. Smiley et al. (2006) observed that abundance increased with increasing water temperatures, increasing percentage of canopy cover, and decreasing dissolved oxygen. Other studies showed a relationship of increasing abundance with presence of aquatic vegetation (Johnston, 1994; Adams and Parsons 1996; Bart and Taylor 1999). Streams in western Kentucky that contained Goldstripe Darter populations were mostly lacking aquatic vegetation; however, most did have heavy canopy cover. The Blood River and Cypress Creek (Standing Rock Creek-Kentucky Lake) drainages have a high percentage of forested land and wooded wetlands, particularly in Kentucky Lake Wildlife Management Area and Blood River Seeps State Nature Preserve. In contrast, the Upper Clarks River drainage is mostly open due to agricultural development. The Upper North Fork Obion River drainage (Terrapin Creek, Powell Creek, and Knob Creek) has more forested land than the Upper Clarks River, but has been cleared to a large extent. Forest cover is patchy in tributaries of the North Fork Obion River in southern Graves County. In the Terrapin Creek drainage, the largest undeveloped tract of wooded wetlands is contained within the Terrapin Creek State Nature Preserve. This area has the largest concentration of Goldstripe

Darter occurrences in western Kentucky.

Conclusions and Management Recommendations

Fish community sampling at 69 sites in Graves and Calloway counties during 2014-2016 detected Goldstripe Darter presence at 5 sites in the lower Tennessee River drainage (Blood River and Cypress Creek systems) and 14 sites in the North Fork Obion River drainage (Terrapin Creek, Powell Creek, and Blackamore Creek systems). We found the species at all but two previously documented locations and 11 new sites. It is most densely distributed and abundant in the Terrapin Creek system, but sparsely distributed elsewhere. Distribution and abundance data were also collected for 10 additional fish SGCN in the Blood River, Terrapin Creek, Powell Creek, and Blackamore Creek drainages. The Dollar Sunfish was collected for the first time in the Blood River drainage and new steam occurrences were documented for the Bluntface shiner, Brown Madtom, Central Mudminnow, Cypress Darter, and Gulf Darter.

Streams in western Kentucky that support Goldstripe Darter populations contain wooded wetland areas and individuals were captured at locations having canopy cover. Blood River Bottoms (Kentucky Lake) Wildlife Management Area, Blood River Seeps State Nature Preserve and Terrapin Creek State Nature Preserve contain perhaps the largest amounts of contiguous suitable habitat for the species. Forest cover is patchy in tributaries of the North Fork Obion River (e.g., Powell and Blackamore creeks) in southern Graves County and in tributaries of the Blood River and Cypress Creek (e.g., Billie Branch) in Calloway County. Individuals captured at these locations probably represent small, isolated populations.

Our survey results indicate that the Goldstripe Darter steadily persists in western Kentucky, especially in the Terrapin Creek drainage. However, it remains vulnerable to habitat loss and modification from development, as described in other parts of its range. For example, in Missouri loss of populations has been attributed to human modifications, including gravel mining, small impoundments, residential effluent, and pipe culverts (Winston 2002). The disappearance of the species at historical locations in Oklahoma may be due to intolerance of changes in habitat and water quality (Lemmons and Pigg 1999). Conservation efforts for the Goldstripe Darter should include protection and maintenance of forested riparian zones adjacent to first-order or headwater streams (Smiley et al. 2006; McAllister et al. 2007).

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Funding Sources: *State Wildlife Grant Program (SWG)*

KDFWR Strategic Plan. Goal 1. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi.

Ichthyofaunal Survey and Assessment of Fish Species of Greatest Conservation Need in the Red River, Lower Cumberland River Drainage, Kentucky

Flame Chub / Matt Thomas

Matthew Thomas and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources

Introduction

The Red River is a fifth-order tributary of the lower Cumberland River located in south-central Kentucky and north-central Tennessee. Eight fish Species of Greatest Conservation Need (SGCN) recognized by the Kentucky Department of Fish and Wildlife Resources (KDFWR 2013) were known to occur in the Kentucky portion of the Red River drainage; seven of these species are also listed by the Kentucky State Nature Preserves Commission (KSNPC 2012) as threatened or of special concern. In addition to rare fishes, the mainstem Red River and Whippoorwill Creek in Kentucky together contain records for four rare mussel species, including one federally listed as endangered and two candidates for federal listing. Whippoorwill Creek and the Red River below Keysburg were identified as "hotspots" based on richness of imperiled fish and mussel taxa, as well as priority watersheds for conservation of rare fishes and mussels (Cicerello and Abernathy 2005). Although the Red River drainage was not identified as a priority conservation watershed in the State Wildlife Action Plan (KDFWR 2013), available fish collection records are sparse and unevenly distributed relative to other basins (e.g., Green River).

The objectives of this project are: 1) utilize available fish collection database resources to assess gaps in distributional information for fish SGCN; and 2) revisit historic localities to assess population status for SGCN; and 3) provide an inventory of the fish species at sites chosen systematically throughout the Red River drainage in Kentucky. These objectives meet priority monitoring, research, and survey needs detailed in the Kentucky Wildlife Action Plan. This study will provide information essential to developing effective conservation policies and management practices aimed at the recovery of fish SGCN and the restoration of their habitats.

Methods

Study Area

The Red River is 100 miles long, unimpounded, and drains an area of 1,482 square miles (U.S. Geological Survey 2012). It originates in north-central Tennessee, drains northwest into south-central Kentucky, and southwest into Tennessee again where it confluences the Cumberland River near Clarksville. Approximately 690 square miles (47%) of the watershed is in south-central Kentucky, including portions of Simpson, Logan, Todd, and Christian counties (Carey 2003). Sizeable tributaries of the Red River in Kentucky are the West Fork Red River (179 square miles), Elk Fork (61 square miles), and Whippoorwill Creek (115 square miles) watersheds.

In Kentucky, the Red River drainage lies mostly within the Western Pennyroyal Karst Plain Subsection of the Interior Plateau Ecoregion; however, headwater reaches of West Fork Red River, Elk Fork, and Whippoorwill Creek are in the Crawford-Mammoth Cave Uplands Subsection. Numerous sinkholes, springs, sinking streams, and dry valleys occur throughout the Red River drainage. Land throughout the watershed is extensively farmed and streams become laden with suspended sediment after heavy rains. Stream channels are deeply entrenched and are fed by cool, nitrate-rich groundwater (Woods et al. 2002). The entire length of the mainstem Red River in Kentucky was listed as impaired based on excessive levels of pollutants including sediment, nutrients, and pathogens (e.g., *Escherichia coli*). Water quality in tributaries such as Whippoorwill Creek, Elk Fork, and South Fork Red River was assessed as "good" indicating all water uses are fully supporting (U.S. Environmental Protection Agency 2010). Whippoorwill Creek is listed as a State Outstanding Resource Water because it supports the Littlewing Pearlymussel (*Pegias fabula*), a federally listed species.

Data Acquisition and Field Methods

Sample localities established throughout the Kentucky portion of the Red River drainage (**Figure 1**) are based on available fish collection data from the Southern Illinois University Ichthyological Collection (SIUC), KY State Nature Preserves Commission (KSNPC), KY Division of Water (KDOW), and the Kentucky Fish and Wildlife Information System (KFWIS) database maintained by KDFWR. Field sampling was conducted from 2011 to 2016 following wadeable stream sampling protocols (Kentucky Division of Water, 2002). Fishes were collected using a backpack electrofisher, dip nets, and 6' X 10' and 6' X 15' (1/8" mesh) seines. At each site, all habitats within a 100-200m reach were worked thoroughly to ensure a representative sample. Additional emphasis was placed on specific habitats known to support targeted fish SGCN. Each site was electrofished for 500-2000 seconds, depending on the size of the stream and available habitat. In larger streams, electofishing was followed by 10-20 seine hauls/sets to effectively work the same area and available habitat. Some sites in the mainstem Red River with extensive deep pools were sampled using boat electrofishing. Most fish collected are identified on site, enumerated, and released. At each site, voucher specimens were retained in 10% formalin, then transferred to 70% ethanol and archived at KDFWR and the Austin Peay State University (APSU) Natural History Collection. For each fish SGCN collected, gender (when possible), total lengths (when >20 individuals), and habitat conditions are recorded. Digital photographs are also taken to document species and habitats at all sample sites.

Results and Discussion

Composition, Abundance, and Distribution of Fishes

The Cumberland River basin supports the most unusual and diverse fish fauna in Kentucky because of its large drainage area, habitat diversity, and complex history (Burr and Warren 1986). Approximately 174 native fish species have been reported from the entire basin, 131 of which are from the lower portion which includes the Red River drainage (Warren et al. 1997; Abernathy et al. 2010). A total of 95 native species have been documented from the Red River drainage in Kentucky and Tennessee (**Table 1**). This represents 55% of the entire Cumberland River basin fish fauna.

A total of 71 species were known from the Red River drainage in Kentucky based on Burr and Warren (1986) and more recent collection records obtained from KFWIS. Our fish community sampling at 79 sites in the Kentucky portion of the Red River and six major tributaries during 2011-2016 produced a total of 73 fish species representing 17 families (**Table 1**). Approximately 79% of the species collected were members of the families Cyprinidae (minnows; 18 species), Percidae (darters; 14 species), Catostomidae (suckers; 12 species), Centrarchidae (sunfish and bass; 9 species), and Ictaluridae (catfishes; 5 species); the remaining 15 species belonged to 12 families. Two non-native species were collected: Rainbow Trout, which is stocked annually in Sulphur Spring Creek as a sportfish; and Common Carp, which is exotic.

We did not detect 27 species that were documented previously from the Red River drainage, including four SGCN (Chestnut Lamprey, Paddlefish, Southern Cavefish, and Redlips Darter). Nine species were only reported from the Tennessee portion, including several lowland and large river species found only in the lower mainstem near the Cumberland River confluence (e.g., Paddlefish, Spotted Gar, Shortnose Gar, Bowfin, and Goldeye)(**Table 1**). Our failure to detect most of the 18 species previously documented in Kentucky is not necessarily an indication of their absence from the drainage. Most of the Red River drainage in Kentucky consists of creek and small river habitats, in which 90% of our sample sites were located (**Figure 2**). It is possible that these species either occurred in areas we did not sample or they exist at densities too low for detection using conventional fish sampling methods.

Our surveys produced records for 18 species that were previously unknown from the Red River drainage in Kentucky, including three SGCN (Flame Chub, Black Buffalo, and Tippecanoe Darter). Also noteworthy is the discovery of a new stream occurrence for the Mottled Sculpin. This species is uncommon in the Cumberland River basin and was known from a single location in the Red River drainage (West Fork Red River, Christian County) where it continues to persist. We report it for the first time in Sinking Creek (Little Whippoorwill Creek drainage, Logan County). The lower Cumberland populations, including the Red River drainage, are at southwestern periphery

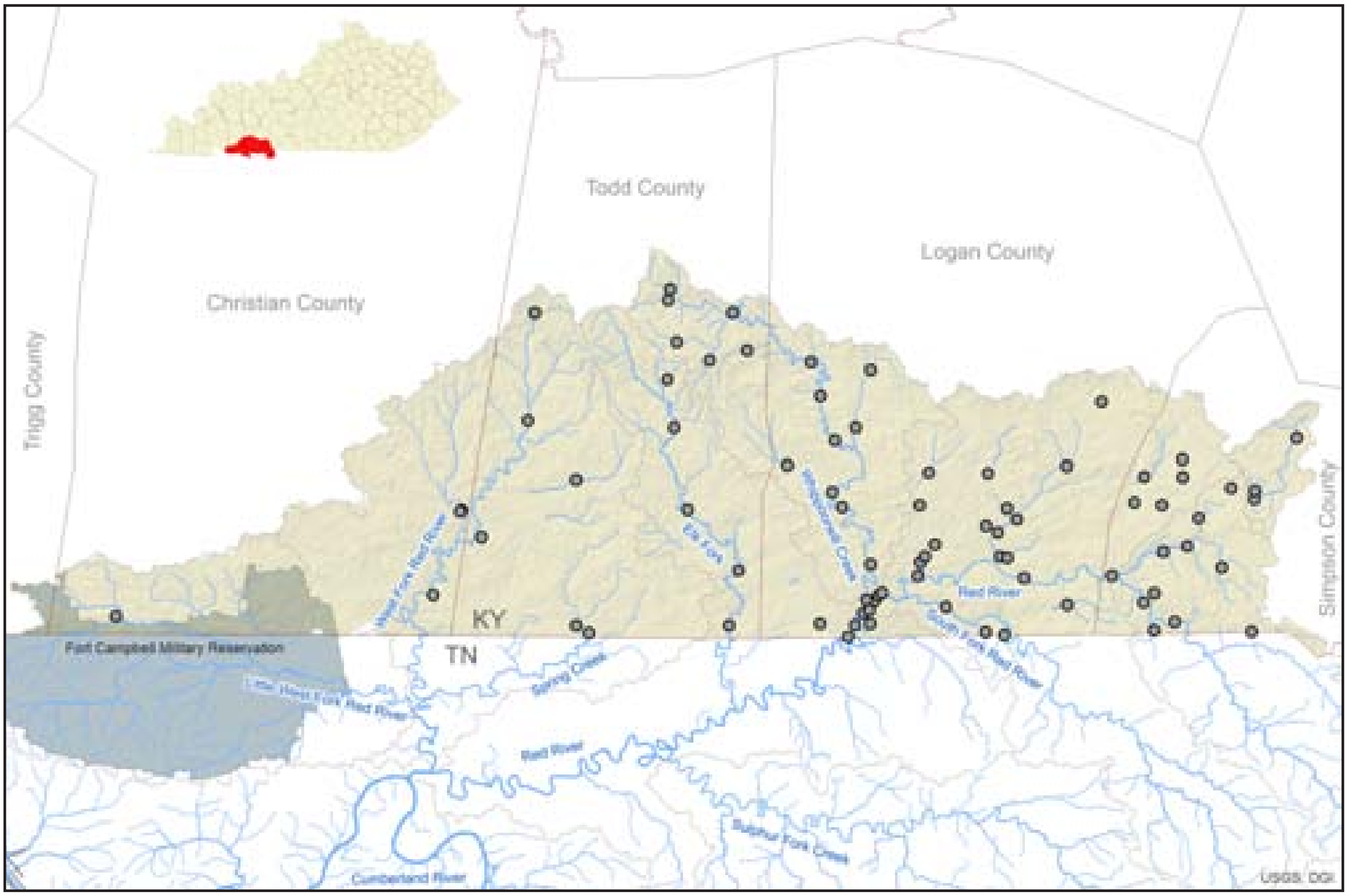

Figure 1. Spatial depiction of sites sampled for fishes in the Kentucky portion of the Red River drainage during 2011-2016.

of the species' range. Preliminary study suggests that they are morphologically and genetically distinct from other populations to the east (David Neely, TNACI, pers. comm.).

Species of Greatest Conservation Need

Native animals designated as SGCN in Kentucky are generally rare or declining and in need of attention to recover or prevent the need for listing under federal regulation (KDFWR 2013). Most fish SGCN in Kentucky are also listed by the KSNPC Natural Heritage Program which monitors rare plants and animals (KSNPC 2012). Prior to our survey, eight fish SGCN (number of sites present) were known from the Red River drainage in Kentucky: 1) Chestnut Lamprey, *Ichthyomyzon castaneus* (1 site); 2)

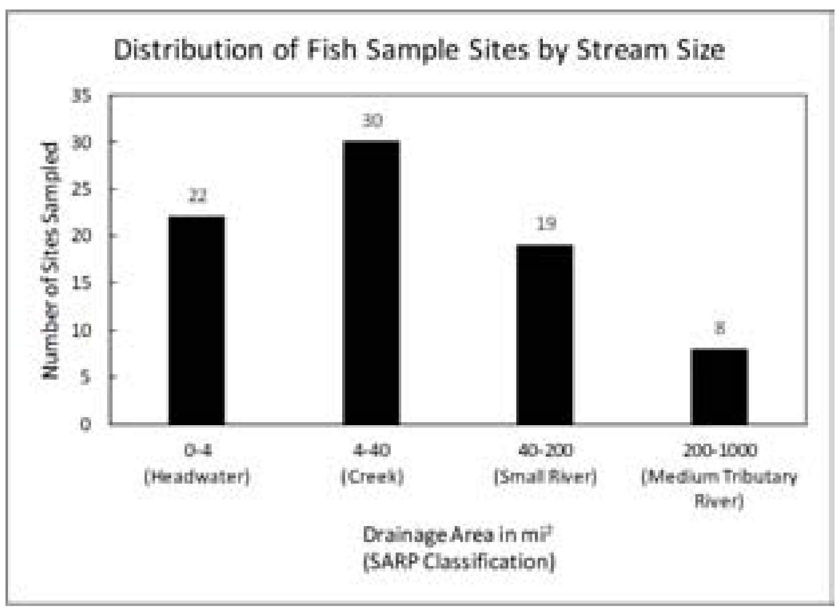

Figure 2. Number of sites sampled within stream size classes developed for the Southeastern Aquatic Resources Partnership (SARP) based on drainage area.

