Kentucky Department of Fish and Wildlife Resources

Annual Research Highlights 2010

Volume IV, Sept. 2011

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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.

Foreword

Tagging juvenile bald eagle / Ray Stainfield

The mission of the Kentucky Department of Fish and Wildlife Resources (KDFWR) is to conserve and enhance fish and wildlife resources and to provide opportunity for hunting, fishing, trapping, boating, and other wildlife related activities. To effectively conserve and enhance game and non-game fish and wildlife resources in Kentucky, long-term planning is necessary. Over the past several years, KDFWR has collaborated with multiple outside agencies, non-profit organizations, professionals, and biologists to complete two important planning documents: The 2008 – 2012 Kentucky Department of Fish and Wildlife Resources Strategic Plan (*http://fw.ky.gov/pdf/strategicplan2008-2012.pdf*), and Kentucky's State Wildlife Action Plan (completed in 2007; (*http://fw.ky.gov/kfwis/stwg/*). Both of these documents are designed to guide agency decisions; however, they serve two unique purposes. The 2008 – 2012 Strategic Plan addresses fish and wildlife management issues as well as agency issues as a whole.

The five primary goals of the Strategic plan are:

1) To conserve and enhance fish and wildlife populations and their habitats;
2) To increase opportunity for, and safe participation in hunting, fishing, trapping, boating, and other wildlife-related activities;
3) To foster a more informed and involved public;
4) To expand and diversify our user base and
5) To create a more diverse, effective, and efficient organization.

Complementing the Strategic Plan, the State Wildlife Action Plan is Kentucky's roadmap for sustaining fish and wildlife diversity. The two primary goals of this plan are to identify and prioritize important species and habitats of conservation concern within Kentucky and to successfully implement conservation measures for these species and habitats.

These two documents are available to the public, and are intended for frequent revision and re-adjustment to incorporate ever changing agency and public needs and interests. The 2010 Kentucky Department of Fish and Wildlife Resources Research Summary represents our targeted efforts to fulfill the goals of our State Wildlife Action Plan as well as the goals of the 2008 – 2012 Strategic Plan. These 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.

Funding Sources and Guidance to Federal Programs

The Kentucky Department of Fish and Wildlife Resources receives no general fund taxpayer dollars. As a result, the Department relies on hunting and fishing license fees, boat registration fees, and federal programs to fund the seven divisions within KDFWR. Projects that are entirely funded by the state are labeled "non-federal aid" (NFA); however, most of the projects included in this document are partially or fully funded by federal programs such as the State and Tribal Wildlife Grant Program, the Wildlife Restoration Act (Pittman-Robertson), the Sport Fish Restoration Program (Dingell-Johnson), 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 follows:

These federal programs provided

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

Collaring and tagging elk / Gabe Jenkins

approximately 16 million dollars to KDFWR in 2010 (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. When possible, we listed these sources in addition to the state and federal funding sources. For each project summary, we also identify the specific goals of the strategic plan or State Wildlife Action Plan, as well as the KDFWR contact responsible for each project.

How to Use This Document

This document is divided into **four main sections**: published research, completed projects, project highlights, 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 2010, a brief 1-page overview of the project is included in the second portion ("**project highlights**") of the document. For select ongoing projects, brief updates are included in the last section ("**project updates**") of this document. In the table of contents, an expected date of completion, where applicable, is listed for each project. This will facilitate looking up detailed summaries of completed projects in later years. A comprehensive **project reference guide** lists all projects included in Research Highlights documents, beginning with publication year 2007.

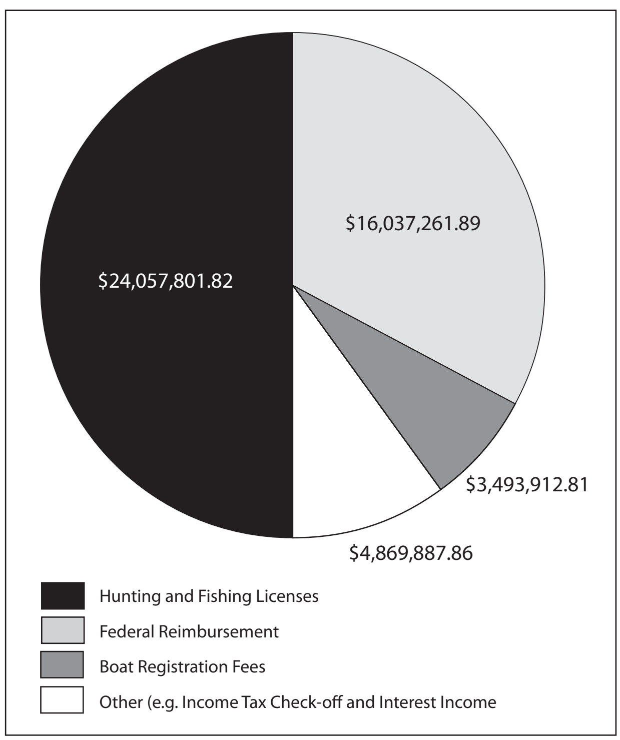

Figure 1. Kentucky Department of Fish and Wildlife Resources Funding Sources 2010. Total revenues for 2010 were $48,458,864.38

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Contact SWG Coordinator, Danna Baxley (danna.baxley@ky.gov), for reprints of these publications.

Barding, E.E., M.J. Lacki, and L.L. Patton. 2010. Recovery of the **river otter** to Kentucky. Proc. Annu. Conf. S.E. Assoc. Fish and Wildlife Agencies (*In press*).

Britzke, E.R., B.A. Slack, M.P. Armstrong, and S.C. Loeb. Effects of orientation and weatherproofing on the detection of **bat echolocation** calls. 2010. Journal of Fish and Wildlife Management 1(2):136-141.

Corn, J.L., M.E. Cartwright, K.J. Alexy, T.E. Cornish, E.J.B. Manning, A.N. Cartoceti, and J.R. Fischer. 2010. Surveys for disease agents in introduced **elk** in Arkansas and Kentucky. Journal of Wildlife Diseases 46(1):186-194.

Edmonds, S. T., D. C. Evers, D. A. Cristol, C. Mettke-Hofmann, L. L. Powell, A. J. McGann, J. W. Armiger, O. P. Lane, D. F. Tessler, P. Newell, K. Heyden, and N. J. O'Driscoll. 2010. Geographic and seasonal variation in mercury exposure of the declining **Rusty Blackbird**. The Condor 112(4):789-799.

Heyden, K.G. 2010. 2010 **Barn Owl** (*Tyto alba*) inventory and current management for the species in Kentucky. The Kentucky Warbler 86(4): 79-85.

Heyden, K. G. 2010. Current status of nesting **Bald Eagles** *(Haliaeetus leucocephalus)* in Kentucky. The Kentucky Warbler 86(4):85-89.

Owen C.T., J.E. Alexander, Jr., and M.A. McGregor. 2010. Control of microbial contamination during *in vitro* culture of larval **unionid mussels**. Invertebrate Reproduction and Development. 54 (4):187-193

Owen, C.T., M.A. McGregor, G.A. Cobbs, and J.E. Alexander Jr. 2010. Muskrat predation on a diverse **unionid mussel** community: Impacts of prey species composition, size and shape. Freshwater Biology 56(3): 554-564.

Patton, L.L, D.S. Maehr, J.E. Duchamp, S. Fei, J.W. Gassett and J.L. Larkin. 2010. Do the **golden-winged warbler** and **blue-winged warbler** exhibit species-specific differences in their breeding habitat use? Avian Conservation and Ecology 5(2).

Ruder, M.G., A.B. Allison, D.L. Miller, and M.K. Keel. 2010. **Pathology** in practice. Journal of the American Veterinary Medical Association 237(7):783-785.

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Corn snake / Dave Baker

Completed Projects

Distribution and Ecology of *Thoburnia atripinnis* (Bailey), the Blackfin Sucker (Cypriniformes: Catostomidae), in the Upper Barren River, Kentucky

Garrett K. Stillings and Dr. Sherry L. Harrel, Eastern Kentucky University
KDFWR Contact:
Matthew Thomas

Barren River / Garrett Stillings

Abstract

The Blackfin Sucker is endemic to the priority conservation area of the Upper Barren River (UBR) drainage of Kentucky and Tennessee, spanning four counties in Kentucky. Due to its endemic distribution, low historic abundance and human induced impacts, the Blackfin Sucker is considered a "Species of Greatest Conservation Need" by the Kentucky Department of Fish and Wildlife Resources. Current data on distribution and conservation need of Blackfin Suckers in the Upper Barren River is lacking, thus our specific objectives were to (1) identify Blackfin Sucker populations in the Upper Barren River, Kentucky, (2) assess the fish community structure and biotic integrity of the Upper Barren River, (3) and compare habitat characteristics among tributaries to assess whether physical habitat alterations are a contributing cause of declining numbers of the species at historical locations.

Thirty sites were sampled, including all 14 historic sites, provided by Kentucky State Nature Preserves Commission. Sampling efforts revealed a total of 34 Blackfin Suckers, found at 9 locations within 3 tributaries above the Barren River reservoir. Adults were almost always captured in habitats that contained undercut bedrock crevices or large flat rocks. Based on the Kentucky Index of Biotic Integrity scores and Shannon-Wiener Diversity Indices, the Barren River tributary averaged a higher score for water quality (72 ± 10) and diversity (2.34 ± 0.32) than other Barren River reservoir tributaries. The maximum length recorded was 150 mm TL and there were at least 4 age classes represented .The information provided will help aid conservation efforts and help ensure the existence of the Blackfin Sucker.

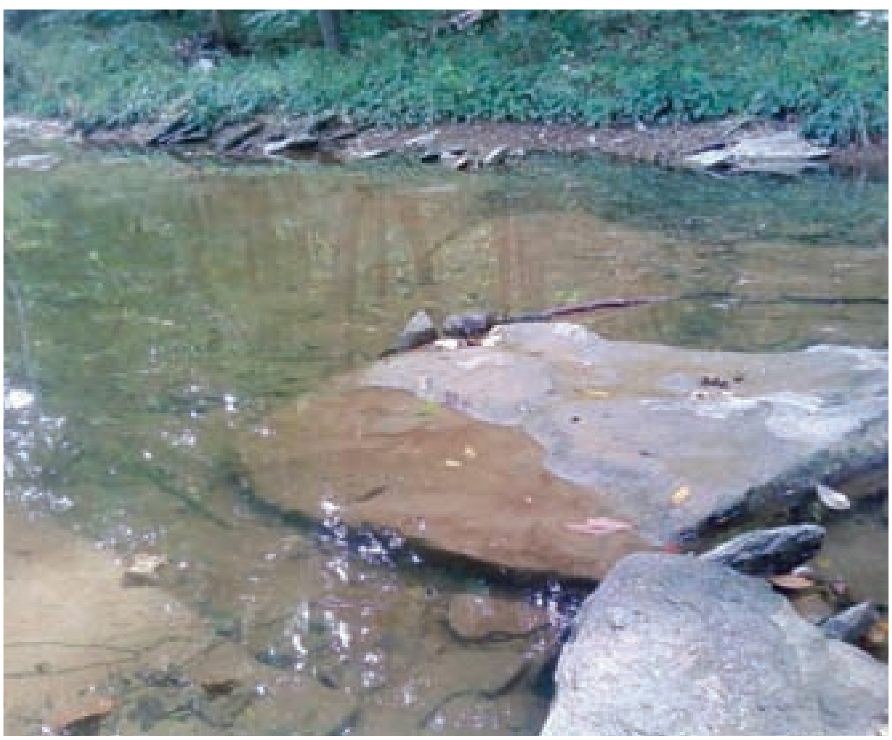
Introduction

The genus *Thoburnia* is a small genus comprising three species. A relict species *T. atripinnis* (Bailey), Blackfin Sucker, geographically only occurs within the headwaters of the Barren River drainage of the Green river system in Kentucky, far west of its relatives (Bailey, 1959). The Blackfin Sucker is a small catostomid species that grows to a maximum total length of 155 mm (6.1 in). The body possesses two dark horizontal lines below the lateral line and six or seven additional dark lines dorsolaterally. The dorsal fin has a black blotch on distal half of anterior 5 or 6 rays (Etnier and Starnes, 1993) (Figure 1). Nuptial tubercles of males have shown to be largest on rays of the anal fin and lower lobe of the caudal fin, small to tiny on upper caudal fin lobe, dorsal surfaces of paired fins, ventral surface of pectoral fins, entire head, and body scales (best developed on lower caudal peduncle where they form a marginal row each scale) (Bailey, 1959).

Decline of native fishes in the southern United States generally is attributable to pervasive and complex habitat degradation across the landscape. Major threats to aquatic life include siltation and stream eutrophication due to agricultural runoff and stream channelization (Warren et al., 1997). Both reduce and fragment ranges and increase isolation of fish populations (Angermeier, 1995; Warren et al., 1997). Human-induced impacts to southern aquatic systems are similar to those repeatedly cited for fish declines or losses across the United States and worldwide (Moyle and Leidy, 1992; Stiassny, 1996). Physical habitat alteration in the form of channelization, impoundment, sedimentation, and flow mediation are frequently associated with species declines and continue to threaten southern fishes (Walsh et al., 1995; Etnier, 1997).

The Blackfin Sucker is endemic to the upper Barren River (UBR) drainage in southern Kentucky and a portion of northern Tennessee (Etnier and Starnes, 1993). The Kentucky State Nature Preserves Commission (KSNPC) has listed the Blackfin Sucker as threatened and recommended it to be a species of special concern in Kentucky (KSNPC 2005). The Kentucky Comprehensive Wildlife Conservation Strategy [Kentucky Department of Fish and Wildlife Resources (KDFWR) 2005] designated the Blackfin Sucker as a "Species of Greatest Conservation Need" (SGCN).

In 1964, the Army Corps of Engineers impounded the Barren River to create a 4.04 hectare (10,000 acre) (at seasonal pool) reservoir (Kleber, 1992). River damming contributes to loss of habitat, change of fish reproductive environments, and cuts off migration routes, resulting in a substantial decline in biodiversity (Park, 2003). A study by Neraas and Spruell (2001) noted that obstruction of fish routes by creating barriers resulting in many genetic risks. In the case of the Barren River reservoir, genetic isolation can result in inbreeding and lack of genetic diversity. In the long term, it can reduce the population's resilience because the population's genetic pool of potential responses to stress is restricted. If a population lacks selectively favorable genes, population declines and eventual extirpation can occur when faced with environmental stressors or changes in stressor intensity (Bagley et al., 2002).



Barren River / Garrett Stillings

Study Area

The watershed of this study, UBR, lies within the Interior Low Plateau of Kentucky and is considered a priority conservation area deemed of ichthyological importance by KDFWR (2005). This system is located in rural, rolling hills of Allen, Barren, Monroe and Metcalf counties. It has three endemic species: Blackfin Sucker, Teardrop Darter *(Etheostoma barbouri)* (Etnier and Starnes 1993) and the Highland Rim Darter *(Etheostoma kantuckeense)* (KDFWR, 2005). Land use within these four counties consists primarily of agricultural croplands. The UBR consists of all waters above the Barren River reservoir which include the main drainages: Barren River, Skaggs Creek, Beaver Creek, Peter Creek and Long Creek (Figure 2). Beaver Creek was omitted from this study due to high degradation and no historical records of Blackfin Suckers, although the South Fork of Beaver Creek was suitable and included. Nearly 93% of the stream kilometers surveyed within this watershed have habitat conditions fully supporting aquatic life and 23.7 km (14.7 mi) of stream have been deemed outstanding resource waters [Kentucky Division of Water (KDOW) 2002].

Material and Methods

Fish Sampling and Observations

Sampling efforts began in March 2009 and ended in May 2010. Each site was sampled once by using a backpack electrofisher (Smith-Root, Vancouver, Washington) and a dipnet and seine (3.4m x 1.8 m with 0.3 cm). Both were used to give a comprehensive measure of the abundance and species richness of each sample site. Representative sites included all microhabitat types (riffle, run, pool) and included at least 100 meters of stream. At least one hour of backpack shocking was utilized at all sites and if applicable, 30 min-

Figure 1: Photograph of the endemic Blackfin Sucker found exclusively in the upper Barren River, KY (picture taken by Matt Thomas, KDFWR).

utes of seining. GPS coordinates of all sample sites were recorded at each site with a Garmin 60CSX (Garmin Corp.), and sites were geo-referenced using Arc GIS; photographs were also taken of all sites and any potential threat to biotic integrity were noted.

Voucher specimens were collected at all sample sites to allow for assessment of community structure. Specimens not vouchered were identified in the field, recorded and released. Voucher specimens were submersed in MS-222 to meet the standards of Eastern Kentucky University's (EKU) Animal Care and Use Committee. Fish collections were preserved in the field using a 10%-15% buffered formalin solution and later transferred to 70% ethanol for long term storage. Voucher specimens were deposited into the Branson Museum of Zoology at EKU.

Habitat

To identify conservation threats, KDOW's Rapid Habitat Assessment protocol was used to evaluate habitat conditions at each sampling location (KDOW, 2002). Habitat parameters such as riparian characteristics, sediment deposition and channel alteration were scored using a range of values from 0-200 for 10 parameters. Substrates were assessed on percentage amounts within velocity/depth regimes. Substrate size was noted as follows: silt/clay, sand, gravel, cobble, boulders and bedrock. Physicochemical parameters such as temperature, pH, dissolved oxygen, and conductivity were measured using a YSI meter (Yellow Springs Instruments, Yellow Springs, Ohio). All microhabitats that were utilized by Blackfin Suckers were measured with a Marsh-McBirney flow meter (Marsh-McBirney Inc, Frederick, Maryland) to obtain water velocity and averaged.

Data Analysis

Diversity of fishes was assessed using the Shannon-Wiener Diversity Index (Krebs, 1999). This characterizes biodiversity in the community based on the number of species and the number of individuals of each species. The Kentucky Index of Biotic Integrity (KIBI) produced a stream condition score ranging from very poor to excellent based upon six metrics: Native Richness (NAT), Darter, Madtom, and Sculpin Richness (DMS), Intolerant Richness (INT), Simple Lithophilic Spawners (SL), Relative Abundance of Insectivorous Individuals, excluding Tolerant Individuals (%INSCT), Relative Abundance of Tolerant Individuals (%TOL), and Relative Abundance of Facultative Headwater Individuals (%FHW) (KDOW, 2002). Age determination was made by using a length frequency histogram. All significant spikes were noted as 1 year class. A Von Bertalanfy model was used to measure growth in Blackfin Suckers and was conducted using Statistical Analysis Software (SAS Institute, 2002).

Results

Age and Growth

Age determination was made for a total of 34 specimens. Total lengths ranged from 44-150 mm, representing at least 4 to possibly 5 age classes. This agrees with previous reports of 4 age classes (Timmons et al., 1983 and Bailey, 1959). Young of year fish or age 0 individuals can be classified at <55 mm TL. Juveniles or age 1 fish, reach about 80 mm TL their first year, 80-105 mm TL at age 2, about 115-125 mm TL at age 3, and around 145 mm TL at age 4. There appears to be a separation of an age 5 class being >150 mm TL, but is possibly just the maximum length for age 4 individuals. The majority of individuals captured in this study were adult fish (> mm TL) and were grouped in the age 4 category (35.29%). Blackfin Suckers grew at a decreasing rate over time. Age 2 suckers were among the lowest found in the collection with only three individuals collected. Age 5 suckers were also found in low numbers with 2 individuals, but this was expected because the longevity of the species has been reported to be five years (Timmons et al., 1983).

Fish Community and Structure

During the present study, a total of 30 sites, including all 14 historic localities and 16 new localities, was sampled. Sampling efforts revealed a total of 34 Blackfin Suckers from nine locations within three tributaries above the Barren River reservoir: Barren River, Skaggs Creek and Peter Creek. Of the 14 historic localities, 4 of these sites produced a total of 18 Blackfin Suckers

(Table 1). Sixteen new localities were sampled and five had produced populations of Blackfin Suckers.

A total of 11 families and 51 species, comprised of 8,411 individuals were collected within the UBR watershed. The most diverse families were: Cyprinidae (17), Percidae (12), and Centrarchidae (8). Three species accounted for >45% of all fishes collected. Large Scale Stoneroller *(Campostoma oligolepis)* comprised 25.97% , Banded Sculpin *(Cottus carolinae)* 9.95%, and Bluntnose Minnow *(Pimephales notatus)* 9.86% of all fishes collected. Blackfin Suckers comprised 0.40% of the entire community collection.

Habitat

Visual examination of habitat utilized by Blackfin Suckers showed that they were typically found in low flow runs and rocky pools. Adults were almost always captured in habitats that contained undercut bedrock crevices or large flat rocks. On two occasions, Blackfin Suckers were collected, probably spawning, in high flow riffles. One adult was found in a pool adjacent to a riffle. Young-of-year suckers (<55 mm TL) were found in riffles composed of primarily large gravel. Depths suckers were found ranged between 0.3 to 0.6 m. Mean water quality values were within normal ranges. Water temperatures ranged from 3.4 to 27.5 º C during this study. All tributaries combined represented approximately 875 square miles of drainage area.

According to the Rapid Habitat Bioassessment protocols (KDOW, 2002), sites were averaged based on drainage. The Long Creek drainage scored the highest with a mean score of 151.5±20, then in descending order: Skaggs Creek drainage (138±16), Peter Creek drainage (135±25), and lastly the Barren River drainage (131.5±21), respectively. The Beaver Creek drainage, with no historic or present populations of Blackfin Suckers, had a score of 144.

The mean KIBI for the five drainages sampled, indicated that all streams scored within the fair water quality range according to the Interior Plateau, Green River standards (51-75). Scores ranged from 62-83, the lowest score of 62 representing South Fork of Beaver Creek and the highest score of 83 representing the Barren River drainage. Mean drainage KIBI water quality scores are listed as follows: 72±10 (Barren River), 63±8 (Skaggs Creek), 61±6 (Peter Creek), 63±8 (Long Creek) and 62 (South Fork of Beaver Creek), respectively.

Discussion

Age and Growth

Age data collected in this study is similar to what Timmons et al. (1983) accounted for in Tennessee. Both studies reported possibly four separate age classes with four being the maximum age. Growth rates and maximum lengths of Blackfin Suckers in Kentucky compared to Tennessee populations seem to be indistinguishable probably due to similar habitat and productivity within these streams. The small size ranges in *Thoburnia* is attributable to their habitat and their ability to adapt to high flow of headwater streams (Bailey, 1959).

Habitat

The primary substrate throughout all sites sampled was bedrock, cobble or gravel. Heavy erosion and channelization was noticed throughout Beaver Creek resulting in no suitable habitat. The tributary south fork of the Beaver Creek drainage, was noted to have primarily bedrock and cobble substrates, but still highly channelized. This was probably influenced by the city of Glasgow. No Blackfin Suckers were found within the drainages of Long Creek or Beaver Creek. Much channel alterations were recorded within the UBR watershed probably related to heavy agricultural land usage that was also noted. Culverts that could possibly restrict fish routes were found in sites 6, 22, 25, 14 and 15.

This study agrees with Etnier and Starnes (1993) and Timmons et al. (1983) in that Blackfin Suckers can be found under large slab rocks in pools with low flow. Blackfin Suckers were particular in habitat preferences and were only found under a large rock within the stream reach. They seemed to be found in cohorts with all individuals being relatively the same length. The exception to this was in spring months, adult and young of year individuals were collected in moderate flow riffles.

Fish Community and Structure

Significant finds within the UBR system were Highland Rim Darter, *(Etheostoma. kantuckeense)* and Splendid Darter, *(Etheostoma. barrenense)*. Both species are common within UBR range and appear to be stable with no need for management actions. Other SGCN species with previous records from the UBR but not found in this study are: Spotted Darter *(E. maculatum)* and Longhead Darter *(P. macrocephala)*. Both are considered rare within their ranges (Natureserve 2004). Etheostoma maculatum has not been found in the UBR since before 1984 (KDFWR 2005) and *Percina macrocephala* was considered more common in its range within the UBR watershed (Burr and Warren, 1986).

Teardrop Darter *(Etheostoma barbouri)*, an endemic to the Barren River and Green River drainages, was considered by Etnier and Starnes (1993) to extend into the UBR, but no specimens were collected during this study. Spottail Darter *(Etheostoma squamiceps)* was only found in the south fork of the Beaver Creek drainage. It was very common within this stream with 24 individuals found at one locality. This should be considered as an isolated population created by the Barren River reservoir acting as a barrier for migration.

Table 1: *Blackfin Sucker historic dates and number of historic and present individuals collected in the upper Barren River, KY. (LC-Long Creek, BR=Barren River, PC=Peter Creek, SC=Skaggs Creek and BC=Beaver Creek).*

Site	Historic Sites Sampled (drainage)	Historic Date Collected	Historic Numbers Collected	Current Numbers Collected
18	LONG CREEK proper	6/8/1956	2	0
		7/12/1961	4	
27	CABLE BRANCH (BR)	4/6/1953	7	0
16	LONG CREEK proper	4/1/1967	1	0
4	FALLING TIMBER CREEK (SC)	4/10/1947	1	1
6	GLOVER CREEK (SC)	5/22/1979	1	0
21	INDIAN CREEK (BR)	9/12/1961	4	0
		8/21/2002	2	
28	EAST FORK BARREN RIVER (BR)	4/2/1999	3	0
12	PETER CREEK proper	8/26/1962	1	0
29	EAST FORK BARREN RIVER (BR)	4/2/1999	6	0
		7/11/1961	3	
30	MILL CREEK (BR)	6/30/1983	2	6
5	FALLING TIMBER CREEK (SC)	10/17/1996	2	0
9	CANEY FORK (PC)	10/6/1996	2	0
8	SKAGGS CREEK proper	9/9/1999	3	6
23	SALT LICK CREEK (BR)	8/7/2001	2	5

Management Implications

Land and water usage in the UBR system over the past 70 years has changed dramatically. Damming of the Barren River to create the Barren River Lake constitutes the most significant change to the watershed. The result of this was the isolation of five major drainages that feed the lake: Beaver Creek, Skaggs Creek, Barren River, Long Creek and Peter Creek. Blackfin Sucker habitat was altered as the result of the reservoir widening and deepening the system. Fish migration routes were possibly hindered due to the reservoir acting as a barrier because of the depth. This isolation and destruction of habitat can obstruct genetic dispersal between drainages. Widespread impoundment and river alterations overtime has eliminated many populations and reduced the potential for dispersal and gene flow between extant populations. With the Blackfin Sucker already endemic and populations being highly fragmented, conservation efforts need to be implemented to conserve the existence of this species. Phylogenetic relationships of UBR populations need to be identified to recognize any geographic isolation that can threaten the species. These results can emphasize the need for possible propagation implementation and a recovery plan to be employed for this unique species

Compared to the Timmons et al. (1983) study, current Blackfin Sucker abundance is low. Their study began on November 1974 and lasted through June 1976. They had 14 collections that produced 180 Blackfin Suckers from 13 localities only within the Barren River portion of Tennessee. Timmons et al (1983) reported that streams inhabited were not extensively farmed and had been left essentially undisturbed except for some gravel removal and stream channelization. Surrounding landscape in Kentucky streams has been heavily cultivated with channelization evident. Most of the land surrounding the UBR is utilized for agricultural croplands. Tennessee's land use map illustrates some croplands,

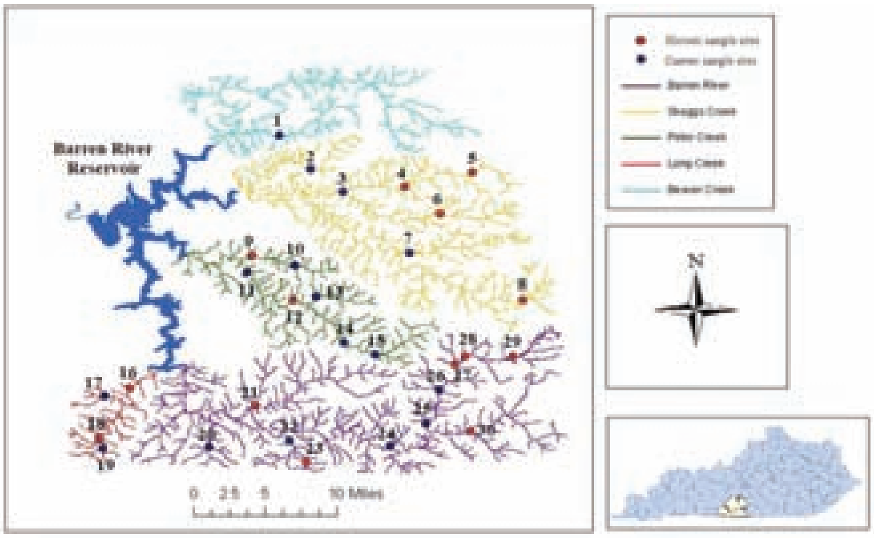


Figure 2: *Blackfin Sucker site localities with the major drainages of Barren River lake, KY.*

but represents more forested lands than in the Kentucky UBR lands (TWRA, 2006). The key factor to abundance in Kentucky and Tennessee streams appears to be related to streams that maintain good to high quality water and habitat.

Nonnative introductions can be accountable for fish extinction (Miller et al., 1989). KDFWR has established a put and take Rainbow Trout *(Oncorhynchus mykiss)* fishery in the Peter Creek drainage (KDFWR 2009). Nonnative trout predation on Mountain Suckers *(Catostomus platyrhynchus)* has been reported by Wydoski and Wydoski (2002). In the Barren River drainage, Muskellunge *(Esox masquinongy)* and Walleye *(Sander vitreus)* are also stocked for sport fishing (KDFWR, 2010). Both species are considered top predators within their range (Etnier and Starnes, 1993). A preliminary investigation of nonnative species predation on native aquatic fauna needs to be applied before the judgment of continued stocking becomes practiced to allow for stringent conservation of the Blackfin Sucker. Since past extensive studies have not been reported on the distribution of the Blackfin Suckers, it is difficult to tell at this point if current stocking has had a considerable effect on populations.

Although numerous factors can adversely affect native fishes, habitat alteration is considered to be the most important factor in the extinction of 40 native North American fishes (27 species and 13 subspecies) during the past century (Miller et al., 1989). Protection of stream habitat is essential for natural reproduction of Blackfin Suckers and may be necessary to prevent extirpation of this species. This is especially important due to their endemic range where populations are sparse and widely scattered. With such low numbers found already, an elevated conservation status needs to be highly considered for the assurance of the continuance of this species. The UBR populations represent the only remaining gene pools presently known and because they represent the limits of the species' known current distribution; they must be considered as important components in the evolutionary legacy of the species.

Literature Cited

Angermeier, P.L. 1995. Ecological attributes of extinction-prone species: loss of freshwater fishes of Virginia. Conservation Biology. 9:143-158

Bagley M.J., S. E. Franson, S.A. Christ, E. R. Waits and G. P. Toth. 2002. Genetic Diversity as an Indicator of Ecosystem Condition and Sustainability: Utility for Regional Assessments of Stream Condition in the Eastern United States U. S. Environmental Protection Agency, Cincinnati, OH.

Bailey, R. M. 1959. A New Catostomid Fish Moxostoma *(Thoburnia) atripinne*, from the Green River Drainage, Kentucky and Tennessee. Occasional papers of the Museum of Zoology. The University of Michigan, Ann Arbor, Michigan.

Burr, B. M., Warren, M. L. Jr., 1986. A Distributional Atlas of Kentucky Fishes. Volume Number 4. Kentucky State Nature Preserves Commission Scientific and Technical Series.

Etnier, D.A. and W.C. Starnes. 1993. The Fishes of Tennessee. The University of Tennessee Press, Knoxville, Tennessee, USA.

Jenkins, R.E and N.M. Burkhead. 1993. Freshwater Fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

KDOW (Kentucky Department for Environmental Protection, Division of Water). 2002. Methods for Assessing Biological Integrity of Surface Waters. KDOW, Frankfort, KY.

KDFWR (Kentucky Department of Fish and Wildlife Resources) 2005. Kentucky's Comprehensive Wildlife Conservation Strategy. Kentucky Department of Fish and Wildlife Resources, #1 Sportsman's Lane, Frankfort, Kentucky 40601. http://fw.ky.gov/kfwis/stwg/ (Date accessed 9/21/2009).

KDFWR (Kentucky Department of Fish and Wildlife Resources) 2009. Trout Streams Program in Kentucky for 2009. #1 Sportsman Lane, Frankfort, Kentucky 40601. http://fw.ky.

gov/troutstreams09.asp (Date accessed 05/17/2010).
KDFWR (Kentucky Department of Fish and Wildlife Resources) 2010. 2010 Fishing Forecasts and Tips. #1 Sportsman Lane, Frankfort, Kentucky 40601. http://fw.ky.gov/pdf/2010fishingforecast.pdf (Date accessed 05/17/2010).
KSNPC (Kentucky State Nature Preserves Commission) 2005. Rare and Extirpated Biota of Kentucky. 801 Schenkel Lane Frankfort, KY 40601-1403. http://www.natu represerves.ky.gov/NR/rdonlyres/C3056FC3-0435-4126-9A2E-6C9AE0D40291/0/ets2005.pdf (Date accessed 03/29/2010).
Kleber, John E. 1992. Lakes" The Kentucky Encyclopedia. Lexington, Kentucky: The University Press of Kentucky.
Krebs, C.J. 1999. Ecological Methodology. Addison Wesley Longman
Inc., Menlo Park, Calif.
Miller, R. R., J. D. Williams, and J. E. Williams. 1989. Extinctions in North American fishes during the past century. Fisheries 14/6:22–38.
Moyle, P. B., and R. A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems evidence from fish faunas. Pages 127-169 *cited in* P. L. Fiedler and S. K. Jain, eds. Conservation biology: the theory and practice of nature conservation, preservation and management. Chapman and Hall, New York.
Neraas, L. P., and P. Spruell. 2001. Fragmentation of Riverine Systems: The Genetic Effects of Dams on Bull Trout *(Salvelinus confluentus)* in the Clark Fork River. Molecular Ecology System 10:1153-1164.
Park Y-S, J. Chang, S. Lek, W. Cao, and S. Brosse. 2003. Conservation Strategies for Endemic Fish Species Threatened by the Three Gorges Dam. Conservation Biology, Vo. 17, No. 6, p. 1748-1758.
Pflieger, W. L. 1997. The Fishes of Missouri. Missouri Department of Conservation, Jefferson City.
Raney, E.C. and E.A. Lachner. 1946. Age and growth of the rustyside sucker, *T. rhothoeca*. American Midland Naturalist 36: 675-681.
SAS Institute. 2002. SAS/STAT user's guide, version 9.1. SAS Institute, Cary, North Carolina.
Stiassny. M. L. J. 1996. An overview of freshwater biodiversity: with some lessons from African fishes. Fisheries 21 (9): 7-13.
Timmons, T. J., W. A. Rogers. 1977. *Dactylogyrus Atripinnei* sp. N. From the Blackfin Sucker in Tennessee. The Journal of Parasitology Vo. 63, No. 2, p. 238-239.
Timmons, T. J., J.S. Ramsey, and B. H. Bauer. 1983. Life History and Habitat of the Blackfin Sucker, *Moxostoma atripinne*, American Society of Ichthyologists and Herpetologists Vo. 1983, No 2, p. 538-541.
Tennessee Wildlife Resources Agency (TWRA). 2006. Tennessee Land Use/Land Cover Classification. 200 Lowell Thomas Drive Jackson, TN 38301 http://www.state.tn.us/twra/gis/maps/tnlc.pdf (Date accessed 5/28/2010).
Walsh, S. W., N. M. Burkhead, and J. D. Williams. 1995. Southeastern freshwater fishes. Pages 144-147 in E. T. LaRoe, ed. Our living resources. A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U. S. Department of Interior, National Biological Service, Washington, DC.
Warren, M. L., P. L. Angermeier, B. H. Burr, and W. R. Haag. 1997. Decline of a diverse fish fauna: patterns of imperilment and protection in the southeastern United States. Pages 105-164 in G. W. Benz and De. E. Collins, eds. Aquatic Fauna Imperil: The Southeastern Perspective. Special Publ. 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, GA.
Water Resources Development Commission (WRDC). 2008. Land Use and Land Cover Digital Data. Department for Local Government, 1024 Capital Center Drive, Suite 340, Frankfort, Kentucky 40601-8204. http://wris.ky.gov/wris/pdfs/kylubase.pdf (Date accessed 5/28/10).
Wine, M. S., M. R. Weston, R. L. Johnson. 2008. Density Dynamics of a Threatened Species of Darter at Spatial and Temporal Scales. Southeastern Naturalist 7(4):665–678.
Woo, P.T.K, David W. Bruno, L. H. Susan Lim. 2002. Diseases and Disorders of Finfish in Cage Culture. Malaysia: CABI.
Wydoski, R. G., R. S. Wydoski. 2002. Age, Growth and Reproduction of Mountain Suckers in Lost Creek Reservoir, Utah. Transactions of the American Fisheries Society. West Maryland Place, Lakewood, Colorado 80232-5288, USA.