Table 1. *Comprehensive list of fishes known from the Red River drainage in Kentucky and Tennessee. Kentucky records are based on results of the present survey (2011-2016) and other collection records (Burr and Warren 1986; KFWIS database). Tennessee records are from Etnier and Starnes (1993). Species of greatest conservation need (SGCN) are in bold print. * Exotic; ** Introduced; 1 recognized as* Campostoma anomalum.

Scientific Name	Common Name	Present Survey (2011-2016)	Prior/other Records in KY	Presence in TN
Ichthyomyzon bdellium	Ohio Lamprey			X
Ichthyomyzon castaneus	**Chestnut Lamprey**		**X**	**X**
Lampetra aepyptera	Least Brook Lamprey	X	X	
Polyodon spathula	**Paddlefish**			**X**
Lepisosteus oculatus	Spotted Gar			X
Lepisosteus osseus	Longnose Gar	X		X
Lepisosteus platostomus	Shortnose Gar			X
Amia calva	Bowfin			X
Hiodon alosoides	Goldeye			X
Dorosoma cepedianum	Gizzard Shad	X	X	X
Dorosoma petenense	**Threadfin Shad		**X	
Campostoma oligolepis	Largescale Stoneroller	X	X	X[1]
Chrosomus erythrogaster	Southern Redbelly Dace	X	X	X
Cyprinella galactura	Whitetail Shiner	X	X	X
Cyprinella spiloptera	Spotfin Shiner	X	X	X
Cyprinella whipplei	Steelcolor Shiner		X	X
Cyprinus carpio	*Common Carp	*X	*X	*X
Erimystax dissimilis	Streamline Chub	X	X	X
Erimystax insignis	**Blotched Chub**	**X**	**X**	**X**
Hemitremia flammea	**Flame Chub**	**X**		
Hybopsis amblops	Bigeye Chub	X	X	X
Luxilus chrysocephalus	Striped Shiner	X	X	X
Lythrurus fasciolaris	Scarlet Shiner	X	X	X
Macrhybopsis storeriana	Silver Chub		X	X
Nocomis effusus	Redtail Chub	X	X	X
Notemigonus crysoleucas	Golden Shiner	X	X	X
Notropis atherinoides	Emerald Shiner		X	X
Notropis boops	Bigeye Shiner		X	X
Notropis micropteryx	Highland Shiner	X		X
Notropis telescopus	Telescope Shiner	X		X
Notropis volucellus	Mimic Shiner		X	X
Pimephales notatus	Bluntnose Minnow	X	X	X
Pimephales promelas	**Fathead Minnow			**X
Pimephales vigilax	Bullhead Minnow		X	X
Rhinichthys obtusus	Western Blacknose Dace	X	X	X
Semotilus atromaculatus	Creek Chub	X	X	X
Carpiodes carpio	River Carpsucker	X		
Catostomus commersonii	White Sucker	X	X	X
Erimyzon claviformis	Western Creek Chubsucker	X	X	X
Hypentelium nigricans	Northern Hog Sucker	X	X	X
Ictiobus bubalus	Smallmouth Buffalo	X		X
Ictiobus niger	**Black Buffalo**	**X**		
Minytrema melanops	Spotted Sucker	X	X	X

Table 1. *Continued*

Scientific Name	Common Name	Present Survey (2011-2016)	Prior/other Records in KY	Presence in TN
Moxostoma anisurum	Silver Redhorse	X		
Moxostoma breviceps	Smallmouth Redhorse	X	X	X
Moxostoma carinatum	River Redhorse	X		
Moxostoma duquesnei	Black Redhorse	X	X	X
Moxostoma erythrurum	Golden Redhorse	X	X	X
Ameiurus melas	Black Bullhead		X	X
Ameiurus natalis	Yellow Bullhead	X	X	X
Ictalurus punctatus	Channel Catfish	X		X
Noturus exilis	**Slender Madtom**	**X**	**X**	**X**
Noturus sp. *cf. flavus*	Highland Stonecat	X		X
Noturus miurus	Brindled Madtom	X		X
Oncorhynchus mykiss	**Rainbow Trout	**X	**X	
Salmo trutta	*Brown Trout		*X	
Esox americanus	Grass Pickerel	X	X	X
Aphredoderus sayanus	Pirate Perch	X	X	X
Forbesichthys agassizii	**Spring Cavefish**	**X**	**X**	**X**
Typhlichthys subterraneus	**Southern Cavefish**		**X**	**X**
Labidesthes sicculus	Brook Silverside			X
Fundulus catenatus	Northern Studfish	X		X
Fundulus olivaceus	Blackspotted Topminnow	X	X	X
Gambusia affinis	Western Mosquitofish	X	X	X
Cottus bairdii	Mottled Sculpin	X	X	X
Cottus carolinae	Banded Sculpin	X	X	X
Morone chrysops	White Bass	X		
Morone mississippiensis	Yellow Bass	X		X
Ambloplites rupestris	Rock Bass	X	X	X
Lepomis cyanellus	Green Sunfish	X	X	X
Lepomis gulosus	Warmouth		X	
Lepomis humilis	Orangespotted Sunfish	X		
Lepomis macrochirus	Bluegill	X	X	X
Lepomis megalotis	Longear Sunfish	X	X	X
Lepomis microlophis	Redear Sunfish	X	X	X
Micropterus dolomieu	Smallmouth Bass	X	X	X
Micropterus punctulatus	Spotted Bass	X	X	X
Micropterus salmoides	Largemouth Bass	X	X	X
Pomoxis annularis	White Crappie		X	X
Pomoxis nigromaculatus	Black Crappie		X	X
Etheostoma blenniodes	Greenside Darter	X	X	X
Etheostoma caeruleum	Rainbow Darter	X	X	X
Etheostoma derivativum	**Stone Darter**	**X**	**X**	**X**
Etheostoma flabellare	Fantail Darter	X	X	X
Etheostoma flavum	Saffron Darter	X	X	X
Etheostoma gore	Longhunt Darter		X	X
Etheostoma maydeni	**Redlips Darter**		**X**	**X**
Etheostoma occidentale	Westrim Darter	X	X	X
Etheostoma sp. *cf. spectabile*	Mamequit Darter			X
Etheostoma squamiceps	Spottail Darter	X	X	X
Etheostoma zonale	Banded Darter	X	X	X

Continued on next page...

Table 1. *Continued*

Scientific Name	Common Name	Present Survey (2011-2016)	Prior/other Records in KY	Presence in TN
Nothonotus camurus	Bluebreast Darter			X
Nothonotus microlepidus	**Smallscale Darter**	**X**	**X**	**X**
Nothonotus rufilineatus	Redline Darter	X	X	X
Nothonotus tippecanoe	**Tippecanoe Darter**	**X**		**X**
Percina caprodes	Logperch	X	X	X
Percina maculata	Blackside Darter	X	X	X
Percina phoxocephala	Slenderhead Darter		X	X
Percina sciera	Dusky Darter	X		X
Aplodinotus grunniens	Freshwater Drum	X	X	X
Total Species:	**100**	**73**	**71**	**87**
Total Native Species:	**95**	**71**	**67**	**85**
Total SGCN:	**12**	**8**	**8**	**10**

Blotched Chub, *Erimystax insignis* (8 sites); 3) Slender Madtom, *Noturus exilis* (5 sites); 4) Spring Cavefish, *Forbesichthys agassizii* (6 sites); 5) Southern Cavefish, *Typhlichthys subterraneus* (2 sites); 6) Stone Darter, *Etheostoma derivativum* (5 sites); 7) Redlips Darter, *Etheostoma maydeni* (1 site); and 8) Smallscale Darter, *Nothonotus microlepidus* (4 sites).

Our sampling efforts failed to detect the Chestnut Lamprey and Redlips Darter. We did not sample cave systems known to support Southern Cavefish but accept recent records as valid (Niemiller and Fitzpatrick (2013). We confirm the presence of five of the remaining fish SGCN (**Table 2**). The Flame Chub (*Hemitremia flammea*), Black Buffalo (*Ictiobus niger*), and Tippecanoe Darter (*Nothonotus tippecanoe*), were previously unknown from the Red River drainage in Kentucky. The Flame Chub was presumed extirpated in Kentucky because there have been no reports of this species anywhere in the state since the late 1880s (Burr and Warren, 1986; KSNPC 2012). Our discovery of a Flame Chub population in streams associated with Robey Swamp (Spring Creek, Sulphur Spring Creek, and Sinking Creek) in Simpson County is significant because it represents a northern extension of the species' current range, most of which is in the Tennessee River drainage of Tennessee and small portions of northern Alabama and Georgia.

The Smallscale Darter and Tippecanoe Darter are considered "at-risk" species because they were included in a petition filed in 2010 to list as endangered or threatened under the Endangered Species Act. The USFWS determined that the petition presented substantial scientific or commercial information that listing these species

Fish SGCN	Drainage (HUC10)							Total Sites Present
	DC	SB-RR	SF-RR	WC	EF-RR	WFRR	LWFR	
	(3)	(11)	(28)	(16)	(11)	(9)	(1)	
Blotched Chub			3		1			**4**
Flame Chub	2	1	3					**6**
Black Buffalo			1		1			**2**
Slender Madtom		1						**1**
Spring Cavefish	2	1	9	3	2	7	1	**25**
Stone Darter				6				**6**
Smallscale Darter			2	1	2			**5**
Tippecanoe Darter					1			**1**
Total Fish SGCN:	**2**	**3**	**5**	**3**	**5**	**1**	**1**	
Total Sites Sampled:	**3**	**11**	**28**	**16**	**11**	**9**	**1**	

Table 2. *Fish species of greatest conservation need (SGCN) collected in the Kentucky portion of the Red River drainage during 2011-2016. Total number of sites sampled for each HUC10 watershed is given in parentheses. Number of streams in which each species was present is given for each HUC10 watershed. DC=Drakes Creek (Green River basin); SB-RR=Summers Branch-Red River; SF-RR=South Fork Red River-Red River; WC=Whippoorwill Creek; EF-RR=Elk Fork-Red River; WFRR=West Fork Red River; LWFR=Little West Fork Red River.*

as endangered or threatened under the Endangered Species Act may be warranted. This evaluation was based on information suggesting that the species may be at risk from present or threatened destruction, modification, or curtailment of their habitat or range, and other natural or anthropogenic factors (USFWS 2016). We collected the Smallscale Darter in lower Whippoorwill Creek (1 site), South Fork Red River (1 site) and Red River downstream of the South Fork confluence (3 sites), including two new occurrence localities. The Tippecanoe Darter was present at a single site in the Red River downstream of Whippoorwill Creek at the KY/TN state line, which represents a new occurrence record for the Red River drainage in Kentucky.

Conclusions and Management Recommendations

Between 2011 and 2016, fish community sampling was completed at 79 sites in 31 streams throughout the Kentucky Portion of the Red River (lower Cumberland River) drainage. We detected a total of 73 fish species, including 8 SGCN. Our sampling failed to detect 27 species previously documented from the drainage, including three SGCN (Chestnut Lamprey, Southern Cavefish, and Redlips Darter); however, we report new records for 18 species, including three SGCN or at-risk species (Flame Chub, Black Buffalo, and Tippecanoe Darter). Our survey efforts along with other previous attempts suggest that the Redlips Darter is extirpated from the Red River drainage; however, other recent surveys indicate that the Southern Cavefish still exists in at least one cave system and our failed detection of Chestnut Lamprey could be an artifact of inadequate sampling. The most significant result of our surveys was the discovery of a new population of Flame Chub, a species long considered extirpated from the state and previously unknown from the Red River drainage. All fish SGCN except for Spring Cavefish have localized distributions in the Red River drainage.

Extensive modification of land through agricultural activity has resulted in high levels of sedimentation, nutrients, and pathogens (e.g., *Escherichia coli*) throughout much of the Red River drainage. The entire length of the mainstem Red River in Kentucky is listed as impaired because of degraded water quality. Because of its karst topography many streams receive cool groundwater discharge which provides conditions suitable for Spring Cavefish and Flame Chub. While the Flame Chub has a localized distribution in streams emanating from Robey Swamp in Simpson County, the Spring Cavefish is much more densely distributed throughout the drainage than prior records indicated, which suggests some degree of resilience to habitat modification.

Streams and habitats having the highest priority for SGCN or at-risk species include the mainstem Red River, South Fork Red River, and the Whippoorwill Creek drainage. Robey Swamp and streams emanating from this remant wetland complex (i.e., Spring Creek, Sinking Creek, and Sulphur Spring Creek) in Simpson County should also be given high priority for conservation action. Watershed monitoring programs dedicated to implementing solutions to improve water quality in the Red River drainage should be continued and supported. A watershed approach that includes partnerships among state and federal agencies, landowners, and local initiatives is necessary to effectively address water quality problems. Ultimately, improvements to water quality and habitat conditions will be the result of successful implementation of regulatory and nonregulatory (voluntary) programs. Continued status assessment work in the Red River drainage is needed to keep information in this report up to date and useful for imperiled fish conservation and recovery.

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KDFWR Strategic Plan. Goal 1. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi.

Status Survey of the Redside Dace, *Clinostomus elongatus*, in Kentucky

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Introduction

The Redside Dace, *Clinostomus elongatus* (Kirtland), is a small minnow with a discontinuous distribution in the northeastern United States and Southern Canada. The species is generally rare and reaches the southern limit of its range on the Western Allegheny Plateau of northeastern Kentucky (Gilbert 1980; Parker et al. 1988). It was first reported from Kentucky in 1940 from Lick Fork, a tributary of the North Fork Licking River in Rowan County (Clark 1940). A second collection was made in 1982 from Edward Branch, a tributary of the Red River in Menifee County (Kuehne 1984). The most comprehensive surveys of the Redside Dace in Kentucky were conducted during 1984-1986 (Meade et al. 1986) and in 1999 (Armstrong 2000). These surveys found the species to be occasional to locally common in several tributaries of the North Fork of the Licking River, Beaver Creek, and Red River.

The Redside Dace is considered vulnerable due to habitat loss and degradation, and other factors including impacts of nonindigenous species, hybridization, competition and/or predation (Jelks et al. 2008). Urbanization and various land use activities resulting in water quality deterioration and excessive siltation have contributed to population declines throughout much of its range (Parker et al. 1988). In Kentucky, the Redside Dace exists in peripherally isolated populations and was considered a species of special concern by Warren et al. (1986) and is listed as a species of greatest conservation need (SGCN) in the Kentucky Wildlife Action Plan (KDFWR 2013).

Streams supporting Redside Dace in Kentucky are cool and clear, have near neutral pH, and are in forested watersheds with canopy cover (Meade et al. 1986). A recent phylogeographic analysis of the species indicated high genetic diversity levels within the Red and Licking River drainage populations relative to other Ohio River basin populations (Serrao 2016). Such high levels of diversity within these isolated southern peripheral populations in Kentucky may reflect successful local adaption and long-term persistence in high quality forested watersheds that remain mostly within the Daniel Boone National Forest (DBNF).

Since 1986, additional Redside Dace occurrence records have been reported from the Licking and Red River drainages by different collectors; however, a concerted effort to sample all historic localities and other streams potentially supporting undiscovered populations has not been done. Currently available data suggest that populations are small and isolated, which makes them vulnerable to habitat loss and degradation. Updated information on distribution, abundance, and habitat conditions is needed to assess the overall stability of these populations.

The objectives of this project are: 1) determine the current distribution and abundance of the Redside Dace in Kentucky; 2) assess spawning activity, general habitat usage, and current habitat conditions within the known range of the species; and 3) document fish community composition with emphasis on other fish SGCN in stream habitats supporting Redside Dace populations. These objectives meet priority monitoring, research, and survey needs detailed in the Kentucky Wildlife Action Plan. This study will provide information needed to develop effective conservation actions and long-term monitoring strategies aimed at preventing declines in fish SGCN and need for Endangered Species Act protection.