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Brown Trout Population Response to Trophy Regulations in a Southeastern U.S. Tailwater

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Brown trout trophy regulations response / John Williams

Introduction

A reservoir tailwater can be described as that portion of a stream or river below a dam that is directly affected by the discharge of water through or over that dam (Parsons, 1957). Tailwaters below most deep-release reservoirs offer low turbidity, cold temperature and stabilized seasonal flow as well as abundant food for trout (Walburg et al., 1981). Between the efforts of the Tennessee Valley Authority and the U. S. Army Corps of Engineers (ACOE), New Deal-era dam construction exploded in the southeastern United States in the middle of the last century. The stocking and management of trout in these altered habitats below high-head dams subsequently became commonplace (Axon, 1975) and thriving trout populations now exist in many of these tailwaters. Rainbow trout are by far the most common trout species stocked because they are highly vulnerable to sportfishing and serve well as a put-and-take species (Fatora, 1978; Swink, 1983; Hartzler, 1988; Heidinger, 1993). To offset heavy angling pressure, rainbow trout are often stocked at very high densities (Weiland and Hayward, 1997). However, brown trout are more difficult to catch, exhibit faster growth and are more tolerant of warm water, making the species ideally suited for put-grow-and-take fisheries where there is a potential to create a trophy fishery (Behnke, 1990; Hudy, 1990; Heidinger, 1993). Although low-density brown trout stockings in conjunction with rainbow trout can produce trophy brown trout fisheries (Hudy, 1990), excessive fishing pressure and high harvest rates can limit such potential. If those conditions exist, special regulations can be used to mitigate for high harvest and pressure.

There has been and increasing demand for quality trout angling experiences over the last 30 years (Fatora, 1978; Barnhart and Roelofs, 1977, 1987; Harris and Bergersen, 1985; Hartzler, 1988; Gigliotti and Peyton, 1993). Further, the exceptional economic return from developing and maintaining high-quality trout fisheries in tailwaters throughout the US, combined with the increasingly limited supply of hatchery sources, requires that existing hatchery products be optimized through active fisheries management to the extent possible (USFWS, 2006). Many fisheries managers attempt to meet the demands for increased recreational quality and efficient use of hatchery production by implementing bait restrictions, restrictive size and creel limits, or some combination of these regulations. However, special regulations alone cannot improve a river's natural capacity to support trout as each system will have its own limits for trout growth, size, and age structure (Behnke, 1990). Behnke (1990) noted, however, that brown trout in large rivers and tailwaters were an exception to this observation and in these systems they can exhibit fast growth and live longer. If conditions for growth and survival are favorable, but not realized due to high fishing mortality, then specialized harvest restrictions can be used to enhance trophy trout fishing potential.

Another factor that must be considered when implementing special regulations is that the success of trophy regulations ultimately depends on angler acceptance (Fatora, 1978; Anderson and Nehring, 1984). Some anglers place high value on harvesting fish, while other anglers enjoy catching and releasing high numbers of fish or simply catching large fish. The ultimate goal of trout management should be to provide quality fishing for the varied desires of the resource users (Fatora, 1978). To facilitate this, Fatora (1978) suggested that the trout resources in a given area should be managed differently to accommodate all angler desires. This concept can also be applied to a single body of water by applying different regulations on two or more trout species that would result in a "put-and-take" and "trophy" component in the same system.

The Kentucky Department of Fish and Wildlife Resources (KDFWR) manages a popular brown and rainbow trout fishery on its largest tailwater located below Lake Cumberland. Brown trout were first introduced into this tailwater in 1982 while rainbow trout were first stocked in 1956. For many years, both trout species were regulated together using no minimum length limits and a combined eight trout daily limit of which three could be brown trout (Kosa, 1999). In an attempt to develop a trophy brown trout fishery, a 20.0-in minimum total length (TL) and one-fish-per-day creel limit regulations were implemented on brown trout in the Lake Cumberland tailwater in 1997. No bait or gear restrictions were enacted.

There is a paucity of peer-reviewed research on the effects of restrictive minimum size and creel limits on salmonid populations (Power and Power, 1996). The goal of this study was to evaluate the effectiveness of restrictive harvest regulations (20.0-in minimum length limit and one-fish-per-day creel limit) which were enacted to increase the numbers of quality-size (15.0 – 19.9 in) and trophy-size (> 20.0 in) brown trout. The specific objectives were to (1) compare the temporal variation in the relative abundance of several size groups of brown trout before and after trophy regulations were implemented, (2) determine if there were any changes in brown trout growth rates or condition, and (3) compare several abiotic variables with brown trout growth rates and condition.

Methods

The Lake Cumberland tailwater in Kentucky is a 75.2 mi section of the Cumberland River which extends from the Wolf Creek Dam to the KY-TN state line. It is located in the Highland Rim Province of southeastern Kentucky but the entire Kentucky portion of the tailwater no longer supports a diverse native fish community due to the habitat alterations resulting from the dam and is now best suited for management as a trout fishery. The study area encompasses the upper 38.3-mi section beginning immediately below Wolf Creek Dam (Figure 1). Average daily discharge from the dam, released from 101 ft below maximum power pool, is 8,475 ft^3/s, but can fluctuate from 20 to 15,000 ft^3/s within 3 h. Daily discharge fluctuations and durations of minimum flows are variable and depend on hydropower demands. Daily water level fluctuations range from 20 ft in the upper reaches of the tailwater to 6 ft at the lower end of the study area. River width varies from 200 to 400 ft. Long (0.5-4.0 mi) pools interspersed with riffles (0.1-1.0 mi) characterize the river. Shoals associated with islands and small tributary streams, along with large woody debris along the banks, make up the primary in-stream habitat (Coopwood et al., 1987; Kosa, 1999).

All brown trout and rainbow trout stocked in the Lake Cumberland tailwater were produced at the Wolf Creek National Fish Hatchery, which is located immediately below Wolf Creek dam. Catchable-size brown trout that averaged about 8.0 in TL were stocked at age-1 in March or early April of each year from 1995 to 2006 (Table 1). Catchable-size rainbow trout that averaged about 9.0 in TL were stocked monthly from April through December from 1995 to 2006 (Table 1). Stocking rates in the study area averaged 783 brown trout per mi and 3,786 rainbow trout per mi. Beginning in 1996, brown trout stockings that had been stocked within 4.5 miles of the dam were moved out of these areas of higher angling pressure to stocking sites further downstream.

Stocked year classes were distinguished by using several different batch marking techniques. From 1997 to 2002, un-coded wire tags were inserted into either the caudal or dorsal region of stocked brown trout, alternating each year, using a Mark IV CWT™ microwire tagging unit from Northwest Marine Technology, Inc., Olympia, Wash. Stocked brown trout were not marked in 2003. After 2003, stocked brown trout were marked each year with a different fin clip. Either tricaine methane sulfonate (MS-222), carbon dioxide (CO2) or Aqui-S™ was used as an anesthetizing agent during marking. Prior to stocking, short-term (approximately one month) tag loss, mean length, weight, and fin clip efficacy were estimated from a random subsample of fish from each cohort. Hale and Gray (1998) documented 99% retention rates of dorsal and caudal wire tags inserted into brown trout in prior work at Wolf Creek National Fish Hatchery. Through anecdotal field observations, fin regeneration of adipose fin clips was rare to non-existent. Pelvic and pectoral fin regeneration is more common; however, anomalous fin characteristics of regenerated fins usually make marked fish obvious.

Trout were sampled at night in November of each year from 1995-2006 using four or five boats mounted with pulsed DC electrofishing gear at four or five fixed sites. Prior to sampling, a request was made to the ACOE to provide a constant single turbine release from Wolf Creek Dam to ensure that all crews experienced a stable flow, thereby reducing sampling variation (Dauwalter et al., 2009). Multiple timed samples (15-min) were collected at each site. Trout captured were measured to the nearest 0.1 in TL, weighed to the nearest 0.01 lb, and any marks were identified. Data collected were used to calculate catch-per-unit-effort (CPUE, fish/h), growth, and relative weight (Wr). Relative weight was calculated based on the standard weight equation for lotic brown trout:

$$\log_{10}(Ws) = -3.366 + 2.96 \log_{10}(L)$$

as referenced in Anderson and Neumann (1996).

Sampling effort consisted of three runs per site in 1995 and four runs per site in 1996 at 4 sites. From 1997-2006, a fifth site was added and sampling effort was increased to five runs at each site. One site was sampled monthly from May to December of 1997-2006, excluding 1998 and 2003, to track monthly changes in growth and condition of brown trout. In each sampling event, successive 15-minute runs were made until a minimum of 30 brown trout were collected which had been stocked earlier during that sampling year. All trout collected were measured, weighed, and checked for microwire tags and fin clips.

The CPUE of each of four size groups (< 15.0 in, 15.0-19.9 in, ≥ 20.0 in, and all sizes combined) of brown trout collected in fall nocturnal samples were analyzed across all years to determine if changes in abundance occurred as a result of the trophy regulations. Relative abundance data was segregated into two time periods: Pre-regulation change and Post-regulation change. After adding 0.5 to remove zeros, the CPUE data were log-transformed and tested for normality using the Shapiro-Wilk test statistic from the UNIVARIATE procedure with the NORMAL option in the Statistical Analysis System (SAS). Because of the time dependent nature of the data, comparison of mean CPUE between periods for each size group was made using a repeated measures analysis of variance (ANOVA). Specifically, the MIXED procedure in SAS was used with no weighting variable and the AR(1) covariance parameter (Neumann and Allen 2007). The AR(1) covariance structure has homogenous variances and correlations decline exponentially with distance in time (i.e., measurements in successive years are more related than those taken five years apart).

Catch rates of larger sizes of brown trout (≥ 15.0 in) would not be expected to increase immediately following the implementation of the more restrictive regulations because fish need time to grow into those size classes (Ross and Kosa, 2001; Dauwalter et al., 2009). For the Pre-regulation and Post-regulation catch rate comparisons, based on known growth rates of the 1997 stocked cohort, the 1997 catch data of 15.0-19.9 in brown trout and the 1997 and 1998 catch data of ≥ 20.0 in brown trout were assigned to the Pre-regulation period.

Several other population parameters were analyzed to determine if there were any density dependent effects due to increases in brown trout population density. First year growth rates (i.e., the slopes of the cohort mean TL versus days post stocking regression line each year) were compared using an ANCOVA. Further testing with linear regression was used to determine if there was a significant relationship between first year growth rate and year. First year monthly growth rates were calculated by multiplying the slope of the regression by 30. Comparisons of cohort mean growth increments of age-3 and 4 brown trout (years two and three post stocking) were made using a one-way ANOVA. A one-way ANOVA was also used to detect differences among years in fall relative weights of brown trout for four size groups (8.0-11.9 in, 12.0-14.9 in, 15.0-19.9 in, ≥ 20.0 in) and all sizes combined. To increase statistical power of trend detection in field studies of trout populations, Dauwalter et al. (2009) suggested the *a* criterion for statistical testing could be relaxed from the traditional 0.05; for this study all statistical tests were considered significant at $a \leq 0.10$.

Results

Fall Nocturnal Electrofishing CPUE

The log-transformed brown trout electrofishing CPUE data of each of the four analysis groups (all sizes combined, < 15.0 in, 15.0-19.9 in, and ≥ 20.0 in) satisfied the assumptions for normality ($P > 0.05$) for both periods (Pre- and Post-regulation) with one exception. The Pre-regulation period electrofishing CPUE of greater than or equal to 20.0 in brown trout did not satisfy the normality assumption ($P < 0.05$) because there were so few large brown trout collected prior to 1999.

Length frequency histograms of fall electrofishing CPUE from 1995 to 2006 show an increasing trend in density of all sizes of brown trout combined in the Cumberland tailwater after institution of the trophy regulations in 1997. Electrofishing catch rate for all sizes combined was significantly higher ($F = 7.48$; df = 1, 10; $P = 0.02$) in Post-regulation years ($\bar{x} = 89.3$ fish/h) than in Pre-regulation years ($\bar{x} = 29.2$ fish/h). The electrofishing catch rate of less than 15.0 in brown trout was significantly higher ($F = 9.11$; df = 1, 10; $P = 0.01$) in Post-regulation years ($\bar{x} = 62.7$ fish/h) than in Pre-regulation years ($\bar{x} = 22.8$ fish/h). The electrofishing catch rate of 15.0-19.9 in brown trout was significantly higher ($F = 5.78$; df = 1, 10; $P = 0.04$) in the Post-regulation years ($\bar{x} = 24.2$ fish/h) than in the Pre-regulation years ($\bar{x} = 4.7$ fish/h). The electrofishing catch rate of 20.0 in or greater brown trout was significantly higher ($F = 3.68$; df = 1, 10; $P = 0.08$) in the Post-regulation years ($\bar{x} = 4.9$ fish/h) than in the Pre-regulation years ($\bar{x} = 1.9$ fish/h).

Growth and Condition

Post stocking growth rates of age-2 brown trout during their first year following stocking varied significantly by year ($F = 6.36$; df = 7, 49; $P < 0.0001$), but did not slow down over the course of the study ($r^2 < 0.0001$; $F = 0.0005$; df = 1, 8; $P = 0.98$). Monthly growth rates of age-2 brown trout in the tailwater ranged from 0.35 in/month in 2003 to 0.70 in/month in 2000 and 2001 and during the Post-regulation years averaged 0.53 in/month.

The annual mean cohort growth increment of age-3 brown trout ranged from 3.0 to 4.8 in for the available years of 1998-2000, 2005 and 2006 and varied significantly among years ($F = 18.41$; df = 4, 472; $P < 0.0001$), but there was not a trend of growth slowing over time. Annual growth increments of age-4 brown trout ranged from 2.4 to 3.1 in per year in the available years of 1999-2001 and 2006. The mean growth rates of age-4 brown trout among years approached significance ($F = 2.01$; df = 3, 173; $P = 0.11$), but there was still no trend of growth slowing over time.

The mean relative weight of all sizes of brown trout combined in fall sampling varied significantly among years from 2000 to 2006 ($F = 104.12$; df = 6, 4,320; $P < 0.0001$). When broken down by size group, condition was also significantly different in the 8.0 to 11.9 in group ($F = 55.4$; df = 6, 1,164; $P < 0.0001$), 12.0 to 14.9 in group ($F = 41.4$; df = 6, 1,705; $P < 0.0001$), 15.0 to 19.9 in group ($F = 26.1$; df = 6, 1,213; $P < 0.0001$) and ≥ 20.0 in group ($F = 2.3$; df = 6, 217; $P = 0.04$). Condition was poorest in 2003 and 2004 for all sizes of brown trout combined and for the 8.0 to 11.9 in and 12.0 to 14.9 in size groups. Condition of 15.0 in and greater fish was variable, but with the exception of 2003, all fish of this size were in excellent condition in Post-regulation years. No groups exhibited any consistent trend of declining condition across years.

Discussion

Prior to the implementation of the trophy size and creel limits for brown trout, there were few large (≥ 15.0 in) brown trout present in the Lake Cumberland tailwater due to high angler harvest (Dreves 2010). High harvest rates of both brown and rainbow trout have previously been documented in other tailwater fisheries (Axon, 1975; Aggus et al., 1979; Wiley and Dufek, 1980; Hudy, 1990; Bettoli et al., 1999). In 1996, the decision was made to manage brown trout as a trophy, put-grow-and-take fishery in the Lake Cumberland tailwater, while simultaneously managing rainbow trout as a put-and-take fishery.

A concurrent creel survey showed that harvest of brown trout was greatly curtailed after implementation of the trophy regulations; however, fishing pressure increased in the Cumberland tailwater (Dreves, 2010). Both electrofishing and angler catch rates increased dramatically for all sizes of brown trout without any concomitant decreases in growth or condition and in the absence of any gear or bait restrictions. Increasing density of brown trout in the Lake Cumberland tailwater as a result of the trophy regulations had the potential to result in decreases in growth rate (Wiley et at., 1993; Weiland and Hayward, 1997; Van Den Avyle, 1993). A decrease in growth rate would result in a longer time to reach quality size (15.0 in) and allow the forces of natural mortality more time to act on fish, which would limit the potential for increasing the density and sizes of fish (Van Den Avyle, 1993). This was not the case for brown trout in the Lake Cumberland tailwater following implementation of the trophy regulations, even though the brown trout density in the tailwater increased significantly. The first year monthly growth rate averaging 0.53 in/month for brown trout in the Lake Cumberland tailwater is greater than first year brown trout growth rates observed in the Elk River, TN (0.22 in/month); Clinch River, TN (0.47 in/month); Caney Fork River, TN (0.31 in/month); and South Fork of Holston River, TN (0.43 in/month) (Bettoli, 1999; Bettoli and Besler, 1996; Bettoli and Bohm, 1997; Devlin and Bettoli, 1999). Growth rates of brown trout in their first three years after stocking did not slow with increasing population density, indicating that the trout populations in the Lake Cumberland tailwater had not reached a level where density-dependent mechanisms were limiting. Stocking rates of brown trout (783/mi) and rainbow trout (3,786/mi) in the Lake Cumberland tailwater are well below those reported for Arkansas tailwaters where stocking rates are as high as 2,080 brown trout per mi and 19,230 rainbow trout per mi (J. Williams, Arkansas Game and Fish Commission, personal communication). Stocking rates in Tennessee tailwaters are more comparable with those in Kentucky as brown trout are stocked at 500 to 1,280 fish per mi and rainbow trout are stocked at rates ranging from 2,435 to 3,970 per mi (Bettoli, 1999; Bettoli and Besler, 1996; Bettoli et al., 1999; Devlin and Bettoli, 1999).

Declining trends in relative weight following implementation of restrictive regulations can also be an indicator of density-dependent effects on a fish population (Van Den Avyle, 1993). As with growth rates, the condition of brown trout in the Cumberland tailwater did not decrease over time as the population increased. Mean relative weight varied but showed no consistent increasing or decreasing trend over the seven years of data. A lack of declining growth and condition suggests that density-dependent processes did not negatively impact the brown trout population in the Lake Cumberland tailwater following implementation of the trophy regulations.

The lack of density-dependent negative effects on the population after the implementation of restrictive regulations is uncommon (Power and Power 1996). Some researchers have documented increases in trout abundance or size structure, but the changes were accompanied by negative density-dependent impacts. For instance, Hunt (1981) compared trout population response to a high minimum size limit/one fish creel limit versus a control reach under less restrictive regulations in a Wisconsin river. Abundance, biomass, and survival all increased in the trophy regulations reach, but Hunt (1981) speculated that density-dependent decreases in growth limited the fishery from “stockpiling” more trophy fish. Negative density-dependent impacts after implementation of restrictive regulations were seen in wild brook and brown trout populations in a Michigan river (Shetter and Alexander, 1966) and in brook trout *(Salvelinus fontinalis)* populations in Lawrence Creek, Wisconsin (Hunt, 1977). Effort has also been directed towards mathematical modeling responses of trout populations to management strategies (Clark et al., 1981; Jensen, 1981; Power and Power, 1996) and in each case the modeler incorporated density-dependent negative impacts into predictions of trout response to various management strategies.

The results of the current research have shown that trophy regulations can positively alter brown trout abundance and size structure without negatively affecting growth and condition. As Power and Power (1996) indicated, because of the nature of our study (i.e. evaluating population response to a simultaneous change in both the size limit and creel limit) it is difficult to identify which of the regulation changes was more responsible for the observed response in the Lake Cumberland tailwater brown trout population. We suggest that density-dependent limitations on growth and condition were not observed because observed increases in brown trout density subsequent to the implementation of the restrictive regulations still remained below carrying capacity of the tailwater. However, we also observed that poor water quality related to high precipitation can be a limiting factor.

Management Implications

The brown trout species is especially well-suited for use in the development of trophy trout fisheries in similar modified river habitats because of its rapid growth to large sizes, ability to tolerate warmer water and lower susceptibility to angling increases long-term survival. This research demonstrates that a high minimum size limit and very restrictive creel limit can result in an increase in quality and trophy sizes of brown trout. At the same time, rainbow trout were managed under more liberal statewide regulations consisting of no size limit and a creel limit of 8 fish. The concept of severely limiting harvest to provide a trophy fishery for one trout species, while managing an additional salmonid species for a more harvest-oriented fishery is unique. This strategy of partitioning the trout fishery caters to the desires of various resource users and should allow for wider angler acceptance of restrictive limits. While acknowledging that regulation complexity can be of concern, we recommend fisheries managers consider the use of similar variable salmonid management strategies where two or more species cohabitate.

Literature Cited

Aggus, L. R., D. I. Morais, R. F. Baker. 1979. Evaluation of the trout fishery in the tailwater of Bull Shoals Reservoir, Arkansas, 1971-73. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 31(1977):565–573.

Anderson, R. M., and R. B. Nehring. 1984. Effects of a catch-and-release regulation on a wild trout population in Colorado and its acceptance by anglers. North American Journal of Fisheries Management 4:257–265.

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447–482 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Axon, J. 1975. Review of coldwater fish management in tailwaters. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 28(1974):351–355.

Barnhart, R. A., and T. D. Roelofs, editors. 1977. Catch-and-release fishing as a management tool. Humboldt State University, Arcata, California. 220 pp.

Barnhart, R. A., and T. D. Roelofs, editors. 1987. Catch-and-release fishing – a decade of experience. Humboldt State University, Arcata, California. 299 pp.

Behnke, R. J. 1990. Roots, origins, and management of Salmo trutta, our most versatile species of trout. Pages 1–2 *in* J.C. Borawa, ed. Brown trout workshop: biology and management. American Fisheries Society, Southern Division, Trout Committee, Asheville, NC.

Bettoli, P. B. 1999. Creel survey and population dynamics of salmonids stocked into the Watauga River below Wilbur Dam. Tennessee Wildlife Resources Agency, Fisheries Report 99-41, Nashville.

Bettoli, P. B., and D. A. Besler. 1996. An investigation of the trout fishery in the Elk River below Tims Ford Dam. Fisheries Report 96-22, Nashville.

Bettoli, P. W., and L. A. Bohm. 1997. Clinch River trout investigations and creel survey. Tennessee Wildlife Resources Agency, Fisheries Report 97-39, Nashville.

Bettoli, P. B., S. J. Owens, and M. Nemeth. 1999. Trout habitat, reproduction, survival, and growth in the South Fork of the Holston River. Tennessee Wildlife Resources Agency, Fisheries Report 99-3, Nashville.

Clark, R. D., Jr., G. R. Alexander, H. Gowing. 1981. A history and evaluation of regulations for brook trout and brown trout in Michigan streams. North American Journal of Fisheries Management 1:1–14.

Coopwood, T. R., S. W. McGregor, T. S. Talley, and D. B. Winford. 1987. An investigation of the tailwater fishery below Wolf Creek dam, Russell County, Kentucky to Celina, Tennessee. U.S. Fish and Wildlife Service, Ecological Services. Cookeville, Tennessee.

Dauwalter, D. C., F. J. Rahel, and K. G. Gerow. 2009. Temporal Variation in Trout Populations: Implications for Monitoring and Trend Detection. Transactions of the American Fisheries Society 138:38–51.

Devlin, G. J., and P. B. Bettoli. 1999. Creel survey and population dynamics of salmonids stocked into the Caney Fork River below Center Hill Dam. Tennessee Wildlife Resources Agency, Fisheries Report 99-8, Nashville.

Dreves, D. 2010. Annual Performance Report. Subsection I: Lake Fisheries Investigation. Kentucky Department of Fish and Wildlife Resources, D-J

Grant Number F-40, Segment 32.
Fatora, J. R. 1978. Stream trout fishery management in the southeastern United States. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 30(1976):280–284.
Gigliotti, L. M., and R. B. Peyton. 1993. Values and behaviors of trout anglers, and their attitudes toward fishery management, relative to membership in fishing organizations: a Michigan case study. North American Journal of Fisheries Management 13:492–501.
Hale, R. S., and J. H. Gray. 1998. Retention and detection of coded wire tags and elastomer tags in trout. North American Journal of Fisheries Management 18:197–201.
Harris, C. C., and E. P. Bergersen. 1985. Survey on demand for sport fisheries: problems and potentialities for its use in fishery management planning. North American Journal of Fisheries Management 5:400–410.
Hartzler, J. R. 1988. Catchable trout fisheries: the need for assessment. Fisheries 13(2):2–8.
Heidinger, R. C. 1993. Stocking for sport fisheries enhancement. Pages 309–330 in C. C. Kohler and W. A. Hubert, editors. Inland Fisheries Management in North America. American Fisheries Society, Bethesda, MD.
Hudy, M. 1990. Brown trout population structures in White River tailwaters currently managed under no special regulations. Pages 94–97 in J.C. Borawa, ed. Brown trout workshop: biology and management. American Fisheries Society, Southern Division, Trout Committee, Asheville, NC.
Hunt, R. L. 1977. An unsuccessful use of catch-and-release regulations for a wild brook trout fishery. Pages 125–136 *in* R.A. Barnhart and T.D. Roelofs, eds. Catch-and release fishing as a management tool. Humboldt State University, Arcata, California.
Hunt, R. L. 1981. A successful application of catch and release regulations on a Wisconsin trout stream. Wisconsin Department of Natural Resources Technical Bulletin 119. Madison.
Jensen, A. L. 1981. Optimum size limits for trout fisheries. Canadian Journal of Fisheries and Aquatic Sciences 38:657–661.
Kosa, J. 1999. Evaluation of rainbow and brown trout stockings in the Lake Cumberland tailwater. Kentucky Department of Fish and Wildlife Resources Bulletin 102. Frankfort.
Neumann, R. M., and M. S. Allen. 2007. Size structure. Pages 375–421 in C. S. Guy and M. L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American Fisheries Society , Bethesda, Maryland.
Parsons, J. W. 1957. The trout fishery of the tailwater below Dale Hollow Reservoir. Transactions of the American Fisheries Society 85:75–92.
Power, M., and G. Power. 1996. Comparing minimum-size and slot limits for brook trout management. North American Journal of Fisheries Management 16:49–62.
Ross, J. R., and J. T. Kosa. 2001. Response of brown trout in Lake Cumberland tailwater to a trophy regulation. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 55:23–37.
Shetter, D. S., and G. R. Alexander. 1966. Angling and trout populations on the North Branch of the Au Sable River, Crawford and Otsego Counties, Michigan, under special and normal regulations, 1958-63. Transactions of the American Fisheries Society 95:85–91.
Swink, W. D. 1983. Nonmigratory salmonids and tailwaters – A survey of stocking practices in the United States. Fisheries 8(3):5–9.
USFWS (U. S. Fish and Wildlife Service). 2006. Economic effects of rainbow trout production by the National Fish Hatchery System: science and efficiency at work for you. U. S. Fish and Wildlife Service, Division of Fisheries and Aquatic Resource Conservation. Arlington, VA.
Van Den Avyle, M. J. 1993. Dynamics of exploited fish populations. Pages 105–135 in C. C. Kohler and W. A. Hubert, editors. Inland Fisheries Management in North America. American Fisheries Society, Bethesda, MD.
Walburg, C. H., J. F. Novotny, K. E. Jacobs, W. D. Swink, T. M. Campbell, J. Nestler, and G. E. Saul. 1981. Effects of reservoir releases on tailwater ecology: a literature review. Technical Report E-81-12. U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS. 216 pp.
Wege, G. J., and R. O. Anderson. 1978. Relative weight (Wr): a new index of condition for largemouth bass. Pages 79–91 *in* G.D. Novinger and J.G. Dillard, eds. New approaches to the management of small impoundments. North Central Division, American Fisheries Society, Special Publication 5.
Weiland, M. A., and R. S. Hayward. 1997. Cause for the decline of large rainbow trout in a tailwater fishery: too much putting or too much taking? Transactions of the American Fisheries Society 126:758–773.
Wiley, R. W., and D. J. Dufek. 1980. Standing crop of trout in the Fontenelle tailwater of the Green River. Transactions of the American Fisheries Society 109:168–175.
Wiley, R. W., R. A. Whaley, J. B. Satake, and M. Fowden. 1993. Assessment of stocking hatchery trout: a Wyoming perspective. North American Journal of Fisheries Management 13:160–170.

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Rockcastle River / Michael Compton

Analysis of the Environmental Requirements for *Etheostoma cinereum* (Ashy Darter) and *Percina Squamata* (Olive Darter) in the Rockcastle River, Kentucky

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Introduction

The Rockcastle River drainage lies within the Southwestern Appalachian Plateau and is recognized as a Tier I priority conservation area (KDFWR, 2005). It contains seven fish species of greatest conservation need (SGCN) identified in Kentucky's Wildlife Action Plan (SWAP) (KDFWR, 2005): *Ichthyomyzon greeleyi* (Mountain Brook Lamprey), *Chrosomus cumberlandensis* (Blackside Dace), *Etheostoma baileyi* (Emerald Darter), *Etheostoma cinereum* (Ashy Darter), *Etheostoma sanguifluum* (Bloodfin Darter), *Etheostoma virgatum* (Striped Darter), and *Percina squamata* (Olive Darter). Because it contains a relatively diverse assemblage of fishes and mussels, several of which are unique in Kentucky, the Rockcastle River drainage has been recognized as a Tier I Priority Conservation Area for aquatic species under the SWAP (KDFWR, 2005). Urban expansion of Mount Vernon and London, the proposed I-66 project, and current agricultural and silvicultural activities are major factors impacting the integrity of aquatic life in the Rockcastle River drainage.

Among the fish SGCN in the Rockcastle River drainage, the Ashy

Darter and Olive Darter are high-priority species of concern because of their rarity within the state and limited distribution within the Cumberland and Tennessee River systems. Various aspects of life history are known for both species, but much information is still lacking. Habitat use, population structure, tolerance to impacts, and current conservation status are largely unknown. Effective conservation management of these species requires a knowledge of population status, life history, and habitat needs. The goals of our study were to: 1) document the distribution and relative abundance of Ashy Darter and Olive Darter, 2) characterize the environmental variables present at sites where either or both species are present, 3) quantify the microhabitat use for both species, 4) identify possible threats to the known populations of both species, and 5) provide conservation status and management recommendations for these and other species of concern within the Rockcastle River drainage.

Methods

Study Area

The Rockcastle River is a moderate gradient 5th order stream that is located in the foothills of the western slope of the Appalachian Mountains in Clay, Jackson, Laurel, Pulaski, and Rockcastle counties, Kentucky. The river flows southward until it confluences with the Cumberland River and has a catchment area of approximately 2000 square kilometers (764 mi.^{2}). The major tributaries (> 100 km^2 catchment area) of the Rockcastle watershed (in upstream sequence) are Sinking Creek, Skegg Creek, Little Rockcastle River, Roundstone Creek, Horse Lick Creek, Middle Fork Rockcastle River and South Fork Rockcastle River (Figure 1). Most of the watershed is within the Southwestern Appalachian Ecoregion, with only the headwater reaches of the tributaries in Pulaski County located within the Interior Plateau Ecoregion. The lower section of the river has been designated as a Kentucky Wild and Scenic River and the immediate river corridor (> 500 m) within the area is mostly forest. A large portion of the watershed is within the boundaries of the Daniel Boone National Forest, but fragmented with private land. Legacy impacts from past coal mining activity is evident within the watershed, but most current land use activities include silviculture, agriculture, and numerous residential communities scattered across the landscape. Interstate Highway I-75 runs north-south through the watershed. There are no large hydrological dams within the watershed but several small impoundments have been established for drinking water supply and recreational use (i.e., Wood Creek). The mouth of the river is inundated by backwaters of Lake Cumberland, which fluctuates seasonally and can influence the river approximately 10 river km upstream, near the KY 192 bridge. Currently, repairs are being conducted to the Wolf Creek Dam and the river is only inundated, during the summer months, the first 5-6 river kilometers, exposing shoals that are typically flooded.

Sampling Design

Fish sampling was conducted at 56 sites for distributional, assemblage, and microhabitat data within the Rockcastle River watershed during the summers of 2008 – 2010 (Figure 2). In 2008, ten random 3rd order sites were surveyed for fish assemblage data and to determine if focal species (i.e., Ashy Darter and Olive Darter) were present. An additional 14 sites were surveyed for fish assemblage data and two sites were established in the lower reaches of the Rockcastle River for gill net collections during 2009 – 2010. Based on the absence of focal species during the 2008 survey and the absence from historical collections within the 3rd order reaches or smaller of the Rockcastle River, a stratified random design was implemented within the 4th and 5th order reaches during the summers of 2009 and 2010. The rationale was to focus sampling efforts within stream reaches likely to contain focal species and to use those data for stream reach scale and microhabitat use modeling of the focal species.

Thirty random sites were established within the 4th and 5th order stream reaches, with eighteen and twelve sites established, respectively. At each of these sites, a series of 3 x 10 m plots were surveyed during summer (July 20 – Sept. 20) of 2009 and 2010, for a total of 60 sample events. The stream reach length and number of plots at a site varied based on stream order, where 200 m and 13 plots and 300 m and 20 plots were sampled at the 4th order and 5th order sites, respectively. This design provided roughly a 10 % (8 – 12%) subsample of a site and allowed for all available habitats, except the deepest waters, to be surveyed and documented thoroughly.

Fish distribution and assemblage data were obtained following protocols outlined in KDOW (2006). All fish specimens encountered within a plot were identified and enumerated, with each subsequent plot data recorded separately. Total length (mm) was measured for all captured individuals of Olive and Ashy darters. Supplemental backpack electrofishing and seining was conducted within targeted areas to provide a comprehensive survey of the fish community at the stream reach scale. Typically, this included an additional 500 – 1000 shocking seconds and 4-8 seine hauls or kicks in areas not previously sampled.

Environmental Variables

Physical, land cover, and water quality data were obtained for each site (Appendix B). Physical data included, catchment area (km^2), mean stream width (m), maximum depth (m), % riffle, % run, and % pool, as well as, the parameters highlighted within the EPA

Rapid Bioassessment Protocol (RBP) form, as modified by KDOW (2006). Water quality data were obtained following protocols outlined in KDOW (2006), with a focus on the nutrient and general water quality parameters including conductivity (µs/cm), pH, temperature (°C), and dissolved oxygen (mg/l) at each site. Landscape data for each major tributary and for the upper and lower Rockcastle River mainstem corridors were obtained from the National Land Cover Database 2001 *(http://seamless.usgs.gov/nlcd.php)*. Land cover was classified as agriculture (cultivated crops and pasture/hay), forest (deciduous, evergreen, and mixed forest), grassland (grassland/herbaceous and scrub/shrub), urban (developed open space, low intensity, medium intensity and high intensity, and barren land) and wetland (woody wetlands and emergent herbaceous wetlands).

At the microhabitat scale, a series of environmental variables were measured at designated areas within each plot. Plots were bisected into two 3 x 5 m areas and the presence/absence of large woody debris (LWD) and *Justicia americana* (American water-willow) were determined for each half. These represented a form of natural cover outside of rock substrate and were noted as being important Ashy Darter habitat (Shepard and Burr, 1984). Also within each half, the b-axis (m) of the largest boulder was measured, if present. In addition, a visual estimation of a flow category was determined for each half, including no flow (<0.01 m/s), slow (0.01 – 0.3 m/s), swift (0.3 – 0.75 m/s), and very swift (> 0.75 m/s); each category was scored as 0, 1, 2, or 3, respectively. Substrate and depth (m) were determined at the corners and center of each half of a plot to estimate overall substrate composition and mean depth for the plot. Substrate was determined as fines (< 0.06), sand (0.06-2 mm), gravel (2-16 mm), pebble (16-64), cobble (64-256 mm), boulder (>256 mm), hardpan clay, and bedrock. Lastly, plots along the margins of the channel were scored as outside or inside bend.