Methods

Study Area

The focal area of this study was the mostly forested hills and ridges of the Western Allegheny Plateau from the vicinity of Morehead, Rowan County, southwest to Irvine, Estill County. It includes parts of Rowan, Bath, Menifee, Morgan, Wolfe, Powell, and Estill counties. Much of this approximately 1,773 square mile area lies within the DBNF and includes sections of the Kentucky and Licking River drainages where the Redside Dace is known to occur. Most available Redside Dace records are distributed within the Northern Forested Plateau Escarpment; a few outlying records are in the Knobs-Lower Scioto Dissected Pleatau and Ohio/Kentucky Carboniferous Plateau (Woods et al. 2002).

The creeks, streams, and rivers along the northwestern edge of the Cumberland Plateau (Pottsville Escarpment) are characterized as upland, having moderate to high gradient, well-developed riffles, rocky substrates and poor to moderate floodplain development. The Escarpment has a very rugged topography with deeply dissected valleys and steep sharp-crested ridges. Mixed oak and oak-pine hardwood forests are common and bottomland hardwood forests grow along the streams. Deep and narrow valleys often include eastern hemlock, *Tsuga Canadensis* and white laurel, *Rhododendron maximum* (Meade et al. 1986). The Western Allegheny Plateau region is unglaciated and underlain by sedimentary rock, including sandstone, siltstone, and shale, with some interbedded coal deposits (Tonning et al. 1998; Woods et al. 2002).

The Upper Red River drainage (Kentucky River basin) includes the Red River Gorge Geological Area, designated a national natural landmark due to its scenic rock features, such as sandstone arches and towering cliffs. A 12,646-acre area of the gorge is designated as Clifty Wilderness and a 9.1-mile segment of the Red River is designated a National Wild and Scenic River. In the Licking River basin, upland streams in well forested watersheds occur around Cave Run Lake and tributary watersheds upstream of the reservoir. Below Cave Run Lake Dam, privately-owned agricultural lands predominate and are characterized by rolling pastures and smaller, fragmented woodlands (NRCS 2008).

Primary land uses are logging and recreation, particularly within the DBNF. On private lands, broader valleys have been cleared for livestock or general farming, especially in the Knobs region. East of the study area in the headwaters of the Licking and Red River drainages, surface and underground coal mining, oil well brines, poor agricultural practices, and sewage discharges have degraded surface water quality (Woods et al. 2002).

Data Review and Field Methods

We compiled and reviewed all available Redside Dace collection records in Kentucky from Clark (1940), Kuehne (1984), Meade (1986), museum records, and unpublished data from Kentucky Department of Fish and Wildlife Resources, Kentucky Division of Water, and U.S. Forest Service. Sample localities were chosen within the study area based on historic (1940-2014) records of Redside Dace presence, as well as additional sites that could potentially result in new occurrences. Field sampling was conducted between 8 April 2015 and 2 December 2016 following wadeable stream sampling protocols (KDOW 2002). Fishes were captured using a backpack electrofisher and dip net, or a 6’ X 10’ (1/8” mesh) seine. At most sites, all habitats within a 100-200 m reach were worked thoroughly to ensure a representative fish community sample. Additional emphasis was placed on specific habitats known or considered likely to support Redside Dace. In some cases, sites were briefly worked either with a seine or visual inspection over a distance of 10-85 m with the objective of documenting Redside Dace presence rather than fish community assessment.

Most fish captured were identified on site, enumerated, and released. A limited number of specimens were photo-vouchered or retained in 10% formalin, then transferred to 70% ethanol and archived at KDFWR. For each Redside Dace or other SGCN collected, gender (when possible), total lengths (when >20 individuals), and habitat conditions were recorded. At each site, basic water quality parameters including temperature, conductivity, and pH were recorded. Habitat type and condition were assessed qualitatively and documented through field notes and digital photographs.

Results and Discussion

Composition, Abundance, and Distribution of Fishes

Between 8 April 2015 and 2 December 2016, we completed fish community sampling at a total of 92 sites in 77 streams (**Figure 1**), including 51 sites (43 streams) in the Licking River basin and 41 sites (34 streams) in the Kentucky River basin. Our surveys within the study area documented at total of 45 species of fish, including four species of greatest conservation need. Because the target species was Redside Dace, sampling was biased towards smaller streams. Over half of the sites (61/92 or 66%) are classified as headwater with a catchment area of less than 3.8 sq. mi.; the remaining sites are classified as creek with a catchment area of less than 39 sq. mi. (Olivero-Sheldon and Anderson 2013). Therefore, the list of fish species documented herein is more representative of headwater and creek assemblages.

Sampling in the Licking River basin (51 sites in 43 streams) produced 35 species, including one SGCN (Redside Dace). By contrast, sampling in the Kentucky River basin (41 sites in 34 streams) produced 43 species, including 4 SGCN. Three fish SGCN found in the Upper Red River (Kentucky River) drainage that are absent in the Licking River drainage are Northern Brook Lamprey (*Ichthyomyzon fossor*), Emerald Darter (*Etheostoma baileyi*), and Frecklebelly Darter (*Percina stictogaster*). All species collected were native except for Rainbow Trout, which has been introduced in selected streams in the Red River Gorge (Chimney Top Creek, East Fork Indian Creek, and Swift Camp Creek) and the North Fork of Licking River drainage (Craney Creek). Brown Trout are also stocked in Chimney Top Creek and East Fork Indian Creek, but none were encountered in our sampling. Generally distributed and often dominant species (present in all watersheds sampled) were Creek Chub (*Semotilus atromaculatus*) and Ohio Stoneroller (*Campostoma anomalum*). Species commonly associated with Redside Dace were Ohio Stoneroller, Southern Redbelly Dace, Western Blacknose Dace, Creek Chub, Mottled Sculpin, and Johnny Darter. Similar associations were observed by Meade et al. (1986).

Redside Dace Distribution and Status

Our sampling results were largely consistent with the previously documented distribution of the Redside Dace. It has been reported from 39 streams in the following HUC10 watersheds of the Licking and Kentucky River basins (number of streams where present in parentheses): Fox Creek-Licking River (1), North Fork of Licking River (12), Blackwater Creek-Licking River (1), Beaver Creek (5), Upper Red River (18), and Sturgeon Creek-Kentucky River (1).

During 2015-2016, we documented Redside Dace presence in 36 streams within the following HUC10 watersheds: Fox Creek-Licking River (1), North Fork of Licking River (12), Blackwater Creek-Licking River (3), Beaver Creek (7), and Upper Red River (13) (**Figure 1**). The species was not detected in Triplett Creek, Lower Red River, or Sturgeon Creek-Kentucky River drainages. The single 1998 record from White Oak Creek (Sturgeon Creek-Kentucky River) is peculiar because it is far removed from other populations in the Upper Red River drainage to the north. Furthermore, White Oak Creek is situated on the boundary of the Knobs and Outer Bluegrass region; habitat conditions were poor and land surrounding the stream was largely cleared and developed for residential use and agriculture. Our repeated sampling in White Oak Creek on three occasions failed to detect the species. Whether the 1998 record represents an artificial introduction (e.g., bait-bucket release) or a waning remnant of a once more widespread population is uncertain.

We documented Redside Dace presence for the first time in 12 streams. In the Licking River drainage, new occurrences include Big Lick Branch, Little Lick Branch, Passenger Branch, Baldwin Creek, Open Fork, Clifton Creek, Leatherwood Creek, and Ratliff Creek. In the Upper Red River drainage, new occurrences include Coldiron Fork, Myers Fork, Right Fork Chimney Top Creek, and Short Creek. We did not detect the species in Lower Lick Fork, North Fork Licking River, or Edward Branch.

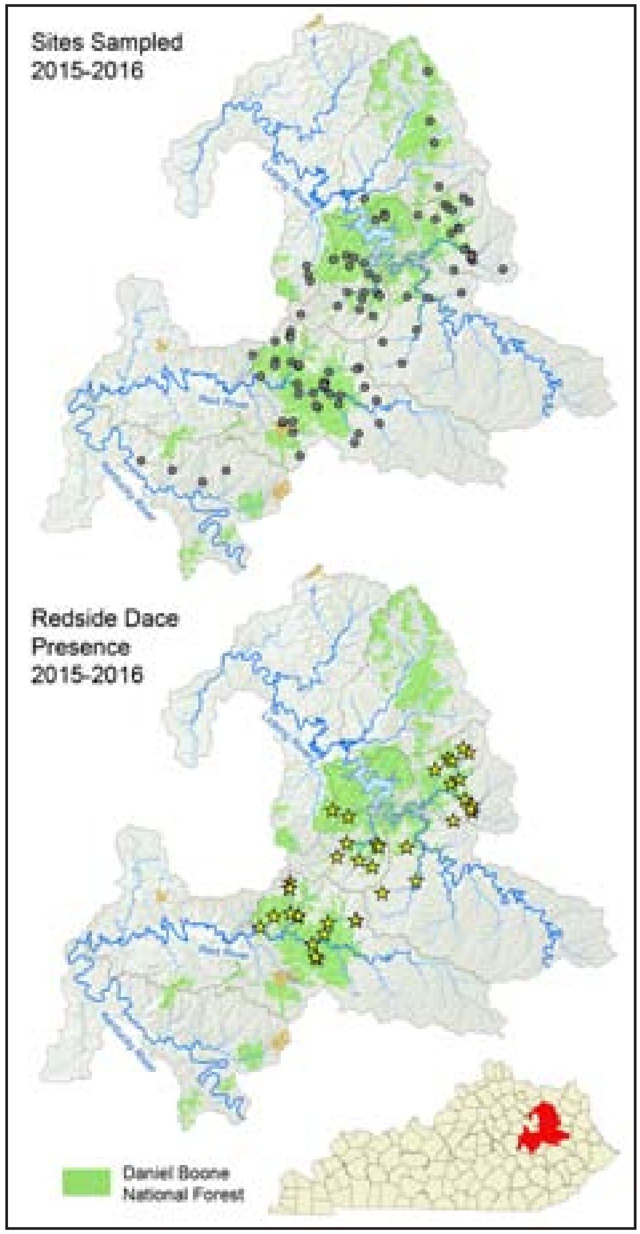


Figure 1. Distribution of fish sampling sites and Redside Dace presence in the Licking and Kentucky River drainages during 2015-2016.

Prior Redside Dace records in the North Fork Licking River and Red River likely represented transient occurrences from smaller tributary creeks. We sampled Edward Branch on four occasions but did not find the species. The reason for its apparent disappearance from this stream is not clear; the watershed is well forested and is within the Red River Gorge Geological Area of the DBNF. Wolfpen Creek is another stream within the Gorge and DBNF where the species had been collected on multiple occasions and as recently as 2014. We sampled Wolfpen Creek on four occasions and collected a single Redside Dace X Southern Redbelly Dace hybrid, suggesting that the species does still persist somewhere in the watershed, but perhaps in low abundance. Nine streams having historic presence were not sampled in 2015-2016; however, because these streams are in forested, high quality watersheds and are within close proximity to other known occurrences, it is likely that the species is present.

Compton et al. (2004) documented the odd presence of Rosyside Dace, *Clinostomus funduloides*, in the North Fork Licking River at the mouth of Bucket Branch. The Rosyside Dace is native and common in the adjacent headwaters of the Little Sandy River drainage (Burr and Warren 1986). The

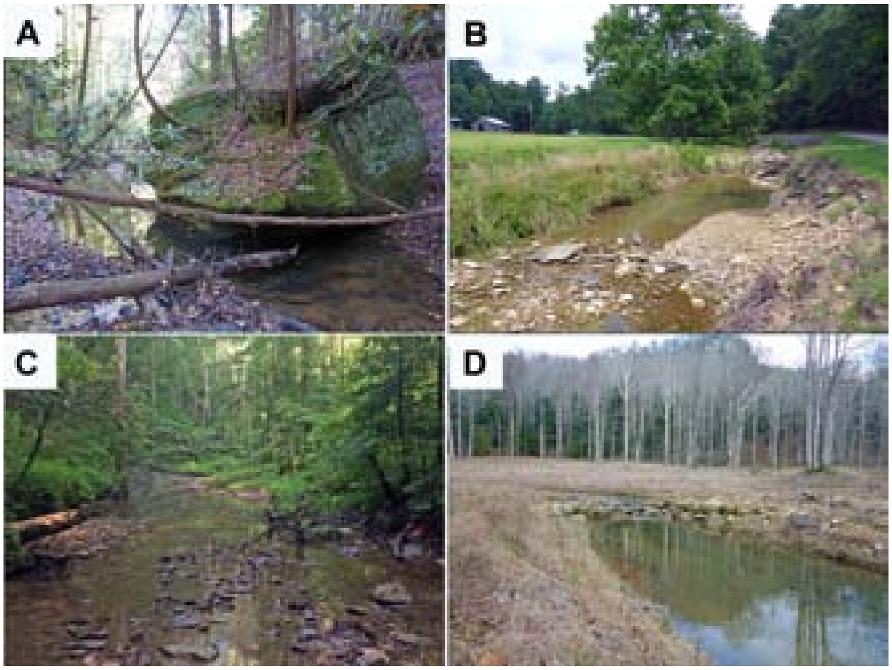


Figure 2. Physical characteristics of streams supporting Redside Dace populations in the Licking and Kentucky River drainages. A) Open Fork (Licking River). B) Upper Lick Fork (Licking River). C) Chimney Top Creek (Red River-Kentucky River). D) East Fork Indian Creek stream restoration site (Red River-Kentucky River).

North Fork record was based on a single individual collected on July 19, 1999 and considered a probable bait-bucket introduction due to its close proximity to a fishing access location (Compton et al. 2004). We resampled this location on October 13, 2016 and did not collect either Rosyside Dace or Redside Dace; however, we did capture Redside Dace (only) in Bucket Branch just upstream of the mouth on the same day.

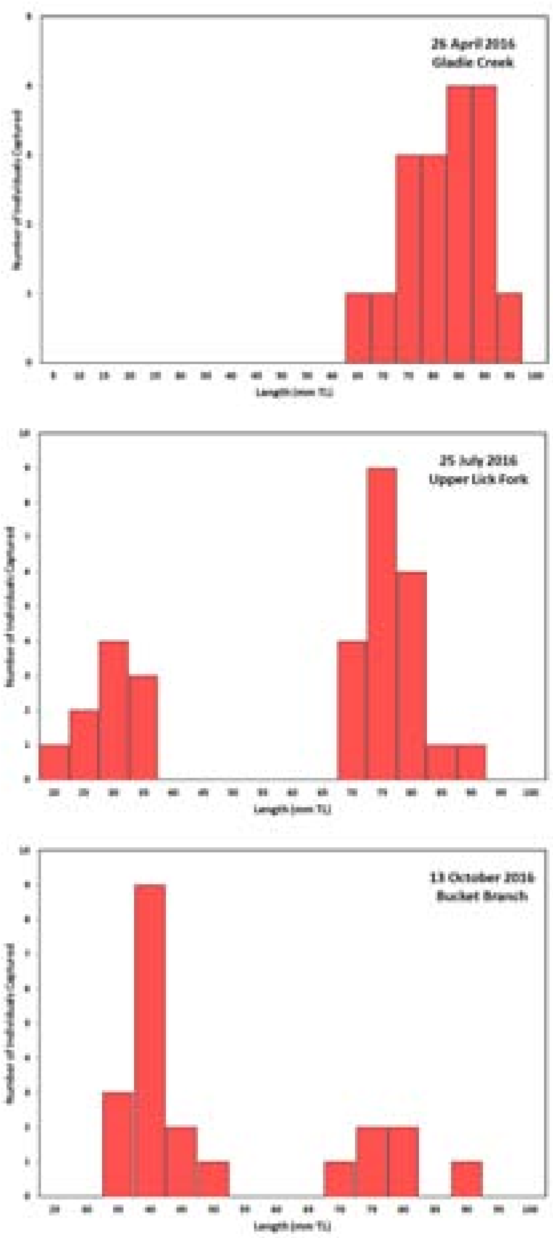
Most Redside Dace occurrences (nearly 90%) are distributed within the North Fork (Licking River), Beaver Creek (Licking River), and Upper Red River (Kentucky River) HUC10 watersheds, each of which has a total area that is 70-80% forested and situated on Plateau Escarpment. Characteristics of streams currently supporting the species are mostly consistent with what was reported by Meade et al. (1986); these include cool and clear water, near neutral pH, in forested watersheds with good canopy cover over the stream (**Figure 2**). We observed that the species predominantly occurs in headwater creeks and small streams with partial to complete forest cover in the watershed.