Analytical Methods

At both stream reach and microhabitat scales, a multivariate approach was used to compare available habitat resources to those used by the focal species. A principal components analysis (PCA) of environmental variables provided a continuous gradient of the aggregate available resources at a site. Only principal components (PCs) with eigenvalues greater than 2.0 were considered to have the most biological relevance and were retained for further analysis. To determine if focal species were selectively occupying sites based on the available habitat parameters the Kolmogorov – Smirnov Test (K – S test) goodness of fit test was performed. Significant P-values (< 0.05) for a given PC would indicate that sites were being used non-randomly by focal species with regard to the environmental gradient. To identify environmental factors that provided the highest concentration of focal species within the sites, kernel density estimation was conducted using confidence levels of 0.25, 0.50, and 0.75; environmental variables were characterized for the level that represented that highest density of focal species.

For watershed assessment, the Rockcastle River was divided into smaller subunits, which included the major tributaries (e.g., Sinking Creek), upper and lower mainstem corridor sections, and minor tributaries of the mainstem (e.g., Cane Creek). We assessed the health of the watersheds using the Kentucky Index of Biotic Integrity (KIBI) (KDOW, 2006). KIBI scores were determined for each site following methods outlined in Compton (2003) and KDOW (2006). Relationships between environmental variables and KIBI scores were used to make inferences about the health and potential stressors influencing specific sites as well as larger sections of the watershed.

Results and Discussion

Fish Distribution and Abundance

A total of 46,475 individuals comprising 79 species of fish were collected from 96 sample events during 2008 – 2010. Seven species were collected for the first time in the Rockcastle River drainage: *Acipenser fulvescens* (Lake Sturgeon – from KDFWR stockings), *Lepisosteus osseus* (Longnose Gar), *Notropis telescopus* (Telescope Shiner), *Gambusia affinis* (Western Mosquitofish), *Morone saxatilis* (Striped Bass), *Lepomis gulosus* (Warmouth), and *Percina sciera* (Dusky Darter). All fish SGCN known to occur in the Rockcastle River were collected except for Chrosomus cumberlandensis (Blackside Dace); however, this is probably due to lack of sampling effort focused on small headwater stream reaches.

The Ashy Darter was encountered at 23 sites but restricted to the larger stream sizes, 4th and 5th order stream reaches greater than 100 km2 in catchment area (Figure 5). It was present at all mainstem sites sampled except for the two most downstream sites, which were inundated by the backwaters of Lake Cumberland. The species was also present in all of the lower reaches of the major tributaries, except for Skegg Creek. Although present in the lower reaches in most of the major tributaries of the Rockcastle River, Ashy Darter was most abundant and consistently detected at downstream locations in Horse Lick Creek, Middle Fork Rockcastle River, and South Fork Rockcastle River. Ashy Darter specimens represented less than 1% of the total fish abundance in samples, but ranged from 0.9 % – 13.9 % of the total darter community, with a median value of 4.9 %.

The distribution of the Olive Darter was also restricted to the larger stream sizes but was more isolated and fragmented than the Ashy Darter throughout the drainage (Figure 6). A total of 23 individuals were captured among eight sites. All of the sites except the Middle Fork Rockcastle River location were 5th order and had a catchment area > 750 km^2, with the majority of locations present within the lower reaches of the mainstem Rockcastle River. Olive Darter specimens represented less than 0.01 % of the total fish abundance in samples, but ranged from 0.4 % – 2.6 % of the total darter community, with a median value of 0.9 %.

Prior to this study, Olive Darter occurrence records did not exist below Hwy 80, Laurel – Pulaski county line (Burr and Warren 1986). However, the majority of the current records are within the lower reaches of the Rockcastle River and only two specimens were collected above Skegg Creek. These results suggest either a lack of previous sampling effort below Hwy 80 or changes in river conditions above Hwy 80 during the past forty years.

Focal Species Stream Reach Analysis

The first three PC axes met our criteria for inclusion and were retained for further analysis. The three axes explained 24.6 %, 14.6%, and 10.1% of the variation in the original data set, respectively. However, the first two PCs are discussed in detail because only two environmental variables were considered biologically meaningful along the third PC axis, and both loaded strongly onto either the first or second PC axis. Eighteen stream reach environmental variables were considered biologically important (Table 1).

Two hundred-twenty seven Ashy Darters (89 juveniles and 138 adults) from 21 sites were encountered during the plot surveys. Ashy Darter presence in PCA showed two small groups of sites occupied by adults and juveniles (Figure 8). The K – S test results demonstrated a non-random distribution of adults and juveniles among sites and separate resource use at the stream reach scale. Kernel density estimation (KDE) for adults at a confidence level of 0.25 identified nine sample events from five sites with a mean of 8.7 individuals per sample event representing the greatest density of Ashy Darter adults. For juveniles, KDE at a confidence level of 0.50 identified seven sample events from five sites with a mean of 6.0 individuals per sample event representing the greatest density of individuals.

Although sites with a confidence level of 1.0 have habitat that is suitable for Ashy Darters, sites identified based on a confidence level of 0.75 in KDE analysis are considered stream reaches that contain optimal environmental resources used by the species and likely do not contain transient individuals. These stream reaches include mainstem Rockcastle River sites with a catchment area of at least 1100 km^2 (Table 4). They were characterized as approximately 55% run and 33 % pool habitat, with a maximum depth of approximately 1.5 meters. Substrate composition was predominantly cobble and pebble, with approximately 15 % boulder substrate present throughout the reach. Land cover associated with these sites was mostly forest (mean 44 %) with about 20 % urban and less than 10 % agriculture. The high degree of forest, large-sized substrate composition and flow regime creates stream reaches with diverse habitats, as indicated by the EPA RBP habitat scores for these sites. The three water chemistry parameters, alkalinity, conductivity, and organic carbon, that were identified as important contributors to the PCA had a mean of 70.08, 223.9, and 2.34, respectively, and are typical values for this region on Kentucky.

Because the Oliver Darter was so infrequently captured, particularly from the plot surveys (7 individuals captured during 4 sample events from 3 sites), analysis was limited to descriptive interpretation. Overall, the species was encountered during eleven sample events from eight sites and placement of those sites within the PCA shows that nine of the eleven sampling events, representing six sites, are tightly grouped (Figure 10). These six sites are situated in the mainstem Rockcastle River with a catchment area of at least 1500 km2. The stream reaches were approximately 55% run and 33 % pool habitat, with a maximum depth of approximately 1.6 meters. Substrate composition was predominantly boulder and cobble, typically 40 % – 50 %, with pebble and gravel 30 % – 40 %. Boulders were distributed throughout the stream reaches, with 90 % of the plots surveyed at a site having at least one boulder present. Land cover associated with these sites is mostly forest (> 50 %) with urban and agriculture roughly 20 % combined. The EPA RBP habitat scores were high, with a median value of 169. Water chemistry parameters were typical for this region of Kentucky and are summarized (Table 5). In general, Olive Darters were present at sites with a large proportion of boulders but also large-sized boulders (> 0.75 m b-axis).

Focal Species Microhabitat Use

Nine hundred-sixty two plots were surveyed from the 30 random 4th and 5th order sites. The PCA of the plot microhabitat data resulted in two PCs explaining 35.9 % of the variation and ten of the 14 environmental variables considered important contributors (Table 6). The distribution of the plot data captured the various flow, depth and substrate regimes present within the Rockcastle River (figure 11).

Etheostoma cinereum:

Two hundred-twenty seven ashy darters were encountered from 18 sites within 123 plots, with 89 juveniles from 62 plots and 138 adults from 80 plots. Darter abundance ranged from 1 – 6 individuals per plot. There were 19 plots with both adult and juvenile ashy darters present. The general concentration of habitat use by the age groups appeared distinct from each other within the PCA (Figure 12). The K – S test results indicated that the distribution of PC 1 values for the available habitat and adult ashy darter habitat use was significantly different (D = 0.289; *P* <0.01). The relative frequency of adult habitat use was typically greater than the available habitat for PC 1 with values less than 0.0 (Figure 13). The distribution of juvenile ashy darter habitat use values across PC 1 was not significantly different (D = 0.139; *P* <0.09) than the available habitat values. The distribution of PC 2 values for both adult and juvenile ashy darter habitat use was significantly different (D = 0.392 and 0.188, respectively; *P* <0.01) than the distribution of available habitat values. Adult habitat use was typically associated with values less than 1.0 and juveniles were typically associated with values greater than 0.0 along the PC 2 habitat gradient. Comparison between the age groups indicated that the distribution of values was significantly different along the PC 1 (D = 0.242; *P* <0.01) and PC 2 (D = 0.401; *P* <0.01) habitat gradients, which indicated that the habitat typically used by adults and juveniles is distinct.

The kernel density estimation (KDE) at the confidence level of 0.25, 0.50, and 0.75 for PC 1 and PC 2 showed differences in the concentration of adult and juvenile habitat use (Figure 14). The KDE at the 0.50 confidence level, for adults and juveniles, identified 37 and 39 plots from 11 sites each as having the greatest density, with means of 2.1 individuals and 1.6 individuals per plot, respectively (Table 7).

Comparison of the microhabitats at the 0.50 confidence level showed similarities in microhabitat use but also great differences in habitat use. These results support the K – S test results that adult and juvenile ashy darters utilize different microhabitats (Table 8). For instance, adult ashy darters were present along the margin of the channel in 58 % of the plots and exclusively utilized the outside bend of the channel when present within those plots, indicating a preference for the erosional zone of the channel over the depositional areas (Figure 15). Juvenile ashy darters were present along the margin of the channel in 49 % of the plots and were present along the outside bend of the channel in 58 % of those plots, suggesting juveniles display no preference of habitat use within the erosional or depositional zones of the channel. These location differences within the channel might explain the slight differences in mean depth of habitat use between the two age groups. Juveniles were found more in the mid-channel of the stream, with a mean depth of 0.38 m, while adult darters were found more frequently along the margins, where the depth is shallower (0.29 m) and the variation depth within the plots greater.

More than 90 % of the plots utilized by adult darters had cobble or boulder present within them and the plots were typically comprised of 50 % cobble and boulder substrates (Figure 16). Also, the size of the largest boulder within the plots had a median value of 0.84 m, b-axis length. In comparison, juvenile ashy darters were typically present in plots dominated by cobble and gravel substrates, with boulder being present in roughly 50 % of the plots, with a median largest boulder size of 0.50 m, b-axis length. Lastly, it is important to note the absence and infrequent use of fine and sand substrates by adult darters. Typically, adults were present in plots with no fines or sand and if present, the fines and sand substrate composition was minimal. Juveniles did associate more frequently with sand substrate, which could be a result of habitats utilized within depositional areas.

The distribution of the rock substrates within the channel and ultimately the use of those substrates by the ashy darter are tied to the stream reach gradient and flow present within a plot. The flow for both adult and juvenile ashy darters within a plot typically was classified as ‘slow’ (0.01 – 0.3 m/s) or less frequently, ‘no flow’ (<0.01 m/s). The intriguing aspect of this flow use associated with the ashy darters, is that the adults have a strong relationship with large substrates and areas with no flow or minimal flow generally are comprised of smaller substrates. However, the use of the outside bend of the channel functions as a mechanism to remove excess fin and sand substrates. We hypothesize, that when water levels and flow velocities increase during and shortly after rain-events the outside bend areas that are being used by ashy darters will be flushed of excessive fine and sand substrates, while simultaneously scouring cobble and boulder substrates of fine material. In addition, the large boulders (> 0.75 m, b-axis) functions as a form of shelter for the darters, against increased suspended material being transported downstream related to the increased water levels and current velocities.

The importance of boulder had been recognized by Shepard and Burr (1984) and Etnier and Starnes (1993). In addition, fractured bedrock was occasionally present within a plot, which mostly likely serves as the same function of a large boulder. Ultimately, it is perceived that adult ashy darters need areas that provide sediment free shelter with minimal flow. These habitats are also inhabited by burrowing mayflies, such as *Ephemera* spp., therefore it is understandable that they have been found to be the dominant food item in the diets of ashy darters (Etnier and Staner 1993).

Juvenile ashy darters appear to be more liberal in their habitat use. The use of rock substrate is most likely tied to the size of the fish and as juveniles grow they move toward larger substrates. Most likely juveniles still need a form of stable cover and the use of large woody debris by juveniles was distinctly greater than the use by adults (18 %). However, only 50 % of the plots with large woody debris and juvenile occupancy were located along the outside of the bend of the channel. The use of *Justicia* spp. (water willow) was infrequent with only one plot utilized by adult darters and three plots occupied by juvenile darters. It could be perceived that large woody debris, water willow and other forms of cover were secondary options for darters. The use of these habitats may be an artifact of the overall site quality and available habitat, or potentially intra- and inter-species competition. However, ashy darters can be fairly dense in certain habitats and it was not uncommon for plots to yield 3 – 5 individuals per plot. For instance, in a targeted sampling effort within Horse Lick Creek, a 9 x 15 m area that featured large boulders along the outside bend of the channel resulted in nine adult ashy darters, with each individual associated with a boulder greater than 0.6 m, b-axis length.

Percina squamata:

Given the lack olive darters encountered during the plot surveys (7 individuals captured within 6 plots from 3 sites), analysis was limited to descriptive interpretation. However, five of the six plots had a PC value less than 0.0 for PC 1 and PC 2, indicating an affinity to larger substrates like cobble and boulder and slower and deeper waters (Figure 17). Characterized of the six plots is summarized (Table 9).

The olive darters that were encountered typically did not fit the habitat descriptions as noted by Etnier and Starnes (1993) and exhibited a wide range of habitats. Encompassing the entire study, olive darters were taken in swift water and associated with large boulders as described in Etnier and Starnes (1993), but they were also taken in areas with minimal flow. In general, based on this study, olive darters could be characterized in areas with large boulders (often over 1.0 m, b-axis length), minimal fine substrate, at least slow some flow, although it can be classified as slow (0.01 – 0.3 m/s). Although only two juvenile darters were collected, they both were located along the margin of the channel. One juvenile, 64 mm TL, was associated with a small boulder and large woody debris. The largest adults were taken in the mid-channel and in the swiftest waters. One adult, 139 mm TL, was taken at the head of a riffle in swift water, associated with a large boulder (1.1 m, b-axis length). All olive darters were encountered via backpack electrofishing. Snorkeling for the species was conducted several times throughout the study and occasionally a few days after first detecting them at a site. However, no olive darters were ever observed while snorkeling.

Watershed Assessment:

Landcover Data:

The 2001 USGS landcover data indicated that the Rockcastle River watershed was roughly 40 % forest with approximately 25 % urban and grasslands each (Table 10). Agriculture was roughly 10 % and comprised mostly of pasture/hay. Open water and wetlands represent less than 2 % of the landcover within the watershed and will not be discussed in detail. The distribution of landcover classes is not uniform and large patches of forest can be found along the corridor of the Rockcastle River, primary within the Daniel Boone National Forest and Wild River Section boundaries (Figure 18). However, large areas of urban and grasslands can be found along the more gently sloped hills and ridges. Roundstone Creek and Little Rockcastle River watersheds have the greatest percentage of ubran landcover. Roundstone Creek also has the greatest percentage (14.1 %) of agriculture, followed by Skegg Creek (11.6%). The lower mainstem of the Rockcastle River had the greatest percentage of forest (54 %), with Sinking Creek second (49.1 %). However, the headwaters of Sinking Creek are heavily urban and grassland. For instance, Mitchell Creek in the upper reaches of Sinking Creek was 46.1 % urban with 29.1 % forest.

Fish Assessment:

A total of 85 fish sample events from 52 sites were assessed using the Kentucky Index of Biotic Integrity (KIBI). Fifty sites were classified as having an 'Excellent' fish assemblage, while 17, 19 and 2 sites were classified as Good, Fair, and Poor, respectively (Table 12). Five watersheds, Skegg Creek, Horselick Creek, Middle Fork Rockcastle River, and the Upper and Lower Rockcastle River sections were classified as Excellent. Two watersheds, Sinking Creek and minor tributaries, were classified as Good. Little Rockcastle River, Roundstone Creek, and South Fork Rockcastle were classified as Fair. Although most watersheds were classified as Excellent or Good, several sites within those watersheds had sites that were classified as Poor. Skegg Creek and the Upper and Lower Rockcastle River sections were the only watersheds that had the all of their sites classified as Excellent. However, Skegg Creek was most likely undersampled, because only one site was established within that watershed. In addition, the Rockcastle River proper sections may not be the ideal setting for assessing stream health based on the used methodology for fish, because of its large catchment area. Compton (2003) noted that the KIBI may be used in large wadeable waterbodies but caution should be applied when interpreting results for streams larger than 300 mi.^{2} in catchment area.

The use of the EPA RBP habitat form was a good predictor of KIBI scores (Figure 19). Fish assemblages that scored well with the KIB were generally sites with high quality of habitat. Mostly these were sites within the mainstem of the Rockcastle River but Horse Lick Creek and Middle Fork Rockcastle has sites that were classified as Excellent. Generally, the epifaunal substrate, embededness, sediment deposition, bank stability, bank vegetation, and riparian zone width parameters of the habitat form were scored high. The fish assemblage traits associated with these sites typically had high species diversity, darter, madtom, and sculpin diversity and a high proportion of insectivores, with minimal tolerant species.

Resource Management

Species Status: *Etheostoma cinereum*

The ashy darter is a frequently encountered darter within the mainstem of the Rockcastle River and lower reaches of the higher quality major tributaries (i.e, Horse Lick Creek). It can be locally abundant at the stream reach scale as well as within ideal microhabitats. It should be present at all large order stream reaches and the abundance will vary based on habitat quality throughout that reach. Extrapolating density data from the 12 sites of the mainstem Rockcastle River, it is conservatively estimated that the ashy darter population, between the 69 river km reach of the Narrows, upstream to the confluence of Horse Lick Creek, ranges from 1500 – 3000 individuals. Given its restricted range throughout Kentucky the ashy darter should remain listed as a Species in Greatest Conservation Need. Although, the population within the Rockcastle River is probably the most stable and abundant, except for maybe the Big South Fork Cumberland River, continued monitoring of the species within and in particular, the Little South Fork Cumberland River, Red River, and Buck Creek should be conducted. Lastly, excessive sediment is one of the largest factors limiting ashy darter presence. Although large boulder may exist within a stream reach, if they were embedded greatly with sediment ashy darters were absent.

Percina squamata:

The olive darter remains to be one of the rarest fishes within Kentucky. It is not completely clear if the fish is extremely rare or if it primarily inhabits the deep waters that were not sufficiently sampled during this study. During this study, it is concerning that several historical locations were void of olive darters, only two specimens were collected above Skegg Creek. The majority of specimens came from a 26 km river section, above the Narrows to the SR 1956 bridge near Billows, Kentucky. It is also concerning that no more than four individuals were ever collected from a site during one sample event, typically one or two individuals were collected. The olive darter should continue to be a Species in Greatest Conservation Need. Future work is needed regarding other aspects of its full life history and continuous monitoring of the Rockcastle River populations is encouraged. Attempts to capture this species in the deeper waters may yield higher occurrences and abundances than the current study. The use of the Missouri trawl could be an effective technique to capture this species. Snorkeling efforts were time consuming and inefficient for detecting olive darters. Efforts were made in areas know to contain olive darters and after a team of snorkelers worked a stream reach (15 man hours), not a single olive darter was observed. As with the ashy darter, it was clear during this study that excessive sediment is a limiting factor to the presence of olive darters.

Watershed Management

The overall assessment of the Rockcastle River watershed is that it is a threatened watershed, but has enough protected areas to provide an offset to the various impacts. The headwaters of Sinking Creek and the Little Rockcastle River are watersheds of the greatest concern as well as Roundstone Creek, given the presence of London and Mt. Vernon Kentucky, respectively. The headwaters in these watersheds are approximately 40 % urban. Sediment is most likely the largest threat to the fish, mussels, and other aquatic invertebrates. The largest contributor of sediment was the development of the land. Frequent observations were made of individuals ‘working’ in the stream and road construction ‘working’ in the stream. The expansion of HWY 30 from Laurel County into Jackson County has increased the level of sediment in the South Fork Rockcastle River noticeably. The South Fork Rockcastle River was always the last tributary to drop its sediment after a rain-event. It is recommended that better oversight and enforcement of Best Management Practices be conducted during this project and similar projects within the watershed.

The importance of the Wild and Scenic River section and the boundary of the Daniel Boone National Forest within the lower reaches of the Rockcastle River cannot be stated enough. The protection and refuge these public areas provide most likely sustains the various populations of fishes, especially the seven Species of Greatest Conservation Need, were encountered during this study. The stream reaches within these boundaries frequently had the greatest habitat quality and fish diversity. However, areas of excessive sediment were seen throughout the reaches, especially immediately below the Sinking Creek confluence.

Six of the seven Species in Greatest Conservation Need were encountered and *Etheostoma virgatum* was one of the most common and abundant fishes within the watershed. It is recommended the species be removed as a Species in Greatest Conservation Need. The fish was encountered in all stream reaches and most habitats, primarily sandy areas, except for very swift water. Also, it was found abundant is several degraded streams.

Lastly, the decreased water levels of Lake Cumberland has exposed roughly 5 km more of flowing water within the lower reaches of the Rockcastle River. Habitats in these once inundated areas are of lesser quality but have the potential to recover in time. Sampling efforts within these areas provided a diverse fish faunal and yielded several new species for the watershed. It is recommend that KDFWR work towards efforts to maintain the current water levels after the repairs to the Wolf Creek Dam have been made.

Literature Cited

Boschung, H.T. and R.L. Mayden. 2004. Fishes of Alabama. Smithsonian Books, Washington, D.C. 736 pp.

Branson, B.A. and G.A. Schuster. 1982. Fishes of the Wild River Section of the Little South Fork of the Cumberland River, Kentucky. Transactions of the Kentucky Academy of Sciences 43: 60-70.

Burr, B.M. and M.L. Warren. 1986. A Distributional Atlas of Kentucky Fishes. Kentucky State Nature Preserves Commission. Scientific Technical Series 4.

Cicerello, R.R. and R.S. Butler. 1985. Fishes of Buck Creek, Cumberland River Drainage, Kentucky. Brimleyana 11: 133-159.

Compton, M.C. and M.D. Moeykens. 2001. Rediscovery of the Ashy Darter, Etheostoma cinereum, (Pisces: Percidae) in Buck Creek, Pulaski County, Kentucky. Journal of the Kentucky Academy of Science 62: 144-145.

EDAS (Ecological Data Application System). 2007. Kentucky Department for Environmental Protection, Division of Water, Frankfort Kentucky. (Accessed September 23, 2007).

Etnier, D.A. and W.C. Starnes. 1993. The Fishes of Tennessee. University of Tennessee Press, Knoxville, Tennessee. 681 pp.

Kentucky's Comprehensive Wildlife Conservation Strategy. 2005. Kentucky Department of Fish and Wildlife Resources, #1 Sportsman's Lane, Frankfort, Kentucky 40601. http://fw.ky.gov/kfwis/stwg/. (Date updated 9/21/2005). (Accessed November 2, 2007).

KDOW (Kentucky Department for Environmental Protection, Division of Water). 2002. Methods for Assessing Biological Integrity of Surface Waters. Frankfort, Kentucky.

KSNPC (Kentucky State Nature Preserves Commission). 2007. Report of Endangered, Threatened, and Special Concern Plants, Animals, and Natural Communities for Rockcastle County, Kentucky. Frankfort, Kentucky.

NatureServe. 2007. NatureServe Explorer: An Online Encyclopedia of Life. Version 6.3 NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Date updated October 6, 2007. (Accessed November 14, 2007).

Page, L.M. and B.M. Burr. 1991. A Field Guide to Freshwater Fishes of North America North of Mexico. The Peterson Field Guide Series, Houghton Mifflin Company, Boston, Massachusetts. 432 pp.

Powers, S.L., R.L. Mayden, and D.A. Etnier. 2004. Conservation Genetics of the Ashy Darter, Etheostoma cinereum, (Percidae: Subgenus Allohistium), in the Cumberland and Tennessee River of the Southeastern United States. Copeia 2004(3) 632-637.

Shepard, T. E. and B. M. Burr. 1984. Systematics, status, and life history aspects of the Ashy Darter, Etheostoma cinereum (Pisces: Percidae). Proceedings of the Biological Society of Washington. 97(4): 693-715.

Thompson, B.A. 1977. An Analysis of Three Subgenera (Hypophomus, Odontopholis, and Swainia) of the Genus Percina (Tribe Etheostamatini, Family Percidae). Dissertation. Tulane University, New Orleans, Louisia.

Funding Source: *State Wildlife Grant (SWG) and Texas Tech University*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi: Taxa specific research and survey project..

Sharp-Shinned Hawks Breeding in Kentucky: Breeding biology, Nesting Habitat, and Nestling Removal by Falconers

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Introduction

Based on Breeding Bird Survey data (Sauer et al., 2008), populations of Sharp-shinned Hawks *(Accipiter striatus)* in North America are thought to be relatively stable, but little is known about their population status in specific portions of their breeding range (Bildstein and Meyer, 2000). Because so little is known about the abundance of Sharp-shinned Hawks at any level (continental, regional, state, and local), assessing possible effects of forest management practices and habitat loss and degradation on their population status is currently not possible. Little is known about their breeding biology, including their habitat requirements, nestling and fledgling behavior, and post-breeding behavior. More specifically, nothing is known about the possible impacts of forest-patch size, age structure, and species composition on their breeding ecology and success (Bildstein and Meyer, 2000).

As is the case elsewhere, little is known about the abundance, distribution, and breeding biology of Sharp-shinned Hawks in Kentucky. Palmer-Ball (1996) noted that "... the breeding status of the Sharp-shinned Hawk in Kentucky has never been well known ..." and, statewide, reported only four confirmed breeding records over a seven-year period (1985 – 1991). Few additional reports of breeding by Sharp-shinned Hawks in Kentucky have been reported since 1991 (e.g., Palmer-Ball and McNeely, 2004). Falconers have requested permits to take nestlings from Sharp-shinned Hawk nests in Hardin, Meade, Daviess, and Graves counties in Kentucky from 2005-2007, but the number of nests located and number of young actually taken is unknown (S. Vorisek, KDFWR, pers. comm.).

There is clearly a need to learn more about Sharp-shinned Hawks in Kentucky and throughout their breeding range. Successful management requires information concerning where and how many birds are breeding and their nesting habitat requirements. In addition, the possible impact of allowing falconers to take young from Sharp-shinned Hawk nests is unclear. Thus, our objectives were to: (1) survey several areas throughout Kentucky where previous observations indicate that Sharp-shinned Hawks may currently be breeding to locate breeding pairs, (2) locate as many nests as possible and quantify features of habitat apparently important in selection of nest sites, (3) determine reproductive parameters for as many nests as possible, include clutch sizes, hatching success, and fledging success, and (4) monitor nests where falconers remove nestlings and determine the fate of remaining nestlings.

Sharp-shinned hawk / Mike McDermott

Methods

Surveys

During April – July 2009 and March-June 2010, we conducted road and foot surveys in several counties throughout Kentucky. Adjacent counties were surveyed in five regions in Kentucky, including: (1) Powell, Madison, Estill, Menifee, Montgomery, and Wolfe counties in eastern Kentucky, (2) Laurel, Pulaski, and Whitley counties in southern Kentucky, (3) Boone, Grant, and Owen counties in north-central Kentucky, (4) Meade, Hardin, and Jefferson counties in central Kentucky, and (5) Trigg Calloway, Christian, Muhlenberg, and Lyon counties in western Kentucky. There have been reports of Sharp-shinned Hawks during the breeding season in all of these regions (Palmer-Ball, 1996).

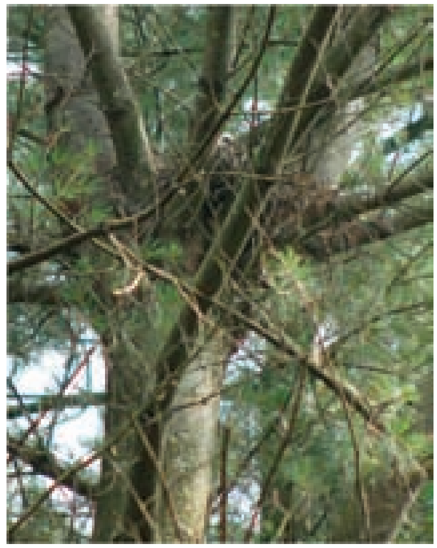
For selected counties, routes were established that traversed from 1.6 to 64 km of apparently suitable (coniferous or mixed conifer forest) habitat (using National Land Use Cover Data from 2001 and state and local road data layers on ArcMap 9.3.1). Specific routes and survey points were selected based on the presence of potentially suitable habitat.

Locating nests

We searched numerous plots or stands for the presence of Sharp-shinned Hawks and nests. When searching for nests, we walked through stands (defined as an area where tree composition and height were similar) while scanning at the height where nests were usually found (about 20 m high). Once located, nests were monitored at least weekly either by direct inspection (for accessible nests) or using binoculars and spotting scopes from the ground. For as many nests as possible, we determined the number of eggs present, hatching success, and fledging success. Nests were defined as successful if at least one young fledged.

After young fledged or a nest failed, the habitat characteristics of nest sites were quantified. A nest site was defined as a 16-m radius (0.08-ha) circle centered on the nest tree. Assuming territories would have a radius of about 500 m (Bildstein and Meyer, 2000), we moved a randomly selected distance (≥ 150 and 480 m) in a randomly selected compass direction from nest trees and, at that point, selected a tree that could have potentially been selected as a nest site (i.e., a tree with a diameter at breast height within 5 cm of that of the nest tree). Except for variables specific to the nest, the same measurements were made at random sites and nest sites.

Multivariate analysis of variance (MANOVA) was used to compare the characteristics of Sharp-shinned Hawk nests and those of randomly selected, unused sites. Variables important in discriminating between used and unused sites were determined by a stepwise discriminant analysis (backward procedure). All analyses were performed using the Statistical Analysis SAS Institute 2004).



Sharp-shinned hawk nest / Tyler Rankin

Results

We searched 248 forest stands during our study and found nests in 11 stands (4.4%), with six Sharp-shinned Hawk nests located in 2009 and five in 2010. Four nests were located at Land Between the Lakes, three at Otter Creek, and one each in Pennyrile Forest State Resort Park, Camp McKee (near Jeffersonville, KY), Powell County (near Stanton, KY), and the Daniel Boone National Forest. All nests were in conifers, with five in loblolly pines *(Pinus taeda)*, four in eastern white pines *(P. strobus)*, one in a shortleaf pine *(P. echinata)*, and one in a pitch pine *(P. rigida)*. Trees (N = 10) at randomly selected points were 50% pine and 50% deciduous.

Nests were located in trees with a mean height of 23.7 ± 1.7 m (range = 14 – 30 m) and a mean dbh of 38.2 ± 2.3 cm (range = 26 – 51 cm). Nests were located at a mean height of 18.6 ± 1.4 m (range = 12 – 26 m). Nest sites were in areas of mixed coniferous/deciduous forest, with 61.4 ± 8.4% of trees within 16 m of nest trees being conifers and 38.6 ± 8.4% deciduous. Mean canopy cover (conifers plus deciduous trees combined) was 77.6 ± 1.9%.

The mean number of eggs per nest was 3.6 (*N* = 5 nests; 4 with 4 eggs and 1 with 2), and eggs hatched during the period from 8 June to 26 June. The mean number of eggs that hatched per nest was 2.6 (*N* = 5 nests; 4 of 4 eggs hatched in each of three nests, 1 of 2 eggs in one nest, and none of 4 eggs in one nest). We determined the fate of 9 nests, and at least one young fledged from 7 (77.8%). Although we estimate that the mean number of fledglings for all 9 nests was 1.1 (10 young fledged from 9 nests), some nests were visited several days after young had fledged and some fledglings may not have been observed either because they had moved away from nests or were hidden in overstory vegetation. Therefore, our estimate should be considered the minimum number of young that fledged.

Nestling Sharp-shinned Hawks fledged from nests during the period from 14 July to 1 August (2009 and 2010 combined). Prior to fledging, falconers removed nestlings from two nests in 2009 (none were removed in 2010). Both nests where nestlings were removed had four nestlings. Three nestlings were removed from one nest and the remaining nestling survived until fledging. Two nestlings were removed from the other nest when nestlings were < 1 week old. We checked the nest one week later and the nest was empty. The cause of nest failure was unknown.

The characteristics of Sharp-shinned Hawk nest sites and randomly selected unused sites differed significantly (Wilk's $\lambda = 0.1$, $F_{13,69} = 5.8$, $P = 0.021$). Stepwise discriminate analysis revealed that six variables, including distance from road, distance from edge, foliage cover, mean tree height, basal area, and percent of deciduous canopy cover, permitted the best discrimination between used and random sites. Compared to random sites, nest sites were in areas closer to roads and edges, and with denser stands of taller conifers and denser understories (below 3 m; Table 1).

***Table 1:** Mean (± SE) characteristics of nest sites of Sharp-shinned Hawks and of randomly selected unused sites in Kentucky, 2009 – 2010. Variables that permitted best discrimination between nest sites and randomly selected, unused sites are in bold font.*

Variable	Nest Sites *(N=11)*	Randomly selected unused sites *(N=10)*[a]
Distance to road (m)	**126.8 ± 24.6**	**156.5 ± 47.6**
Distance to edge (m)	**52.3 ± 14.2**	**70.6 ± 19.0**
Foliage cover (no. of 'hits')	**34.5 ± 7.4**	**23.7 ± 4.7**
Mean tree height (m)	**15.4 ± 0.7**	**12.7 ± 0.8**
Basal area (m2/0.08 ha)	**2.17 ± 0.18**	**1.61 ± 0.14**
Canopy cover, deciduous (%)	**12.3 ± 4.3**	**37.5 ± 9.5**
Number of small (< 1.5 m in height) shrubs	215.1 ± 68.1	173.9 ± 53.3
Shrubs of large (1.5 – 3 m in height) shrubs	61.5 ± 19.5	29.2 ± 8.6
Understory trees (dbh < 10 cm)	12.7 ± 2.4	17.0 ± 3.5
Overstory trees (dbh ≥ 10 cm)	33.5 ± 3.6	21.9 ± 3.6
Mean vegetation height (cm)	41.1 ± 11.6	32.9 ± 6.7
Mean dbh (cm)	24.3 ± 1.7	22.0 ± 1.5
Total canopy cover (%)	78.5 ± 2.8	76.6 ± 2.5
Coniferous canopy cover (%)	51.4 ± 4.6	34.5 ± 9.5

[a]*Except distance from edge (N = 9)*

Discussion

We searched 248 forest stands and found nests in only 11 (4.4%). Such results suggest that there are few breeding pairs of Sharp-shinned Hawks in Kentucky. Even in large areas of apparently suitable habitat in Kentucky, nesting densities appear to be low. For example, falconers searching for Sharp-shinned Hawk nests at Land Between the Lakes over a period 'exceeding 20 years' located only 32 nests (M. McDermott, pers. comm.)

Of nine Sharp-shinned Hawk nests where the outcome was known, at least one young fledged from seven (77.8%). Nesting success (with success defined as ≥ 1 fledging) at other locations include 92% in Oregon (Reynolds and Wight, 1978) and 59% in southern Quebec (Coleman, 2001). Because few investigators have attempted to document the nesting success of nesting Sharp-shinned Hawks, causes of nest failure are not well understood. For most species of birds, predation is a major cause of nest failure (Martin, 1995). Possible predators of Sharp-shinned Hawk nests in Kentucky include raccoons *(Procyon lotor)* and Great Horned Owls *(Bubo virginianus)*.

Because nestlings were only taken from two nests by falconers, we can say little about the possible effects of such removal. Our results do indicate that adult Sharp-shinned Hawks do not abandon nests after nestlings are removed, but permit no conclusions concerning the typical effect of such removal on nesting success. As noted previously, our results do seem to suggest that the number of breeding pairs of Sharp-shinned Hawks is likely relatively low compared to other areas within their breeding range. Because that number is unknown, the possible impact of removal of nestlings by falconers on the Sharp-shinned Hawk population in Kentucky is also unknown.

All Sharp-shinned Hawk nest sites were located in dense stands of tall conifers with dense ground cover and were close to edges. Similarly, Wiggers and Kritz (1991) located 17 Sharp-shinned Hawk nests in Missouri and all were in stands of either short-leafed pine or mixed species of pines. As in our study, Sharp-shinned Hawks in Missouri nested in high-density stands of pines that averaged 16.7 m in height (Wiggers and Kritz, 1991). Although Sharp-shinned Hawks will nest in deciduous trees (Bildstein and Meyer, 2000), our results and those of previous investigators indicate that conifers are more often used as nest sites and, specifically, conifers located in relatively dense stands of young (~25-50 years), even-aged conifers about 15 – 20 m in height. Reynolds et al. (1982) suggested that dense vegetation may provide cover and protection from possible predators. Wiggers and Kritz (1991:575) also suggested that nests in dense canopies 'appeared to be more concealed' and that such concealment may be beneficial for Sharp-shinned

Hawks because smaller raptors experience greater predation pressure than larger raptors (Newton, 1979).

Nest sites in our study were closer to edges than random sites, with edges being where nest stands (i.e., dense stand of pines) transitioned into areas with fewer conifers and more deciduous trees. These adjacent areas, in contrast to Sharp-shinned Hawk nest sites, had more, shorter deciduous trees and less foliage cover than nest stands. Other investigators have also noted that the nest sites of Sharp-shinned Hawks may be adjacent to clearings, brushy areas, or open deciduous forest (Palmer, 1988). Such areas may provide better foraging habitat because small birds, the primary prey of Sharp-shinned Hawks, may be more abundant in mixed stands (with both coniferous and deciduous trees) than in dense stands of conifers (Palmer, 1988). Thus, when choosing nest sites, Sharp-shinned Hawks likely prefer areas with dense stands of conifers that provide nest sites, but with adjacent areas within 1 – 1.2 km consisting of mixed stands of forest where more potential prey are available.

Management Reccomendations

Our results indicate that good nesting habitat for Sharp-shinned Hawks includes dense, even-aged stands of conifers (typically pines) that are 15 to 20 m in height and encompass an area of about 1 ha. These stands provide nest-site habitat, but not good foraging habitat. Therefore, nest stands should be adjacent to areas with fewer conifers and more deciduous trees; areas that provide better habitat for songbirds, the primary prey of Sharp-shinned Hawks.

Our results and those of previous investigators (e.g., Mengel, 1965; Palmer-Ball, 1996) also suggest that nesting densities of Sharp-shinned Hawks are low. Reasons for this are unclear, but may include a lack of suitable breeding habitat. It may also be the case that Kentucky is simply near the southern edge of the breeding range of Sharp-shinned Hawks, with most breeding in conifer-dominated areas further north. For many species, population density tends to decline near the edges of ranges and this may also be the case for Sharp-shinned Hawks. Regardless of the cause(s), Sharp-shinned Hawks are at best rare summer residents in Kentucky (Palmer-Ball, 2003). As such, we recommend that removal of nestlings from nests by falconers in Kentucky be limited or prohibited. Impacts of such removal on the state population are clearly unknown. However, removal does reduce the number of young that fledge for some pairs and, in addition, adult Sharp-shinned Hawks may, after removal (i.e., partial predation), as is typical of birds, disperse to new breeding locations (perhaps out of state) in subsequent breeding seasons.

Literature Cited

Bildstein, K. L., and K. Meyer. 2000. Sharp-shinned Hawk *(Accipiter striatus)*. The Birds of North America Online (A. Poole, ed.). Cornell Lab of Ornithology, Ithaca, NY. Retrieved from the Birds of North America Online: *http://bna.birds.cornell.edu/bna/species/482*

Coleman, J. L. 2001. Ecology of the Sharp-shinned Hawk *(Accipiter striatus)* in southern Quebec. M. S. thesis, McGill University, Montreal, Quebec, Canada.

Martin, T. E. 1995. Avian life history evolution in relation to nest sites, nest predation, and food. Ecological Monographs 65: 101–127.

Mengel, R. M. 1965. The birds of Kentucky. Ornithological Monographs No. 3, The American Ornithologists' Union.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD.

Palmer, R. S. (ed.). 1988. Handbook of North American birds, vol. 4. Yale University Press, New Haven, CT.

Palmer-Ball, B., Jr. 1996. The Kentucky breeding bird atlas. The University of Kentucky Press, Lexington, KY.

Palmer-Ball, B., Jr. 2003. Annotated checklist of the birds of Kentucky, second edition. Kentucky Ornithological Society and Gateway Press, Inc., Louisville, KY.

Palmer-Ball, B., Jr., and L. McNeely. 2004. The summer season 2004. Kentucky Warbler 80: 79-86.

Reynolds, R. T., E. C. Meslow, and H. M. Wight. 1982. Nesting habitat of coexisting Accipiter in Oregon. Journal of Wildlife Management 46: 124-138.

Reynolds, R. T., and H. M. Wight. 1978. Distribution, density, and productivity of Accipiter hawks breeding in Oregon. Wilson Bulletin 90: 182–196.

SAS Institute. 2004. SAS® 9.1.2 user's guide. SAS Institute Inc., Cary, NC.

Sauer, J. R., J. E. Hines, and J. Fallon. 2008. The North American Breeding Bird Survey, results and analysis 1966 - 2007. Version 5.15.2008. U.S.G.S. Patuxent Wildlife Research Center, Laurel, MD.

Wiggers, E. P., and K. J. Kritz. 1991. Comparison of nesting habitat of coexisting Sharp-shinned and Cooper's hawks in Missouri. Wilson Bulletin 103: 568–577.

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KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2. Priority Survey Project #3.

Efficacy of Surrogate Propagation™ As a Quail Restoration Technique in Central Kentucky

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Introduction

Quail hunting is a valuable time-honored tradition in the southeast, with the thunderous sound of quail covey rise a once-common occurrence across the American landscape. Over the past century, quail populations in the United States have undergone substantial declines (Brennan, 1994). Although the annual rate of population decline for Kentucky is unknown, estimates of population declines for quail in the United States range from 1.8% annually in Oklahoma to 8.2% annually for the entire West Gulf Coastal Plain Bird Conservation Region (Dimmick et al., 2002). As a result of these declines, public agencies and private companies have been searching for an effective mechanism to increase quail populations since the 1920's (Ocker, 1925). Releasing pen raised adult birds became the restoration method of choice in the 1930's and 40's (Hart, 1935; Phelps, 1948); however, it was not long before biologists and land managers came to regard stocking pen-raised quail as ineffective (Buefchner, 1950). The Kentucky Department of Fish and Wildlife Resources began an ambitious program of pen-raised quail release in 1942, releasing approximately 5.5 million birds over the course of 45 years. Despite these efforts, quail populations continued to decline in Kentucky. Figure 1 displays the results of mail carrier surveys between 1960 and 2009, encompassing the years of aggressive quail release by KDFWR. Pen raised quail have demonstrated high mortality rates (Barbour, 1950), low flying ability (Frye 1942, Pierce, 1951; Perez et al., 2002), and have problems adapting to natural food sources upon release (Klimstra and Scott, 1973). Additional concerns from land managers include the cost of pen-raised quail and potential negative genetic effects should pen-raised quail breed with native quail (Brennan, 1991).

Biologist Joe Lacefield with the Surrogator™ / Ben Robinson

Quail restoration has emerged as one of the most difficult problems in wildlife conservation today. Although the solution to this problem is not yet clear, the cause of quail population declines across the southeast is well understood (Guthery 1997, Veech 2006). Decreases in quail numbers are a direct response to widespread habitat changes throughout the southeast. Historically, much of Kentucky was characterized by woodlots and small farms with fallow fields and brushy fencerows of shrubs, briars, native grasses, and forbs. Today, our landscape is much different as Kentucky farms have become larger and cleaner with very little cover for quail. Fallow fields are now rare and fescue has replaced native grasses. These changes decreased quail brood rearing and foraging habitat and created a landscape where predators easily detect and prey upon quail chicks and adult birds. Over the past 15 years, state fish and wildlife agencies across the southeast have collectively moved towards a habitat-based restoration initiative to improve quail populations. Simultaneous with the shift of the public sector away from pen-reared quail restoration efforts, a new technology for quail restoration-The Surrogate Propagation™ system-emerged from the private sector and quickly gained momentum as a restoration tool. The Surrogator™, designed by Quail Restoration Technologies is a self-contained field unit that is marketed as a way to

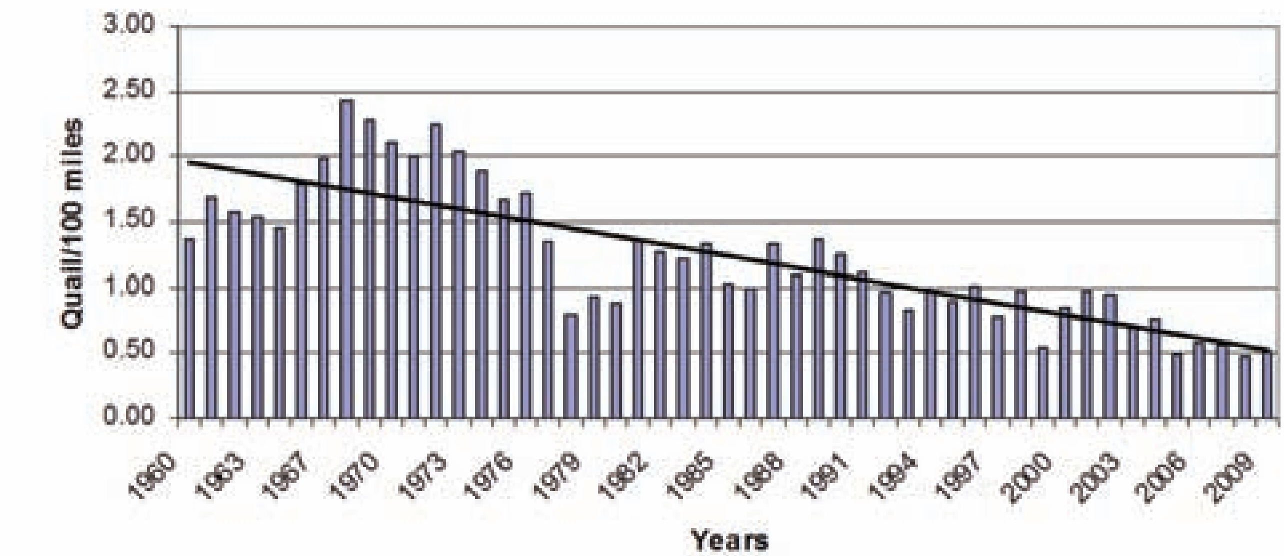

***Figure 1:** Mail carrier survey quail index between 1960 and 2009.*

establish huntable populations of game birds, which will survive, reproduce, and provide hunting opportunities well after release (www.quailrestoration.com). The Surrogator™ unit houses a heater, food, and water (Figure 1) and houses 125 day-old quail chicks until the chicks are 5 weeks old. Surrogate PropagationTM is based on the idea that quail chicks develop their natural survival instincts within the SurrogatorTM unit, imprint on the area, and have limited human contact, creating an ideal situation for birds to survive and reproduce (www.quailrestoration.com).

Landowners in search of ways to increase quail populations on their land routinely contact KDFWR's private lands biologists. Over the past several years, one of the most asked-about systems for quail restoration is the Surrogator™. The Surrogator™ has been evaluated for Pheasants by Nebraska Game and Parks (170 Pheasants released, 3.5% returned to bag, $331.98 cost/pheasant returned to bag when price of unit is included in cost, Lusk et al.), and for quail in Georgia (hunter bag return = 0.8%, cost per bird returned to bag = $74.53 not including price of unit, Ga. DNR unpubl. data). To our knowledge, no studies have evaluated the efficacy of the Surrogator™ as a quail restoration technique in Kentucky. To evaluate the Surrogator™ as a management tool for quail, KDFWR conducted a research project, beginning in 2007, following the Quail Restoration Technologies protocol to assess whether the SurrogatorTM is an effective tool for quail population restoration.

Study Site

This project occurred on two privately owned farms totaling approximately 750-acres in Woodford County, Kentucky. Woodford County is in the heart of the Bluegrass Region, famous for its thoroughbred horse farms and vast expanses of manicured fescue. As a result of these habitat types, the Bluegrass Region has widespread areas devoid of quail. Over the past decade, KDFWR biologists have partnered with Paul Huber and Jackson Watts, owners of the study site, to create ideal quail habitat. Habitat practices that have been implemented include: fescue conversion to native warm season grasses, prescribed burning, and invasive species removal. Wild quail have not responded to these habitat enhancements likely because the area is disjunct from potential source populations. Point count data as well as anecdotal information from area biologists and landowners revealed a near-total absence of quail from this area. Between 1999 and 2006, Joe Lacefield, KDFWR biologist, conducted Partners in Flight (PIF) counts on the study site and detected one whistling male during these surveys. As a result of habitat restoration efforts, the study site has high quality habitat with no resident quail, creating an ideal area to test the effectiveness of the Surrogator™.

Methods

Surrogate Propagation™ System

We followed Quail Restoration Technologies Surrogator™ System Guide (2008) specifications for set-up and placement of the Surrogator™ unit (Figure 2). We selected three sub-sites on the study site for Surrogator™ quail release, since Quail Restoration Technologies recommends three releases of SurrogatorTM birds are necessary to establish a huntable population. The sites where we reared surrogator broods were all in close proximity to high quality habitat (adequate shrub/forest cover and native warm season grass stands). We released surrogator birds at each of these three sites in 2007 and 2009 (six total releases). For each Surrogator™ rotation, we purchased 125 day-old or week-old quail chicks, placed them in the sterilized Surrogator™ unit, and checked on them daily for the first week after placement in the unit. We purchased chicks from different vendors in an attempt to maximize the genetic diversity of quail released. After the first week, we checked the units at least once per week to ensure the chicks had adequate food, a working heater, and ample water.

When mortality events occurred, we immediately removed dead chicks. When chicks reached five weeks of age, we marked them with plastic colored leg bands (2007) or metal game preserve leg bands (2009) and released them on-site. We took care to check weather forecasts so that quail were not released when rain was imminent. In 2007, the first clutch was released 7 August and the last clutch was released 12 October, while in 2009 we released the first clutch 1 July and the third clutch 6 October.

Fall Covey Counts

We conducted fall covey counts on the Huber Farm in 2007, 2008, and 2009 between 10 October and 30 October. We established five listening stations, and observers at each station listened for covey calls beginning at first light (7:00 a.m.) and ending between 8:30 a.m. and 9:00 a.m. Covey counts were conducted on mornings where wind speeds were below nine miles per hour and temperatures were above 40º F. Five observers were present for each survey, and each observer recorded time of covey call, and noted the direction of the call so coveys were not double counted. After the survey listening portion ended, we attempted to flush detected coveys with people and dogs.

Spring Whistle Counts

We conducted spring whistle counts in 2008, and 2009 between 28 May and 26 June. Six listening points were established, these points were identical to PIF route (Partners in Flight) points from an inactive PIF route. Observers conducted a 10-minute point count at each of the six points and recorded each individual whistling male. Whistle counts were conducted between sunrise and 10:00 a.m., and we did not conduct whistle counts during rainy weather, when wind speeds were above 5 miles per hour, or when cloud cover was greater than 5%.

Callback Traps

We conducted callback surveys between 23 January and 23 March 2009. By placing a wild quail in a modified wire funnel trap, coupled with an electronic quail caller, we sought to recover banded Surrogator™ quail. Paired funnel traps (one of which contained the callback bird) were set out each evening approximately 30 minutes prior to dusk, and were checked each morning between 7:15 a.m. and 8:45 a.m. Dove traps were placed in fields of native warm season grass, or in briar thickets, and we camoflauged the traps to prevent avian predation. We removed callback birds from traps each morning, placed them in a chicken coop with a heat lamp, and supplied them with food and water ad libitum. All callback quail were banded to prevent possible confusion between Surrogator™ quail and escaped call back quail. For data collection purposes, we defined one trap night as one callback trap opened for one night.

Figure 2: *Quail Restoration Technologies Surrogator™*

Controlled Hunting and Hunter Satisfaction

Controlled hunts were conducted between 19 November and 12 January for the 2008-2009 quail season and between18 November and 22 January for the 2009-2010 quail season. Number of hours hunted, number of hunters, and number of dogs were recorded for each hunt. Hunts were scheduled in the morning, ended prior to noon, and were not scheduled during high winds or inclement weather. We defined a "hunt hour" as one hunter hunting for one hour. We also recorded the number of coveys flushed per hour and total number of birds harvested for each hunt. Participants completed hunter satisfaction surveys for all controlled hunts occurring during the 2009-2010 season.

Results

Surrogator™ Release Data

In 2007 and 2009, we purchased 940 quail chicks, held them in the Surrogator™ until they were five weeks of age, and released a total

	2007	2009	TOTAL
# Quail Purchased	390	550	**940**
# Quail Released	294	277	**571**
Mortality	24.6%	49.6%	**39.3%**

Table 1: *Number of quail purchased, number of quail released, and average mortality while in the Surrogator™ for 2007 and 2009 releases.*

Item	Cost
940 quail chicks	$0.45/quail x 940 = $423.00
Surrogator™ brooder	$1,849
Propane	$150
Feed	$150
Total	***$2,572***

Table 2: *Approximate materials costs of releasing 6 broods of Surrogator™ quail.*

of 571 5-week old quail on site (Table 1). Total mortality while in the Surrogator™ was 39.3% across all releases. Most mortality occurred during the first week in the Surrogator™ unit; however, several instances of heater failure (wind blowing out heater) resulted in mass mortality events. Furthermore, one group of day-old quail chicks exhibited high mortality (greater than 50%) around week 3 with no malfunction of the Surrogator™ unit. Total costs for materials and quail for this study totaled $2,572 (Table 2). We did not include time or travel expenses in our cost estimates.

Fall Covey Counts

In total, eight fall covey counts (each count had five observers at a unique listening station) were conducted from 2007-2009. In 2007, observers identified five coveys and attempted to flush the identified coveys using people and dogs. One covey was flushed consisting of 12-15 birds. The majority of birds showed strong flight characteristics, but several individuals demonstrated weak flying ability. Birds appeared to be adult size; however, no leg bands were visible. In 2008, four covey counts were conducted, with one covey detected on 30 October 2009. In 2009, one covey was detected (27 October 2009) during four covey counts. Efforts to flush coveys in 2008 and 2009 were unproductive.

Spring Whistle Counts

Spring whistle count surveys were conducted in 2008 and 2009. In 2008, six unique males were detected between 28 May and 26 June at the six established whistle count points. In 2009, no singing males were detected in whistle counts conducted between 9 and 26 June.

Callback Traps

In 2009, we conducted callback sampling for a total of 53 trap nights. We captured no wild or banded quail in callback traps. To test the efficacy of callback trapping, on 22 March at 11:00 a.m., we released a banded quail approximately 300 meters from one of our callback traps. When we checked traps at dusk on 22 March, the banded quail was trapped with the callback bird in the nearest set of traps.

Controlled Hunting and Hunter Satisfaction

We hunted for a total of 135.5 hunt-hours averaging 3.9 dogs per hunt (Table 3). A variety of hunting breeds were utilized including the following: Gordon Setter, English Setter, Brittany Spaniel, and Labrador Retriever. Although three quail were killed during these hunts, none were banded, and all three were juveniles. Hunter surveys conducted during the 2009-2010 season indicated that 72% of hunters were highly unsatisfied with the number of coveys encountered and 23% were unsatisfied with the number of coveys encountered. Overall hunt

	2008-2009 Season	2009-2010 Season
# Hunt Hours	90	45.5
Average # Dogs per Hunt	3.3	4.8
# Birds Observed	5	3
# Birds Shot	2	1
Status of Shot Birds	Juvenile/unbanded males	Juvenile/unbanded male

Table 3: *Hunt Data 2008-2010.*

quality was either highly unsatisfactory or unsatisfactory for 68.2% of hunters, while the remaining 31.8% ranked the overall hunt quality as either neutral or satisfactory.

Landowner Reports and Anecdotal Sightings

Several anecdotal sightings were reported throughout this study (Appendix A).

Discussion / Management Implications

Despite a total of 571 quail released from 2007 through 2009, extensive hunting did not recover any banded Surrogator™ quail. Given the high certainty that the study site had no initial, resident quail population, the recovery of 3 unbanded juvenile quail is troublesome. Several explanations exist for this occurrence: the Surrogator™ birds may have exhibited a high rate of band loss, the birds may have been recent colonizers of the study site, the birds may be offspring of Surrogator™ birds, or the unbanded birds may be part of a very small wild population persisting on the site. Regardless of the explanation for the lack of bands on recovered quail, the small number of quail killed (3 birds during 135.5 hunt hours) and the low levels of hunter satisfaction indicate that the Surrogator™ did not effectively restore quail to our study site, nor did it result in an effective put and take system during the years of our study.

Our high mortality rates for chicks within the Surrogator™ units (39.3%) is probably atypical. Two severe wind storms (winds greater than 25 miles per hour) extinguished the pilot light of the Surrogator™ heater during early stages of brooding, which resulted in high mortality. Additionally, several clutches seemed to be affected by either bad genetics, disease, or both. One Surrogator™ clutch exhibited high rates of mortality around week three, with no obvious cause, while another clutch was characterized by 5-week old chicks with bowed legs which were positioned at atypical angles. As a result of these diseased/deformed clutches, we purchased quail from an assortment of vendors during the second year of the study to attempt to maximize genetic variation and minimize Surrogator™ losses.

Hunter surveys indicated that the majority of hunters (72%) were not satisfied with the number of coveys flushed per hour, and 68.2% of hunters were not satisfied with the overall quality of the hunt. For the 31.8% of hunters who ranked the overall hunt quality as either neutral or satisfactory, all indicated that the comraderie of fellow hunters and the experience of walking through the woods was what made the hunt "satisfactory," not the number of coveys flushed and number of birds killed (or lack thereof).

Due to costs, this study was not replicated (we had only one study site), so we can not generalize the results of this study to the Bluegrass region at large. However, the results of this study on the local level are clear: surrogate propagation did not result in a viable population of reproducing quail during the 3 years of our study. Additionally, the surrogate propagation was an ineffective put and take method to increase quail numbers, since no banded Surrogator™ quail were recovered during extensive organized hunting. Our results align with the results of a recent study conducted by the Georgia Department of Natural resources (2006). Similar to the Georgia study, we can not conclusively determine if the lack of birds detected was a result of high mortality or emigration out of the study area. Considering the high costs involved in Surrogator™ propagation ($2,572 for 6 releases), and the low survival and/or site fidelity of SurrogatorTM quail in our study, this technology was not successful in achieving quail management goals on our site. At the scale of our study area, quail restoration efforts using the Surrogator™ were not effective; consequently, we recommend shifting time and resources towards habitat management and improvement efforts.

Literature Cited

Barbour, R. W. 1950. A high mortality of pen-raised bob-white quail. The Journal of Wildlife Management 14:474-475.

Brennan, L. A. 1991. How can we reverse the northern bobwhite population decline? Wildlife Society Bulletin 19:554-555.

Brennan, L. A. 1994. Broad-scale population declines in four species of North American Quail: an examination of possible causes. Pages 44-55 in Sustainable ecological systems: implementing an ecological approach to land management. U.S. Forest Service General Technical Report RM-247, Fort Collins, Colorado, USA.

Buechner, H. K. 1950. An evaluation of restocking with pen-reared bobwhite. The Journal of Wildlife Management 9: 363-377.

Dimmick, R. W., M. J. Gudlin, and D. F. McKenzie. 2002. The Northern Bobwhite Conservation Initiative. Miscellaneous publication of the Southeastern Association of Fish and Wildlife Agencies, South Carolina, USA.

Frye, Jr., O. E. 1942. The comparative survival of wild and pen-reared bobwhite in the field. North American Wildlife Conference 7:168-178.

Occurrence	Observer
Flushed 3 coveys of 12 -15 birds	Joe Lacefield
10 individual males singing	Joe Lacefield
Flushed a covey of 8-12 birds 3 times from same location	Joe Lacefield
Quail chick found in mowed strip	Landowner, Paul Huber
Observed covey of 12-20 quail	Landowner, Jay Simpson
Flushed 2 coveys of quail	Hunters, Brian Kelly and R.W. Hicks

Appendix A: *Anecdotal reports*

Guthery, F. S. 1997. A philosophy of habitat management for northern bobwhites. Journal of Wildlife Management 64:646-662.

Hart, D. 1935. Restocking with day-old quail. Transactions of the North American Game Conference 21:241-245.

Klimstra, W. D., and T. G. Scott. 1973. Adaptation of pen-reared bobwhites to foods in a natural environment. Journal of Wildlife Management 37:492-494.

Lusk, J. J., J. S. Taylor, M. Feeney, M. Bresley, and B.M. Meduna. 2009. An Evaluation of the SurrogatorTM captive propagation system for ring-neched pheasants. Final Report. Nebraska Game and Parks. Unpublished.

Ocker, W. H. 1925. Conservation and propagation of quail. Maryland Conservation 2(1):28.

Percent return to bag of pre-season released pen-reared bobwhites. 2006. Final Report. Georgia Department of Natural Resources: Grant Number 8 -1. Unpublished.

Perez, R.M., D.E. Wilson, and K. D. Gruen. 2002. Survival and flight characteristics of captive-reared and wild northern bobwhite in southern Texas. National Quail Symposium Proceedings 5:81-85.

Phelps, C. F. 1948. Some results of quail restocking experiments in Virginia and neighboring states. Virginia Wildlife 9(4):16-18.

Pierce, R. A. 1951. Survival of pen-reared quail. Kentucky Division Fish and Game Investigation, Project 6-R, Frankfort, Kentucky, USA.

Veech, J. A. 2006. Increasing and declining populations of northern bobwhites inhabit different types of landscapes. Journal of Wildlife Management 70:922-930.

Quail Restoration Technologies, Pheasant Restoration Technologies Surrogator™ System Guide. 2008. Available here: *http://www.wildlifemanagementtechnologies.com/surrogator.html.*

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

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

South Fork Kentucky River, Elk Shoals / Ryan Evans

Freshwater Mollusk Monitoring in the South Fork Kentucky River System

Ryan Evans, Kentucky State Nature Preserves Commission
KDFWR Contact: *Danna Baxley*

Introduction

This study was developed with the idea of identifying patterns in habitat quality and impacts to freshwater mollusks, both in terms of species and assemblage distributions, in the South Fork Kentucky River system. The South Fork Kentucky River watershed is one of the most important remaining aquatic biodiversity areas remaining in the Kentucky River system. Within the Kentucky River system, the South Fork is generally regarded today as having some of the best water quality (KWRRI, 2002) although sections of 9 streams are listed as impaired or only partially supporting water quality standards under the US Clean Water Act (KYDOW, 2008).

Methods

Freshwater Mussel Sampling

A two-phase sampling approach was used to sample freshwater mussels. Qualitative surveys were conducted at 77 sites in the watershed. At each site, a diminishing returns curve was kept to determine when adequate search effort had been expended (Dunn, 2000). To develop the curve, mussels were identified and enumerated at 10, 20, 40, and 60 intervals. All sites were sampled between May and October. The goal of this phase was to generally characterize the mussel community composition. Measurements of a subset of each species were taken at each site (generally a maximum of 40-50 individuals). Species richness and relative abundance were calculated for the qualitative sampling dataset. Simpson's Index, a measure of community diversity and weighted percent dominance, was calculated using the formula:

$$H = -\Sigma P_i (\ln P_i)$$

where P_i is the proportion of each species in the sample.

Quantitative surveys were conducted at three sites in the basin selected from qualitative sampling (one site at Redbird River Mile 5.4 using (1) m^2 quadrats and two sites in South Fork Kentucky at SFRK 41.4 and 13.0 using (0.25) m^2 quadrats). A systematic sampling design with three random starts (Smith *et* al., 2001; Strayer and Smith, 2003) was implemented. Sampling goals were set to estimate densities roughly within 20% of the mean at 95% level of confidence. Due to the small size of Redbird River and the destructive nature of quantitative sampling with full excavation, this threshold was raised to 30 - 35% of the mean for that site in order to reduce faunal and habitat disturbance. Each quadrat was excavated to a depth of approximately 15 cm. Mussels were identified to species, shell length was measured, and species were returned to suitable habitat adjacent to excavated areas.

Voucher photos of rare species (live animals) were taken; shells were retained of representative species when available. SCUBA was used in portions of certain South Fork Kentucky River sites. At the majority of sites, a modified KY Division of Water Rapid Bioassessment Protocol (RBP) assessment was conducted to rate habitat quality. This is a multi-metric score based on riffle quantity and quality, substrate quality, embeddedness, siltation, and riparian quality.

Table 1: *Mussels located during qualitative sampling. Numbers refer to number of sites where species were found; parentheses note either sites where weathered dead (WD) shells were located or site where only fresh dead (FD) shells were located.*

Scientific Name	Common Name	Goose Creek	Sexton Creek	Redbird River	South Fork Kentucky River
Actinonaias ligamentina	Mucket			6	28
Alasmidonta viridis	Slippershell				1 (as WD)
Amblema plicata	Threeridge	6		12	24
Elliptio dilatata	Spike			10	25
Epioblasma triquetra	Snuffbox				2 (2 FD)
Fusconaia flava	Wabash Pigtoe	1		10	10
Fusconaia subrotunda	Longsolid				8
Lampsilis cardium	Pocketbook			12	12
Lampsilis fasciola	Wavyrayed Lampmussel			8	12
Lampsilis siliquoidea	Fatmucket	4	1 (WD)	10	11
Lasmigona costata	Flutedshell				10
Leptodea fragilis	Fragile Papershell				1
Megalonaias nervosa	Washboard			8	6
Obovaria subrotunda	Round Hickorynut	1 (WD)		2	5
Pleurobema sintoxia	Round Pigtoe			4	16
Potamilus alatus	Pink Heelsplitter			2	12
Ptychobranchus fasciolaris	Kidneyshell	1		9	21
Quadrula pustulosa	Pimpleback			7	20
Quadrula cylindrica cylindrica	Rabbitsfoot				1
Quadrula verrucosa	Pistolgrip			9	17 (1 FD)
Utterbackia imbecillus	Paper Pondshell				1
Strophitus undulatus	Creeper				1 (as WD)
Toxolasma parvus	Lilliput				1 (as WD)
Villosa iris	Rainbow			3	3
Villosa lienosa	Little Spectaclecase			1 (as WD)	4 (4 FD)

Freshwater Snail Sampling

Due to time constraints, intensive qualitative and quantitative freshwater snail surveys were not completed; rather, snails were opportunistically collected at mussel sites. Specimens were fixed and preserved in 80% denatured ethanol and returned to the lab for final identifications.

Statistical Analyses

A Mann-Whitney test was used to examine potential differences in Encounter Rate and Simpson Index from sites above or greater than 2.5 km below versus sites immediately below listed 303(d) or tributaries otherwise observed to be impaired from sediment or excessive nutrients. A Student t-test was used to examine overall differences in Encounter Rate between Goose Creek and Redbird River versus South Fork Kentucky River. Data were screened for assumptions of normality and log-transformed prior to analysis as necessary.

Hierarchical Cluster Analysis using Sorenson's distance measure and flexible beta linkage of - 0.25 (per McCune *et* al., 2002) was used to discern any differences in faunal assemblages across all sites in terms of percent composition. Proportion data were arcsin-root transformed prior to analysis. Species present at only one site and zeros were removed from the dataset and Outlier Analysis was used to remove outliers. Indicator Species Analysis was used to prune the dendrogram to the final solution. Statistical tests were done using Systat (Version 11) and PC-ORD software (PC-ORD 4, MJM Software Design, Gleneden Beach, Oregon). Unless otherwise noted, all tests were performed at the α = 0.05 level of statistical significance. Voucher materials (shells of mussels and ethanol preserved samples for snails) and voucher photos are housed at KSNPC in Frankfort.

Results

A total of 25 species of live or fresh dead freshwater mussels were collected during this study (Table 1). Freshwater mussels achieved their highest measured density in the basin at South Fork Kentucky River Kilometer (SFRK) 41.2. As is typical with mussel distributions, species richness generally increased with increasing drainage area. The highest mean species richness (9.5 species) was found in the South Fork Kentucky. A statistically-significant difference was found in Encounter Rates between Redbird River/Goose Creek versus South Fork Kentucky River ($p = 0.01$). A Mann-Whitney test showed that a statistically-significant difference in Encounter Rates from areas below impaired tributaries (U-test statistic = 0.00; $p = 0.001$), suggesting that densities are depressed below impaired (Clean Water Act 303(d) listed) tributaries.

A new South Fork Kentucky River basin record for *Toxolasma parvus* (Barnes, 1823) was found during the current study; weathered-dead specimens were collected at SFRMK 42.0 (above Lower Island Creek) in a muskrat midden. Live or fresh-

Order: Family	Scientific Name	Common Name	Records in Current Study	No. of Sites
Pulmonata: Ancylidae	*Ferrissia rivularis* **(Say, 1817)**	Creeping Ancylid	1,2,3	18
	Laevapex fuscus **(C.B.Adams, 1841)***°	Dusky Ancylid	2,3	2
Pulmonata: Lymnaeidae	*Galba obrussa* **(Say, 1825)** °	Golden Fossaria	2	2 (1WD)
	Pseudosuccinea columella **(Say, 1817)** °	Mimic Lymnaea	2	3
Pulmonata: Physidae	*Physa acuta* **(Draparanaud, 1805)**	European Physa	1	1
	Physa gyrina **(Say, 1821)**	Tadpole Physa	1,2	10
	Physa sp. **(unidentifiable)**			3
Pulmonata: Planorbidae	*Helisoma anceps* **(Menke, 1830)**	Two-Ridge Rams Horn	1,2,3,4,5	23
	Micromenetus dilatatus **(Gould, 1841)** °	Bugle Sprite	2	7
	Planorbella trivolvis **(Say, 1817)**	Marsh Rams-Horn	2	1
Architaenioglossa: Viviparidae	*Campeloma decisum* **(Say, 1817)**	Pointed Campeloma	1,2	5
	Campeloma sp **(unidentifiable)**			2
Neotaeniglossa: Hydrobiidae	*Amnicola limosus* **(Say, 1817)***°	Mud Amnicola	1	1
Neotaeniglossa: Pleuroceridae	*Elimia semicarinata* **(Say, 1829)**	Fine-Ridged Elimia	1,2,3,4	32
	Pleurocera acuta **Rafinesque, 1831**	Sharp Hornsnail	1,2	6
	Pleurocera canaliculata **(Say, 1821)**	Silty Hornsnail	1	2

Table 2: *Freshwater snails observed during this study. 1 = Mainstem South Fork Kentucky; 2= RedbirdRiver; 3 = Goose Creek; 4 = Sexton Creek; 5 = Bullskin Creek; * = new Kentucky River system records*

dead specimens were not located for *Alasmidonta viridis* (WD specimens were obtained), *Pyganodon grandis*, *Strophitus undulatus* (WD specimens were obtained), or *Truncilla truncata*. *Leptodea fragilis* and *Quadrula cylindrica cylindrica* were collected located at only 1 site each, which is the same number of sites as historical records. All state-listed species were located in the study: *Epioblasma triquetra* (live at 2 sites and FD at 2 sites) *Fusconaia subrotunda* (live at 8 sites), *Obovaria subrotunda* (4 sites), *Quadrula cylindrica cylindrica* (1 site), and *Villosa lienosa* (collected only as FD shells at 4 sites and WD at 1 site).