We observed spawning activity over mixed-size gravel nests on May 19, 2015 in Myers Fork and Indian Creek, and on May 9, 2016 in Coldiron Fork, Clifton Creek, and Ratliff Creek. During these times, flows were slightly elevated and water temperatures were 56.6-64.8°F. Males had developed a brilliant scarlet red lateral stripe (**Figure 3**) and were concentrated around nests with other minnows, which included the Central Stoneroller, Striped Shiner, Creek Chub, Southern Redbelly Dace, and Western Blacknose Dace. Nest association, the habit of spawning over the nest of another species, is widespread among minnows of the eastern U.S. (Johnston 1991). In this case, the larger species (Ohio Stoneroller, Striped Shiner, and Creek Chub) are the hosts (nest builders); Redside Dace, Southern Redbelly Dace, and Western Blacknose Dace are associates, all of which lay their eggs in the nest. Although this phenomenon can result in the frequent production of hybrids (Koster 1939), hybridization is not considered to be a serious problem for Redside Dace (Becker 1983). We observed occasional hybrids between Redside Dace and Southern Redbelly Dace, but it was infrequent.

The Redside Dace is relatively short-lived, reaching a maximum age of 4 years (Koster 1939). Growth is rapid during the first year, when individuals achieve nearly 50% of their maximum

Figure 3. Breeding male Redside Dace, Clinostomus elongatus (97 mm TL), captured in Myers Fork (Indian Creek-Red River drainage), Menifee County, on May 19, 2015.

Figure 4. Length frequency distributions of Redside Dace captured in different streams during 2016. At least two age classes were evident in July and October with the appearance of young-of-year in samples.



size (McKee and Parker 1982). From the size distribution of Redside Dace captured during late summer/early fall of 2016, it appears that the species lives at least 3 years in Kentucky (**Figure 4**).

In small streams, sampling with a backpack electrofisher was effective in capturing the complete fish species diversity at a given site, as well as the presence of Redside Dace; however, our ability to detect the species at sites in larger streams and small rivers (e.g., North Fork of Licking River) was probably diminished. During periods of low flow (e.g., late summer/fall) performing seine hauls in pools was most effective in capturing the species, often in larger numbers. Our sampling observations are consistent Tiemann and Sabaj Pérez (2012) who described finding the species as usually an all-or-none phenomenon. The dace can be extremely patchy, often occurring in widely separated schools that are easily missed even during extensive sampling.

Conclusions and Management Recommendations

Fish community sampling at 92 sites in 77 streams in the Licking and Kentucky River basins during 2015-2016 detected Redside Dace at 38 sites in 36 streams. Three additional fish SGCN were detected in the Upper Red River drainage: Northern Brook Lamprey (1 site, 1 stream), Emerald Darter (9 sites, 6 streams), and Frecklebelly Darter (15 sites, 13 streams). The Redside Dace is more widely distributed and occupies more streams in the Licking River basin than the Kentucky River basin. Current centers of Redside Dace abundance are in the North Fork (Licking River), Beaver Creek (Licking River), and Upper Red River (Kentucky River) drainages, where forested land makes up over 70% of the watershed area. These populations represent the southernmost periphery of the species' range. The Western Allegheny Plateau has apparently served as a glacial refugium for the species based on high levels of genetic diversity documented within Licking and Kentucky River basin populations. Considering the evidence of high genetic structuring within Redside Dace populations indicating a general lack of gene flow among populations, maintenance and protection of Kentucky's populations is important for the overall conservation of the species.

A decrease in the range and abundance of the Redside Dace has been attributed primarily to activities that increase turbidity, silt deposition, mean water temperature in small streams (either as a result of dams or removal of riparian areas), and introduction of top predators (Trautman 1981; Lyons et al. 2000; COSEWIC 2007). In Wisconsin, Lyons et al. (2000) reported the loss of Redside Dace from streams in the Rock River drainage associated with expansion of Brown Trout populations into the headwater habitats used by the dace, but no cause and effect relationship was established. While impacts of trout stocking on Redside Dace in Kentucky are unknown, the species has persisted in streams that have been stocked with Rainbow Trout and Brown Trout dating back to the 1980s.

The continued persistence of Redside Dace in Kentucky is largely dependent upon the integrity of headwater habitats that support reproductively viable populations. This includes maintaining well forested watersheds in the DBNF and preventing further degradation of streams on private lands. Our survey results indicate that populations in the Licking and Red River drainages are generally stable, with additional stream occurrences than previously reported. Periodic surveys of Kentucky populations should be continued every 5-10 years to monitor changes in the distribution, abundance, and habitat conditions.

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Funding Source: *State Wildlife Grant Program (SWG)*

KDFWR Strategic Plan. Goal 1. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi.

Cave survey / Kevin Kelly

New Projects

Survey of the Fishes of the Lower Ohio River Drainage in the Coastal Plain Province of Western Kentucky

Seining in Humphrey Creek, Ballard County. Bottom: Lake Chubsucker (left) and Taillight Shiner (right)/ Stephanie Brandt and Matt Thomas.

Matthew Thomas and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources

The lower Ohio River drainage in McCracken and Ballard counties harbors a rich assemblage of Coastal Plain fishes. In addition to the main-stem Ohio River, the area includes six minor tributaries as well as one of the largest concentrations of floodplain lakes, vegetated wetlands, oxbows, sloughs, ditches, and backwaters (i.e., Palustrine System) in the state.

A total of 116 species of fish have been documented from the Coastal Plain Province of the lower Ohio River drainage in Kentucky. Most (81 species) occur in the minor tributaries and palustrine habitats. Of these species, 18 are in need of protection, research, and/or management because they are rare, the number of known populations is declining or low, or their distribution has been reduced. Half of these species occur either exclusively or mostly in palustrine habitats, while the remaining half occur in the mainstem Ohio River; however, several of the large riverine species also may utilize tributaries and palustrine habitats as feeding and rearing areas.

Previous survey efforts in the region have been patchy and infrequent. Distributional data for most of the rare lowland species are more than 10 years old and with fewer than 10 occurrences for the area. Updated distributional information on Coastal Plain fishes in the lower Ohio River drainage, particularly rare species and non-native invasive species, is needed to determine high priority aquatic habitats for conservation, and determine future research and monitoring needs.

The objectives of this project are to: 1) compile and verify existing fish collection data in the lower Ohio River drainage of western Kentucky from all available sources; 2) conduct fish surveys to determine species composition, abundance, and distributions at sites established throughout the study area; and 3) Submit a final report that assesses the distribution and status of rare fishes in the lower Ohio River drainage for future conservation planning and monitoring.

Between August 2016 and October 2017 we completed fish community sampling at 39 of 75 sites selected throughout the study area. Streams, oxbows, sloughs, and wetlands were sampled using a backpack electrofisher, dip nets, and different sized seines (15’ X 6’ and 20’ X 6’,1/8” mesh). In September 2016, we completed a 3-day effort on the mainstem Ohio River using an 8’ modified trawl designed to capture small bodied fishes in deeper riverine habitats. Field sampling for this project will be completed in 2018 and a final report will be available in spring 2019.

Funding Source: *Kentucky Aquatic Resources Fund (KARF)*

KDFWR Strategic Plan. Goal 1. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi.

Distribution and Status of Rare and Endemic Fishes in the Barren River Drainage, Kentucky

Matthew Thomas and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources

The Barren River drainage is the largest tributary watershed in the Green River basin, draining 2,264 sq mi, including about 380 sq mi of headwaters in Tennessee. It is situated on the Interior Plateau where it crosses sections of the Crawford-Mammoth Cave Uplands, Western Pennyroyal Karst Plain, and Eastern Highland Rim. With approximately 108 native fish species, the Barren River drainage is also the most species rich tributary of the Green River basin. The Barren River near Bowling Green, Barren River Lake and Skaggs Creek drainages were considered priority watersheds for conservation because they contain a relatively large number of imperiled species of fish and/or mussels. The Barren River drainage contains 17 species of greatest conservation need (SGCN) recognized in Kentucky's Wildlife Action Plan. Nine of these species are state-listed as endangered, threatened, or special concern by the Kentucky State Nature Preserves Commission and four are considered at-risk by the U.S. Fish and Wildlife Service.

In spring 2017, we began a survey project to assess the current status of fish SGCN in the Barren River drainage in Kentucky. Our project objectives are: 1) review historic and recent collection records for fish SGCN and compile all literature pertinent to the fish fauna of the Barren River drainage; 2) conduct fish sampling at an array of sites representative of different stream sizes and habitat conditions throughout the Barren River drainage to determine species composition, distribution, and relative abundance; and 3) relate current populations of fish SGCN to historical information.

We completed fish community sampling at 42 sites from 5 tributary watersheds in the Barren River drainage below Barren River Lake. Our efforts produced 63 fish species, including 8 of 17 SGCN known from the drainage. Drakes Creek had the highest number (7) of SGCN among the five systems sampled. Popeye Shiner (*Notropis ariommus*), Longhead Darter (*Percina macrocephala*), and Frecklebelly Darter (*Percina stictogaster*) were rare, represented in our sampling by 1-2 individuals at single localities. In contrast, Kentucky Snubnose Darter (*Etheostoma rafinesquei*), Splendid Darter (*E. barrenense*), and Highland Rim Darter (*E. kantuckeense*) were present at over 50% of sites sampled within their respective ranges.

In 2018, we will conduct fish community sampling at additional sites in the lower Barren River drainage and expand eastward into tributary watersheds draining into Barren River Lake and above the reservoir. This project will provide information necessary to facilitate appropriate conservation actions that will benefit fish SGCN in the Barren River drainage.

Left: Fish sampling in West Fork Drakes Creek, Simpson County / Stephanie Brandt. Right (top to bottom): Popeye Shiner, Splendid Darter, Highland Rim Darter, and Frecklebelly Darter.

Funding Source: *State Wildlife Grant Program (SWG)*

KDFWR Strategic Plan. Goal 1. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi.

Evaluation of Angling Effort Using Remote Cameras

Dane Balsman, Jason McDowell and Bobby Widener, Kentucky Department of Fish and Wildlife Resources

Time lapse photo used to determine angling effort at Easy Walker Park Lake in Mt. Sterling.

The Fishing in Neighborhoods (FINs) program began in 2006 as a cooperative endeavor between Kentucky Department of Fish and Wildlife Resources (KDFWR) and local municipalities to provide access to quality fishing opportunities close to large populations of people. The FINs program currently includes 44 lakes in 28 counties across Kentucky. Fishing pressure was extremely high at FINs lakes where creel surveys were conducted from 2010-13 with total angler-hrs ranging from 11,000 – 66,000 hours per lake or 1,400 – 9,500 angler-hrs/acre. Angling effort is perceived to be high at most other FINs lakes, however quantifying effort using creel surveys is expensive and would be cost prohibitive to conduct at all lakes. However, a new tool is available in the form of remote time-lapse cameras, which offer a cost effective way to estimate angling effort. Using these remote, fixed position cameras it is possible to effectively monitor multiple lakes, capturing effort for a full 12-month period, while capturing daily and seasonal trends.

A total of 31 Reconyx Hyperfire HC500 cameras were purchased along with metal lock boxes in 2015. Prior to installing cameras, a letter was sent to lake owners explaining the purpose of the study and seeking the owner's permission to use cameras within their park. An additional waiver, consent and release form was drafted by the KDFWR attorney and signed by lake owners prior to implementation. The first year of the study (2015-16) included 19 FINs lakes ranging in size from 1-14 acres. Currently (2017-18), a separate group of 15 lakes ranging from 1-25 acres are being surveyed.

The cameras do not cover 100% of the bank access at most lakes, so a correction factor was employed to account for missed anglers and estimate total angler effort. The correction factor was developed by making in-person counts that are later correlated with camera counts. Cameras were set up to take a picture every half-hour from daylight to dusk. Only images at the top of the hour were used for analysis; however, the half hour pictures helped postulate if someone was fishing as well as aided in the number of in-person visual counts that could be collected for the correction factor. Timelapse Image Analyzer was used to assist KDFWR personnel with image analysis. This free software sped up image analysis and reduces errors, by automatically populating many of the fields needed for analysis and reduces data entry errors by placing the image and data entry on the same form.

To calculate total angling effort, a daily total of the numbers of anglers observed on camera(s) was summed from the hourly counts and then multiplied by the correction factor for each lake. Angling effort at the 19 FINs lakes where remote camera surveys were completed ranged from 1,815 – 23,674 total angler-hrs, or on a per acre basis, effort ranged from 180 – 6,446 angler-hrs acre. Effort was highest at most lakes from April – June, which aligns with the months that fish are heavily stocked. This spring – early summer period coincides with our "front-loaded" fish stocking efforts and promoting the FINs program to get anglers to purchase a license and use the resource. Angling effort was expected to be lower in the winter, and was verified with the camera survey as pressure was much lower from November – February, and very little effort concentrated in December or January. Five of the 19 lakes surveyed had angling effort exceeding 5,000 angler-hrs/acre with all of these lakes being small (< 5.0 acres).

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan. Goal 2. Strategic Objective 3, Goal 3. Strategic Objective 1


Osprey banding

Project Updates

Alligator Gar Propagation and Restoration in Western Kentucky

Fisheries Staff at PFH tagging young Alligator Gar; KDFWR staff photo.

Stephanie Brandt, Matt Thomas, Josh Pennington, and Noah Nelson, Kentucky Department of Fish and Wildlife Resources

The Alligator Gar (*Atractosteus spatula*) is the largest of the living gars and one of the largest freshwater fishes in North America. These fish are capable of reaching lengths of over 9 feet and weights of over 300 lbs. The largest reported specimen was 9 feet, 8 inches with an approximate weight of 302 lbs. Females grow larger than males, reaching sexual maturity at 11 years and have a lifespan of at least 50 years. Males reach sexual maturity at 6 years and live up to 26 years.

Its native range once occurred from the Florida panhandle west into the Gulf Coastal Plain to Veracruz, Mexico and throughout the Mississippi River Basin, including the lowermost Cumberland and Tennessee Rivers. In Kentucky, the Alligator Gar is native to the Ohio, Mississippi, lower Cumberland and lower Tennessee River systems.

Little is known about the biology and habitat of this species in Kentucky. In its southern range, the Alligator Gar typically inhibits big rivers, swamps, bayous, and brackish waters. The Alligator Gar is the most salt tolerant of all the gar species. In Kentucky, the Alligator Gar historically occupied sluggish pools, backwaters, and embayments of big rivers and larger reservoirs in the western portion of the state. Alligator Gar records have been confirmed from five locations in Kentucky: 1) Cumberland River, 3 miles below Dycusburg, Crittenden County (1925); 2) Ohio River at Shawnee Steam Plant, McCracken County (1975); 3) mouth of the Ohio River, Ballard/Carlisle County (1966); 4) mouth of Bayou du Chein, Fulton County (1974); and 5) Kentucky Lake at Cypress Creek embayment, Henry County, TN (1976). Alligator Gar have not been reported in Kentucky since 1977, despite numerous surveys. Currently, the Alligator Gar is listed as endangered by the Kentucky State Nature Preserves Commission and is listed as a Species of Greatest Conservation Need by the Kentucky Department of Fish and Wildlife Resources Wildlife Action Plan.

In an effort to restore this species back to the waters of the Commonwealth, the Kentucky Department of Fish and Wildlife Resources (KDFWR) implemented a captive propagation and stocking program in 2009. In partnership with the United States Fish and Wildlife Service (USFWS), the KDFWR has committed to a long-term restoration effort of this species. The Pfeiffer Hatchery receives Alligator Gar fry from the USFWS Pvt. John Allen Fish Hatchery in Tupelo, MS. The fry are reared to 8-10 inches in length and tagged with microwire prior to stocking. Stocking sites are areas that have historically contained Alligator Gar and which still provide suitable habitat for optimal survival.

From 2009-2017, a total of 43,317 Alligator Gar were stocked by the KDFWR. Size at stocking ranged from 7.3 to 14.5 inches. Alligator Gar were stocked in the following areas: (1) Clarks River; (2) Phelps Creek; (3) Bayou Creek; (4) Tradewater River; (5) Deer Creek; (6) Obion Creek; (7) Massac Creek; (8) Bayou de Chien; (9) Mayfield Creek; (10)Ballard WMA; (11) Barlow Bottoms WMA; and (12) Doug Travis WMA.