Of the tributaries examined in the study, the best remaining mussel populations were in the Redbird River, with 17 species located live or from shell remains. Mean site species richness was 5.9 while mean Encounter Rate was 11.6 ± 5 individuals/hour (SD = 10.9; range 0 – 36.8). Two state-listed species were found in the Redbird (*Obovaria subrotunda*, live at 2 locations, and *Villosa lienosa*, as WD shell at 1 location). Species richness generally increased with watershed area but as previously noted by Cicerello (1996), mussels were largely absent or depressed below the confluence of Big Creek in the Redbird River.

Comparison of the previous study of the mussels of the Redbird River reveals a decline in species richness at 78% of sites (Figure 1). Further examination of data for selected species, through comparison of qualitative versus quantitative length-frequency histograms, provides more insight on the status of freshwater mussels in the Redbird River (Figure 8). It would appear that very little recruitment is occurring in the dominant mussel species of the lower Redbird River. Counts of external annuli during quadrat sampling, a crude estimate of age, indicated that the youngest individuals of *Amblema, Actinonaias*, and *Ptychobranchus* were anywhere from 14 + to 30 + years old, with some individuals of *Lampsilis siliquoidea* ranging from 5-7 years.

A total of 23 species were located from the mainstem as live or fresh dead shell specimens. Mean species richness was 8.8 while mean Encounter Rate was 32 ± 13.6 individuals/hour (range 0 - 153). Freshwater mussels were more or less regularly distributed throughout the mainstem of the South Fork. A conspicuous absence of mussels was noted at the confluence of Lower Teges Creek and the confluence of Bullskin Creek. Marked drops in species richness were noted in the stream reaches below the confluence of Crane Creek, the stream reach just above and below Booneville, below the confluence of Lower Island Creek and below the confluence of Lower Buffalo Creek. The maximum species richness observed was at SFRK 41.08, which is within the river reach where the highest RBP scores were observed (from RK 66.4 to RK 26.3).

Quantitative sampling revealed fairly diverse mussel communities in the South Fork Kentucky. Densities at the two quantitative sampling sites in the mainstem South Fork Kentucky were 6.28 ± 0.47 m^2 and 4.45 ± 0.45 m^2 (middle river sample and lower river sample, respectively). Quantitative sampling at the mouth of Laurel Creek, a site chosen in the lower end of the Redbird River, showed a density of 1.26 ± 0.52 m^2. Examination of external annuli indicated recent recruitment in several species at South Fork Kentucky River Kilometer (RK) 41.4: *Actinonaias ligamentina* (several individuals observed within last 3, 5, and 7 + years), *Epioblasma triquetra* (within last 3-7 years), *Obovaria subrotunda* (within last 3–5 years), *Pleurobema sintoxia* (within last 5-7 years), and *Ptychobranchus fasciolaris* (within last 5-7 years). Recruitment was also observed at SF RK 13.0 primarily in *Actinonaias ligamentina* (several individuals within last 2-4 years) and *Ptychobranchus fasciolaris* (within last 4-5 years). State-listed species located at the site had evidence of recruitment within the last 5 years: *Obovaria subrotunda* (within last 2-3 years) and *Epioblasma triquetra* (within last 4-5 years).

Pooling data from the 2 quantitative sampling sites, 9% of all *Actinonaias ligamentina* were smaller than 110 mm. This indicates younger cohorts are present in the system. Also it can be inferred, as quantitative sampling produced similar data to the qualitative sampling, that roughly 50% of the individuals of *Amblema plicata* and *Elliptio dilatata* were in smaller size classes from the modal values.

Three assemblages of freshwater mussels were determined to occur in the basin:

Generalist assemblage. This group was typically dominated by *Lampsilis siliquoidea* (Fatmucket). This group generally occurred in extreme headwater environments and in areas in higher order sections of the basin in more depositional or less quality mussel habitat. In this study, this assemblage was found in the basin from less than 255 to 1201 square kilometers (Figure 11) but occurred in a variety of habitats, from mud/silt to sand dominated.

Spike-Threeridge assemblage: This was a variable group, typically characterized by *Elliptio dilatata* (Spike) and/or *Amblema plicata* (Threeridge). This assemblage occurs across various longitudinal locations in Redbird River and South Fork Kentucky River. This assemblage was found in the basin in areas ranging from 255 to 1520 square kilometers.

Mucket-Medium River assemblage: This group is dominated by *Actinonaias ligamentina*, as well as most of the rare species in the basin (*Epioblasma triquetra*, *Fusconaia subrotunda*, *Obovaria subrotunda*, *Villosa lienosa*). With the exception of one location in the lower Redbird River, where very high quality habitat occurred, this was the dominant assemblage from stations in the reach above Buffalo Creek to the lower sections of the South Fork Kentucky River. It generally was found in areas greater than 1200 square kilometers.

Opportunistic sampling resulted in a total of 15 species of freshwater snails (Table 2). The dominant taxa, in descending order in the number of site records, were *Elimia semicarinata*, *Helisoma anceps*, and *Ferrissia rivularis*. This includes the first recorded South Fork Kentucky River basin records for 5 and Kentucky River system records for 2 species:

- *Amnicola limosus*(1 specimen, Mud Amnicola; Hydrobiidae)
- *Galba obrussa* (Golden Fossaria; Lymnaeidae)
- *Laevapex fuscus* (Dusky Ancylid; Ancylidae)
- *Micromenetus dilatatus* (Bugle Sprite; Planorbidae)
- *Pseudosuccinea columella* (Mimic Lymnaea; Lymnaeidae).

The highest species richness occurred in headwater areas. This was an assemblage dominated by *Physa, Ferrissia*, *Pseudosuccinea* as well as *Elimia*. Higher order sections of the river system, which received less intensive sampling due to time constraints, were dominated by *Elimia*. Stations in the study on the South Fork Kentucky River below Booneville had records of *Pleurocera canaliculata* as well. Sampling did not locate specimens of *Lioplax sulculosa* (Furrowed Lioplax) despite previous records from the Kentucky River system.

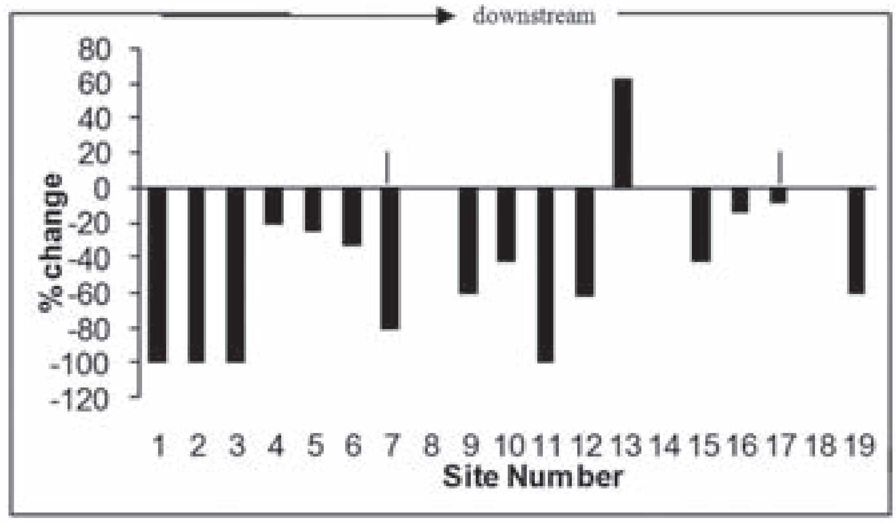

Figure 1. *Comparison of species richness for the Redbird River from Cicerello (1995) with current study. Vertical hashmarks indicate no change at a respective site.*

Discussion and Management Implications

Threats observed to the mollusk fauna in the South Fork Kentucky basin are numerous. Overall, perturbations to the mollusk fauna of the basin likely stem from water quality and habitat conditions as opposed to a net hydrological alteration in the basin. In many portions of the watershed, coal mining and floodplain agriculture has taken a visible toll on the mussel fauna. Coal deposits, in the form of coal fines and coal pieces, were visible at many sites in mainstem Goose Creek. New gas and coal mining activities in the Red Bird and South Fork Kentucky tributaries should be of serious concern. Coal mining has been implicated in the decline of mussels in other Kentucky streams as well (Layzer and Anderson, 1991; Warren and Haag, 2005).

In terms of determining trends for long-term health of the mussel resources of the basin, monitoring will be imperative. In general, recruitment is low but present at detectable levels in the South Fork Kentucky River. Within the Kentucky River system, the South Fork watershed appears to be the remaining stronghold for *Villosa lienosa* and, along with the Red River, *Epioblasma triquetra.* The South Fork Kentucky is also the sole remaining stream in the Kentucky River system for *Quadrula cylindrica cylindrica*. Population viability analyses will be needed to fully ascertain the projected persistence of the current mussel fauna of the basin.

Should global climate change affect Kentucky's streams, this shift, towards warmwater-dominated assemblages, could occur. Climate change has been predicted to favor more warmwater assemblages of fishes (Buisson *et al*., 2008) but also decreases in many native warmwater fishes in the midwestern U.S. (Eaton and Scheller, 1996). However, Matthews and Zimmerman (1990) suggested that shift of species composition would be somewhat related to northern stream corridors which would allow latitudinal shifts in distributions. Given the northward flow of the Kentucky River system, this effect could be potentially attenuated, but a high degree of habitat modification and a series of 14 dams on the Kentucky River (which provide continuous impoundment to the confluence with the Ohio River) limits the longitudinal connectivity of the basin. These results also trend with results of classification of mussels in the Atlantic Slope by Strayer (1993) and Walsh *et al* (2007) in terms of generalists and assemblages predicted by stream order. It is with these issues in mind that managers should be considerate of mussel assemblage composition in relation to protection and maintenance of the rare species in the basin. The assemblages in the South Fork Kentucky River and Redbird River should be seen as an important benchmark for future restoration efforts in the Middle and North Fork Kentucky Rivers, which are beset by many more water quality issues.

Given these results, it is obvious that restoration efforts are needed with the South Fork Kentucky basin. Beyond the rare species in the freshwater mussel fauna, the Redbird River basin is a stronghold for the Kentucky Arrow Darter (*Etheostoma sagitta spilotum*), which has declined dramatically over a 15 or 20 year period and is suspected to be due to water quality and habitat impairments from coal mining. Water quality and habitat protection efforts in small tributary streams could doubly benefit the fish and mussel fauna of the basin.

Literature Cited

Buisson, L., Thuiller, W., Sovan Lek, P.L., and G.L. Grenouillet. 2008. Climate change hastens the turnover of stream fish assemblages. Global Change Biology 14: 2232-2248.

Cicerello, R.R. 1996. A survey of the unionids (Bivalvia: Unionidae) of the Red Bird River, Clay and Leslie Counties, Kentucky. Technical Report to the Daniel Boone National Forest. iii + 14 pp.

Dunn, H. 2000. Development of strategies for sampling freshwater mussels (Bivalvia: Unionidae). Pp. 161-167 in Johnson, P.D., and R.S. Butler (editors). Freshwater Mollsuk Symposia Proceedings. Ohio Biological Survey, Columbus, Ohio. xxi + 274 pp.

Eaton, J.G., and R.M. Scheller. 1996. Effects of climate warming on fish thermal habitat in streams of the United States. Limnology and Oceanography 41(5): 1109-1115.

Kentucky Division of Water (KYDOW). 2008. Final 2008 integrated report to Congress on the Condition of Water Resources in Kentucky. Volume II. 303(d) list of surface waters. Frankfort, KY. viii + 252 pp. + appendices.

Kentucky State Nature Preserves Commission (KSNPC). 2010. Rare and Extirpated and Natural Communities of Kentucky. Kentucky Academy of Sciences. 71 (1-2): 67-81.

Kentucky Water Resources Research Institute (KWRRI). 2002. Kentucky River basin management plan. Final report to Kentucky River Authority. 429 pp.

Layzer, J.B., and R.M. Anderson. 1991. Impacts of the coal industry on rare and endangered aquatic organisms of the upper Cumberland River basin. Final report prepared for Kentucky Department of Fish & Wildlife Resources and Tennessee Wildlife Resources Agency. 118 pp.

Matthews, W.J., and E.G. Zimmerman. 1990. Potential effects of global warming on native fishes of the southern Great Plains and the Southwest. Fisheries 15: 26-32.

McCune, B., Grace, J.B., and D.L. Urban. 2002. Analysis of ecological communities. MJM Software Design, Gleneden Beach, Oregon. iv + 300 pp.

Smith, D.R., R.F. Villella, and D.P. Lemarie. 2001. Survey protocol for assessment of endangered freshwater mussels in the Allegheny River, Pennsylvania. Journal of the North American Benthological Society 20 (1):118-132.

Strayer, D.L. 1993. Macrohabitats of freshwater mussels (Bivalvia: Unionacea) in streams of the northern Atlantic Slope. Journal of the North American Benthological Society 12(3): 236-246.

Strayer, D.L., and D.R. Smith. 2003. A guide to sampling freshwater mussels. American Fisheries Society, Monograph 8, Bethesda, Maryland. xi + 103 pp.

Walsh, M., Deeds, J., and B. Nightingale. 2007. Classifying lotic systems for conservation: project methods and results of the Pennsylvania aquatic community classification project. Pennsylvania Natural Heritage Program, Pittsburgh, PA. vi + 73 pp.

Warren, M.L. and W.R. Haag. 2005. Spatio-temporal patterns of the decline of freshwater mussels in the Little South Fork Cumberland River, USA. Biodiversity and Conservation 14(6):1383-1400.

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KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2, Class Bivalvia. Priority Survey Project #1.

Role of DOC (Dissolved Organic Carbon) in Freshwater Mussel Diets

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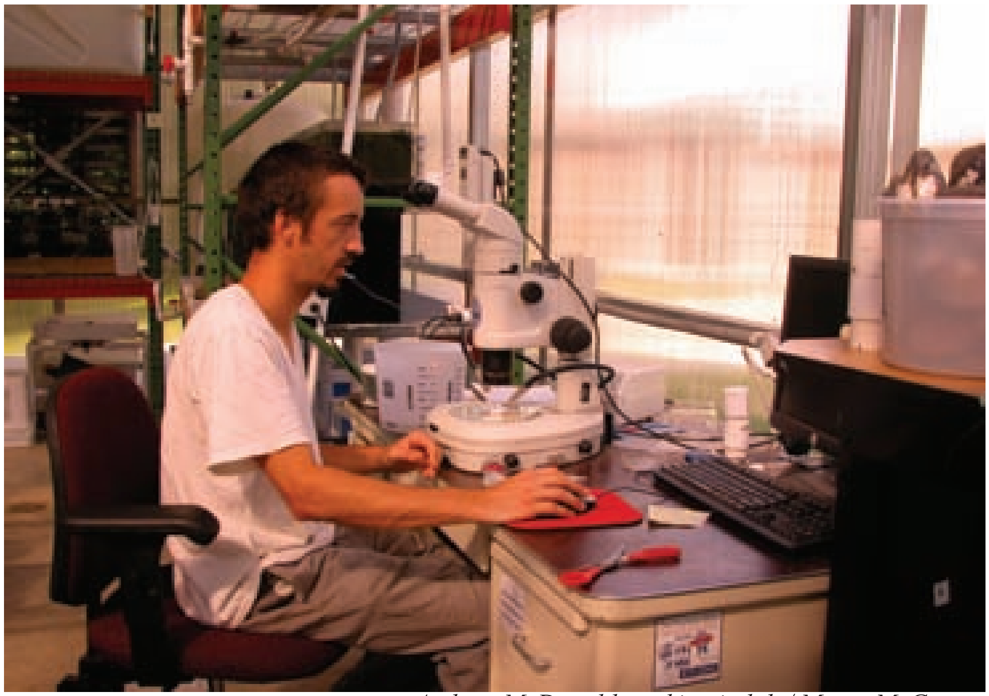


Andrew McDonald working in lab / Monte McGregor

Introduction

Freshwater mussels are the most imperiled group of fauna in North America, with an estimated 70% of our 300 species being extinct, imperiled or in need of special protection. Many populations of mussels are no longer successfully reproducing in the wild, as a result of their own unique life cycle requirements and the manipulation and degradation of our waterways. A female freshwater mussel holds her fertilized eggs in special "brood chambers" within her gills, where they develop into larvae. The larvae of a freshwater mussel must attach themselves to the gills of a fish (known as "encystment"), for a period of a week up to several months, where the mussel transforms from undeveloped larvae to free-living juvenile. After this transformation, the juvenile mussel drops from the gills of the fish to live out its life on the bottom of the stream or river. This complex life cycle means that mussels cannot reproduce if their fish hosts are no longer present in their habitat (due to dams, habitat impairment or water quality issues). Also, the reproductive cycle of mussels is highly dependent on temperatures and flow regimes, which are adversely affected by various types of dams.

Being able to artificially propagate mussels in captivity is of crucial importance to save species from extinction and re-populate areas with mussels where conditions are favorable. The procedures for transforming mussels using captured fish hosts are well-established and have been quite successful in recent years. Once juvenile mussels reach several millimeters in size in captivity, survival is relatively assured, and mussels are grown out to a taggable and releasable size. The most challenging part of the mussel propagation process in recent years has been to successfully raise the newly-transformed mussels (~250µm in length) to that stable size of ~2mm. One of the main reasons for this difficulty is the lack of knowledge about the necessary feeding requirements for these young, developing mussels. Different facilities utilize different techniques and feeding regimens, and in fact, there is still debate about the feeding habits of adult mussels as well. Most discussions of freshwater mussels' feeding habits focus on their suspension-feeding capabilities, and it has often been assumed that phytoplankton make up the bulk of their diets. However, that assumption has been called into question (Strayer et al. 2004). Recent stable isotope studies suggest that bacteria actually provide the majority of the carbon assimilated by mussels (Nichols and Garling 2000, Christian et al. 2004). Silverman et al. (1997) demonstrated that freshwater mussels can effectively filter *E.coli* suspensions in the laboratory. Nichols and Garling (2000) reported that while algae cells are concentrated in the guts of freshwater mussels, they often pass through the intestine undigested. Studies have shown that diets of algae alone are usually inferior to diets that also provide some sort of natural river sediment (likely containing an assemblage of bacteria), whether delivered in suspension or as a substratum (Gatenby et al. 1996, Hudson and Isom 1984). Other researchers have used water sources, like a managed pond or a healthy river, to provide mussels with a natural assemblage of foods, sometimes supplementing this with cultured algae (Beaty and Neves 2004, Zimmerman 2003).

Besides algae and bacteria, another potential source of nutrition for freshwater mussels in their natural habitat is Dissolved Organic Matter (DOM). Leaf litter shredded by macroivertebrates, as well as exudates from instream macrophytes, algae, and bio-films, all contribute to the DOM pool of an aquatic environment. The DOM compostition of a river, stream or lake includes carbohydrates, fatty acids, and proteins that could provide nutrition to resident mussels (Findlay and Sinsabaugh 2003). The DOM in the aquatic environment has been demonstrated to be a significant source of nutrition for zebra mussels (Baines and Fisher 2005), black fly larvae (Cibrowski et al. 1997), and the post-larval stage of abalones (Kawamura et al. 2005). The ability of Unionids to utilize such a diffuse source of nutrition has not been previously investigated, but several authors have mentioned the need for such studies (Vaughn et al. 2008, Christian et al. 2004, Strayer et al. 2004). It is hypothesized that providing high levels of DOM in the early stages of juvenile mussel growth could increase mussel growth and survival by providing an additional source of nutrition.

In order to develop a more appropriate and successful diet for newly-transformed juvenile mussels, a more thorough understanding of their feeding habits is needed. Therefore, a series of experiments was undertaken at the Center for Mollusk Conservation to determine the most important source of nutrition for these animals. Experiment 1 was designed to determine whether the mussels could utilize DOM as a source of nutrition, and Experiment 2 was designed to compare the nutritional importance of live bacteria, algae- and sediment-particles, and DOM.

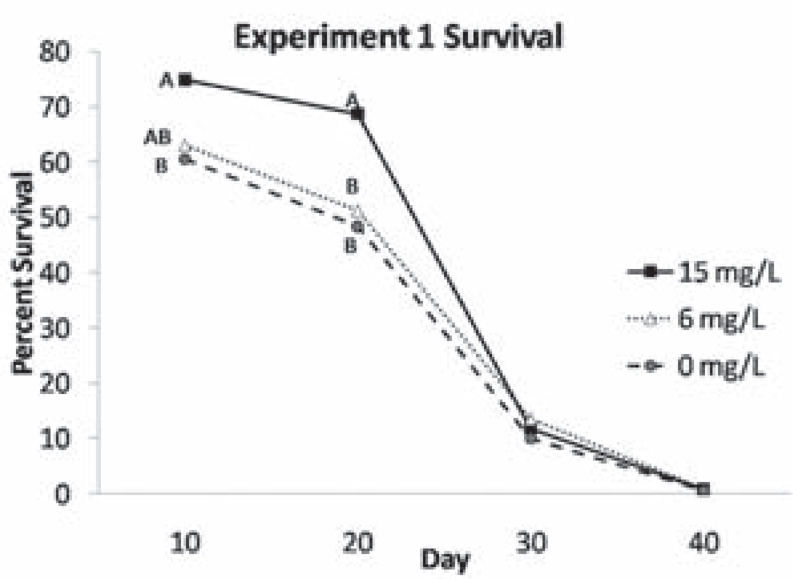


Figure 1: *Experiment 1 survival data. Means with same lowercase letter are similar according to Fisher's LSD test (α<0.05)*

Methods

Mussel propagation

The Painted Creekshell, *Villosa taeniata,* was used in all experiments and is a common species of the Cumberland and Tennessee River systems of North America. The *Villosa* genus contains several threatened and endangered species, and *V. taeniata* is considered representative of the life history, habitat and food requirements of these species. As such, propagation experiments with *V. taeniata,* (whose gravid females are readily available for several months of the year) may prove valuable in developing procedures for endangered species like *Villosa trabilis*. Rock bass (*Ambloplites rupestris*), a common host fish for *Villosa taeniata,* were collected using a backpack shocker (Smith-Root, Inc.) in Elkhorn Creek (Franklin County, Kentucky) and held in a 200 L tank with 10 cm (4") PVC pipe for shelter. Water was recirculated through a trickle bio-filter with Bio-Sphere media (Aquatic Eco-Systems, Inc.), and aerated with airstones and sponge filters. Gravid *Villosa taeniata* were collected from the lower portion of Sinking Creek in the Rockcastle River system (Laurel County, Kentucky) on 10 May 2010 and transported to the Kentucky Department of Fish and Wildlife Resources' Center for Mollusk Conservation (CMC) in Frankfort, Kentucky in aerated coolers filled with creek water (18^{o}C). The following day, larvae were extracted from the females for use in Experiment 1. For Experiment 2, gravid females not used in Experiment 1 were held in a chilled water system (16^{o}C) to prevent release of larvae. These were supplemented with gravid females collected from the middle portion of the Rockcastle River (Laurel and Pulaski counties) on 26 August 2010, and larvae were extracted on 30 August 2010 for Experiment 2.

For both experiments, larvae were extracted by rupturing each brood chamber with an 18 gauge needle and flushing the larvae out with water,

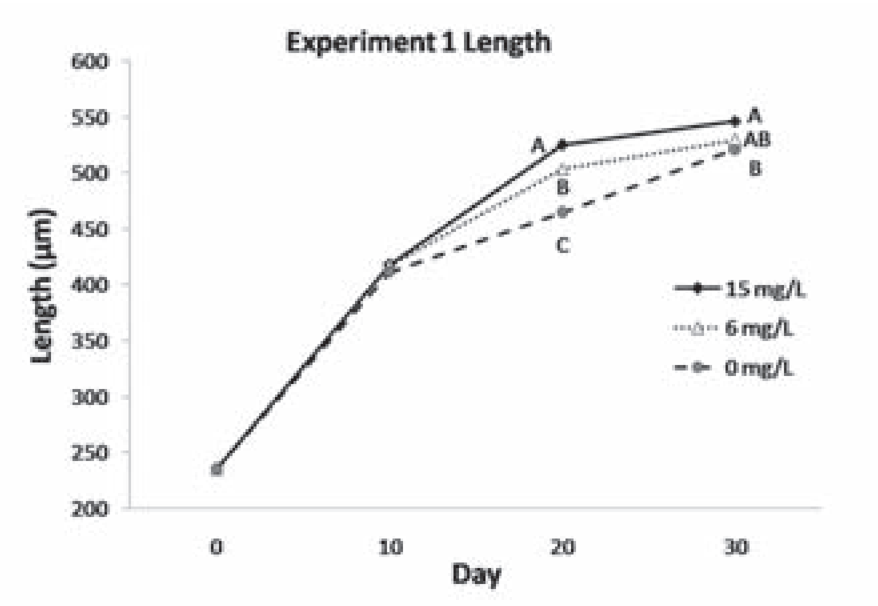


Figure 2: *Experiment 1 length data. Means with same lowercase letter are similar according to Fisher's LSD test (α<0.05)*

then collecting and concentrating them on a 100-µm mesh screen. A small sub-sample of each batch was evaluated for viability by observing the closing of valves in reaction to added salinity (Neves et al. 1985). Collected larvae from 5 females were pooled and distributed evenly into three 20L buckets, each containing about 15 Rock Bass and 6 L of water (sufficient to cover dorsal fins of fish). Rigid airlines were placed at the bottom of each bucket, which were propped at a 30° angle to keep glochidia in suspension. The fish remained in the buckets for approximately 15 minutes to allow glochidia to attach, before being returned to the holding tank for the duration of the encystment period. Gills of 5 fish were observed to confirm adequate attachment of glochidia.

The fish holding tank was equipped with a 100 µm screen above the trickle bio-filter to capture excysted juvenile mussels. Water temperature was increased over several days, and then held at 25°C. Juvenile mussels were collected by rinsing the 100 µm screen and by siphoning the tank. Once sufficient numbers of juvenile mussels were obtained, (approximately 2000 individuals), the experimental units were stocked. This took place 16 days after infestation for Experiment 1 and 23 days after infestation for Experiment 2.

Experimental setup

The experimental culture system consisted of 18 (Experiment 1) or 20 (Experiment 2) completely independent airlift-driven downweller units in 1.5 L rectangular acrylic tanks. Downwellers were crafted from 3.2cm (1.25") PVC pipe and couplers, such that the mussels were held on a 150 µm screen, with another 150 µm screen above preventing escape. A 1.3 cm (0.5") airlift pipe was attached to this mussel-holding chamber, and a rigid airline inserted into the air-lift pipe delivered air bubbles that provided water circulation from the tank to the mussel chamber. The tanks were each filled with ~900 mL of water during the experiments, so that the water level was just below the top of the downweller unit to allow for optimal airlift function and water flow through the mussel chamber (Figure 1). These replicate tanks were clearly labeled and randomly arrayed on top of a thermostatically controlled heating mat set at 24°C. The entire experimental sysytem was covered with a plexi-glass cover to prevent contamination. Each downweller replicate housed 100 juvenile mussels.

Experimental Procedures

Experiment 1 was designed to determine the nutritional value of DOM for newly transformed juvenile mussels. Therefore, mussels were fed either a High-DOM diet (15mg/L of carbon) or a Low-DOM diet (6 mg/L carbon) or were placed in the unfed control. These DOM-based diets were developed from the current diet used at the CMC, which consists of a mixture of cultured *Chlorella sorokiniana* (a small, unicellular algae) and collected sediment from the Licking River (Rowan County, KY). In order to remove the particles from this mixture, it was run through a cream separator, and the DOM-rich liquid was collected and used as the diet.

In Experiment 1, each tank received a water exchange of 1/4th of the volume in the tank each day, and screens were rinsed to insure adequate water flow. Mussels were removed from screens and counted and measured every ten days, at which time a total water exchange was also implemented.

For Experiment 2, a similar DOM-based diet was used as in Experiment 1, as well as the standard CMC diet (containing the algae and sediment). Two more diets were developed by ozoning the DOM and CMC diets before feeding in order to destroy live bacterial cells. These diets are referred to as DOM-Oz and CMC-Oz. The unfed control treatment brought the total number of treatments in Experiment 2 up to five.

Since Experiment 2 was designed to determine the nutritional importance of live bacteria, the control water used was ozoned each night before being added to tanks in order to eliminate live bacteria. Also, full water exchanges and tank cleanings were implemented in each tank on a daily basis to prevent the undesired growth of bacteria in the treatment tanks. Bacteria concentrations in each treatment were determined by creating three replicates of 1:1, 1:100, 1:1000, and 1:10,000 dilutions of each diet treatment: distilled water from 3 tanks of each treatment. A 0.5mL sample of each dilution was spread on an LB agar plate, incubated for 24 hours, and colonies were counted and multiplied by the appropriate dilution factor to obtain cfu/mL (Colony Forming Units/mL). These mussels were counted and measured approximately every 10 days.

Results

On days 10 and 20 of Experiment 1, survival was significantly higher in the high DOM treatment than in the low DOM treatment or control (Fig. 1). On day 20, the mussels in the high DOM treatment were significantly larger than mussels in the low DOM treatment, which were in turn significantly larger than the control (0 DOM) mussels. On Day 30, the mussels in the High DOM treatment were significantly larger than mussels in the Control, although survival was low (~12%) in all treatments (Fig. 2).

In experiment 2, survival in the CMC, CMC-Oz, and DOM treatments was significantly greater than in the DOM-Oz and Control treatments (but not significantly different from each other) at day 13 and day 23 (Fig. 3). By day 33, no living mussels remained in any treatment. On day 6, mussels in the CMC diet treatment were significantly larger than all other treatments, except for the DOM treatment mussels. The DOM mussels were not significantly different in size from the CMC mussels or the CMC-Oz mussels, but were significantly larger than the DOM-Oz and Control mussels. CMC-Oz mussels were significantly larger than DOM-Oz mussels, which were significantly larger than Control mussels. On day 13, mussels in the DOM treatment were significantly larger than those in the CMC treatment, which were significantly larger than the CMC-Oz mussels, which were significantly larger than the DOM-Oz and Control mussels, which were not significantly different. On day 23, the CMC treatment mussels were significantly larger than the DOM treatment mussels, which were significantly larger than the DOM-Oz mussels, but not significantly different from the CMC-Oz mussels, which were also not significantly different from the DOM-Oz mussels (Fig. 4). Length values for DOM-Oz mussels on day 23 were based on measurements of the few remaining mussels in that treatment (averaging 2.25 mussels per replicate). Mussel length was regressed over bacterial concentration in treatment tanks in Fig. 5. The equation for this logarithmic relationship is $y = 7.670\ln(x) + 273.1$, $R^2 = 0.811$.

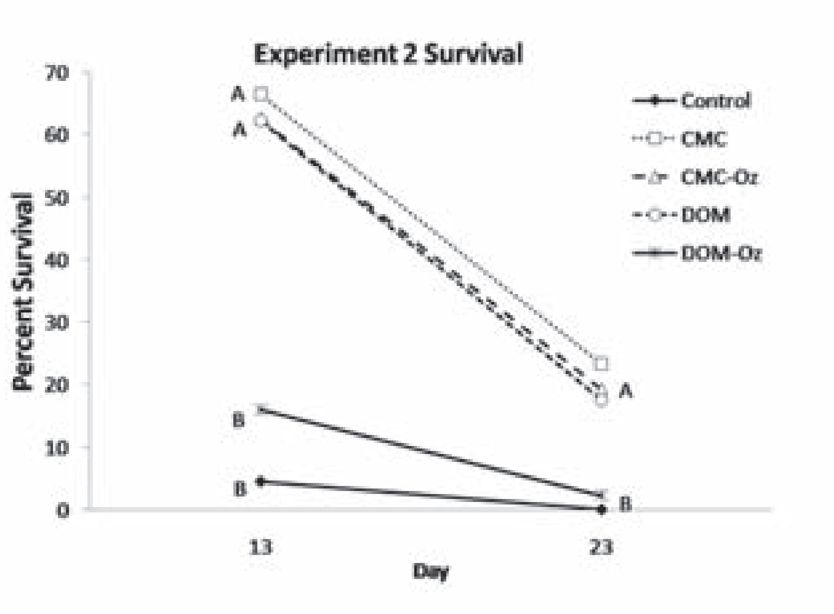


Figure 3: *Experiment 2 survival data. Means with same lowercase letter are similar according to Fisher's LSD test (α<0.05)*

Discussion

In Experiment 1, the High DOM treatment mussels had greater survival than the control mussels on Days 10 and 20, and both DOM treatments led to greater mussel length (compared to controls) by Day 20. This would imply that mussels were obtaining nutrition from the algae- and sediment-derived DOM nutrients that were supplied in the diet treatments. However, after conducting a bacterial count, it became apparent that a significant amount of bacteria was growing in the tanks of all three treatments. A bacterial count suggested that the DOM diets were supporting a higher bacterial population, which could also explain the differences in survival and growth of the mussels in those treatments.

Control tanks had bacterial concentrations approximately half those of the Low DOC and High DOC treatments. These data indicate the possibility that the juvenile mussels were utilizing the bacteria present in all treatments as a source of nutrition. Previous studies of the role of DOM in bivalve nutrition have concluded that non-acidic fatty acids and amino acids are readily absorbed by zebra mussels, and can provide 10-25% of the mussels' maintenance ration (Baines et al. 2005). Without some specialized adaptation for absorbing DOM, small actively developing juvenile unionids may be able to glean even less of their maintenance ration from this rather diffuse nutritional source.

Experiment 2 was designed to separate the effect of live bacteria from the effect of DOM and the effect of particulates in the diets of these newly-transformed mussels. In this experiment, the control water was ozoned to kill live bacteria prior to adding to tanks. Also, daily total water exchanges and tank cleanings were implemented to prevent the growth of bacteria in situ. The results of this treatment were dramatic, in that the Control mussels had only 4.5% survival by Day 13 and all were dead by Day 23 (compare to 60% live at Day 10 and 50% live at Day 20 in Experiment 1). The other treatment with very low numbers of bacteria, (DOM-Oz), also had very poor survivals. These findings suggest that live bacteria play an important role in survival of freshwater mussels in the days directly following excystment from the fish host. While other researchers have noted the "inherent" ability of juvenile unionids to live for up to several weeks without feeding (Gatenby et al. 1996), these data suggest that these mussels were relying upon ambient bacterial populations to supply maintenance levels of nutrition.

The two treatments which were not ozoned (CMC and DOM) had the highest levels of bacteria, and also supported the greatest survival and growth. The CMC-Oz treatment had far less viable bacteria than the un-ozoned CMC diet (8,500 cfu/mL compared to >200,000), but it seems that this was a high enough concentration for the mussels, as survival was similar to un-ozoned treatments and growth was only slightly less. The close positive relationship between shell length and bacterial density (Fig. 5), regardless of whether the diets contained particulates and algae cells or nothing but DOM and bacteria, suggests that live bacteria is of first importance in the diets of

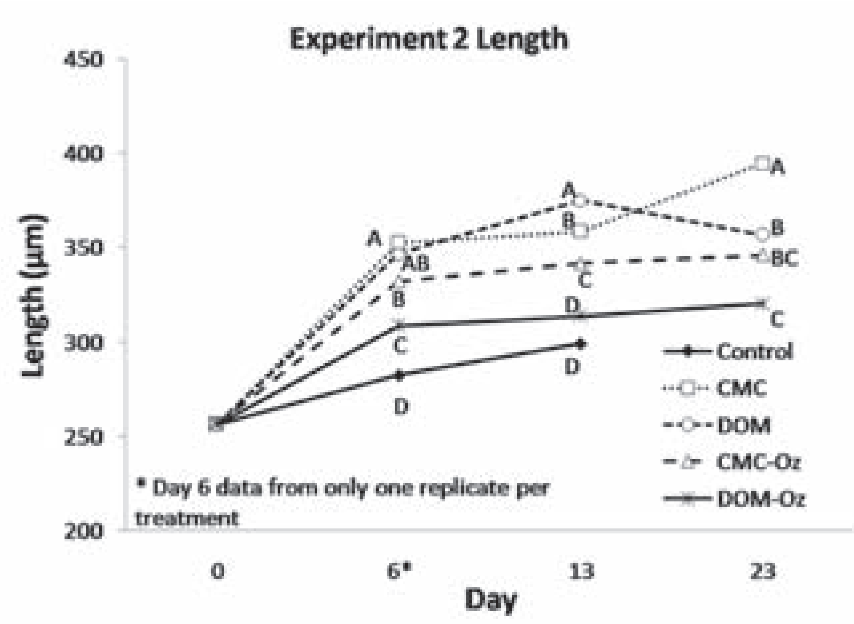


Figure 4: *Experiment 2 length data. Means with same lowercase letter are similar according to Fisher's LSD test (α<0.05) *day 6 data based on only one replicate per treatment.*

newly transformed juvenile mussels. The difference in survival between the DOM-Oz and the DOM treatment also suggest that in Experiment 1, it was in fact bacteria that was feeding the mussels, and the DOM additions simply served to feed and enrich the bacterial population. Bacterial counts from the unfed Controls in Experiment 1 and CMC-Oz treatment in Experiment 2, along with examination of the growth curve (Fig. 5) suggest that 10,000-50,000 cfu/mL of desired bacteria may be sufficient to support survival and growth.

These data likely indicate an important role for live bacteria in the diets of newly-transformed juvenile mussels. The exact mechanisms by which these mussels utilize bacteria are unknown at present, and several possibilities exist. Previous researchers have discussed the potential probiotic effect that bacteria may have by outcompeting pathogenic bacteria for nutrients (Vincie 2008). Kesarcodi-Watson et al. (2008) review several moderately successful uses of probiotic bacteria in bivalve culture to kill pathogenic bacteria that would otherwise hinder survival and growth of the bivalves. If the low survival in these experiments was in fact due to a microbial pathogen then the positive effect of high bacterial concentrations in the diet may be due to this sort of competitive exclusion "probiotic" relationship. The most obvious direct effect of bacteria would be if the mussels simply ingest the bacteria and digest them for their nutrient content. This possibility is supported by several recent stable isotope studies which found mussels to utilize bacterial (as opposed to algal) carbons for the majority of their metabolic needs (Nichols and Garling 2000, Christian et al. 2004). The degree to which bacterial density affected survival in the first 13 days post-metamorphosis suggests that this a critical period for the mussels in which live bacteria are vital to the young mussels, perhaps for reasons beyond their direct nutritional value. The larvae of many aquatic organisms rely upon the enzymes of

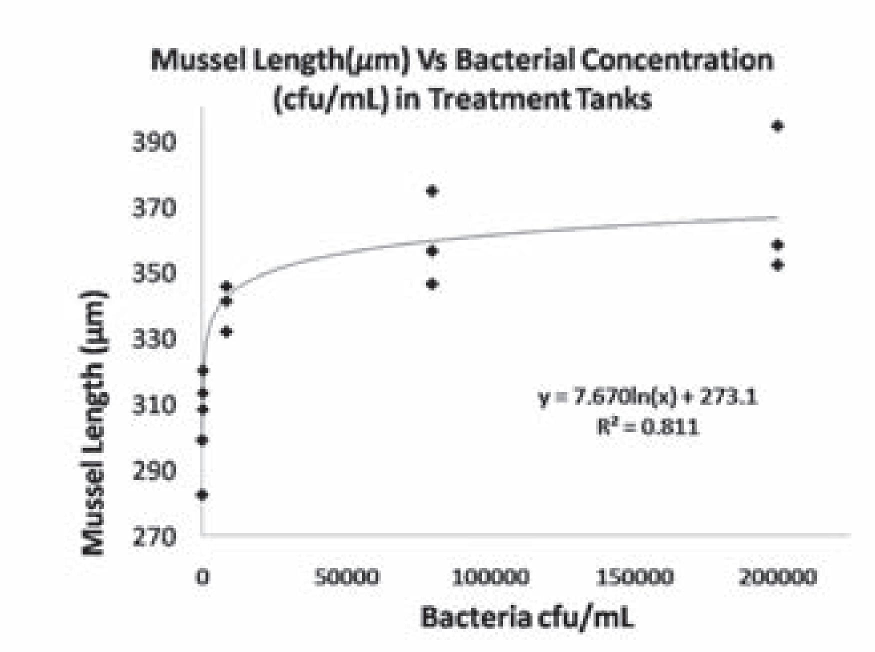


Figure 5: *Mussel length versus bacterial concentration in treatment tanks. Trend line based on averages of length values- suggesting a logarithmic correlation between bacterial concentration and mussel growth.*

bacteria to help digest their food and obtain nutrition before their digestive systems have developed fully (Hansen and Olafsen 2000). Shivokene et al. (1986) found microorganisms in the gut of *Unio tumidus* to contribute amylase, cellulase and protease. The crystalline style of *Mytilus edulis* has been found to contain bacteriolytic enzymes produced by bacteria associated with the style itself. The crystalline style has an inner core of food particles, and is other food particles are threaded around the outside of the style, all of which is returned to the stomach for further digestion (Nelson 1918). This increases the residence time of bacteria in the gut as well as encloses the bacteria in mucuous with other food particles, (similar to a bio-film) which greatly increases the effectiveness of bacterial exozymes (Plante et al. 1990, Azim et al.2005). Plante et al. (1990) suggest that the style sac may be an adaptation (rare amongst aquatic organisms) for retaining bacteria in the foregut, which would suggest an important mussel-bacteria relationship. The early formation of the crystalline style in the development of the juvenile mussels (Lasee 1991) may therefore be another indication of the importance of proper gut bacteria at this young stage.

Management Implications

Based on these data, bacteria seem to be of great importance to the survival and growth of juvenile mussels in captivity. Maintaining bacterial concentrations of 10,000-50,000 cfu/mL in the culture systems should increase success of propagation activities. Utilizing systems in which the mussels are placed on a substratum of sediment may allow the mussels to more readily feed upon the bacteria which thrive upon the sediments. Once a system is shown to successfully provide for mussel growth, it may be advantageous to allow that system to continue operating in order to maintain that population of the correct species of bacteria. Additions of algae are still necessary, however, in order to provide the mussels with vitamins and nutrients that bacteria cannot provide. The algae also serve to feed and enrich the bacterial population in the system. Future studies should work to clear up the relationship between these developing mussels and bacteria, and to determine those bacterial species that are most beneficial. Efforts to obtain and culture bacteria from the mussels' native environment should also be undertaken, particularly for those species which have been difficult to propagate in artificial environments thus far. With the understanding that live bacteria are important for these mussels, propagation efforts can be managed to more successfully produce rare freshwater mussels of a taggable size for population augmentation efforts.

Literature Cited

Azim, M. E., M. C. M. Beveridge, A. A. vanDam and M. C. J. Verdegem. "Periphyton and Aquatic Production, an Introduction." M.E. Azim, M.C.J. Verdegem, A.A. vanDam, M.C.M. Beveridge. Periphyton: Ecology, Exploitation and Management. Cambridge: CABI Publishing, 2005. 1-11.

Baines, S., N. Fisher, J. Cole. "Uptake of Dissolved Organic Matter and its Importance to Metabolic Requirements of the Zebra Mussel, Dreissenna polymorpha." Limnology and Oceanography 50.1 (2005): 36-47.

Beaty, B. B. and R. J. Neves. "Use of a natural river water flow-through culture system for rearing juvenile freshwater mussels (Bivalvia:Unionidae) and evaluation of the effects of substrate size, water temperature, and stocking density." American Malacological Bulletin 19.1/2 (2004): 15-23.

Christian, A. D., B. N. Smith, D. J. Berg, J. C. Smoot, R. H. Findlay. "Trophic Position and Potential Food

Sources of Two Species of Unionid Bivalves in 2 Small Ohio Streams." Journal of the North American Benthological Society 23.1 (2004): 101-113.
Ciborowski, J. H., D. A. Craig, K. M. Fry. "Dissolved Organic Matter as Food for Black Fly larvae (Diptera: Simuliidae)." Journal of the North American Benthological Society 16.4 (1997): 771-780.
Findlay, S. E. G. and R. L. Sinsabaugh. Aquatic Ecosystems: Interactivity of Dissolved Organic Matter. San Diego, CA: Academic Press, 2003.
Gatenby, C. M., R. J. Neves, B. C. Parker. "Influence of Sediment and Algal Food on Cultured Juvenile Freshwater Mussels." Journal of the North American Benthological Society 15.4 (1996): 597-609.
Hansen, G. H. and J. A. Olafsen. "Review Article: Bacterial interactions in early life stages of marine cold water fish." Miicrobial ecology 38.1 (1999): 1-26.
Hudson, R.G., and B. G. Isom. "Rearing of juveniles of the freshwater mussels (Unionidae) in a laboratory setting." Nautilus 98 (1984): 129-135.
Kesarcodi-Watson, A., H. Kaspar, M. J. Lategan, L. Gibson. "Probiotics in Aquaculture: The need, principles and mechanisms of action and screening processes." Aquaculture 274 (2008): 1-14.
Lasee, B. A. Histological and Ultrastructural studies of Larval and Juvenile Lampsilis from the Upper Mississippi River. PhD Dissertation. Ames, Iowa: Iowa State University, 1991.
Nelson, Thurlow. "On the Origin, Nature and Function of the Crystalline Style of Lamellibranchs." Journal of Morphology (1918): 53-108.
Neves, R. J., L. R. Weaver and A.V. Zale. "An Evaluation of Host Fish Suitability for Glochidia of Villosa vanuxemi and V. nebulosa." American Midland Naturalist 113 (1985): 13-19.
Nichols, S. J., D. Garling. "Food-web Dynamics and Trophic-Level Interactions in a Multispecies Community of Freshwater Mussels." Canadian Journal of Zoology 78 (2000): 871-882.
Plante, C. J., P. A. Jumars, J. A. Baross. "Digestive associations between marine detritivores and bacteria." Annual review of ecology and systematics 21 (1990): 93-127.
Shivokene, Y. S., D. P. Sinyavichene, B. P. Shal'chyute. "Ecological and physiological features of bivalve mollusks of the superfamily Unionaceae 6. Functional activity of the microorganisms of the digestive system of Unio tumidas as a function of its diet." Liet tsr mokslu akad darb ser c biol mokslai 6.3 (1986): 28-33.
Silverman, H., J. S. Cherry, J. W. Lynn, T. H. Dietz, S. J. Nichols, and E. Achberger. "Clearance of laboratory-cultured bacteria by freshwater bivalves: differences between lentic and lotic unionids." Canadian Journal of Zoology 75.11 (1997): 1857-1866.
Strayer, D. L., J. A Downing, W. R. Haag, T. L. King, J. B. Layzer, T. J. Newton, S. J. Nichols. "Changing Perspectives onPearly Mussels, North America's Most Imperiled Animals." Bioscience 54.5 (2004): 429-439.
Vaughn, C. C., S. J. Nichols, D. E. Spooner. "Community and foodweb ecology of freshwater mussels." Journal of the north american benthological society 27.2 (2008): 409-423.
Vincie, M. E. Development of a Suitable Diet for Endangered Juvenile Oyster Mussels, Epioblasma capsaeformis (Bivalvia: Unionidae), Reared in a Captive Environment. Master's Thesis. Virginia Polytechnic Institute and State University. Blacksburg, Virginia, 2008.
Zimmerman, L.L. Propagation of juvenile freshwater mussels. Master's thesis. Blacksburg, Virginia: Virginia Polytechnic Institute and State University, 2003.

Funding Source: *U.S. Fish and Wildlife Service, Kentucky Department of Fish and Wildlife Resources, and Kentucky State University*

KDFWR Strategic Plan: Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2, Class Bivalvia. Priority Research Project #1.

Collared elk / Gabe Jenkins

Project Highlights

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

Dave Dreves and David Baker, Kentucky Department of Fish and Wildlife Resources

Two nice muskies taken during spring sampling at Cave Run Lake / Chad Nickell

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) on the Green River and Cave Run Lake (8,270) on the Licking River. The Kentucky Department of Fish and Wildlife Resources 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 regulations such as minimum size and bag limits. These regulations are designed to protect certain size classes of fish and equitably distribute the catch in order to develop the trophy fishery

In an effort to enhance the quality of the Muskellunge fishery, the KDFWR will increase the minimum length limit for muskellunge in Buckhorn, Cave Run and Green River lakes from 30 to 36 inches during the spring of 2010 and maintain the daily bag limit 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 in the population. 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, as well as how these population changes may affect the entire fish community. A thorough evaluation of this management strategy will add to the existing knowledge base in the field and allow the KDFWR to most effectively manage the muskellunge fishery and fish community in these reservoirs.

Population sampling will be conducted with boat-mounted pulsed DC electrofishing gear from mid-February through the end of March. All individuals of each cohort of stocked Muskellunge will be permanently marked with a fin clip prior to stocking each fall. Electrofishing catch per unit effort data (CPUE) collected in the spring of each year will be used to index age-1 year-class strength, the relative frequency of various length groups of interest and mortality calculations. Statistical comparisons of CPUE of size groups for pre-regulation and post-regulation change will be made. We will also compare the changes in CPUE of size groups within and among the three study lakes. Length at age, relative weight and length-weight equations will be calculated and analyzed for changes in growth and condition. Creel surveys and angler attitude surveys will be conducted at each study lake. Muskellunge harvest data from the creel survey will be used to estimate angler exploitation. All existing Muskellunge data on each of the study lakes will be compiled, including CPUE, creel and angler attitude data.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Evaluation of a Supplemental White Crappie Stocking Program at Four Kentucky Reservoirs

Christopher W. Hickey and Ryan Kausing, Kentucky Department of Fish and Wildlife Resources

A mess of crappie / Ryan Oster

In Kentucky, crappie is the second most sought after sport fish species, following only behind black bass. Crappie populations have always been peculiar in that they can change dramatically from one year to next. This happens primarily because a successful crappie spawn and recruitment of new fish into the fishery relies upon a number of different environmental factors coming together at just the right time. Although it has not been determined exactly why it happens, these same environmental factors can also have an impact on the abundance of white crappie and black crappie in any specific lake. In some of Kentucky's most popular crappie lakes, there has been a noticeable shift in the last decade where black crappie have become more prominent during annual sampling and have even been found in higher numbers than white crappie. This has recently been most noticeable in two of Kentucky's largest reservoirs and most popular crappie fisheries, Lake Barkley and Kentucky Lake.

Different habits of the crappie species is what sets them apart when it comes to crappie anglers. Black crappie tend to move shallow earlier in the year and stay there longer, which requires angling techniques that are similar to bass fishing to be successful at catching them. On the other hand, white crappie are usually only in shallower water for a short time period during the spawn in early spring. They will then congregate in deeper habitat to feed for the rest of the year. White crappie are vulnerable to more common angling techniques associated with crappie fishing, such as vertical jigging and using live bait under a bobber. Hence, when the numbers of white crappie decrease, either because of lower recruitment or an increase in black crappie abundance, the more traditional crappie anglers will often experience a decline in catch rates. When this happens for a couple years in a row, crappie anglers turn to the KDFWR to take any management actions necessary to increase the number of white crappie available. Since regulations are already in place at many of the most popular crappie fisheries in Kentucky, KDFWR looked to stocking as a possible way to bolster the white crappie populations. The goal of this project is to evaluate the new white crappie stocking program at 4 different reservoirs spread throughout Kentucky.

The actual locations chosen for this study include the Blood River embayment of Kentucky Lake, Little River embayment of Lake Barkley, Taylorsville Lake, and Carr Creek Lake. The white crappie needed for the stocking program will be produced at a state-owned hatchery from adults that are collected from different crappie fisheries throughout Kentucky. The white crappie fingerlings will be marked before going out to the different locations so they can be tracked for years after they are stocked. Every time that crappie are marked, transported, and stocked in one of the study lakes, a subsample will be collected and held in nets near the stocking sites in order to estimate the mortality that can be attributed to the stress of stocking. The densities (# fish/acre) at which the crappie fingerlings are stocked will be manipulated until the most beneficial stocking density is determined. Crappie populations at each study lake will be sampled annually using a combination of different methods that include trap-nets, electrofishing, and trawling (if necessary). Any marked fish that are sampled will be counted and used to determine the contribution this stocking program makes to the natural crappie population.

This 6-year project will also use creel surveys to determine what impact the white crappie stocking program has on the anglers' catch rates and their satisfaction with the fishery. White crappie from different angling clubs and tournaments will also be collected during later years of the project to determine if stocked white crappie actually do contribute to their catch and harvest. Overall, this project will help to determine if stocking white crappie is a feasible management tool that can be used in Kentucky, and whether or not it actually has any influence on large crappie populations and the anglers that fish for them.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Fanshell Mussel / Monte McGregor

Fanshell, *Cyprogenia stegaria* augmentation in Ohio and West Virginia

Monte McGregor, Jacob Culp, Adam Shepard, Fritz Vorisek, Ben Davis, and Travis Bailey, Kentucky Department of Fish and Wildlife Resources; John Navarro, Ohio Department of Natural Resources; Tom Watters, Ohio State University; Janet Clayton, West Virginia Department of Natural Resources; Leroy Koch and Patricia Morrison, US Fish and Wildlife Service

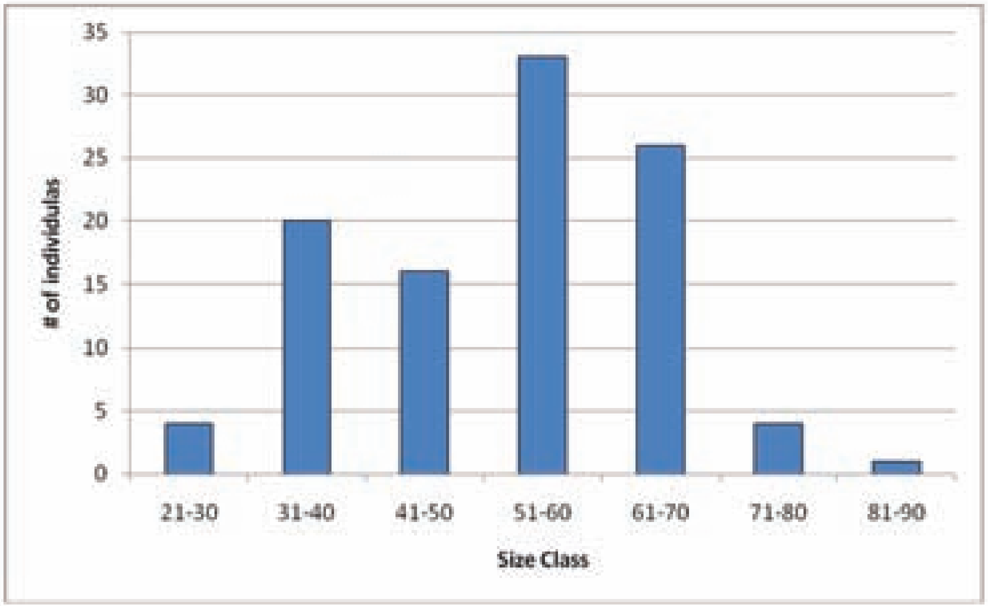
In September 2010, The Kentucky Department of Fish and Wildlife's Center for Mollusk Conservation spear-headed a multi-agency collaboration to augment the Federally Endangered Fanshell, *Cyprogenia stegaria* in three rivers in Ohio and West Virginia. Two of the rivers are in West Virginia; the Kanawha River, and the Ohio River near Muskingum Island. The third river, the Muskingum River, is in Ohio. The 600 individuals that were translocated came from the source population of *Cyprogenia stegaria* in the lower Licking River, KY.

On September 22 and 23, KDFWR and USFWS staff collected *C. stegaria* from the Licking River at Morning View using both quantitative and qualitative methods. To monitor effects of removal of *C. stegaria* on their population in the Licking River, a 5 m x 5 m area was quantitatively surveyed. During the survey, every Fanshell encountered was measured, aged, and removed from the population for translocation out-of-state. All other mussel species were identified, counted, and measured, then returned to the m^2 grid where they were found (see Table 4 for summary of quantitative survey). A total of 104 individuals of *C. stegaria* were found in the 5 m x 5 m survey area, and their size and age distributions can be examined in Figures 1 and 2.

The other 496 *C. stegaria* were found during qualitative sampling in a large shoal area that was rapidly losing water due to drought conditions in 2010. After quantitative sampling was

# m2 samples	# collected	mean density (#/m2)	species	C. stegaria density (#/m2)
25	912	36.5	24	4.2

Figure 1: Size distribution of C. stegaria collected during quantitative sampling on Licking River 2010.



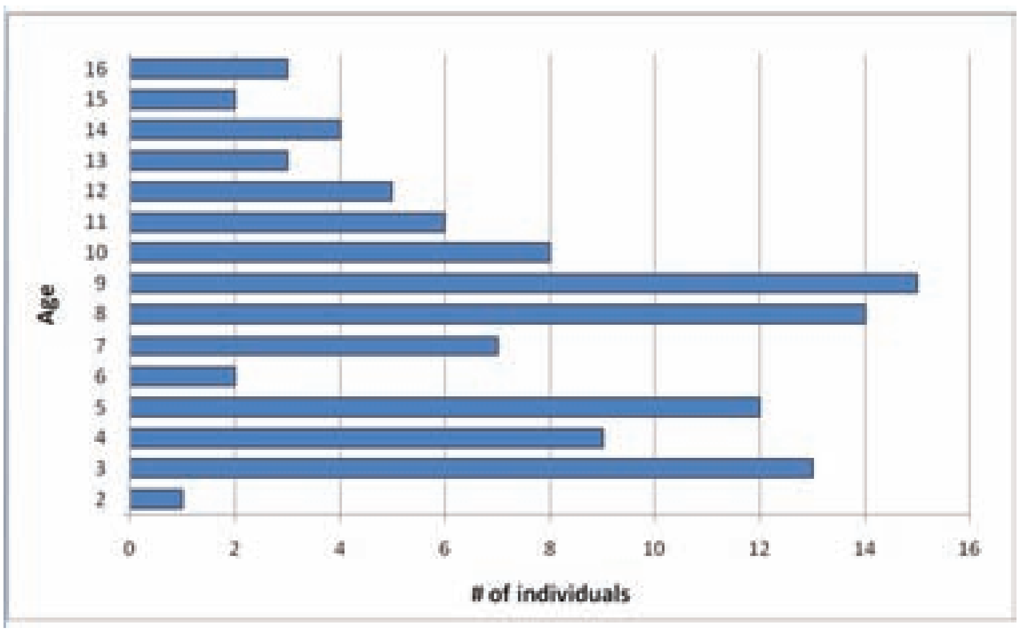


Figure 2: Age distribution of C. stegaria collected during quantitative sampling on Licking River 2010.

completed, a large-scale qualitative search began with a total of 47 hours of effort. This collection lasted two days and involved 11 people. All Fanshell collected were kept at the Center for Mollusk Conservation in Licking River water. Twelve individuals were randomly selected and checked for gravidity, and 6 of the 12 were found gravid. On September 28, mussels were transported to Ashland, KY and delivered to the WVDNR. Each site in West Virginia and the site in Ohio were augmented with 200 individuals from Kentucky. These sites, and the 5 m x 5 m section of the Licking River, will be monitored regularly to follow trends in each Fanshell population.

Funding Source: *Endangered Species Act (Section 6), Kentucky Department of Fish and Wildlife Resources.*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2, Class Bivalvia. Priority Survey Research Project #1.

Fish host determined for the Kentucky Creekshell, *Villosa ortmanni* and a new fish host found for the Cumberland Combshell, *Epioblasma brevidens*

Fish host system / Jacob Culp

Monte McGregor, Jacob Culp, Adam Shepard, Fritz Vorisek, Ben Davis, and Travis Bailey, Kentucky Department of Fish and Wildlife Resources

In June 2010, two Kentucky Creekshell females were found to be gravid in captivity at KDFWR's Minor Clark Facility in Morehead, KY. The Kentucky Creekshell, *Villosa ortmanni*, is a Kentucky State Nature Preserves threatened species and is endemic to the Green River in Kentucky. No fish hosts are currently known for *V. ortmanni*. On June 9, 2010, Center for Mollusk Conservation staff infested 20 fish species from several different families with larvae from *V. ortmanni*. Fish were held in individual tanks and after 10 days tanks were checked for transformed juveniles of the Kentucky Creekshell. On June 22 (13 days after initial infestation) 5 juveniles were found in a tank containing the Johnny Darter, *Etheostoma nigrum*. Additional fish host tests are necessary to confirm the Johnny Darter as the host for *V. ortmanni*, which the Center for Mollusk Conservation staff will continue during 2010-2011.

In May 2010, several females of the Cumberland Combshell, *Epioblasma brevidens* were infested on a Cumberland endemic fish, the Striped Darter (*Etheostoma virgatum*). The Striped Darter had not been previously tested or documented as a fish host for the Cumberland Combshell. Approximately 14 days post-infestation, juveniles were found in Striped Darter tanks, confirming it as a new host for the federally endangered *Epioblasma brevidens*.

Funding Sources: *Endangered Species Act (Section 6) funds, U.S. Fish and Wildlife Service*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2, Class Bivalvia. Priority Research Project #1.

Rockcastle River Mussel Survey

Monte McGregor, Adam Shepard, Fritz Vorisek, Ben Davis, and Travis Bailey, Kentucky Department of Fish and Wildlife Resources

From July to September 2010 the Kentucky Department of Fish and Wildlife's Center for Mollusk Conservation staff surveyed 10 sites on the main stem of the Rockcastle River, and 4 sites on its tributaries. This included a day-long, 6 mile canoe trip with 6 sites sampled during the trip. One

Site #	Site description	Date
1	Rockcastle River Canoe Site 1 near Livingston, KY	9/9/2010
2	Rockcastle River Canoe Site 2 near Livingston, KY	9/9/2010
3	Rockcastle River Canoe Site 3 near Livingston, KY	9/9/2010
4	Rockcastle River Canoe Site 4 near Livingston, KY	9/9/2010
5	Rockcastle River Canoe Site 5 near Livingston, KY	9/9/2010
6	Rockcastle River Canoe Site 6 near Livingston, KY	9/9/2010
7	Rockcastle River at mouth of Lick Creek	7/8/2010
8	Rockcastle River below Forks of Rockcastle	7/27/2010
9	Rockcastle River 300 m downstream of Sinking Creek	7/29/2010
10	Rockcastle River at river mile 47, near Livingston, KY	9/2/2010
11	Middle Fork Rockcastle River ~ 5 miles above Lamera, KY	7/27/2010
12	Laurel Fork at the confluence of Indian Creek	8/3/2010
13	Horse Lick Creek at mouth of Raccoon Creek	8/25/2010
14	Horse Lick Creek at mouth	8/25/2010

Table 1: *Complete list of sampling sites in the Rockcastle Drainage 2010*

Rockcastle River / Monte McGregor

of the main goals of this large-scale survey was to evaluate the current distribution of the federally endangered Cumberland Bean, *Villosa trabalis*. A total of 20 species were found in all 14 sites. *Villosa trabalis* was found live in 5 sites and a fresh dead shell was found at another. A fresh dead shell of a second federally endangered species, the Littlewing Pearlymussel, *Pegias fabula*, was found at Horse Lick Creek. The Painted Creekshell, *Villosa taeniata*, was found at every site sampled. See tables 1 and 2 for complete information.

Funding Source: *Endangered Species Act (Section 6) funds, U.S. Fish and Wildlife Service*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2, Class Bivalvia. Priority Survey Project #1.

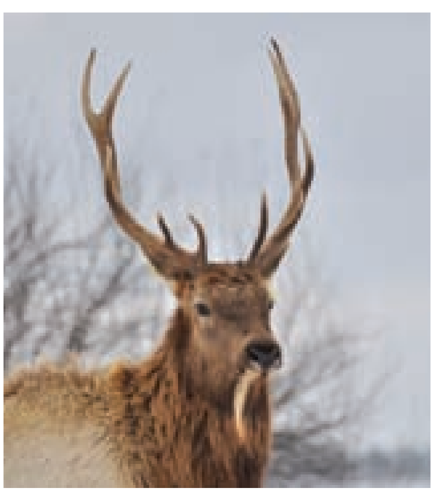
Table 2: *Species list and abundance ranks for Rockcastle River survey 2010 A=abundant (>50 ind.), C=common (6-50 ind.), UC= uncommon (3-5 ind.) R =rare (2 ind.), VR=very rare (1 ind.), x=no abundance data taken, r = relict shell*

sampling sites ->	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Species														
Actinonaias ligamentina				VR	R		C		R	VR				
Actinonaias pectorosa						UC	A		C	VR				
Amblema plicata	C	C	C	A	C	C	C	UC	r	VR	UC			
Cyclonaias tuberculata		R	UC	C	C	C	C		r	UC				
Elliptio dilatata	C	C	C	C	C	R	A	UC	C	C	C	UC	x	
Lampsilis cardium	UC	VR	VR	UC	VR		C		C	UC	R	R		
Lampsilis fasciola	C	UC	UC	UC	VR		C	UC	C	UC		VR	x	
Lasmigona costata		VR		UC	R				VR	VR				
Leptodea fragilis							VR							
Ligumia recta							R		r					
Medionidus conradicus													x	
Pegias fabula													r	
Pleurobema sintoxia	VR	VR	R	VR	C		R							
Potamilus alatus		VR					C							
Ptychobranchus fasciolaris	C	C	C	A	C		C	R		C	R		x	
Quadrula pustulosa	R	R	R	UC	VR	UC	C	VR	VR	VR				
Toxolasma lividus											VR			
Villosa iris					r		R	R			UC		x	
Villosa taeniata	A	A	A	A	C	C	A	C	C	C	C	C	x	x
Villosa trabalis	R	R	r				VR			VR	VR			
Total # of species->	**9**	**12**	**10**	**11**	**12**	**6**	**16**	**7**	**11**	**12**	**8**	**4**	**7**	**1**

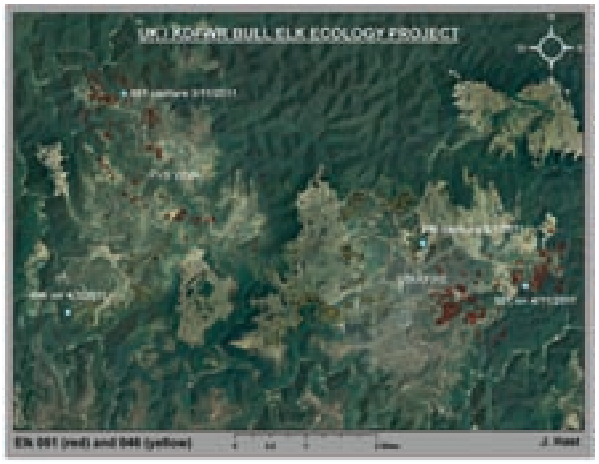
Resource Selection, Movement Patterns, Survival, and Cause-Specific Mortality of Adult Bull Elk in Kentucky

John Hast and John J. Cox, University of Kentucky; Tina Brunjes, Dan Crank, Will Bowling and Gabriel Jenkins, Kentucky Department of Fish and Wildlife Resources

Although much information has been obtained from a decades-long research program at the University of Kentucky on reintroduced elk in the Commonwealth, little is known about bull elk ecology. Mature bull elk are an ecologically important age-gender class within the growing population in south-eastern Kentucky. Although harvest numbers have been recorded since the implementation of a sustainable hunting season, other sources of mortality for mature bull elk are unclear. We also know little about the temporal and seasonal habitat use and spatial patterns of bull elk and, through anecdotal evidence, believe that these characteristics considerably differ among biological seasons than that of other age and gender classes. Finally, bull elk home range establishment in Kentucky is unclear in terms of space use versus individual relatedness and how these parameters influence dispersal across the landscape.



Bull elk in snow / John Hast



Elk Map / John Hast

The following eight project objectives will be implemented to fill the knowledge gaps addressed above and expand our knowledge of the Kentucky bull elk:

1. Characterize fine scale resource use patterns of bull elk
2. Characterize seasonal movement patterns of bull elk
3. Identify individual and population movement corridors of bull elk
4. Determine survival and cause-specific mortality of bull elk
5. Characterize dispersal movements of bull elk
6. Determine the influence of relatedness on space use of bull elk
7. Evaluate parasite occurrence on elk and their potential impacts on bull elk
8. Determine the influence of the Kentucky elk herd as an EHD/ bluetongue reservoir

To accomplish the above objectives, 60 mature bull elk were fitted with a global positioning system (GPS) or very high frequency (VHF) tracking collars sized specifically for the individual animal in the winter of 2011. Upon the application of a local anesthetic, one premolar was pulled from each captured elk using a dental elevator for the purposes of cementum annuli age determination. A tissue sample was collected from the ear with a tissue punch for the purposes of genetic analysis. Additionally, individual animals were marked by the use of two colored and numbered standard cattle ear tags. 10ml of whole blood was drawn for serological analysis. The recumbent animal was surveyed for ectoparasites and a scat sample was collected.

GPS collars of bull elk will collect one location every two hours and be used to accomplish such objectives as resource use and the analysis of movement corridors. VHF collared bull elk will be tracked from the ground or by fixed-wing aircraft once per week for the life of the collar (approx. 4 years). All collars, VHF and GPS (n=60), will be included in the survival and cause specific mortality objective.

Funding Source: *Pittman Robertson (PR) and University of Kentucky*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Population Size and Density of Black Bears in McCreary County, Kentucky

Sean Murphy, University of Kentucky; Steven Dobey, Kentucky Department of Fish and Wildlife Resources

Since 2005, the population status of black bears in McCreary County, KY has gained increasing attention from the KDFWR as sighting reports, nuisance complaints, and vehicle collisions have increased. As a result, the KDFWR initiated cooperative research in 2010 with the University of Kentucky to estimate the size, density, and distribution of bears in this region.

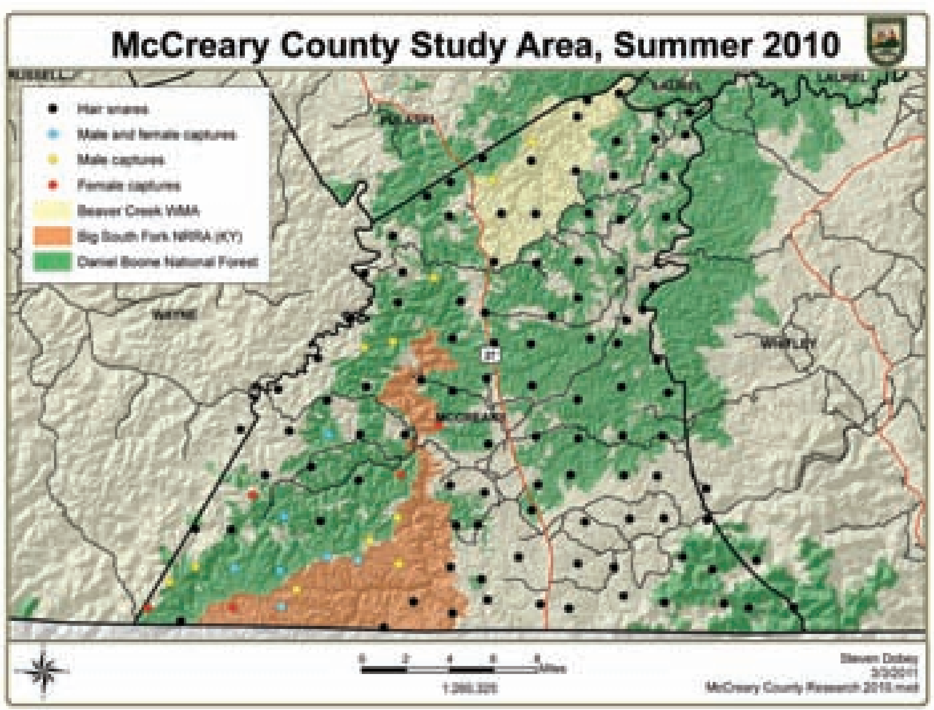
Beginning in June 2010, researchers installed 126 hair snares across the entire county-wide region. Following installation, traps were baited and hair samples were collected at approximate 7-day intervals. At the conclusion of the 6-week sampling period, 159 hair samples were collected from 23 individual snares. Of those, microsatellite DNA analyses identified 29 (16M:13F) individual bears that were captured on 86 (58M:28F) occasions. The geographic distribution of captures, however, was distinctly restricted with 93% (*n* = 54) of male captures and 100% (*n* = 28) of female captures occurring with the southwest quadrant of McCreary County that contains Big South Fork Natural River and Recreation Area. Forthcoming analyses using mark-recapture histories obtained from the genetic sampling will be used to estimate the size and density of black bears on the McCreary County study area.