A telemetry study conducted by Murray State University from 2010-2012 provided details on stocked Alligator Gar movement in the Clarks River drainage. In addition, several noteworthy recaptures of fish stocked been reported. While some were found in western Kentucky, others had moved out of state. During 2010-2011, two sonic tagged individuals of unknown size were detected by passive receivers in the Mississippi River from the Ohio River confluence downstream to Caruthersville, Missouri. In 2017, two wire-tagged individuals, each over 43 inches and 50 lbs were reported by anglers in Ohio River tributaries in southern Illinois and Indiana. These reports confirm survival, growth, and movement of at least a small percentage juvenile Alligator Gar stocked in western Kentucky since 2009.

Funding Source: *State Wildlife Grant Program (SWG)*

KDFWR Strategic Plan. Goal 1. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi: Taxa specific project.

Cumberland Darter *(Etheostoma susanae)* Restoration Monitoring in Cogur Fork, Upper Cumberland River Drainage, Kentucky

Matthew Thomas and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources

The Cumberland Darter is endemic to a limited portion of Cumberland River drainage above Cumberland Falls in KY and TN. It was federally listed as endangered in 2011 due to range curtailment and fragmentation from habitat loss and degradation. From 2008-2015 KDFWR partnered with Conservation Fisheries, Inc. to develop spawning protocols for the species and produce offspring needed to re-establish extirpated populations within its historic range. We selected Cogur Fork, a 10 sq km tributary of Indian Creek, as a suitable stream for reintroduction because habitat conditions were suitable but it did not contain a pre-existing population.

A total of 4,945 captive spawned, VIE-tagged fish were stocked in Cogur Fork during 2008-2015 with the objective of establishing a viable, self-sustaining population. The following actions are required to achieve this objective: 1) annually stocking captive-spawned fish a period of 3-5 years; 2) monitoring survival, movements, and natural reproduction on a periodic basis every year; and 3) monitoring genetic diversity in the population established in Cogur Fork. The first objective has been accomplished. Continued annual surveillance on a seasonal basis is required to achieve the second and third objectives. Stocking ceased after 2015 and our focus shifted to long-term monitoring to assess survival, reproduction, and movements within Cogur Fork.

During a pre-spawning survey in late February 2017, we captured 10 individuals representing at least two year classes; 4 untagged juveniles (presumed 2016 year class), 4 untagged adults, and 2 tagged adults (2015 year class). We returned in late November and captured 9 individuals representing at least two year classes; 4 untagged YOY, 3 untagged adults, and 2 tagged adults (2015 year class).

These surveys confirmed survival of 2015-year class fish (4 total tagged fish recaptured) and provided evidence of natural reproduction and successful recruitment (15 total untagged YOY and adult fish captured). The steadily increasing trend in numbers of untagged individuals observed in our surveys during the past 5 years indicates successful spawning and recruitment in Cogur Fork.

We will continue to monitor the Cumberland Darter population established through annual reintroductions that occurred during 2009-2015 in Cogur Fork. In 2018 we will begin tissue sampling (non-lethal fin clips) for genetic monitoring to ensure long-term viability of the population (objective action #3).

Top: Cumberland Darter habitat in Cogur Fork, McCreary County / Matt Thomas. Bottom: Adult male Cumberland Darter / Conservation Fisheries, Inc.

Funding Source: *State Wildlife Grant Program (SWG)*

KDFWR Strategic Plan. Goal 1. . Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi.

Kentucky Arrow Darter *(Etheostoma spilotum)* Restoration Monitoring in Long Fork, Red Bird River Drainage, Kentucky

Matthew Thomas and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources

The Kentucky Arrow Darter is endemic to headwater streams in the upper Kentucky River drainage. It was federally listed as threatened in 2016 due to significant population declines, particularly where coal mining, gas/oil exploration, and land development have intensified during the past two decades.

From 2012-2015 KDFWR partnered with Conservation Fisheries, Inc. to develop captive spawning protocols and produce offspring needed to re-establish extirpated populations within the species' historic range. We selected Long Fork, a 3.6 sq km tributary of Hector Branch (Red Bird River drainage), as a suitable stream for reintroduction because habitat conditions were suitable but it was isolated and did not contain a pre-existing population.

A total of 1,823 captive spawned, VIE-tagged fish were stocked in Long Fork during 2012-2015 with the objective of establishing a viable, self-sustaining population. Achieving this objective requires: 1) annual stocking of captive-spawned fish for 3-5 years; 2) monitoring survival, movements, and natural reproduction on a periodic basis every year; and 3) monitoring genetic diversity in the population established in Long Fork. The first objective has been accomplished. Continued annual surveillance on a seasonal basis is required to achieve the second and third objectives.

Stocking ceased after 2015 and our focus shifted to long-term monitoring to assess survival, reproduction, and movements within Long Fork and dispersal into its receiving stream watershed, Hector Branch. Long Fork and its receiving stream, Hector Branch were surveyed in late October 2017. Eight adults (3 tagged 2015 year class and 5 untagged fish) were captured in Long Fork and 3 untagged adults were captured at two locations in Hector Branch. Our monitoring efforts have confirmed the survival of tagged fish and successful reproduction in Long Fork since 2012.We have documented dispersal into Hector Branch, but have not observed evidence of spawning outside of Long Fork.

Top: Confluence of Long Fork and Hector Branch, Clay County / Matt Thomas. Bottom: Adult male Kentucky Arrow Darter / Conservation Fisheries, Inc.

In early 2018 (February-March), we will conduct pre-spawning surveys for Kentucky Arrow Darters in Long Fork and Hector Branch to assess overwinter survival and dispersal. Early spring sampling will include the upper reaches of Long Fork and Hector Branch and tributaries, since flows will be elevated and the darters tend to move into headwater reaches in preparation for spawning. A second round of sampling in Long Fork and Hector Branch will occur in late summer/fall to assess reproduction and recruitment, as well as survival and dispersal. At that time, all young-of-year captured will be biopsied for DNA (non-lethal fin clips). These samples will be sent to an appropriate DNA repository for genetic monitoring to ensure long-term viability of the population (objective action #3).

Funding Source: *State Wildlife Grant Program (SWG)*

KDFWR Strategic Plan. Goal 1. . Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi.

Lake Sturgeon Restoration in the Upper Cumberland River Drainage in Kentucky

2017 Lake Sturgeon trotline sampling on Cumberland River near mouth of Laurel River. Fisheries Staff: Stephanie Brandt, Jay Herrala, Dirk Bradley

Stephanie Brandt, Matt Thomas, Josh Pennington and Noah Nelson, Kentucky Department of Fish and Wildlife Resources

The Lake Sturgeon (*Acipenser fulvescens*) is considered critically imperiled in Kentucky, where it is currently limited to the Ohio and Mississippi rivers. In 2007, Kentucky Dept. of Fish and Wildlife Resources (KDFWR) initiated a long-term (20+ years) project to restore a self-sustaining population of Lake Sturgeon to the upper Cumberland River drainage, where the species occurred historically. The project area extends from Wolf Creek Dam, upstream to Cumberland Falls, including major tributaries such as Rockcastle River and Big South Fork Cumberland River.

Since 2007, fertilized eggs have been obtained annually from the Wisconsin Dept. of Natural Resources taken from upper Mississippi basin stock. These eggs are hatched at the KDFWR Pfeiffer Fish Hatchery in Frankfort and the young are reared to an approximate average of 7.5-10.2 inches total length. Since spring 2008, 42,738 young Lake Sturgeon have been released annually at two locations in the upper Cumberland River drainage: Cumberland River at the mouth of Laurel River and the Big South Fork Cumberland River at the Alum Creek. Prior to release, young Lake Sturgeon are differentially marked by sequentially removing two adjacent scutes in the lateral series to distinguish year classes: right anterior scutes 2-3 for 2007, left anterior scutes 2-3 for 2008, right anterior scutes 3-4 for 2009, left anterior scutes 3-4 for 2010, right anterior scutes 5-6 for 2011, left anterior scutes 7–8 for 2014, and right anterior scutes 7-8 for 2015, left anterior scutes 1-2 for 2016, and left anterior scutes 3-4 for 2017. Stocking did not occur in 2012 or 2013. Local print media (Times Tribune, Corbin, KY) and Corbin High School students have been present at the Lake Sturgeon release events each year. Kentucky Afield television, magazine, and radio have also featured the reintroduction and sampling efforts for this rare species in the Cumberland River.

Angler reports of Lake Sturgeon have steadily increased since 2008 with reports of fish captured from various locations in the impounded portion of the river (Lake Cumberland) and below Wolf Creek Dam. The individuals below the dam either passed through the turbines of Wolf Creek Dam from the reservoir or migrated upstream from Tennessee. A variety of sampling techniques are being evaluated to determine survival, habitat use, and movement patterns of stocked fish and will continue in 2018.

Funding Source: *State Wildlife Grant Program (SWG)*

KDFWR Strategic Plan. Goal 1. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi: Taxa specific project.

Targeted Sampling for Fish Species of Greatest Conservation Need in Kentucky

Matthew Thomas and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources

In 2017, we collaborated on four projects with the U.S. Fish and Wildlife Service Kentucky Field Office (KFO), KY State Nature Preserves Commission (KSNPC), Tennessee Aquarium Conservation Institute (TNACI), and the Yale University Peabody Museum of Natural History (YPM). Our objectives were to obtain fish community data and tissue samples of target SGCN for population genetics research. These projects have conservation implications for fish SGCN in Kentucky.

Species Discovery and Delimitation of Barcheek Darters.— Barcheek Darters are a closely related group of species distributed in the lower Tennessee River, Duck River, lower and middle portions of the Cumberland River, and upper portions of the Green and Barren river systems in Kentucky and Tennessee. Molecular phylogenetic analyses indicate the Barcheek Darter group contains multiple undescribed species. In 2017 we collected Barcheek Darter (*Etheostoma obeyense)* DNA samples from six tributary watersheds in the middle Cumberland River drainage in south-central Kentucky. Specimens were shipped to YPM for genetic and morphological analyses to determine phylogenetic relationships and assess species boundaries drawn from traditional morphological traits.

Left: Seining for Cumberland Darters in Wolf Creek, Whitley County / Stephanie Brandt. Right (top to bottom): Barcheek Darter, Cumberland Darter, Relict Darter, and Western Sand Darter.

Population Genetic Assessment of the Cumberland Darter.— The Cumberland Darter (*Etheostoma susanae*) is a federally endangered species endemic to tributaries above Cumberland Falls in Kentucky and Tennessee. We assisted TNACI, KSNPC, and KFO with collecting DNA samples to assess gene flow and genetic diversity within and among populations. Fish were captured using a small seine and nonlethal fin biopsies were obtained from up to 35 individuals from each stream sampled. Samples were collected from 7 streams representing 5 of the 6 known populations in Whitley and McCreary counties. Tissue collection and genetic analyses will be completed in 2018.

Fish Community Sampling Following Removal of Green River Lock and Dam 6.— In August, we assisted KSNPC and KDOW with fish sampling at 3 sites on the Green River in Edmonson County for baseline data to assess changes in the fish community following the removal of Lock and Dam 6. Four fish SGCN are known to occur within our sample reach: Popeye Shiner (*Notropis ariommus*), Stargazing Minnow (*Phenacobius uranops*), Western Sand Darter (*Ammocrypta clara*), Spotted Darter (*Nothonotus maculatus*), and Tippecanoe Darter (*Nothonotus tippecanoe*). We collected Western Sand Darters at two sites where sandy substrates were present. Stargazing Minnows were present only at one site in deep (0.5-1.0 m), gravel-bottomed runs. Popeye Shiners were present at two sites in gently flowing pools up to 1.5 m in depth. Multiple age classes were evident among Popeye Shiners indicating the presence of a successfully reproducing population.

Status Survey and Population Genetics of the Relict Darter.— The Relict Darter (*Etheostoma chienense*) is a federally endangered species endemic to the Bayou du Chien drainage in far western Kentucky. In October, we assisted KFO with Relict Darter sampling at two locations in Bayou du Chien using backpack electrofishing in both quantitative and qualitative surveys. All Relict Darters captured were counted, measured, biopsied for DNA, and released unharmed. Data collected will be used to evaluate abundance and population trends (e.g., increasing, decreasing, stable) for a 5-year review to be completed in 2018. DNA samples were shipped to Southeastern Louisiana University for analysis of genetic structure, levels of gene flow, and effective population size. Fish sampling and genetic analyses will be completed in fall 2018.

Funding Source: *State Wildlife Grant Program (SWG)*

KDFWR Strategic Plan. Goal 1. . Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi.

Using telemetry to monitor the movements and distribution of Asian Carp in the Ohio River

Chris Hickey, Jason Curry, Chris Bowers, and Paul Wilkes, Kentucky Department of Fish and Wildlife Resources (KDFWR);

Neil Gillespie, US Fish and Wildlife Service (USFWS)

Ohio Department of Natural Resources (ODNR), West Virginia Division of Natural Resources (WVDNR)

Installing a transmitter into a silver carp / Taylor Nagle.

In the 1970's, both Silver Carp (*Hypophthalmichthys molitrix*) and Bighead carp (*H. nobilis*) were imported into the US by aquaculture facilities that used them to counter water quality issues caused by intensive fish production. Unfortunately, the "Asian Carp" eventually started popping up in water bodies outside of these facilities, and by the early 80's, there were enough Bighead and Silver Carp in the lower Mississippi River to facilitate the establishment of new populations. The excellent dispersal capabilities of the Asian Carp allowed the populations to expand up the Mississippi River Basin, which would inevitably include one of its largest tributaries, the Ohio River. As in other waterways, the Asian Carp easily expanded throughout the lower to middle Ohio River Basin, which was aided by successful spawning efforts that were noted as far upstream as the Cannelton Pool near Louisville, KY. Both Bighead and Silver carp have become commonplace within the first 600 miles of the Ohio River basin, but there are still relatively few of either species inhabiting the upper ~350 miles of the river. This very prompted resource management agencies to monitor the distribution and movement of Asian carp on the Ohio River in the hopes of identifying ways to limit their dispersion.

The Asian Carp Telemetry Project is a collaborative research effort that the KDFWR and USFWS initiated to study the distribution and movements of Bighead and Silver Carp across numerous pools of the Ohio River. When it began in 2014, a ~300 mile array with <70 receivers was established across 5 pools of the Ohio River in order to monitor ~160 Asian Carp that had been surgically implanted with ultrasonic transmitters. By the end of 2017, the project successfully expanded to create the current 500-mile telemetry array, which now covers some portion of 9 different main stem pools and 26 major tributaries. This telemetry array provides a receiver coverage to monitor 508 Asian Carp (n = 44 Bigheads + 464 Silver Carp) that have been implanted with transmitters.

Biologists make monthly visits to the telemetry sites to download any new Asian Carp detections that were logged by the receivers. Preliminary analysis of the data indicated that 51% of the 158 active receivers contributed one or more detections to the 2017 database, which consisted of 8+ million tagged carp detections after the last of the data was uploaded in late December 2017. A total of 263 tagged carp were responsible for all 8+ million detections made throughout 2017. Encouragingly, more than 80% of the detected carp finished the year with average upstream-downstream movements of less than 5 miles and more than 95% of the tagged carp detected since 2014 have stayed in the same pool that they were originally tagged in. Lastly, an early comparison of their habitat usage indicates that the Asian Carp were much more likely to occupy tributaries than the main stem Ohio River.

Tagging efforts in 2018 will be solely focused on lower density populations where additional Bighead and/or Silver Carp are definitely needed to replace tagged fish that will be undetectable after the summer of 2018, which is when the project's first transmitters are expected to shut down after reaching the end of their 5-year battery life.

Funding Sources: *Water Resources Reform and Development Act of 2014 and United States Fish and Wildlife Service*

KDFWR Strategic Plan. *Goal 1. Strategic Objective 4.*

Control and Containment of Asian Carp in the Ohio River

Andrew Stump, Chris Bowers, Jason Curry, and Paul Wilkes, Kentucky Department of Fish and Wildlife Resources

Kathrine Zipfel and Stephen Floyd, West Virginia Division of Natural Resources

Quinton Phelps, West Virginia University

The invasive carps (Silver carp, *Hypophthalmicthys molitrix*; Bighead carp, *Hypophthalmichthys nobilis*; Black Carp, *Mylopharyngodon piceus*; and Grass carp, *Ctenopharyngodon idella*), commonly referred to as Asian carps, have successfully expanded their range into the Ohio River basin since their introduction into the Mississippi River. In recent years these species have proven to cause significant problems in areas where they become established. Eradication of invasive species after establishment is difficult and often limited by available resources. Prevention and rapid response are typically the best tools for limiting establishment once alien species begin to expand into new territory. Physical removal is currently the only prevention tool available for a river system as large as the Ohio River while research is underway to determine the distribution, spawning habits, and strongholds for populations of invasive carps in the basin. Consistent removal pressure where carp are established decreases pressure on barriers to dispersal, reduces numbers while giving us additional information population characteristics, and may aid in protecting species of conservation need and important fisheries.