In addition to noninvasive genetic sampling, researchers also used Aldrich spring-activated snares to capture 17 bears (11M:6F) on 19 (13M:6F) occasions during the first summer of research. Limited cell phone reception in the McCreary County region precluded the use of Argos-enabled GPS radio collars; however, all female bears were equipped with VHF radio collars.

Mean weights for male and female bears captured on the McCreary County study areas were 273.6 (*n* = 11) and 93.3 (*n* = 6) pounds, respectively. Survival of female bears on this study area was 1.0 (*n* = 6), with all radio collared bears still alive in March 2011.

Den work from the 2010-2011 season documented the births of 13 (8M:5F) cubs from 6 litters. Mean litter size for female bears on the McCreary County study area during the 2010–2011 season was 2.2 cubs/female. Den sites were documented as laurel thickets (*n* = 3), brush piles (*n* = 2), and rock cavity (*n* = 1).

Currently, microsatellite DNA comparisons between bears on the McCreary County study area and those further east along Pine Mountain suggest that these are two geographically distinct populations. As such, findings from this study will greatly assist in the successful management of this bear population that continues to expand in range and numbers.



Bear map / KDFWR GIS

Funding Source: *Pittman Robertson (PR) and University of Kentucky*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Mammalia: Taxa specific conservation project.

Conservation Reserve Enhancement Program (CREP) Landscape Monitoring Initiative

Native prairie planting / Zac Danks

John Morgan, Keith Wethington, Shawchyi Vorisek and Gary Sprandel, Kentucky Department of Fish and Wildlife Resources

The Conservation Reserve Enhancement Program is a partnership between the United States Department of Agriculture and the Commonwealth of Kentucky. The state, non-governmental organizations and federal collaboration resulted in an unprecedented grassland restoration project resulting in 101,500 acres almost entirely planted to native grasses and wildflowers. The project area included Grayson, Edmonson, Hart, Green, Taylor, Adair, Metcalfe, Barren, Warren, Allen, Simpson, Logan, and Butler counties. Ultimately, the program represents the most significant grassland restoration project ever completed in Kentucky.

The expansive habitat restorations posed a unique and rare opportunity to assess the landscape-level influence of habitat restoration for local populations of northern bobwhite and a suite of grassland songbirds. In concert with the Farm Service Agency and Mississippi State University, Department personnel embarked on an elaborate experimental designed aimed at understanding how density of restored habitat effects bird density at the local scale (i.e, farm). Randomly selected monitoring points contain between 3 and 9% native grassland restoration within 500 m (547 yards) of the listening point. A control will also be monitored which has less than 1.5% grassland restoration within 500 m and 3000 m (3280 yards) of the point. So, essentially no restoration influences.

The restoration effect will be evaluated by four categories at the landscape scale. The landscape is defined as the land within 3000 m of the sampling point. Therefore, the local or farm level represents a 194 acre area and the landscape a 6,991 acre area. A low landscape influence has less than1.5% grassland restorations at the landscape scale. Two moderate categories included 5-10% and 11-15% restoration. Finally, a high category is defined as greater than 16% restoration.

Over the next 5 to 7 years, Department staff will monitor 254 points each year to determine densities of northern bobwhite and grasslands songbirds. We hope to understand and demonstrate how higher amounts of grassland restoration in a landscape result in higher bird densities at the farm level. Ideally, we will gain a better understanding of habitat restoration thresholds that generate significant bird responses. For example, a restoration that enhances greater than 10% of the landscape will double local bird densities compared to those restorations that enhance only 5% of the landscape. Understanding how much habitat restoration at the landscape scale is needed to generate bird responses will provide the foundation for restoring bobwhite and grassland birds across Kentucky and beyond.

Funding Sources: *Pittman Robertson (PR), Kentucky Department of Fish and Wildlife Resources*

KDFWR Strategic Plan. Goal 1. Strategic Objective 2.

Barn Owl Management Update and 2010 Inventory

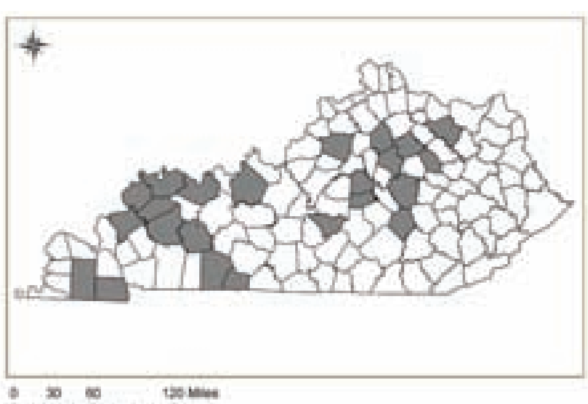
Kate Heyden, Kentucky Department of Fish and Wildlife Resources

Barn Owl young in a KDFWR nest box / Kate Heyden

Due to assumed local declines and conservation concern, the Barn Owl has been listed as a Species of Greatest Conservation Need in Kentucky's State Wildlife Action Plan. Conservation actions for declining species are usually best implemented when the status of the population is known. In the case of Barn Owl, so little was known about its status in Kentucky that KDFWR decided to conduct a statewide inventory in 2010.

Twenty-six confirmed Barn Owl nest locations were documented during the 2010 inventory. Most nests were found on privately owned land, although three were in nest boxes on Wildlife Management Areas. Nests were found in a variety of structures including nest boxes, silos, grain bins, barns, hollow trees, chimneys, and even shooting houses. Nests were scattered throughout much of central and western Kentucky, but none were reported in southeastern Kentucky (Figure 1).

Figure 1: *County distribution of known nesting Barn Owl pairs documented during 2010.*



Once located, the productivity of each nest was monitored where possible. Nests contained 2–8 young. Nesting was typically initiated during spring (March–April) and most young fledged by the end of July. Unexpectedly, nesting activity continued into late summer and fall/winter with five nests documented with young after September. Surprisingly, "double-brooding" or attempting to raise two nests of young in one year was documented at two of these late nests which continued into December.

Suitable nest site availability in the proximity of areas with a large prey base is assumed to be a major limiting factor for Barn Owl populations. KDFWR established a program to install nest boxes in suitable habitat on WMAs and other public lands in 2006. Since 2006, 37 nest boxes have been installed on public lands. Although several nest boxes on public lands have already become active, in 2010 our nest box efforts switched to maximizing the productivity of existing Barn Owl nests - whether they are on public or private land. Productivity may be hindered at unreliable nest sites, perhaps contributing to Barn Owl declines. For example, many nests are discovered when hollow trees are cut down, grain bins are drained, or old barns are demolished. In 2010, KDFWR worked to ensure that all known nesting Barn Owl pairs had a safe and permanent nest site by installing many nest boxes on private lands. Overall, since 2006, KDFWR has installed 75 nest boxes on public and private lands. It is hoped that these efforts will encourage a more stable Barn Owl nesting population statewide.

Funding Sources: *State Wildlife Grants (SWG)*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2. Priority Survey Project #3.

Studying the Movements of Two Young Bald Eagles

A young eagle wearing a satellite transmitter / Bryan Watts, CCB

Kate Heyden, Kentucky Department of Fish and Wildlife Resources; Libby Mojica and Bryan Watts, Center for Conservation Biology, College of William and Mary

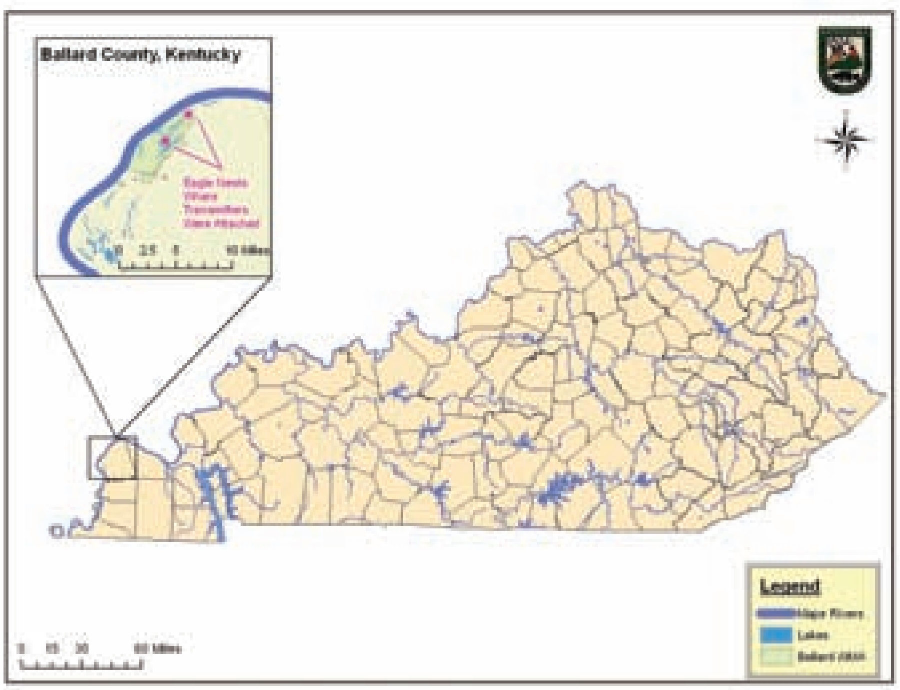
In May 2010, the Kentucky Department of Fish and Wildlife Resources (KDFWR) partnered with The Center for Conservation Biology (CCB) to attach 2 satellite transmitters to nestling bald eagles at Ballard Wildlife Management Area (WMA) in Ballard County, KY. The nestling eagles (one male and one female) originated from two different nests on the WMA. They wear a 70g solar-powered GPS satellite transmitter, attached externally, like a backpack. Solar panels recharge the transmitter's battery and hopefully three to five years of tracking data will be recorded for each of these birds.

The transmitter will not affect the eagle's ability to fly, forage, or breed. Each transmitter, or tracking device, will allow KDFWR to follow the young bald eagle's movements, providing information on dispersal, roosting and foraging patterns, as well as the survival of each eagle.

A website on the project has been completed to allow the public to view up-to-date maps of the eagle's movements and information about the project. Please visit our Bald Eagle Tracking Website at http://fw.ky.gov/baldeagletracking.asp for more details. This is the first study tracking bald eagles using satellite telemetry in Kentucky.

Funding Sources: *US Army Corps of Engineers, Kentucky Department of Fish and Wildlife Resources*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5, Goal 3. Strategic Objective 3. Comprehensive Wildlife Conservation Strategy: Appendix 3.2. Priority Survey Project #3.



Map / KDFWR GIS

Turkey and Black Vulture Invertebrate Nest Association

Bill Lynch, Kentucky Department of Fish and Wildlife Resources

Six vulture nests, one Turkey and five Black Vulture, were sampled for invertebrates in South Central Kentucky. The intent of the sampling was:

1) To determine the invertebrate composition of the nests.
2) Determine whether nest type (abandoned human structure, cave or hallow trees) yields a different suite of invertebrates.

Additional nests will need to be sampled before correlations between nest type and invertebrate population can be determined.

Preliminary organization of the data indicated that the dominate Order of invertebrates were Coleoptera (49%) followed distantly by Diptera (21%). Table 1 shows the remaining breakdown of invertebrate Orders.

Some of the Arthropods found in the nests were unexpected. The Hemiptera (Spittle Bugs) are live plant consumers. It is suspected the Hemiptera either flew or were blown in mass from the adjacent tree canopy or nearby grass fields through the broken windows of this nest site. A small number of Book Lice (Psocoptera) were found in a 20 year old fescue seed bin utilized as a nest by Black Vultures. Book Lice are scavengers of organic matter and fungi. Both of these energy sources were found in abundance in the fescue seed bin nest.

Funding Source: *Kentucky Department of Fish and Wildlife Resources, Western Kentucky University*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

__Table 1:__ Arthropod Orders found in Black and Turkey Vulture nests. Data Collected in South Central Kentucky between June 18 and July 11, 2010.

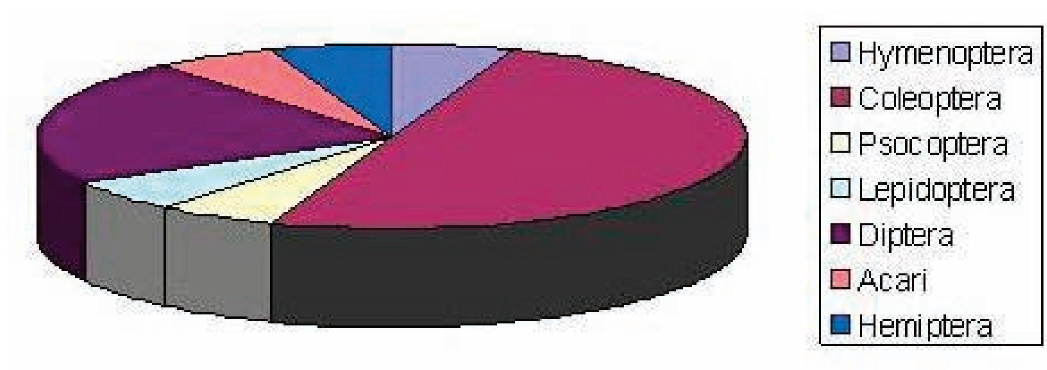
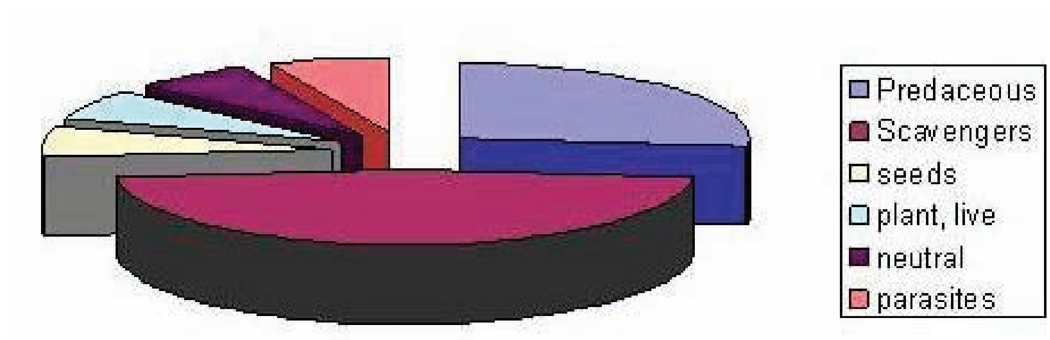


__Table 2:__ Food habits of Arthropod found in Black and Turkey Vultures nest in South Central Kentucky between June 18 and July 11, 2010.



Dale Hollow Lake smallmouth / Lee McClellan

Project Updates

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

Dane Balsman and Jeremiah Smith, Kentucky Department of Fish and Wildlife Resources

In an effort to boost declining license sales in recent years, and increase fishing opportunities, The Kentucky Department of Fish and Wildlife Resources (KDFWR) has expanded the Fishing in Neighborhoods (FINs) program. The FINs program began in 2006 with five lakes in Louisville, Frankfort, and Northern Kentucky, but over the last two years has expanded to 34 lakes in 21 counties. There are now quality fishing opportunities in most large cities across the Commonwealth as well as many smaller cities around the state, courtesy of the FINs program. Many of the lakes in the FINs program are owned by city and county municipalities. As part of a cooperative agreement between KDFWR and local governments, the lake owners have committed to cover 25% of the cost of fish stockings. With the cooperative agreement, KDFWR works with the local parks departments to provide technical guidance, arrange fish stockings, and promote fishing in the park lakes. The KDFWR is also working with local parks departments to host clinics and fishing derbies. A rod loaner program is being implemented at several of these lakes to provide equipment at no cost for rent to novice anglers that may not yet own equipment.

These lakes are conveniently located near large populations of people without the need to travel far from home to find good fishing. In 2011, 124,000 trout and 95,000 catfish will be stocked in the FINs lakes to provide fishing opportunities to lakes that in the past were overfished due to their size and fishing pressure exceeding the resources capabilities. These lakes require routine stockings of catchable-size fish to sustain quality fishing opportunities to a diverse group of anglers. Lakes are stocked up to four times annually with catchable-size catfish (13-16") and three times annually in the cool months (Oct.-Mar.) with rainbow trout (8-12"). Bass and sunfish populations are continually monitored to ensure natural reproduction is meeting the needs of the anglers. Supplemental stockings of bass and bluegill occurred in 2010 at FINs lakes that needed a boost. A standard set of creel limits was established for all FINS lakes to assist in spreading out angler harvest of fish and ensure fishing opportunities can be enjoyed by as many people 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.

Information kiosks have been erected at nearly all of the lakes to disperse information to the public about the program. Additionally, the program has been intensively marketed through press releases, social media, radio, television, license vendors, boat shows, and the KDFWR website. Stocking rates and fishing pressure will be continually monitored. Attitude and creel surveys are ongoing at several FINs lakes. Fishing pressure continues to increase at these lakes and the feedback from local parks and anglers has been very positive. An exploitation study began in the fall 2010 to assess fishing harvest and stocking rates at the FINs lakes. The goals of the FINs program include increasing fishing access, recruiting new anglers and retaining existing anglers, and providing quality fishing opportunities to large population of people close to their homes.

Redear sunfish collected from a FIN's lake / Dane Balsman

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

KDFWR Strategic Plan. Goal 2, Strategic Objective 3.

Use of Flathead Catfish to Reduce Stunted Fish Populations in a Small Kentucky Impoundment

Dane Balsman and Jeremiah Smith, Kentucky Department of Fish and Wildlife Resources

Flathead catfish stocked in A.J. Jolly Lake / Jeremiah Smith

A.J. Jolly Lake, a 175 acre impoundment located in Campbell County, Kentucky has historically contained a sub-par sport fishery for sunfish and largemouth bass. The Kentucky Department of Fish and Wildlife Resources (KDFWR) has tried several alternative management actions in an attempt to improve growth of sunfish and largemouth bass. Management actions have included stocking intermediate-sized largemouth bass to improve recruitment of largemouth bass and stocking of blue catfish to consume overabundant sunfish. Unfortunately, these management actions have proven unsuccessful.

In 2007 the KDFWR stocked 417 flathead catfish that ranged in length from 8.4 to 36.0 inches in an attempt to reduce overabundant sunfish numbers and improve growth of sunfish and largemouth bass populations. An additional 308 flathead catfish that ranged from 3.0 to 25.4 inches were stocked in September 2009. Flathead catfish were obtained from Georgia Department of Natural Resources as part of their non-native flathead catfish eradication program. All flathead catfish were fin-clipped prior to stocking to differentiate from native flatheads in subsequent sampling attempts. The hypothesis of the project was that the stocking of a top-level predator would reduce densities of abundant sunfish. Ultimately, this should help improve size structure and growth rates of sunfish and possibly other sport fish species including largemouth bass and channel catfish.

Prior to 2009, sampling efforts had yielded low numbers of flathead catfish. To ensure that flathead catfish were not being harvested by anglers, a catch and release only regulation was implemented September 1, 2009. This regulation was critical to ensure that the stocked flathead catfish remain in the lake. Sunfish and bass electrofishing are conducted each spring and fall to determine abundance, size structure, age, and growth. Bass catch rates and size structure have improved over the last several years. However, sunfish size structure has continued to decline. The catch rate for bluegill continues to increase, but the number of fish ≥ 6 inches has continued to decline. Sampling for flathead catfish has yielded low numbers of fish. Sampling has been conducted at various times of the year, and with different DC pulse electrofishing settings with little luck. Trot lines and jug lines have also been used for sampling. Little information exists on effective ways to sample for flathead catfish in small impoundments. A total of 31 flathead catfish were sampled in 2010. Of those, 15 fish were from the Georgia stockings and 16 were native flathead catfish. Current sampling techniques are proving ineffective to determine the population size structure of flathead catfish in A.J. Jolly Lake. A final stocking is planned for 2011 to bring flathead catfish to densities to a level capable of having the desired effect.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Brown trout fin clipping / Don Bunnell

Relative Survival, Growth and Susceptibility to Angling of Two Strains of Brown Trout in the Lake Cumberland Tailwater

Dave Dreves and David Baker, Kentucky Department of Fish and Wildlife Resources

Trout (*Oncorhyncus* spp. and *Salmo* spp.) sport fisheries in Kentucky's reservoir tailwaters are unique and important resources. These fisheries were created in reservoir tailwaters having coldwater discharges for either the entire year or a portion of the year. The Lake Cumberland tailwater trout fishery is the largest in Kentucky with more than 75 miles of suitable habitat available throughout the entire year. The Lake Cumberland tailwater receives the largest stocking in the state allocation of trout with approximately 161,000 rainbow (*O. mykiss*) and 38,000 brown (*S. trutta*) trout stocked per year. Growth and survival of stocked trout in the Cumberland River are sufficient to create a high quality trout fishery with opportunities to catch trophy-size fish. Since the brown trout fishery in the Lake Cumberland tailwater is managed as a trophy fishery, it is imperative that stocked brown trout grow rapidly and reach trophy size in as short a time period as possible. Over the last 15 years, the Kentucky Department of Fish and Wildlife Resources (KDFWR) has used regulations and stocking practices to enhance the trout fishery in the Lake Cumberland tailwater. One further way to optimize stocking includes determining the most suitable strain of trout for the physical conditions and management goals of a particular fishery. Characteristics such as movement, mortality, growth and susceptibility to angling are of particular importance.

In 2007, a comparison was conducted between the Plymouth Rock (PR) and Sheep Creek (SC) strains of brown trout stocked in the Lake Cumberland tailwater. Like a previous rainbow trout strain analysis, the PR strain is a more "domesticated" hatchery strain while the SC strain is considered to be relatively "wild". Preliminary results from this study showed that growth was similar between the two strains but the SC strain was much more abundant after one growing season than the PR strain. This same comparison was made again in 2009. This cohort of the two strains performed more evenly. However, the Wolf Creek Dam rehabilitation has resulted in poor water quality conditions in the Lake Cumberland tailwater since 2007 and have affected the comparison. The rehabilitation has also affected the susceptibility to angling component of the research as poor water quality and lower survival of brown trout has made it challenging to catch enough of the marked fish to make comparisons. Another cohort of the two strains will be compared in the future after the rehab has been completed.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Investigation of the Walleye Population in the Rockcastle River and Evaluation of Supplemental Stocking of Native Strain Walleye

Dave Dreves and David Baker, Kentucky Department of Fish and Wildlife Resources

Prior to impoundment in 1952, the Cumberland River was known for tremendous spring runs of walleye (*Sander vitreum*) that provided a very popular regional fishery. This fishery included the Rockcastle River, a tributary to the Cumberland River which enters at what is now the headwaters of Lake Cumberland. Walleye spawning runs at Lake Cumberland rapidly declined in the late 1950's and early 1960's due to a variety of factors including: 1) lack of spawning sites due to the inundation of rock shoals by the impoundment; 2) overharvest of adults during spawning runs; and 3) acid mine pollution of spawning areas. The KDFWR first stocked walleye in the Cumberland River, above Lake Cumberland, in 1973 in attempts to improve the declining walleye fishery in the river. These broodfish were not from rivers in Kentucky, but were fish from Lake Erie origins. The Erie strain walleye evolved in a lentic (lake) environment, thus they generally do not make large spawning migrations up rivers in the spring, but rather spawn within the lake or reservoir. Before advances in genetics, it was erroneously assumed that all walleye were the same and these stocked walleye would perform well in lotic environments. It is now believed that the majority of these walleye, because of their lentic origins, made their way back down into the lake and remained within the reservoir. Fortunately, no Erie strain walleye were ever stocked by the KDFWR above the inundated portion of the Rockcastle River. Consequently, Kentucky's unique strain of walleye still exists in the Rockcastle River, while Lake Cumberland continues to support the Erie strain.

There are two main goals of this study: 1) to assess the genetic origin of the existing walleye population in the Rockcastle River and what, if any temporal and spatial differences exist between the native strain and the Lake Erie strain; and 2) to evaluate the contribution of stocked native strain walleye to the existing population. We collect native strain walleye from the Rockcastle River each spring and transport them to Minor Clark Fish Hatchery to be used as broodfish. These walleye are spawned and resulting fish are reared to fingerling size (1.5 in). Fingerling walleye were marked with oxytetracycline (OTC) prior to stocking. Target stocking rates were a minimum of 20 fingerling/acre (180 fingerlings/mile) for 6 years. We conduct electrofishing surveys during various seasons and locations throughout the 54 miles of the mainstem Rockcastle River to monitor the walleye population. Captured walleye are measured, weighed, tagged, released, and fin clips are taken for genetic analysis. Small individuals are sacrificed and otoliths removed for later examination for OTC marks.

Releasing walleye back into the Rockcastle River / John Williams

To date, all walleye captured in the free-flowing section of the Rockcastle River were found to be genetically pure native walleye. The overwhelming majority of walleye examined were stocked fish, indicating no natural recruitment of native walleye from 2002 to 2007. After 6 consecutive years of stocking, native walleye stocking was discontinued to determine the effect of stocking on the production of natural year-classes. No recruitment has been observed since stocking was discontinued. This research study will conclude in 2012.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Evaluation of White Bass Stocking to Enhance Existing Reservoir Populations

Dave Dreves and David Baker, Kentucky Department of Fish and Wildlife Resources

The white bass (*Morone chrysops*) is native to the southern Great Lakes, Mississippi River basin, and Gulf Coastal drainages and is notorious for having highly variable recruitment. However, the factors affecting recruitment in reservoirs are not yet completely understood. Since the 1980's, many Kentucky reservoirs have experienced severe declines in white bass populations, especially Barren River Lake and Dewey Lake. The cause of the declines in white bass fisheries at either lake are not completely understood, but may be related to a number of factors including increased siltation and deficiencies in physical parameters such as rainfall and/or reservoir inflow during consecutive years.

Typically, resource agencies have expended very little effort managing white bass populations. Realizing that white bass populations were going to undergo variable recruitment and the popularity of the fishery was often seasonal, fisheries managers preferred to live with the cyclic nature of the fishery and focus management efforts on other species. Current angler dissatisfaction over poor white bass populations in Kentucky reservoirs that historically had very popular fisheries has resulted in the need to try to develop new management strategies.

This study aims to determine if the stocking of white bass fingerlings at Barren River and Dewey Lakes can enhance the existing white bass populations and recruit to the reproductive stock, ultimately leading to the restoration of a self-sustaining high quality fishery. Concurrent monitoring of white bass population changes in relation to other biotic and abiotic variables over a number of years will give insight into factors affecting recruitment in Kentucky white bass populations. Beginning in 2003 and continuing through 2007, white bass fingerlings were stocked at a density of 30 fish/acre, and all stocked white bass were marked as fingerlings with OTC (Oxytetracycline) to facilitate mark-recapture population estimates and analysis of growth rates. White bass were sampled, using experimental gill nets, with a preferred minimum catch of 100 age-1 white bass. In addition, spring electroshocking was conducted in the headwaters of each of the study reservoirs to allow the determination of the contribution of stocked white bass to the reproductive stock. Contributions of stocked fish have been variable but in general the contribution was higher at Dewey Lake. Beginning in 2008, white bass fingerlings were no longer stocked at both Barren River Lake and Dewey Lake to allow the monitoring of the impact of no stocking on the production of natural year-classes. The study will continue for an additional 4 years with no stocking to follow the impacts of previously stocked year-classes and evaluate the strength of natural year-classes in the absence of stocking.

White bass / Dave Dreves

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Evaluation of a 15-20 Inch Protective Slot Limit and 5 Fish Creel Limit on Rainbow Trout in the Lake Cumberland Tailwater

Dave Dreves and David Baker, Kentucky Department of Fish and Wildlife Resources

A healthy rainbow from the Cumberland tailwater / Dave Dreves

Prior the last decade, the Kentucky Department of Fish and Wildlife Resources (KDFWR) has attempted to optimize stocking practices in the Lake Cumberland tailwater to increase the quality of the put-and-take rainbow trout fishery. The KDFWR commission passed new regulations for rainbow trout that were implemented in 2004. These regulations were a 15-20 inch protective slot limit with a creel limit of 5 trout per day (only one of which may be over 20 inches). These regulations are expected to protect enough rainbow trout to prevent overharvest and increase quality, yet still allow for a put-and-take fishery.

The primary goal of this project is to evaluate the effectiveness of these more restrictive regulations on rainbow trout in Kentucky's most valuable trout fishery. Additionally, Wolf Creek National Fish Hatchery annually stocks a minimum of 5 strains of rainbow trout, and long-term performance of these various strains in the Cumberland tailwater is unknown. As part of the special regulation evaluation, we differentially batch marked and stocked two rainbow trout strains in the tailwater (one domesticated strain and a relatively wild strain). The goals of the strain evaluation were to determine if there is differential growth and survival, and if the wild strain fish are less susceptible to angling. The survival, growth, and contribution to the population of the two rainbow trout strains are being monitoring by conducting electrofishing surveys for fish previously marked with fin clips.

Changes in the size and structure of the rainbow trout population as a result of the change in size and creel limit will be evaluated by relative abundance estimates from fall nocturnal electrofishing surveys. Periodically during the project, we clipped the adipose fin of a cohort of fish and then determined monthly growth rates of rainbow trout during their first growing season by collecting those fish during monthly electrofishing. This analysis near the end of the study will show if growth rates have slowed down, indicating the trout population has reached the carrying capacity in the tailwater. We also conducted a creel survey in 2006 and 2009 to assess changes in angler catch rates, harvest rates, and pressure in comparison to the 2002 creel survey. Initial results of the strain analysis revealed that the domestic Arlee strain rainbow trout grew more slowly and suffered higher mortality than the McConaughy strain. Creel survey results indicated that the Arlee strain was harvested at a much higher rate.

The Wolf Creek Dam rehabilitation has resulted in poor water quality conditions in the Lake Cumberland tailwater since 2007. These conditions are limiting the rainbow trout population response to this new regulation. This research study will end in 2012.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Tagged sunfish / Dave Dreves

Preliminary Assessment of Bluegill and Redear Sunfish Populations in Small Impoundments

Dave Dreves and David Baker, Kentucky Department of Fish and Wildlife Resources

Department-owned small impoundments in central Kentucky are noted for providing good fisheries for both bluegill (*Lepomis macrochirus*) and redear sunfish (*L. microlophus*). One technique employed by the KDFWR to manage for the bluegill fisheries is to not stock shad in these waters or selectively remove them from impoundments to be managed for sunfish, thus eliminating a potential competitor and leaving bluegill as the primary prey of largemouth bass. The direct and indirect effects of gizzard shad have been shown to affect both bluegill growth and population size structure. The KDFWR maintains the bluegill fisheries in these small impoundments by undertaking shad removal efforts with low concentration rotenone application where shad introductions have occurred and occasional fertilization to increase production. However, no size limits and very limited creel limit restrictions (Cedar Creek Lake and Greenbo Lake) for bluegill have ever been imposed by KDFWR.

When considering harvest restrictions such as length limits, estimates of exploitation, natural mortality, and growth rates are more valuable than other measures such as size structure or angler catch rates. Preliminary data is necessary to calculate growth and mortality rates for bluegill and redear sunfish in these small impoundments before those fisheries could be managed effectively with length limits. Given the absence of data to support harvest restrictions, the goals of this study are to: 1) determine the growth, mortality and exploitation of bluegill and redear sunfish in three central KY impoundments (Beaver, Elmer Davis, and Corinth Lakes); 2) calculate a recruitment index; and 3) monitor the seasonal physicochemical characteristics of each lake and relate these characteristics to population dynamics.

Beginning in spring 2006, we collected bluegill and redear sunfish by electrofishing gear during May in each of the 3 study lakes. A total of 10 fish per inch class were sacrificed and otoliths removed for calculation of age, growth, and mortality. Fall electrofishing was also conducted to calculate relative weights of both species. We visited each lake at least monthly from May through October to monitor physicochemical conditions. Several stations were established at each study lake where we measured monthly temperature/dissolved oxygen profiles at 2 ft. intervals and turbidity was measured with a Secchi disk. We plan to compare the fish population data with the physical observations made at each lake and trends will ultimately be analyzed. A number of bluegill and redear sunfish greater than 6 inches were tagged at Beaver Lake in 2008, Elmer Davis Lake in 2009, and Corinth Lake in 2010 for year-long angler exploitation studies. Bluegill exploitation has ranged from 21 to 36 % and redear sunfish exploitation ranged from 17 to 42 %. These data will then be used to model various regulation schemes to determine if minimum size limits or creel limits can be used to enhance the bluegill or redear sunfish populations in the study lakes and/or applied to other lakes across the state. The expectation is that the conclusions generated by this research will result in increased quality of bluegill and redear sunfish fisheries in small impoundments in Kentucky, thereby leading to increased angler satisfaction.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

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

Dave Dreves and Jason Russell,
Kentucky Department of Fish
and Wildlife Resources

Native walleye from the Upper Barren River / Dave Dreves

Walleye is a freshwater fish native to most of the major watersheds in Kentucky, including the Barren River watershed located in southwestern Kentucky. By the late-1800's, 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 two 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. Biologists later realized that these northern walleye are genetically distinct from native Kentucky walleye; as a result, 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 (e.g. Lake Cumberland). Another walleye stocking attempt (4.15 million walleye fry) in the Barren River occurred in 1966, in response to low population numbers, shortly after the river was impounded in 1964. Since there are no known recent reports of walleye from the Barren River or Barren River Lake, it is suspected that the "northern" strain fry stockings in 1917 and 1966 were not successful and the native population in the river has been lost.

Although portions of the Barren River are impounded, there are approximately 31 miles of unimpounded mainstem of the Barren River above Barren River Lake. The broad goal of this project is to re-establish a reproducing native "southern" strain walleye population to this section of the Barren River. An established population of native walleye in the Barren River will serve as a source of broodstock for potential native walleye restorations in other Kentucky river systems and will create a walleye sport fishery in the upper Barren River. In order to accomplish these restoration goals, beginning in 2007, native strain walleye are collected from Wood Creek Lake and the Rockcastle River in the spring and transported to Minor Clark Hatchery to be used as broodfish. Walleye are spawned and the resulting fry are reared to fingerling size (1.5 in.) in ponds, then stocked in the Barren River in late May or early June. We are using a stocking rate of a minimum of 20 fingerlings/acre (180 fingerlings/mile), and we plan to continue these efforts through 2011. In conjunction with stocking, we assess 24-hour stocking mortality using mesh-lined barrels secured in the river. To monitor and assess stocking success, we sample walleye in the spring at multiple sites using pulse DC electrofishing gear, and a sample of walleye are collected such that weight and length measurements and sex ratios can be recorded. In 2008, we began marking stocked fingerlings with oxytetracycline (OTC) to determine recruitment of stocked fish. We also have been PIT tagging captured walleye so movement and growth rates may be determined. Walleye sampling in the Barren River is slated to continue through 2015 to allow for the reproductive potential of the stocked walleye population to reach a point where natural recruitment is possible and detectable.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

The Evaluation of a 40-in Muskellunge Minimum Length Limit at Buckhorn Lake

Christopher W. Hickey, Kentucky Department of Fish and Wildlife Resources

The muskellunge *Esox masquinongy* is an ecologically and economically important sportfish in many states that have temperate fresh water ecosystems. Management strategies for this species are most often directed towards establishing trophy fisheries through the use of continuous stocking and highly-restrictive regulations. In Kentucky, the muskellunge population at Buckhorn Lake took shape when the KDFWR began stocking the species in 1996. As with many other muskellunge populations in the region, the habitat required for successful natural reproduction is not present, thus its continued existence in Buckhorn Lake relies solely upon the KDFWR's annual stocking program.