Spawning patches on the underside of a silver carp / Andrew Stump.

Both boat electrofishing and gill netting are conducted from April through December with the aim of targeting and removing bigheaded carps and grass carps in the pools of the middle Ohio River (Cannelton – RC Byrd). This section of river is currently where the transition between established populations of Silver Carp change over to more of an "invasion front," where occasional adult carp are found, but likely not reproducing successfully. Originally, it was assumed *H. nobilis* followed a similar pattern of establishment as Silver Carp in this section of river; however, more recently, it has been noted that frequent captures in upper pools of the project area indicate otherwise. As a response, specific efforts and resources have been re-directed to target bighead carp further up the system. Removal locations focus on location (mainly large tributaries) where catchability has been the highest in previous years, as well as additional areas identified through monitoring efforts.

Using information and lessons learned from the previous seasons, crews removed 20,000 lbs of carp in 2017 from the middle Ohio River system. Additionally, some collaboration between KDFWR and USFWS has led to hydroacoustically directed sampling in the cooler months of the year. Through the use of hydroacoustic equipment, large schools of fish were targeted in the Cannelton pool near Cloverport, KY. Main stem removal efforts using this technology did not produce promising results, however, tributary sampling in Clover Creek after a school was located using hydroacoustic equipment just upstream of the tributary mouth yielded promising numbers of both Bighead and Silver Carp. Removal will continue to expand into internal Kentucky tributaries and focus on bighead carp suppression in more upriver locations in an effort to control additional progression of carp through our natural systems.

Funding Sources: *United States Fish and Wildlife Service, Water Resources and Redevelopment and Development Act*

KDFWR Strategic Plan: Goal 1, Strategic Objective 4.

Impacts of Asian Carp Harvest Program on Sportfish in Kentucky


Commercial fishermen with a boat full of Asian Carp / Josh Tompkins

Jessica Morris, Matthew Combs, Joshua Tompkins, Jason Young, Andrew Porterfield, and Troy Hubbard, Kentucky Department of Fish and Wildlife Resources

Kentucky is the home to fertile waters including the intersection of some of the nation's largest rivers which have long supported rich fisheries and a tradition of commercial fishing. These fertile waters are now being exploited by the highly invasive Asian carp and as carp numbers increase, commercial markets follow. The Asian Carp Harvest Program (ACHP) was created in 2013 to increase commercial harvest of Asian carp in Kentucky waters to assist in the control of their rapidly expanding population. In 2015, the Kentucky Department of Fish and Wildlife (KDFWR) initiated a 5 cent/lb subsidy to incentivize the harvest of Asian carp from Kentucky Lake and Lake Barkley. The ACHP allows commercial fishing access in areas that are popular sportfisheries such as below dams and in reservoirs. The objective of this study is to obtain daily reports from and observe commercial fishers to assess direct impacts of commercial fishing on sportfish in Kentucky waters.

Since the implementation of the Asian Carp Harvest Program, commercial fishers in Kentucky have harvested a total of 3,974,195 lbs of Asian carp (3,901,668 lbs silver carp, 72,527 lbs bighead carp) through the program. The number of commercial fishers using the ACHP has increased since 2013, peaking at 27 participating fishermen in the 2016 commercial license year. In 2017 the number of fishermen declined (15), and was potentially the result of instability in the local processors ability to purchase Asian carp consistently. KDFWR personnel conducted 31 ride alongs with commercial fishers fishing under the ACHP during January-December 2017. During ride alongs 32,391 yards of gillnet was fished and 75,499 lbs of Asian carp were harvested. The most common gear types used were 4-5" mesh gill nets. However, 3.5" inch mesh was found to have the highest catch per unit effort of mesh sizes used by commercial fishermen. This is due to the 2015 year class of silver carp becoming susceptible to this mesh size. The majority of commercial fishing effort under the ACHP was in Lake Barkley and Kentucky Lake.

Increased effort by commercial fishermen fishing under the ACHP has translated into a growing amount of bycatch. However, the survival rate (fish that swim away after release) of sport fish has remained relatively high through 2017 (95.5% survival). In relation to total bycatch, the number of sport fish captured in 2017 was low (32% during ride-alongs in 2017, 6% from all commercial fishermen reports in April-December 2017). The most common species of sport fish caught in commercial gillnets during ride-alongs was blue catfish (47 fish), followed by flathead catfish (19 fish), and channel catfish (17 fish). Survival rates of all sport fish remained high (>80.0%). Only one crappie and very few *Morone* sp. (3 fish total) were observed in commercial gill nets during ride-alongs in 2017. Paddlefish was the most common bycatch species during ride-alongs in 2017 making up 21% of all bycatch. The mean survival rate of paddlefish during ride-alongs was 48.4% but varied between water bodies and number captured. Other species of fish that were commonly observed as bycatch included common carp (11% of bycatch) and freshwater drum (9% of bycatch).

In 2017, interest by commercial fishermen in the Asian carp subsidy program was renewed at the close of paddlefish season, with two fishermen signing up to receive subsidy funds. However, with only two fishermen actively participating in the program, KDFWR initiated a reform of the subsidy program in July 2017. In 2017, all fishing trips covered under the subsidy program were conducted on Lake Barkley (53 trips). Pounds of Asian carp harvested totaled 204,222 lbs (202,554 lbs silver carp, 993 lbs bighead carp, 675 lbs grass carp) with $10,211.10 of subsidy funds spent in 2017.

As concerns grow over the impacts of Asian carp to native ecosystems, management agencies scramble to find solutions. Commercial fishing is one of the only tools currently available to limit those impacts. Some fish and wildlife agencies are reluctant to allow commercial fishing with gillnets due to a negative public perception and lack of information on the potential impacts. This study shows that the common gear types used in Asian carp commercial fisheries in Kentucky pose no threat to sportfish in our waters.

Funding Sources: *United States Fish and Wildlife Service State/Interstate Aquatic Nuisance Species Funding Program (SIANSMP)*

KDFWR Strategic Plan: Goal 1, Strategic Objective 4.

Monitoring and Evaluation of Asian Carp on the Ohio River

Measuring a bighead carp / Andrew Stump.

Andrew Stump, Chris Bowers, Jason Curry, and Paul Wilkes, Kentucky Department of Fish and Wildlife Resources

Katherine Zipfel and Stephen Floyd, West Virginia Division of Natural Resources

Craig Jansen, Indiana Department of Natural Resources

The invasive carps (Silver carp, *Hypophthalmicthys molitrix*; Bighead carp, *Hypophthalmichthys nobilis*; Black Carp, *Mylopharyngodon piceus*; and Grass carp, *Ctenopharyngodon idella*), commonly referred to as Asian carps, have successfully expanded their range into the Ohio River basin since their introduction into the Mississippi River. Silver and Bighead carp are filter-feeding planktivores, capable of producing many offspring in one season. Black Carp are specialists that feed primarily on mollusks and only a handful of individual fish have been found in the lowest sections of the Ohio River basin. Grass carp are a species used to control aquatic vegetation and feral populations have been documented throughout the state. In 2015, the Kentucky Department of Fish and Wildlife Resources initiated a study on the Ohio River to determine the distribution, relative abundance, and population characteristics of invasive carps along the upper edge of their invasion front.

Since the project's inception, KDFWR has monitored carp distributions and relative abundances along with native fish species over spring and fall seasons. This baseline information has allowed for the refocusing of removal efforts in areas where carp are most abundant and susceptible to our equipment. Annually, data suggests that Silver Carp densities are higher in lower pools and decrease drastically as you move upriver. Bighead do not appear to follow the same density pattern and range farther upriver than Silver Carp with some pools having higher number of captures than others. Grass Carp appear to be sporadically distributed throughout all pools of the Ohio and are most often encountered during spring monitoring in slow-moving tributaries. Using lessons learned, KDFWR removal crews have doubled their efficiency over the past two years, removing almost 20,000 lbs in 2017 alone.

Monitoring efforts have also tracked signs of spawning activity in bigheaded carps and used this information to inform larval studies and define general spawning periods. Females participating in a spawning event will display a bloody "patch" or raw abrasion due to male attention on the most ventral portion of the breast, between their pectoral and pelvic fins. Fish in the Ohio River have consistently attempted to spawn for the past three spring seasons and fresh spawning patches have continued display on female fish for several months, extending well into the summer.

Fish captured post spawning were also weighed and measured to determine overall condition. Both male and female Silver and Bighead Carp display similar body conditions when compared to other invasive populations in different parts of the country. As removal efforts continue, changes in condition will be noted annually and will be paired with aging data to track year-classes and provide an assessment of population control efforts. Preliminary sampling data indicates that the dominant ages for Silver Carp captured in the Cannelton pool have shifted from four years old in 2015 to six years old this season. However, there has been an increase in capture of smaller length-classes of fish in the past couple of seasons, indicating that a younger group of fish are likely going to begin showing up in annual sampling efforts. Further work is needed to identify and pinpoint nursery and spawning locations to determine if targeted sampling and spawning disruption could aid in furthering population control efforts.

Funding Sources: *United States Fish and Wildlife Service, Water Resources and Redevelopment and Development Act*

KDFWR Strategic Plan: Goal 1, Strategic Objective 4.

The Fishing in Neighborhoods (FINs) Program: Providing Fishing Opportunities to Residents in Cities across the Commonwealth

Dane Balsman, Jason McDowell and Bobby Widener, Kentucky Department of Fish and Wildlife Resources

In an effort to boost license sales and increase fishing opportunities, the Kentucky Department of Fish and Wildlife Resources (KDFWR) initiated the Fishing in Neighborhoods (FINs) program in 2006. The FINs program currently provides quality fishing opportunities at 44 lakes in 28 counties around the Commonwealth. Many of these lakes are located near large population centers, where fishing opportunities would otherwise be lacking. The FINs program thrives on partnerships between KDFWR and local municipalities. As part of a cooperative agreement, lake owners provide 25% in-kind match of services to maintain and promote fishing access at these lakes to offset stocking costs.

In 2017, 119,300 rainbow trout and 118,020 catfish were stocked in FINs lakes. The catfish stockings were a combination of channel, blue, and channel x blue catfish hybrids. These stockings of "keeper-size" fish provide angling opportunities to a diverse group of anglers. In the past, many of these lakes were overfished due to their size and location. Lakes are stocked up to four times annually with catchable-size catfish (12 – 20 inch) and three times annually in the cool months (October – March) with rainbow trout (10 – 11 inch). Bass and sunfish populations are routinely sampled to ensure natural reproduction is meeting the needs of the anglers. In 2017, 31,000 (5 – 9 inch) hybrid sunfish were stocked in June at lakes that had poor sunfish numbers, heavy fishing pressure, or fishing events. A standard set of creel limits is in place at all FINs lakes to help spread out fish harvest and ensure fishing opportunities for as many anglers as possible. Daily limits for each angler fishing a FINs lake includes five rainbow trout, four catfish, one largemouth bass over 15 inches, and 15 bluegill or other sunfish.

Since 2010, creel surveys have been conducted at five FINs lakes and fish tagging studies to determine exploitation were conducted at four lakes. These studies have shown angling effort and utilization of stocked fish to be high. However, these studies were costly to administer and time consuming. Additionally, the study lakes were all located in the central part of the state. To assess angling pressure at FINs lakes statewide, 30 remote cameras were mounted at 20 FINs lakes late in 2015. These remote cameras captured angling effort through time lapse photography for a 12-month period. Cameras were relocated and installed at an additional 15 lakes in 2017. This data will aid in assessing if current stocking strategies are adequate for the amount, and timing of angling effort.

Anglers Fishing at Alexandria Community Park Lake, a FINS lake in Campbell County / Dane Balsman.

Advertising and marketing efforts were employed in a continuing attempt to raise awareness of the FINs program, increase participation, and recruit new anglers. Facebook and Twitter notifications were posted around stocking dates. District fisheries biologists also mentioned the FINs program and stocking schedules in their KY Afield weekly fishing report. Flyers promoting the FINs program were distributed at boat shows. A one-page advertisement for the FINs program appeared in the Kentucky Fishing and Boating Guide, as well as a one-page stocking table appearing in the Kentucky Afield calendar. Newspaper and radio interviews, as well as press releases, were issued to promote the program. All lake owners were notified prior to fish being stocked so they could contact their followers via social media. The FINs website was routinely updated to convey the latest stocking information and list of lakes enrolled in the program. Kiosk posters promoting the FINs program and KDFWR's role in fish management and stocking was displayed at 25 of the 44 lakes.

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan. Goal 2. Strategic Objective 1, Goal 3. Strategic Objective 1, Goal 4. Strategic Objective 1.

Evaluation of Stocking Original and Reciprocal Cross Hybrid Striped Bass in Three Kentucky Impoundments

Dane Balsman, Jason McDowell and Bobby Widener, Kentucky Department of Fish and Wildlife Resources

Hybrid striped bass caught by Kevin Barry at Herrington Lake / Kevin Barry.

The Kentucky Department of Fish and Wildlife Resources (KDFWR) began stocking hybrid striped bass in 1979. The original cross of hybrid *Morone* spp. consists of crossing the male white bass *Morone chrysops* with the female striped bass *Morone saxatilis,* while the reciprocal cross consists of using a female white bass and male striped bass. Over the past three decades both original and reciprocal crosses of hybrid striped bass have been stocked in Kentucky reservoirs. However, since the mid 1990's KDFWR has been stocking almost entirely reciprocal cross hybrids. Little is known on the differences in growth, recruitment, or maximum age and size of original versus reciprocal cross hybrid striped bass in reservoirs.

The objective of this study is to determine which cross of hybrid striped bass performs better in three Kentucky impoundments (Rough River Lake, Herrington Lake, and Taylorsville Lake). This will be determined by comparing the following parameters of the two crosses within each reservoir over time: growth, recruitment to age-1+, 2+, and 3+, condition, and relative abundance.

During the first two weeks in June, 10 fish/acre of each of the reciprocal and original cross hybrid striped bass were stocked annually from 2015 to 2017 in the three study impoundments. Original hybrid striped bass were marked with oxytetracycline (OTC) as fingerlings before being stocked. Reciprocal cross hybrid striped bass were not marked with OTC. Stocking and hauling mortality were calculated by placing approximately 100 fish in 30-gallon holding drums with fine mesh panels floated at the stocking sites for 24 hours. Each lake had three replicates for each cross. At the end of the holding period, fish were counted and mortality rates calculated. In 2015, mortality ranged from 4-8% for original cross and 2% for reciprocal cross hybrid striped bass. In 2016, mortality estimates were considerably higher, ranging from 18-20% for reciprocal, and 7-53% for original cross hybrid striped bass at the three study lakes. Water temperatures varied by as much as 18° F between the transportation truck and lake surface temperature, which could have contributed to high stocking mortality in 2016. A tempering protocol for hybrid striped bass stocking was developed and implemented in 2017. This entailed slowly raising the water temperature at the hatchery and hauling the fish at a water temperature that would closely match the waterbody being stocked. Hybrid striped bass 24-hr hauling and stocking mortality estimates ranged from 0-10% for reciprocal cross and 3-16% for original cross in 2017.

Monofilament gill nets were used to sample hybrid striped bass populations in the three study lakes in late October-November when water temperatures are 55-60°F and after destratification has occurred. Otoliths were removed to determine cross and age and growth information. Potential growth differences among crosses and sex of hybrid striped bass were analyzed with ANOVA (alpha level of 0.05). There was a significant difference in growth at Herrington Lake with the reciprocal cross (21.2 in) exhibiting faster growth to age-2 than original cross (20.5 in). There was also a significant difference in growth between sexes by age-2 at Herrington Lake with females (21.5 in) having a greater mean length than males (20.6 in). No significant differences in length were observed at Taylorsville Lake between crosses or sexes. Reciprocal cross hybrid striped bass at Rough River Lake also exhibited significantly faster growth at age-2 (18.6 in) compared to the original cross (18.0 in). The mean length of age-2 female hybrid striped bass (19.0 in) was also greater than males (17.8 in) of the same age.

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5

Evaluation of a 36-inch Min. Length Limit on Muskellunge at Three Kentucky Reservoirs

Brandon Sawyers with a trophy muskellunge collected from Green River Lake / Joseph Zimmerman.

Dave Dreves, Nick Keeton, and Joseph Zimmerman, Kentucky Dept. of Fish and Wildlife Res.

The muskellunge (*Esox masquinongy*) is an ecologically and economically important sport fish in many temperate fresh water ecosystems of North America. The species is native to many of the river drainages of Kentucky, including the Green, Kentucky and Licking River drainages and historically provided very popular fisheries. During the 1960's and 1970's, the U. S. Army Corps of Engineers constructed dams impounding these rivers, creating Buckhorn Lake (1,230 acres) on the Middle Fork of the Kentucky River, Green River Lake (8,210) and Cave Run Lake (8,270) on the Licking River. The KDFWR maintains a muskellunge fishery in these reservoirs through annual stockings of 0.33 fish/acre. Each of these reservoirs now supports excellent sport fisheries for muskellunge with exceptional growth potential. A demand for increased quality of muskellunge fisheries by anglers precipitated recent fisheries management strategies directed towards establishing trophy fisheries through the use of size and creel regulations.

In an effort to enhance the quality of the muskellunge fishery, the KDFWR increased the minimum length limit for muskellunge in Cave Run and Green River lakes from 30 to 36 inches in spring 2010. The minimum size limit was also set at 36 inches at Buckhorn Lake, which had been changed to a 40-inch size limit in 2003. The daily bag limit at all lakes was maintained at one fish per day. The expected result of this regulation change is to increase the abundance of muskellunge below 36 inches and to increase the average length of all muskellunge at Cave Run and Green River lakes. However, due to the paucity of information pertaining to stocking efforts and the aforementioned regulation changes, it is unknown whether these effects will be realized with this management strategy. A thorough evaluation of this management strategy will allow the KDFWR to most effectively manage the muskellunge fishery in these reservoirs.

Each year, stocked muskellunge receive a batch mark (fin clip or wire tag) prior to stocking in the fall. From 2010 through 2013, the following fin clips were used: left pectoral, right pelvic, and left pelvic, respectively. From 2014 to 2017, the following microwire tags were used: left cheek, dorsal tag, right cheek, and caudal peduncle respectively. Population sampling is being conducted with boat-mounted pulsed DC electrofishing gear in early spring at all three reservoirs. Electrofishing catch per unit effort data (CPUE) is being used to index age-1 year-class strength, the relative frequency of various length groups of interest and mortality calculations. The muskie populations are being monitored for changes in growth and condition.

Overall muskellunge catch rates at Buckhorn Lake and Green River Lake have been steadily declining since 2010. For Buckhorn Lake, the 2017 overall catch rate was 6.8 fish/hr with a 7-year average of 7.7 fish/hr. Catch rates of muskellunge 36.0 in. and greater have been variable at an average catch rate of 1.2 fish/hr. For Green River Lake, the 2017 overall catch rate was 4.0 fish/hr with a 7-year average of 8.3 fish/hr. Catch rates of muskellunge 36.0 in. and greater have been consistent at an average catch rate at 1.5 fish/hr. For Cave Run Lake, overall catch rates and greater than 36.0 inch catch rates of muskellunge have been consistent throughout the study period at an average of 9.3 fish/hr and 1.9 fish/hr, respectively. Condition of muskellunge at all three reservoirs has been good with consistent relative weights in the 80% to 90 % range. Growth has been similar at all three reservoirs, with muskellunge reaching the 36.0 inch minimum size limit at age 4 or 5 and the potential to reach 40.0 inches at age 6.

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*,

KDFWR Strategic Plan. Goa1 1

Silver Carp Demographics

Jessica Morris, Joshua Tompkins, Matthew Combs, Jason Young, Troy Hubbard, and Andrew Porterfield, Kentucky Department of Fish and Wildlife Resources

Adult Asian carp (silver carp and bighead carp) invaded Kentucky Lake and Lake Barkley as early as 2004. As populations increased, commercial markets developed leading to an increase in the harvest of Asian carp. To further encourage harvest of Asian carp, Kentucky Department of Fish and Wildlife Resources (KDFWR) created an Asian Carp Harvest Program (ACHP) that allows commercial fishermen targeting Asian carp to fish in otherwise closed waters under close supervision. This program creates a platform for monitoring the population dynamics of Asian carp to provide a tool to assess the effectiveness of commercial removal efforts. Biological factors that are important in managing Asian carp in Kentucky Lake include the source of fish in the population, growth rates, mortality rates, and the frequency and timing of spawning events.

Projects aimed at reducing the negative impacts of Asian carp require information about the source of Asian carp within a river system. Young of year Asian carp have only been captured in Kentucky Lake or Lake Barkley in 2015. Although KDFWR has not intensively sampled for young of year Asian carp in subsequent years, neighboring agencies and partners have continued sampling with no verified captures since 2015. Growth of the 2015-year class of silver carp has been tracked by KDFWR and exhibits high growth rates with silver carp exceeding 400mm in just two years. KDFWR also partnered with Southern Illinois University (SIU) to conduct otolith microchemistry on otoliths collected from silver carp in Kentucky and Barkley lakes in an attempt to determine where these fish originated from. At this time KDFWR is still awaiting the full report from SIU.

To assess population parameters of silver carp in Lake Barkley, length, weight, sex, and gonad weights were recorded from 361 silver carp collected from commercial processors monthly from April – December 2017. Pectoral fin rays were also removed for aging. The primary size of silver carp was 800-900mm. Ages of silver carp collected by commercial fishermen ranged from 3-10 years and were dominated by four and five-year-olds. Commercial fishermen predominately use gill nets with mesh sizes of 4.25" – 5". Therefore, it can be inferred that silver carp do not efficiently recruit these mesh sizes until 4 years of age. Length-weight relationships showed that fish were relatively heavy at a given length when compared with silver carp from other populations. The mean relative weight for silver carp captured in Lake Barkley from April-December 2017 was 100.16 (N=320), which is indication that silver carp being harvested by commercial fishermen from Lake Barkley are in above average condition. Gonads of silver carp harvested from Lake Barkley were weighed to calculate the mean gonadosomatic index (GSI). The highest mean GSI for males and females in 2017 occurred in April, which coincides with high water flows in the lake. Spawning patches were also observed on female silver carp harvested from Lake Barkley on multiple occasions, suggesting that silver carp attempted to spawn in the lake. However, no young of year silver carp were observed in Lake Barkley in 2017. The weighted catch curve regression produced an annual mortality rate of 60.6% for silver carp in Lake Barkley in 2017. This is similar to the mortality rate of silver carp in the Mississippi (63.0%) and Illinois Rivers (63.3%), which have well-established commercial harvest. These data provide a baseline for future assessment of Asian carp harvest in Lake Barkley.

Boat full of fish after a day of sampling Asian Carp / Jessica Morris.

Funding Source: *Kentucky Department of Fish and Wildlife Resources*

KDFWR Strategic Plan: Goal 1, Strategic Objective 4.

Assessment of Statewide Size and Creel Limits on Smallmouth Bass in Old Pool 6 of Green River

Jason Herrala, Wade Massure, Ryan Kausing, and Brandon Sawyers, Kentucky Department of Fish and Wildlife Resources

Green River trophy smallmouth / Nick Keeton

In Kentucky, smallmouth bass are generally distributed in upland streams throughout the eastern two-thirds of the state. Smallmouth bass are a popular sport fish among both Kentucky anglers and nationwide. As a result of high angler interest, management agencies are beginning to implement stream specific strategies to improve and enhance stream smallmouth bass fisheries.

Old Pool 6 of the Green River (125 miles in length) is part of the Blue Water Trails Adventure Tourism Initiative and is located from immediately below Green River Lake downstream to the former site of Lock and Dam 6 (removed in 2017) near Mammoth Cave National Park. The majority of this pool is unimpounded and provides free flowing habitat to support a quality smallmouth bass fishery. Public boat ramps and canoe carry-down sites are located throughout this pool, and Mammoth Cave National Park reports that recreational canoeing, kayaking and boating has increased 18.8% from 2003-2012 in Old Pool 6 of Green River.

During May 2017, black bass sampling was completed at four sites. Smallmouth bass were collected at 35.2 fish/hr and ranged from 3.2 – 20.5 in. Forty-nine percent of the sample was above quality size (≥12.0 in) while trophy size (≥20.0 in) fish have been present in the spring sample each year since 2012. The smallmouth bass fishery received an assessment score of 16, representing an "excellent" rating for the third consecutive year.

Fall electrofishing was conducted during October 2017 at three sites. Smallmouth bass were collected at 19.8 fish/hr with fish ranging from 5.1 – 19.7 in. Relative weight of smallmouth bass was 82—just above the historical average of 81.

Otoliths were collected in 2014 to assess age and growth. Smallmouth bass were represented from age-1 through age-11 (no age-9 fish) and the 2.0-20.0 in size classes. Back-calculated mean length at age indicated good growth, with smallmouth bass on average reaching the statewide 12.0 in minimum statewide size limit by age-4, 14.4 in at age-5 and 15.5 in at age-6. Total annual mortality was estimated at 36.2% using weighted catch-curve regression.

An exploitation study began on April 26, 2016 and concluded on April 25, 2017 to evaluate the contribution of fishing mortality on this population. A total of 213 smallmouth bass ≥12.0 in were tagged. Forty-seven tags were reported (22.1%) of which 34 smallmouth bass were released and 13 smallmouth bass were harvested. Based on tag returns the corrected annual exploitation rate (annual fishing mortality) was 6.8% (annual natural mortality = 29.4%).

The majority of regulations in Kentucky and other states are harvest driven. Since harvest is low in Old Pool 6 of Green River, changes in regulations are unlikely to result in significant changes to the smallmouth bass population. The corrected annual exploitation rate of 6.8% is low and all population modeling explored indicated that exploitation would need to increase drastically in order to see evidence of overfishing. We recommend that the current statewide regulations of a 12.0 in minimum size limit and six fish daily creel limit be left in place.

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan: Goal 1

Evaluation of Muskellunge Stockings in the Kentucky River

Jason Herrala, Wade Massure, Ryan Kausing, and Brandon Sawyers, Kentucky Department of Fish and Wildlife Resources

The Kentucky River has been stocked for many years with multiple fish species including largemouth bass, blue catfish, channel catfish, walleye, sauger, white bass hybrid striped bass, and muskellunge. Electrofishing studies along various pools of the river have shown that the return on stocked fish is low and some species can only be maintained through stocking. Of particular interest is the muskellunge. While stockings of this species do occur, they are in low numbers (up to 50 fish/per pool for pools 4-14) and infrequent as stocking only occurs when hatcheries have excess production. Routine electrofishing surveys conducted by the KDFWR on the Kentucky River during late winter and fall yielded low but consistent numbers and sightings of muskellunge. Low stockings with noticeable returns are indicative that stockings of muskellunge are likely effective in bolstering population numbers in the Kentucky River since natural reproduction is thought to be negligible. Habitat and prey base could be affecting the survival of other sport fish that have not seen elevated success in the Kentucky River. Studies have shown that the preferred habitat of stocked musky was submerged woody debris. The Kentucky River is lined with downed and submerged trees that provide cover. The Kentucky River is also home to a large population of rough fish such as common carp, drum, and redhorse, all of which are common food items of muskellunge.

In 2014, stocking rates were augmented in pools 2 and 3, and initial sampling began to monitor the impacts of these stockings and document any natural reproduction. Prior to stocking, all fish were fin clipped to distinguish between stocked year classes. Additionally, all 13.0 in musky received a microwire tag to identify stocking size. Pools 2 and 3 received a total of 298 fingerlings (50% 9.0 in fingerlings and 50% 13.0 in fingerlings) at a rate of 9.0 fish/mi. from 2014 to 2016. Pool 4 was a control site and did not receive any stockings. Due to poor returns, stocking rates in pools 2 and 3 were doubled (18.1 fish/mi) in 2017.

Muskellunge from Kentucky River / Ryan Kausing

Muskellunge catch rates in the Kentucky River in 2017 (spring/fall and diurnal/nocturnal) were low once again. Previously, movement of fish out of this study site has been documented, with downstream movement of at least 100 miles. Additionally, an 8-year old fish was captured during fall sampling in 2015, that originated in Buckhorn Lake, a reservoir on the Middle Fork of the Kentucky River more than 100 mi upriver. These movements may be a result of the extremely prolonged, high water during certain years, but this potential cannot be overlooked as it may play a critical role in the success of stocking efforts in pools 2 and 3 of the Kentucky River.

Further study into muskellunge post-stocking movements is needed to determine the most effective stocking strategies and locations. Because of limited returns and concerns with downriver emigration of stocked muskellunge in the Kentucky River, it is unlikely that the objectives of this project can be met. As a result, the project will be terminated. Taking the knowledge gained from this project, a new study will be developed focused on determining downriver dispersal of stocked muskellunge.

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan: Goal 1

Evaluation of New Commercial and Recreational Regulations on Catfish in the Ohio River

Jason Herrala, Wade Massure, Ryan Kausing, and Brandon Sawyers, Kentucky Department of Fish and Wildlife Resources

Historically, Ohio River catfish were commercially harvested for flesh. Recently, the commercial harvest of trophy-sized catfish for pay lakes has become popular. A high quality, recreational catch and release trophy catfish fishery also exists in the Ohio River, which has led to conflict between the two groups. On December 1, 2014 the following regulations were enacted:

> Recreational fishermen on the main-stem Ohio River will be allowed one blue catfish ≥35.0 in, one flathead catfish ≥35.0 in, and one channel catfish ≥28.0 in. The majority of commercial fishermen fishing in the Ohio River and tributaries where legal will be allowed one blue catfish ≥35.0 in, one flathead catfish ≥35.0 in, and one channel catfish ≥28.0 in per day. However, 50 commercial will be allowed to harvest 4 (in aggregate) blue catfish and flathead catfish ≥40.0 in and channel catfish ≥30.0 inches in Kentucky's portion of the Ohio River and its tributaries open to commercial fishing below Cannelton Lock and Dam.

Trotlines were used to sample catfish, and CPUE of all species of catfish has shown a slight increase since 2013. Issues with baiting techniques were brought to the Department's attention after the 2017 sampling season, and, upon futher evaluation, bait type as well as gear specifications were changed for future sampling to more accurately sample catfish populations.

Ride-alongs with commercial hoop net fishermen and Department hoop netting were also conducted to gather data. Commercial ride-alongs data from 2017 showed that blue catfish and flathead catfish CPUE were both lower than 2015. 2017 was the first year that baited hoop nets were used to sample channel catfish. CPUE and size structure were excellent—sampling yielded the highest recorded catch rates and fish ranged from 4 – 30 inches.

Electrofishing was conducted in June 2017. A total of 30 hr of electrofishing effort was conducted across all pools resulting in record high CPUE of blue catfish (25.2 fish/hr) and flathead catfish (40.6 fish/hr).

Six tournaments were attended with 730 boats competing in 2017. Tournament CPUE was 2.2 fish/boat, and has fluctuated very little since tournament data collection began in 2013. Blue catfish had a mean CPUE of 1.6 fish/boat (record high), channel catfish a mean CPUE of 0.5 fish/boat, and flathead catfish a mean of CPUE of 0.2 fish/boat.

In spring 2017, otoliths were taken from blue catfish, channel catfish, and flathead catfish to assess growth rates. On average, it took blue catfish 17.7 years to reach trophy size (≥35.0 in). Channel catfish reached trophy size (≥28.0 in) at 20.0 years. Overall, flathead catfish reached trophy size at 20.1 years. Growth of all three species of catfish sampled was extremely variable, particularly as fish grew older and larger, with some fish growing much slower than the Von-Bertalannfy model described and some growing much faster.

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan: Goal 1

Ohio River trophy blue catfish / Wade Massure

Investigation of the Restoration of Native Walleye in the Upper Barren River

Wade Massure, Jason Herrala, Ryan Kausing, and Brandon Sawyers, Kentucky Department of Fish and Wildlife Resources

Walleye is a freshwater fish native to most of the major watersheds in Kentucky, including the Barren River. Growing concern for declining fisheries prompted the stocking of Kentucky rivers and lakes by the U.S. Fish Commission and the Kentucky Game and Fish Commission. In 1912, and from 1914-1917, these agencies stocked walleye fry in various rivers and streams throughout Kentucky, including the Barren River. Unfortunately, it was not yet known that the Lake Erie strain walleye used in the stocking efforts are adapted to lentic (lake) environments, unlike the native Kentucky walleye which are adapted to lotic (river) environments. It is believed that the majority of these stocked northern walleye could not survive in the river environment or were ultimately confined to lake systems. The Barren River was impounded in 1964 forming Barren River Lake. In response to low population numbers in the new reservoir, another walleye stocking occurred in 1966. A lack of recent reports of walleye from the Barren River or Barren River Lake, indicates that the "northern" strain fry stockings in 1917 and 1966 were not successful and the native population in the river has been lost.

The broad goal of this project is to establish a reproducing native "southern" strain walleye population to this section of the Barren River.

Native walleye from Upper Barren River / Wade Massure

An established population of native walleye in the Barren River will serve as potential broodstock source and provide an additional fishing opportunity. Beginning in 2007, native strain walleye were collected from Wood Creek Lake and the Rockcastle River in the spring and transported to Minor Clark Hatchery to be used as broodfish. Walleye were spawned and the resulting fry were reared to fingerling size (1.5 in.) and then stocked in the Barren River in late May or early June. The stocking rate was a minimum of 50 fingerlings/acre or about 600 fingerlings/mile. In 2008, we began marking stocked fingerlings with oxytetracycline (OTC) to determine recruitment of stocked fish. Beginning in 2013, small walleye were sacrificed to examine otoliths for OTC marks. Good electrofishing catch rates of adult walleye in 2014 led to the recommendation to cease stocking and begin the natural recruitment monitoring phase.

In the 2017 sample, a total of 8 walleye were collected during 6.50 hrs of electrofishing (CPUE=1.2 fish/hr). Fish ranged from the 13.0-16.0 in size classes with majority of the sample comprised of the 16.0 in size class. Overall catch rates in Barren River are historically low with catch rates averaging 2.9 fish/hr from 2010-2017. Catch rates in 2017 were similar to those collected in 2016, and the lowest observed since 2010. No fish were collected from the <10.0 in, 20.0-24.9 in, and ≥25.0 in size groups. Overall, catch rates remain low and it appears that there has yet to be any one particular year class with superior survival. Sampling/natural recruitment monitoring will continue through 2019. Prior to the spring electrofishing survey of Upper Barren River, it should be noted that broodfish collection was conducted on this river and several others. A total of 38 fish were sampled between Upper Barren River (13 fish) and Barren River Lake Tailwaters (25 fish). However, effort was highly variable between each site and fish ranged in size from 13.0-20.7 in size classes.

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan: Goal 1

Lake Sturgeon Restoration in the Cumberland River

Lake Cumberland lake sturgeon / Matt Thomas

Jason Herrala, Wade Massure, Matt Thomas, Stephanie Brandt, Ryan Kausing, and Brandon Sawyers, Kentucky Department of Fish and Wildlife Resources

In Kentucky, lake sturgeon were once native to the Mississippi, Ohio, and Cumberland River drainage, but since the 1950's lake sturgeon have been extirpated from the Cumberland River. In 2008, KDFWR began reintroducing lake sturgeon into the Cumberland River and committed to a 20-year restoration effort. Eggs are obtained annually from the Wisconsin Department of Natural Resources and hatched at KDFWR's Pfeiffer Fish Hatchery. Young-of-year sturgeon are reared to a target length of 7.5 in and marked for year class identification by removing scutes prior to stocking. From 2008 through 2017, a total of 42,742 lake sturgeon fingerlings have been stocked; 23,670 in the Cumberland River at Noe's Dock at the mouth of Laurel River and 19,072 in the Big South Fork of the Cumberland River at Alum Ford boat ramp. No lake sturgeon fingerlings were stocked in 2012 or 2013 due to production issues.

Lake sturgeon sampling is conducted annually using trotlines (250.0 ft long with 50 hooks baited with nightcrawlers). Prior to 2017, the Cumberland River and Big South Fork were sampled in alternating years. Sampling was increased in 2017 and new sampling sites were added to collect additional data and attempt to decrease variability in catch rates. During December 2017, a total of 46 trotlines were successfully set and retrieved; 25 in the Cumberland River and 21 in the Big South Fork. A total of 72 lake sturgeon were collected with a CPUE of 1.6 fish/line. Fifty-five lake sturgeon were collected from the Cumberland River (CPUE=2.2 fish/line), and 17 fish were collected from the Big South Fork (CPUE=0.8 fish/line). CPUE in the Cumberland River was identical to 2016, but 2017 was the first year that any fish were collected on the Big South Fork. Sturgeon ranged from 13.5 – 41.3 in fork-length with a mean fork-length of 21.8 in in the Cumberland River and ranged from 14.5 – 42.7 in fork-length with a mean fork-length of 29.4 in in the Big South Fork.

Year class catch rates were variable among locations. Eight of nine possible year classes were observed in the Cumberland River. The 2015 year class (age-2 fish) were the most prevalent in the Cumberland River (CPUE=1.2 fish/line) followed by the 2014 year class (CPUE=0.4 fish/line). Only four year classes were observed in the Big South Fork with the 2009 year class being the most prevalent (CPUE 0.3 fish/line). No lake sturgeon were stocked in 2012 or 2013, and as a result no fish from those year classes were present in the sample.

Mean fork-length at age of capture indicates that growth of stocked lake sturgeon appears to be good. Although sample size from the Big South Fork is somewhat limited, no obvious differences in growth between the Cumberland River and Big South Fork were apparent. On average, fish reached 25.9 in by age-4, and were near 40 in by age-10.

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan: Goal 1

Ohio River *Sander* Investigations

Jason Herrala, Wade Massure, Ryan Kausing, and Brandon Sawyers, Kentucky Department of Fish and Wildlife Resources

Ohio River sauger / David Baker

The Ohio River Fish Management Team (ORFMT) had traditionally completed annual population surveys of *Sander spp.* in the Ohio River. Due to time and budget constraints this cooperative effort stopped in 2007. However, recent concerns of a possibly declining fishery as well as threats from the expanding Asian carp population led biologists to reinitiate these annual surveys in 2014. KDFWR, Ohio Department of Natural Resources, West Virginia Department of Natural Resources, Indiana Department of Natural Resources, and Illinois Department of Natural Resources all agreed to sample tailwaters of Ohio River dams. KDFWR was tasked with sampling the Markland, Cannelton, and JT Myers tailwaters. After three years of sampling, all agencies reported lower catch rates than in the past and noted a lack of sauger age 3 and older.

Six 10-minute transects were completed in the Markland, Cannelton, and JT Myers tailwaters in 2017 for a total 18 transects and 3.0 hr of effort. A total of 226 sauger, 10 walleye, and 3 saugeye were collected. Overall CPUE of sauger was 75.3 fish/hr, a sharp decrease from 289.5 fish/hr in 2016. Lengths ranged from 7.1 – 19.8 in with a mean length of 10.8 in. Walleye (CPUE=3.3 fish/hr) and saugeye (CPUE=1.0 fish/hr) were captured at much lower rates .

Otoliths were taken from a subsample of sauger to assess age structure and growth. Based on back calculated lengths at age, sauger growth in all tailwaters was good with age-1 sauger averaging 8.9 in, age-2 sauger averaging 12.3 in, and age-3 averaging 15.0 in. Sauger in the Cannelton tailwater displayed faster growth than those in the Markland and JT Meyers tailwaters. Age-0 and age-1 sauger traditionally dominate the catch. While age-1 sauger still comprised much of the catch, numbers were significantly lower than in previous years. Age-0 fish were not nearly as prevalent as in past years and the apparent poor year class may be the result of higher than normal flows proceeding the spawn in spring 2017. As in years past, very few age-3 fish were observed, and no age-4 sauger were collected in any tailwater sampled. Total annual mortality of sauger was 83.5% in the Markland Tailwater and 75.9% in the Cannelton Tailwater. Total annual mortality was not calculated in the JT Meyers tailwater due to an extremely small sample size and lack of older year classes.

As a result of sampling the tailwaters in late fall, very few large fish had begun to stage below lock and dams, and therefore, very few were seen in the sample at either of the tailwaters. Mortality estimates may have been inflated due to the early sample, but exploitation of sauger is also thought to be quite high on the Ohio River. Modeling by Southern Illinois University of ORFMT data suggested that overfishing is occurring and that regulations should be implemented on the Ohio River sauger population. A 14.0 in minimum size limit with a 6-fish creel limit has been suggested and passed by Illinois DNR. This same regulation has been proposed by KDFWR for all *Sander* species statewide, which would include the Ohio River, and would go into effect in 2019 if approved by the legislature. Other ORFMT states are considering similar sauger regulations, but currently, regulations for the Ohio River are no minimum size limit and a 10-fish creel limit.

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan: Goal 1

Warmwater Streams Sport Fish Surveys

Wade Massure, Jason Herrala, Ryan Kausing, and Brandon Sawyers, Kentucky Department of Fish and Wildlife Resources

There are countless miles of rivers and streams that flow throughout Kentucky making stream fishing accessible to all of Kentucky's anglers. Anglers have taken notice to the resource and realize how valuable and productive stream fishing can be throughout the state. The Kentucky Department of Fish and Wildlife Resources (KDFWR) has determined that more information is needed to better inform the public of these opportunities while making sure that these resources are being managed in a way that not only protects these fisheries but maximizes the fisheries potential.

During 2017, general sport fish surveys were completed in the Russell Fork, Levisa Fork, Green River, Kentucky River, Barren River, Upper Cumberland River, and Tradewater River. These sites were selected based on public input received primarily from Fisheries District Offices. New sites are continually being added with streams scheduled to be sampled on a 3-5 year rotation in effort to develop trend data. The purpose of collecting this data is to help KDFWR make informed management decisions, inventory current access sites, and identify new areas that could benefit from future management.

Ten species of sport fish were collected in Russell Fork River. Population assessments for smallmouth bass in Russell Fork River received an "excellent" rating whereas rock bass received a "good" assessment rating. In the Levisa Fork River, smallmouth bass received a "good" population assessment rating while both rock bass and largemouth bass received "poor" ratings and spotted bass received a "fair" assessment rating. Fourteen species of sport fish were collected from Levisa Fork River. Pool 1 of the Green River had a relatively low abundance of the species collected.

Hybrid striped bass / Wade Massure

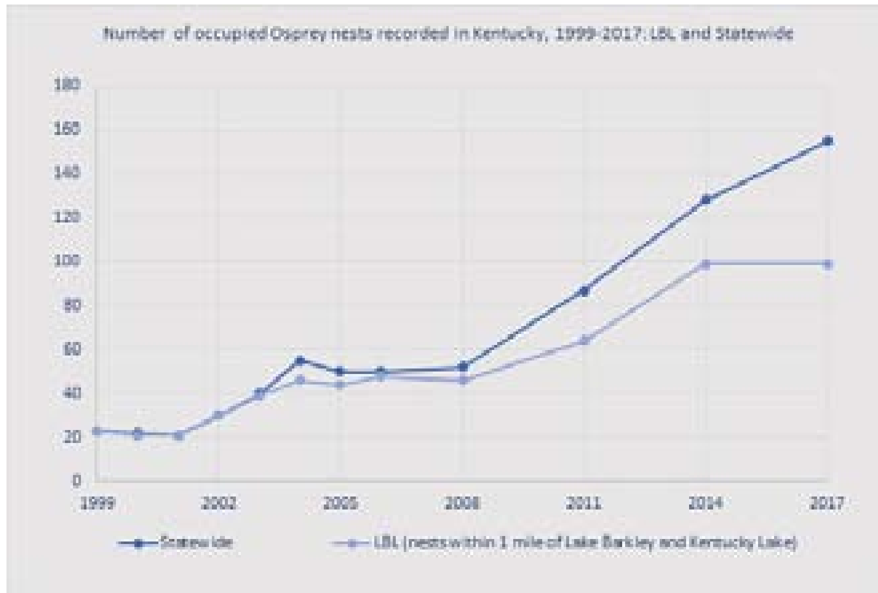
Overall, spotted bass, bluegill and channel catfish made up 67% of the total sport fish sampled on Pool 1 of the Green River. The three most abundant species collected in Pool 5 of the Green River were largemouth bass, spotted bass and bluegill. The overall relative weight of both spotted and largemouth bass populations was good. In old Pool 6 of the Green River, smallmouth bass received an "excellent" population assessment rating with trophy (≥20.0 in) size smallmouth bass present. Smallmouth bass and rock bass made up 97% of the entire sport fish sample from Pool 6 of the Green River. Smallmouth bass ranging in size from 5.0-19.0 in classes, trophy muskellunge (≥40.0 in) and a variety of other sport fish were collected in Barren River. Catch rates of rock bass increased dramatically compared to the 2016 sample and are similar to those from 2010-2014. In both Pools 3 and 4 of the Kentucky River, smallmouth, largemouth and spotted bass were the most abundant species in each sample. In Pool 3 of the Kentucky River trophy size muskellunge (≥40.0 in) were collected. Sauger were collected up to 15.0 in size class in both Pools 3 and 4. A total of eleven sport fish species were collected in Tradewater River. Bluegill were the most abundant sport fish making up 27% of the total catch, followed by largemouth bass (16%) and black crappie (13%). Eighty-three percent of the overall catch from Upper Cumberland River consisted of channel catfish (25.4 fish/hr), spotted bass (17.7 fish/hr), walleye (5.7 fish/hr) and smallmouth bass (5.4 fish/hr).

Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan: Goal 1

Statewide Osprey Survey Update

Loren Taylor, Kate Slankard and Pat Hahs, Kentucky Department of Fish and Wildlife Resources



Osprey populations along with many other raptor species suffered range wide declines during the mid-1900's, largely in response to the widespread use of the pesticide DDT. No successful Osprey nests were documented in Kentucky between 1949 and 1985. After the ban on DDT in 1972, federal and state agencies led statewide restoration efforts, including the release of 97 young Ospreys, during the 1980'sand 1990's. Following these restoration efforts, the first successful Osprey nest acknowledged in Kentucky since 1949, was built along the Ohio River in Livingston County in 1986.

Annual Osprey nest surveys were conducted at Land Between the Lakes (LBL) by Ed Ray, a KDFWR volunteer, between 1999 – 2008. As Ospreys began expanding their range eastward, KDFWR conducted statewide nesting inventories on three-year intervals starting in 2011. Known nesting locations were checked, by ground and boat, during the nesting season (late March-July). Nests were considered occupied if one or more adults were observed at the nest during the nesting season. .

2011. The 2011 statewide Osprey nesting inventory yielded observations of 87 occupied nests, the majority (64) of nesting was observed in LBL area (within 1 mile of Lake Barkley and Kentucky Lake).

2014. The 2014 inventory yielded 128 occupied Osprey nests, with 99 nests recorded in the LBL vicinity.

2017. During the 2017 survey, 155 occupied nests were recorded. The LBL area showed no signs of population growth in 2017, with 99 occupied nests observed in 2014 and 2017. However, many new nests were found along the Tennessee (16) and Cumberland Rivers (6) north of Kentucky and Barkley Dams. East of LBL, notable new nesting locations were recorded at Green River Lake and Taylorsville Lake. The LBL area has long been important to the recovery of this species in the state and it continues to support the majority of the nesting population. Interestingly, the number of nests in the LBL area seems to have leveled off in recent years, perhaps indicating that this population is near or at carrying capacity. KDFWR plans to continue monitoring nesting Osprey in the LBL area in 2020. All new nesting records continue to be recorded in a statewide database. As expected, the increase of Kentucky's nesting Osprey population has resulted in increased utilization of manmade nest structures. Nesting on power poles and power transmission towers has doubled in the last seven years. These situations can be problematic and as Osprey nesting in Kentucky continues to expand, KDFWR will continue to advise private companies on how to manage Ospreys in these situations, to ensure Ospreys have safe nesting locations well into the future. A guide to the management of Osprey is available by request from Loren Taylor, KDFWR: loren.taylor@ky.gov.

Funding Sources: State Wildlife Grants (SWG)

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.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Elk roundup / John Brunjes

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Big Game
(Elk and Deer)

Small Game
(Quail, Squirrels, Rabbits)

Turkey

Furbearers

Bear

Birds
(Songbirds and Raptors)

(Migratory Shorebirds and Colonial Nesting Waterbirds)

Bats

Reptiles and Amphibians

Mollusks

Crayfish

Fishes

Habitat Restoration / Management

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