In 2003, the goal of establishing a premier muskellunge fishery at the lake led to the implementation of a highly-restrictive regulation that included a 40-inch (in) minimum length limit and 1 fish daily creel limit. This new regulation, the first of its kind for this species in Kentucky, replaced the original 30 in minimum and 2 fish daily limit that was still in place at Kentucky's other reservoir muskellunge fisheries. Although there are many goals for this kind of trophy regulation at Buckhorn Lake, most of the expected benefits were centered on a clear increase in the abundance of large muskellunge (> 30 in), and a boost in the anglers' catch of large fish and their satisfaction with the fishery.

Muskellunge have been monitored at Buckhorn Lake since the first stocking in 1996, which provided reliable data on the fishery while it was still under the original size and creel limits. With the implementation of the new trophy regulation, it was essential to continue with the same sampling protocol. This allowed researchers to attribute any changes to the population to the new regulation. Each year muskellunge were stocked at the same density, and the individual year-classes were marked with a unique fin clip so the age of the fish could be identified without the need to collect otoliths. Annual sampling was conducted via electrofishing in late winter/early spring when length and weight data was gathered from all muskellunge that were collected. Throughout the project, stomach contents were examined on over 200 muskellunge to determine if the new regulation resulted in an increased depredation of other sportfish. Along with the electrofishing, creel surveys were used to determine what impact the new regulations had on the anglers' catch and their level of satisfaction with the fishery.

Musky from Buckhorn Lake / Chris Hickey

Results of this project showed that the muskellunge population at Buckhorn Lake underwent several changes as a result of the trophy regulation. When compared to before the regulation change, there were substantial increases in the abundance of fish that were > 30 and 40 in. The average length of muskellunge that was harvested from the lake had increased from 36 in to 42 in. Examination of stomach contents indicated that the muskellunge did not increase their consumption of sportfish at any time during the project.

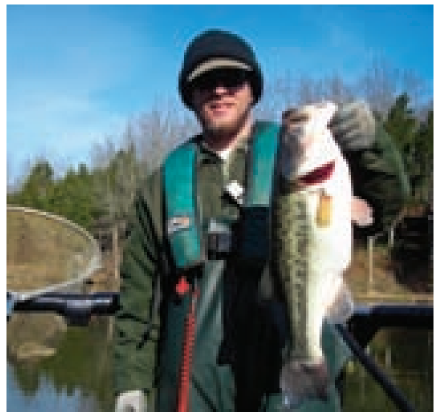
In 2010, Buckhorn Lake's muskellunge population was included in yet another regulation change when it joined up with the two other reservoir muskellunge fisheries in Kentucky, Green River and Cave Run lakes, under a standard 36-in minimum size limit. A final report, which is currently being worked on, will provide a more detailed account of the changes brought on by the 40-in min. length limit and mark the official conclusion to this project. However, a new research project has already started that will monitor any changes that all three reservoir muskellunge populations could experience as a result of the 36-in min. length limit.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Evaluation of a 20-in Minimum Length Limit on Largemouth Bass at Cedar Creek Lake

Christopher W. Hickey and Ryan Kausing, Kentucky Department of Fish and Wildlife Resources



Largemouth Bass from Cedar Creek Lake / Chris Hickey

As the most sought after sport fish in Kentucky, KDFWR often manages black bass populations to give anglers access to a quality bass fishery regardless of where they are in the state. However, even with a number of water bodies that possess what would be classified as very high quality bass fisheries, Kentucky did not have a true "trophy bass" lake. A trophy bass fishery requires many factors to fall into place at just the right time in order to be successful. It was Kentucky's newest reservoir, Cedar Creek Lake, where the KDFWR felt there was the best opportunity for the establishment of such a fishery. The construction of this 784-acre lake was finished in 2002 and it was completely full of water by the spring of 2003. History has shown that a reservoir's productivity is generally highest in the first several years following construction. It was this high productivity and abundant fish habitat that was to help the largemouth bass at Cedar Creek Lake reach its trophy potential. As a result, KDFWR enacted a highly restrictive 20-inch minimum size limit and 1 fish daily creel limit on largemouth bass to promote the Commonwealth's first trophy bass fishery. This research project was developed to monitor the largemouth bass population at Cedar Creek Lake and determine if the restrictive limits helped promote and sustain a trophy status.

The largemouth bass population is sampled via nocturnal electrofishing during the spring and fall. Sampling data provides insight into density, length frequency, size structure, condition, and recruitment success. Additional sampling is conducted in the summer to examine the stomach contents of largemouth bass in an effort to keep track of their diet. As a practice that takes place every few years, a subsample of largemouth bass was collected in the spring of 2010 for age and growth analysis via otolith examination. Also, creel surveys were conducted in 2005 and 2009 to determine fishing pressure and the anglers' satisfaction with the fishery. Additionally, summer electrofishing is used to assess forage quality by collecting data on the density, length frequency, and size structure of bluegill and redear sunfish.

Preliminary results have shown that the restrictive regulations appear to be protecting the largemouth bass as they begin to near the 20-inch mark. The first largemouth bass ≥ 20-inches were sampled in 2006 and their numbers have steadily increased from 2007 through 2009. Recently, the number of largemouth bass ≥ 20-inches declined slightly from 19 in 2009 to 15 in 2010. However, the decrease can more likely to be attributed to normal sampling variation rather than an actual drop in the abundance of trophy largemouth bass. It is unlikely that the decrease will continue because catch rates of largemouth bass just below the minimum length limit were the highest in 2010 when compared to the past 5 years.

Age and growth analysis indicates that it takes 4 years for largemouth bass to reach 15 inches; the length at which they can be harvested in many of Kentucky's other high quality largemouth bass fisheries. This is the same time period to reach 15 inches as was found in the previous age and growth analysis that was conducted in 2007. On average they still grow 3 – 4 inches a year until they reach about 15 inches when length slows down and weight gain increases. Also, just like previous years, stomach content analysis indicates that crayfish and fish, primarily sunfish, continue to be the preferred food item of largemouth bass at Cedar Creek Lake. Sampling has shown the numbers of sunfish have been relatively steady over the past several years and results from 2010 continue to support that trend.

The largemouth bass population will continue to be monitored very closely at Cedar Creek Lake especially as the reservoir continues to age. Fishing pressure has increased several fold since the first years after impoundment and with high satisfaction rates of the bass anglers, it appears that the largemouth bass fishery at Cedar Creek Lake has become extremely popular regardless of whether or not it ever reaches the "trophy" status.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Evaluation of a 12.0-in Minimum Size Limit on Channel Catfish in Kentucky's Small Impoundments

Christopher W. Hickey and Ryan Kausing, Kentucky Department of Fish and Wildlife Resources

In Kentucky, 80-100 public fishing lakes and small impoundments are stocked annually with approximately 150,000 hatchery-reared channel catfish. These annual stockings are necessary to maintain catchable populations of channel catfish, as a result of poor natural reproduction, low survival, and high harvest rates. These channel catfish are commonly stocked at a length of 6.0-12.0 inches (in) and at densities of 10-25 fish/acre. Limited creel data indicates that anglers harvest anywhere between 30% and 63% of the channel catfish during each stocking year. Prior to 2004, there were no size and/or creel limits on these channel catfish, and the small size at harvest and low catch rates that were characteristic at many of Kentucky's small impoundments was a good indication of overharvest. Beginning in 2004, a 12.0-in minimum size limit was implemented at eleven state-owned small impoundments to help improve populations of channel catfish. This research project was developed to measure the effectiveness of the 12.0-in minimum size limit, and determine if it can be used at other small impoundments to improve the quality of the channel catfish fishery.

In this project, four state-owned lakes with the new 12-in minimum size limit were chosen to be monitored for changes in their channel catfish populations as a result of the new regulation. Unfortunately, during the years prior to the implementation of the new size limit, there is very little data concerning channel catfish populations in Kentucky's small impoundments. As a result, two additional lakes that were not among those that had the new 12-in minimum size limit were sampled concurrently as control lakes. The study began by looking at a variety of methods (i.e. gill netting, hoop nets, etc.) to sample channel catfish. Ultimately, tandem hoop nets (a series of 3 hoop nets tied together in a straight line) were chosen as the method to collect the most representative sample for each lake. Channel catfish at all six lakes are sampled every year with five sets of baited tandem hoop nets that are soaked for 72 hours before being checked. At the start of this project, any channel catfish that were collected in the hoop nets were counted, measured, and released back into the lake. In 2010, weights were added to the list of data that was to be collected from each channel catfish. The new combination of length and weight data allows researchers to now calculate the condition of the channel catfish in each lake.

Sampling for the project officially began in 2006, but as with any new gear, it took some time to set up a protocol for the use of tandem hoop nets in the sampling of channel catfish populations. As of 2010, sampling data had already determined that the new 12-in minimum size limit was protecting the smaller catfish too well at two of the experimental lakes. Sampling data indicated that these lakes had abnormally high numbers of channel catfish below the 12-in size limit, which could be either the result of stunted channel catfish growth or stocking rates that were too high for a lake under the 12-in minimum size limit. Consequently, stocking rates of these two lakes are now more than 50% lower than they were when the project started in order to prevent any further stockpiling of channel catfish < 12.0 in. The other two experimental lakes contain channel catfish populations that have been rather stable since the study began with a relative density and length frequency of thriving catfish populations. The control lakes in this project contained catfish populations that would have been expected in lakes with a lot of angling pressure and no regulations to protect the fish. The overall amount of catfish sampled at the control lakes was substantially lower than any of the experimental lakes and the length frequencies of the channel catfish are erratic.

Weight data that was collected during 2010 indicated that the channel catfish in all of the study lakes, with one exception, were found to be in at least "good" condition. The exception was the one lake that recently experienced a pile-up of channel catfish below the 12-in size limit. The condition of the fish in this population was considered to be "fair". Additionally in 2010, a subsample of channel catfish from each lake under the 12-in minimum size limit was collected for age and growth analysis. The otoliths of these fish will be examined in 2011 and will help determine the growth rates for each population and whether stunting is becoming an issue at any of the lakes.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Evaluation of Kentucky's Largemouth Bass Stocking Initiative

Christopher W. Hickey and Ryan Kausing, Kentucky Department of Fish and Wildlife Resources

Stocking is a very common management tool that is used by fish and wildlife agencies throughout the country. In some cases, stocking is the only way to sustain a fish population that does not reproduce on its own, but to a lesser degree it can be used to supplement a population that is experiencing reduced natural reproduction. Supplemental stocking has often been used in Kentucky to enhance largemouth bass fisheries, but limited space at the state's only two hatcheries requires the smart use of its largemouth bass resources. In order to make better use of stocking, it would be ideal to develop a system that could predict the abundance of age-1 largemouth bass before it was too late for resource managers to respond. For example, if the system predicts that a lake will have high numbers of age-1 bass the following spring, then the stocking could be diverted elsewhere and there is less chance of unintentionally disrupting the natural population. On the other hand, if a population has undergone a below average, or poor, spawn, then the system would predict a low abundance of age-1 largemouth bass for the following spring and stocking could be used in the fall to offset these low numbers. Kentucky's Largemouth Bass Stocking Initiative (BSI) attempts to do just that by developing a protocol that successfully predicts which lakes will have a below average number of age-1 largemouth bass next spring by looking at the abundance of age-0 bass during fall samples.

The BSI takes a proactive approach of identifying weak year-classes of largemouth bass. For each of the 34 lakes in the project, historical data is used to understand the specific relationship between the density of age-0 fish in the fall and the density of age-1 fish of the same year class that are sampled the following spring. Two predictive equations and an average year-class strength were developed for each lake using this historical data. The first equation uses the overall age-0 catch rate (CPUE) of largemouth bass in the fall to make a prediction about spring age-1 density. The second equation is very similar, except that it relies only on the fall age-0 CPUE of largemouth bass with a length 5 inches or greater. The regression equation with the lowest p-value was considered more accurate for the lake and was used to predict the density of the year class at age-1. When fish biologists conduct routine fall sampling for largemouth bass, they report the catch rates of age-0 fish to researchers. This value is added to the most accurate equation and the prediction is checked against the average age-1 density for the lake. If the predicted value is above or equal to the average, then that lake is not considered for supplemental stocking. However, if that value is below the average, then it is stocked that fall with largemouth bass fingerlings. The amount of fish that are stocked has varied throughout the project from a low of 2.5 fish/acre to a high of 15 fish/acre; and is based upon how far below average the predicted spring age-1 catch rate is utilizing the predictive equations.

All the largemouth bass fingerlings used in this project receive a specific fin clip to distinguish them from natural fish and to identify what year the fish was stocked.

Since 2005, the BSI has been used to determine where largemouth bass are stocked, and in earlier years of the project, larger, high priority lakes with perennial spawning problems (i.e. Laurel River Lake) received the bulk of the fish. In the fall of 2009, 14 smaller lakes were stocked at higher densities of 10–15 fish/acre. The highest stocking density ever used in the BSI, 15 fish/acre, resulted in more recaptures of stocked fish in 2010 than in any previous spring sampling. Of the 14 lakes that received bass in 2009, only two of them did not report any recaptures. One could not be sampled because of poor sampling conditions and the other was one of the only two lakes that did not get stocked at a density of 15 fish/acre. In the fall of 2010, eight lakes were stocked as part of the BSI, which was a substantial drop from 2009. However, the majority of the lakes in 2010 experienced an above average natural spawn with some lakes even having the highest number of age-0 fish sampled in the past 10 years. Lakes that did receive fingerling largemouth bass were again stocked at 10-15 fish/acre. If the elevated stocking rates, especially the 15 fish/acre, continue to result in more recaptures of stocked largemouth bass during 2011 spring sampling, then the higher rates will likely become the new standard in Kentucky's supplemental stocking program. As the BSI continued from 2005 through 2010, the majority of equations that were used to predict year class strength became more accurate. This increased accuracy should continue as more data is collected. The stronger predictive equations coupled with the ideal stocking density of 15 fish/acre will continue to make the BSI a stronger tool for the management of largemouth bass fisheries throughout Kentucky.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Preliminary Assessment of a Newly Established Blue Catfish Population in Taylorsville Lake

Christopher W. Hickey and Ryan Kausing, Kentucky Department of Fish and Wildlife Resources

In Kentucky, blue catfish contribute to a number of valuable fisheries outside the boundaries of its few major river systems. It was not long ago when several small lakes and reservoirs in Kentucky were first stocked with blue catfish by the KDFWR. A good percentage of the original stockings have since developed into quality sport fisheries with some even exhibiting the potential to produce trophy-sized blue catfish. However, population dynamics of these relatively new fisheries have only recently been studied. Further research is necessary to determine whether restrictive size and creel limits may be necessary to promote further development of blue catfish fisheries in Kentucky and how to best manage these unique resources.

Taylorsville Lake has been regularly stocked with blue catfish since 2002 (intermittent stocking occurred during the late 1990's) and has quickly developed into a high quality fishery. Taylorsville Lake has a large density of forage fish and, at an annual stocking rate of at least 8 fish/acre (approx. 23,000 fish/year), it possessed a blue catfish population that was becoming extremely popular among anglers from all over the state. It was not long before there was a growing concern among resource managers, and the anglers themselves, that the fishery could soon be experiencing issues associated with overharvest. The main purpose of this project was to collect annual data on the blue catfish population at Taylorsville Lake and to determine if management actions were needed to sustain its high quality status while encouraging the development of a trophy component to the fishery.

The project officially began in 2007, but some data that was collected at Taylorsville Lake prior to this indicated that the blue catfish population was doing well with growth rates of 3–5 inches a year. Low-pulse electrofishing was conducted during summer in the upper and lower ends of the lake from 2007 to the present. All blue catfish were counted, measured and weighed each year and the data was used to identify any changes to the fishery over time. In 2008, an angler exploitation study was conducted by tagging 1,000 blue catfish and releasing these fish back into Taylorsville Lake. The exploitation study lasted one year and a reward system was used to encourage anglers to report any tagged fish that were caught. In 2009, a creel survey was conducted to determine fishing pressure, anglers' catch rates, and angler satisfaction with the fishery. Also, a subsample of blue catfish was taken in 2009 for age and growth analysis via the examination of the otoliths.


Blue catfish from Taylorsville Lake / Chris Hickey

The initial sampling in 2007 indicated that the blue catfish population at Taylorsville Lake was in good shape. From both the upper and lower ends of the lake, a total of 590 blue catfish were sampled for a catch rate of 236.0 fish/hour. However, by 2009, the catch rate had decreased to only 119.1 fish/hour, which was reinforced again in 2010 when sampling exhibited the lower catch rate of 116.1 fish/hour. During the exploitation study in 2008, 120 tags were reported by anglers and of those 120 blue catfish, 81% were harvested from the lake. The 2009 creel survey had estimated that nearly 12,000 blue catfish were harvested that year, which is a significant increase from only 2,400 blue catfish that were harvested during the 2006 creel survey. Also in 2009, anglers began to express concern about the decreasing catch rates and the possibility of the over-harvest of blue catfish at Taylorsville Lake. The most recent age and growth analysis showed that growth had declined slightly, however not to a significant degree. The bigger issue was the substantial decline in abundance of blue catfish that were being sampled, and the concerns of the anglers.

By 2010, 100% of the catfish anglers interviewed were in favor of some kind of regulation. This, in conjunction with the results of the exploitation study, decreasing catch rates of blue catfish, and high estimates of harvest, influenced the KDFWR to implement a creel limit of 15 catfish per day/person with only one fish allowed to be over 25 inches. This regulation went into effect in March 2011. Blue catfish at Taylorsville Lake will continue to be stocked and sampled in 2011 as the study moves toward monitoring any changes to the fishery that are brought on by the new regulation.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Evaluation of the Growth of Two Different Stocking Sizes of Blue Catfish Stocked into Three North Central Kentucky Small Impoundments

Christopher W. Hickey and Ryan Kausing, Kentucky Department of Fish and Wildlife Resources

Blue catfish await tagging / Chris Hickey

Blue catfish stocking in some of Kentucky's small impoundments initially began as a possible tool to improve bluegill fisheries. Although blue catfish did not turn out to be the ideal predator to control bluegill populations, they themselves soon became a popular fishery at some of the small lakes where they were stocked. It was soon discovered that the growth rates of these blue catfish populations were erratic. Some populations contained a number of catfish that were same age, but differed in length by as much as 15 inches (in). This large disparity in growth was not easily explained, but there was a possibility that the size at stocking was a factor that influenced how much blue catfish would eventually grow. A review of different research showed very little about the relationship between growth and stocking size for blue catfish in small impoundments. And since it is known that the growth of predator fish does not really start until they are feeding primarily on fish, it was hypothesized that blue catfish that are already large enough to consume the forage fish in these small impoundments when they are stocked may have greater growth potential. The purpose of this project is to determine if the size at which blue catfish are stocked influences their overall growth rates.

In order to address the issue, two distinct size classes (< 10 in and > 12 in) of blue catfish were stocked into three small impoundments at a rate of 10 fish/acre for each size class. These specific lakes were chosen because they already contained blue catfish populations that exhibited the large disparity in growth rates for fish of the same age class. From 2007 to 2009, age-1 blue catfish were stocked annually during the late summer at each lake. All stocked blue catfish received two different marks: a coded micro-wire tag that identified which size-class they were stocked at and a specific fin clip that marked the year that they were stocked. Sampling of blue catfish was conducted throughout the year at the study lakes using low-pulse electrofishing. Any blue catfish sampled were measured, checked for the presence of coded micro-wire, and examined for any fin clips. The abundance and average lengths of each study group of blue catfish were continually monitored to determine if there are any differences that can be attributed to size at time of stocking.

Sampling in 2008 and 2009 found that nearly 80% of the tagged blue catfish collected were from groups that were stocked at the smaller size class (< 10 in). This initially led researchers to believe that the smaller sized blue catfish had better survival rates because they were considered too small to be harvested by anglers. However, sampling efforts in 2010 started to locate more blue catfish that were originally stocked from the larger size class (> 12 in). With more representative data from both size groups of stocked blue catfish, researchers were able to start looking for any differences in growth associated with the size at stocking. Early results have shown that both size groups are growing, but no one size group appears to be doing substantially better than the other. As of 2010, there are still a couple inches separating the two stocking sizes (< 10 in and > 12 in). However, with the oldest groups of blue catfish in this study being only 4 years old in 2010, it may be too early to observe any large difference in growth rates between the two stocking sizes. With the actual stocking for this project completed, more time will be placed on locating and gathering data on stocked blue catfish in 2011. Sampling efforts will be increased substantially and spread out during the seasons with the goal of finding higher numbers of tagged blue catfish than in any previous year of the project.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Impacts of Spawning Habitat Manipulation on Largemouth Bass Year-Class Production in Meldahl Pool, Ohio River

Doug Henley and Nick Keeton, Kentucky Department of Fish and Wildlife Resources

Electrofishing data from previous studies indicated that a relatively poor largemouth bass population exists in Meldahl Pool (Maysville area) as compared to other pools in the river. For example, in previous years, Markland Pool (Cincinnati area) had largemouth bass catch rates that were 2.3 fold greater than those found in Meldahl Pool. In addition, largemouth bass year-class strength was also 2.5 fold greater in Markland than in Meldahl Pool. Young-of-the-year (YOY) surveys indicate that largemouth bass year-class production may be limited by the lack of suitable spawning habitat. Spawning substrates, such as gravel and cobble, in tributaries and embayments have been covered with silt. The occurrence of cover in these embayments has also declined. The possibility exists that largemouth bass spawning success could be enhanced through introduction of high quality supplemental spawning structures and cover. Two embayments received supplemental spawning structures and habitat (Bracken Creek and Big Snag Creek); while 2 other embayments were used as controls with no addition of spawning structures or cover (Big Turtle Creek and Big Locust Creek).

Spawning habitat project / Doug Henley

Approximately 100 supplemental spawning structures were placed in Bracken and Big Snag Creek in 2005 and removed before the spawning season of 2010. Nursery habitat (evergreen trees and blocks) have been placed in each embayment since the start of the study and this activity continues even though the spawning structures have been removed. Each of the four embayments (2 experimental and 2 controls) continue to be monitored each spring and fall with nocturnal electrofishing surveys to evaluate largemouth bass spawning success and year-class strength. Catch rates of different age groups of bass in each experimental embayment indicate that providing artificial nesting structures can enhance recruitment. However, preliminary analysis suggests that abiotic factors such as weather, water levels, and temperature may play a more important factor in determining reproductive success of bass in Ohio River embayments.

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

KDFWR Strategic Plan. Goal 2, Strategic Objective 3.

Ohio River blue catfish / Doug Henley

River Sport Fish Surveys – Ohio River

Doug Henley and Nick Keeton, Kentucky Department of Fish and Wildlife Resources

The Ohio River Fish Management Team is a working group of 6 states that border the Ohio River. The list of states includes Illinois, Indiana, Kentucky, Ohio, West Virginia, and Pennsylvania. Administrators from these states have been working in unison to manage fisheries issues on the Ohio River common to each state. Biologists conduct field surveys annually to monitor select species that are important to each state and its users. The list of species monitored includes black bass, sauger, paddlefish, and catfish.

Population data is collected on target species for a variety of reasons along the length of the Ohio River. All states are concerned with the status of both black bass and sauger because of their importance to sport anglers. Monitoring these fish help each agency and the partnership as a whole to keep track of population trends that may need special actions to ensure their viability over time. Other species such as blue, channel, and flathead catfish are important to multiple user groups. Ohio and West Virginia manage these species as sport fishes, whereas Indiana, Kentucky, and Illinois must split the importance of catfish between sport anglers and commercial fishers. Monitoring commercial catch in the Ohio River has been done since 1999. Collection of population data of each catfish species began in 2004 in the lower reach and in 2009 in the upper reach of the Ohio River. Paddlefish is a species of inter-jurisdictional importance in the Ohio River. The three upper states of Pennsylvania, Ohio, and West Virginia consider this fish a species of special concern. They have programs that stock or protect paddlefish populations. The lower three states allow commercial harvest of paddlefish populations within their reach.

Work will continue in the Ohio River through the auspices of the Ohio River Fish Management Team into the future. This is to ensure that fish issues common to each state are addressed in a uniform manner for the benefit of the resource and the user.

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

KDFWR Strategic Plan. Goal 2, Strategic Objective 3.

River Sport Fish Surveys – Kentucky River

Doug Henley and Nick Keeton, Kentucky Department of Fish and Wildlife Resources

Trophy blue catfish from the Kentucky River / Doug Henley

The Kentucky Department of Fish and Wildlife implemented a percid (sauger and walleye) study along the entire reach of the Kentucky River in the winter/spring of 2002-2003. Several fishery districts were responsible for sampling specific tailwater areas during this period. From that survey, four mid to upper river tailwaters were chosen for further monitoring. The goal of this study is to provide and evaluate the potential to establish a self-sustaining sauger and white bass recreational fishery through time-limited stockings in select pools of the upper Kentucky River. Hybrid striped bass were also stocked to provide an additional game fish species in the Kentucky River.

In 2006, the Kentucky Department of Fish and Wildlife began stocking sauger fingerlings into the Kentucky River. The initial stocking of sauger was 76,320 fingerlings (1.5 – 2.0 inch). Since then a total of 505,912 sauger have been stocked in the Kentucky River. Both white and hybrid striped bass stockings have occurred during this same period with the exception of 2007 and 2010 for white bass. To date, nearly 254,722 white bass fingerlings and 3,099,317 hybrid striped bass fry or fingerlings have been stocked. Sauger fingerlings were marked with oxytetracycline (OTC) at the hatchery and this mark is used to differentiate between stocked and naturally reproduced fish.

For the fifth year, spring nocturnal electrofishing surveys were conducted in 2010 in the tailwaters of Dams 5, 10, 11, and 12. Sauger catch rates this spring (32.8 fish/hour) were 21.5 fish/hour less than those observed the previous spring (54.3 fish/hour). Surveys were also conducted in the Kentucky River in the fall. These surveys consisted of 6 nocturnal electrofishing transects in the upper and lower pool areas below each dam surveyed in the spring. The catch rate of sauger declined from 7.4 fish/hour to 4.1 fish/hour this fall. OTC marks on fish collected indicate that the majority of sauger sampled are stocked fish. Reproduction of stocked sauger at a level necessary to sustain a population has not been documented to date.

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

KDFWR Strategic Plan. Goal 2, Strategic Objective 3.

Ohio River Supplemental Stocking Survey

Doug Henley and Nick Keeton,
Kentucky Department of Fish and Wildlife Resources

Angler concerns over the decline in largemouth bass in the Ohio River became apparent to the Kentucky Department of Fish and Wildlife in 1997. Research was initiated to document largemouth bass populations in specific pools of the Ohio River in an effort to identify causes for these declines. Largemouth bass reproduction is thought to be negatively influenced by a number of variables including water levels, limited spawning habitat, and extreme siltation in spawning areas. Largemouth bass year-class production in the Ohio River appeared to be primarily impacted by habitat degradation through embayment siltation and loss of cover for young bass.

Supplemental stocking in large riverine systems has been shown to benefit largemouth bass population levels. Because these stockings are complex, the exact contribution of these fish depends upon natural production, carrying capacity, and the relative survival of stocked and naturally produced fish. However, stocking appears to be the next logical step in largemouth bass management options for the Ohio River. Supplemental stocking may be a means to enhance year-class strength of largemouth bass in some embayments of the Ohio River. This would in turn result in the improvement in the largemouth bass fishery in that pool, which may result in increased angler satisfaction.

Markland Pool has a total area of approximately 27,874 surface acres of water with an estimated 3,177 acres of backwater areas. In order to attempt to make a difference through supplemental stocking, it was determined that we would stock approximately 2,041 acres (16 embayments) on both the Indiana and Kentucky sides of the river. The surface area of these 16 embayments represents 64% of the total backwater area and 7% of the total area of the pool. A stocking rate of 100 fingerling bass per acre was the target for each embayment. Stocking embayments ranged from 0.5 miles above Markland Dam to approximately 64 miles upstream. A total of 204,925 largemouth fingerlings that ranged from 1.8 and 2.2 in (mean = 2.0 in) were stocked in June, 2010. The 2010 stockings represent the fourth year that fingerling bass were stocked into Markland Pool embayments.

Surveys conducted since 2007 indicate that stocked largemouth bass are contributing to the total bass population in Markland Pool. Catch rates of fingerlings the first fall after being stocked have been high. During the fall of 2007, 74% of the fingerling largemouth bass sampled were stocked fish. Stocked fingerlings contributed between 47% and 62% to the samples observed during the falls of 2008 through 2010.

A survey of select bass tournaments in the Markland Pool was used to estimate the contribution of stocked largemouth bass to the angler. Subsamples of angler catch from 4 bass tournaments were made during the summer of 2010. Two year-classes (2007 and 2008) were represented in the catch and marked (stocked) fish contributed 48% of the bass sampled (22 of 46 fish).

Stocking largemouth bass in the Ohio River / Chris Hickey

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

KDFWR Strategic Plan. Goal 2, Strategic Objective 3.

Black Bass Tournament Results in Kentucky

Christopher W. Hickey and Ryan Kausing, Kentucky Department of Fish and Wildlife Resources

The KDFWR routinely samples black bass populations in reservoirs and small impoundments throughout the state, and conducts creel surveys on a limited number of water bodies. The current databases, particularly with respect to angler success and angler catch rates, are very limited. The high cost of conducting creel surveys for consecutive years to assess relationships between bass populations and angler catch often makes it unfeasible. Thus in 1999, the KDFWR began to tap into another source of angler success and catch rates when it began to collect data from black bass tournaments in Kentucky. This invaluable data on fishing pressure, catch, and success rates of tournament anglers will be used to build a long-term database to monitor trends in black bass fisheries by lake and on a statewide basis. These data, in combination with survey data collected by biologists during routine sampling, will increase the ability of resource managers to explain and forecast changes in black bass population abundance throughout the state. In addition, the summarized data will also be useful to bass anglers when planning future fishing trips and help them understand the normal fluctuations (small increases or decreases) that occur in bass populations.

At the onset of this study, researchers sent packets containing information about the project to bass clubs and other known tournament organizers throughout Kentucky. Over time, an online system of scheduling tournaments and reporting catch data has made the process much more efficient. Participation in the project has grown significantly since its inception because of information passed on by tournament organizers and the ongoing efforts of researchers. Tournament data is analyzed at the end of each year after reminders are sent out to anglers who scheduled a tournament. Catch data is analyzed in such a way that it provides tournament anglers with invaluable information and still gives resource managers further data on the black bass fisheries in their lakes and rivers. These results are published in a report every year that is mailed to all participating tournaments. The annual reports are also made available to the public via the KDFWR's website.

In 2010, some major changes were made to what type of catch data is reported by tournament directors. This was the first time that any changes were implemented since the inception of the project. The idea behind these changes was to reduce the amount of time it took to collect weights on the larger bass and increase the accuracy of the results by separating out the different types of tournaments. In the past, individual and team (2 anglers fishing for 1 creel limit) tournaments were treated the same way. By reporting these tournament formats differently, researchers are able to increase the accuracy of the results by treating teams like a single unit rather than two individual anglers. Since nearly 77% of all bass tournaments in 2010 were comprised of a team format, these changes should have a major impact on the tournament data from this year and many more to come.

The number of tournaments participating in the project has generally increased each year from the start, and in 2010, a new high of 376 tournaments reported their catch data. This is a substantial increase from the first year of the project in 1999, when only 110 tournaments participated. In 2010, 59% of all scheduled tournaments reported their catch data, which was just shy of the highest reporting rate and an excellent indicator of the project's popularity considering that participation is voluntary. Tournament catch data was reported from 33 different water bodies throughout Kentucky. From the 376 tournaments that reported catch data, it was determined that 10,739 angling-units (individual anglers + teams) brought in 22,009 bass that weighed a total of 52,332 lbs. The number of bass caught by tournament anglers/teams decreased by 2.6% from 2009 when 22,587 bass were caught, however this is an extremely nominal decrease considering that bass populations naturally fluctuate from one year to the next. The mean winning weight for a tournament in 2010 was 13.11 lbs, which was also down from 13.40 pounds in 2009. The highest winning weight for a 1-day tournament in 2010 was 27.7 lbs at Kentucky Lake and the biggest bass caught in a tournament was 8.56 lbs from Lake Barkley. Tournament data can be analyzed in several different ways and can be used effectively to identify trends in angler catches at several popular tournament lakes and rivers throughout Kentucky. Because of its popularity with tournament anglers and the importance of the expanding database, this project will likely convert to a long-term program that will always be a good tool for both resource managers and bass anglers alike.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Status, Life History, and Phylogenetics of the Amblyopsid Cavefishes in Kentucky

Benjamin M. Fitzpatrick and Matthew L. Niemiller, University of Tennessee
KDFWR Contact: *Ryan Oster*

Spring Cavefish / Matt Niemiller

Over 95% of subterranean species in North America are considered vulnerable or imperiled, mainly because of habitat degradation and restricted geographic ranges. Unfortunately, data on the distribution and status of cave-obligate species is incomplete or lacking entirely, making conservation and management decisions difficult. Additionally, species with large distributions are often thought to represent species complexes, consisting of multiple, morphologically indistinguishable species. Therefore, a need exists to document subterranean diversity, diagnose cryptic lineages, and identify threats that impinge upon the continued survival of these species.

Three species of Amblyopsid cavefishes occur in Kentucky: Spring Cavefish (*Forbesichthys agassizii*), Northern Cavefish (*Amblyopsis spelaea*), and Southern Cavefish (*Typhlichthys subterraneus*). Although these species have been known to science since the early 1840s, little is known about the demography and persistence of local populations and the systematic relationships among species and among populations within species. Here we investigate the status, distribution, ecology, and threats to populations of these cavefishes. In particular we are conducting surveys and status assessments for each species within the state including both searches of historic and new localities, while obtaining life history data and acquiring tissue samples for genetic analyses. We also are using molecular techniques to investigate cryptic diversity, particularly in *Typhlichthys*, where preliminary data now suggest the existence of two undescribed species that are unique to Kentucky. Finally, we are conducting surveys and collecting specimens of invertebrate cave organisms to determine species distributions and community associations.

Surveys over the past year have focused on determining the status, distribution, and abundance of the Spring Cavefish in surface springs, spring runs, and streams in central and western Kentucky. A spring and spring run in Warren County that has been the subject of repeated research and surveys over the past 50 years continues to support a large (>10,000 individuals/hectare) population of Spring Cavefish despite significant agricultural development in adjacent habitat during the last 20 years. In March 2009, the U.S. Fish & Wildlife Service and KDFWR issued cave advisories to slow the spread of White Nose Syndrome afflicting millions of bats in the Northeast United States. The closing of caves restricted field sampling in 2009 and 2010. This research will provide KDFWR with important data regarding the status, distribution, life history, and genetics of these species. In addition, data acquired on other cave fauna can also be used when making conservation and management decisions.

Funding Sources: *State Wildlife Grant (SWG), University of Tennessee*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi: Taxa specific research project #1.

Alligator Gar Propagation and Restoration in Western Kentucky

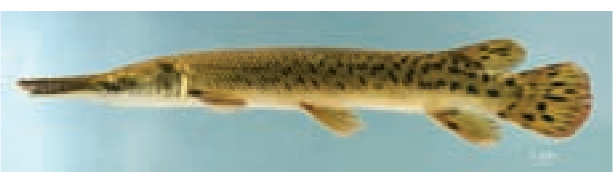
Steve Marple, Matt Thomas, and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources

The alligator gar (*Atractosteus spathula*) 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 size of an alligator gar is 9 feet, 8 inches. This specimen weighed approximately 302 lbs. 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, and lower Cumberland and Tennessee River systems.

Little is known about the biology and habitat of this species in Kentucky and throughout the majority of its native range. In its southern range, the alligator gar typically inhabits 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 occupied sluggish pools, backwaters, and embayments of big rivers and larger reservoirs in western Kentucky. Female alligator gar tend to grow larger than males and reach sexual maturity at 11 years and live in excess of 50 years. Males reach sexual maturity at 6 years and live up to 26 years.

Sightings of alligator gar in Kentucky have been tied to five areas. These areas include the Cumberland River (3 miles below Dycusburg in 1925), the Ohio River at Shawnee Steam Plant (1975), the mouth of the Ohio River (Ballard/Carlisle County), the mouth of Bayou du Chein (Fulton County), and Kentucky Lake at Cypress Creek embayment (Calloway County, 1977). 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.

The last alligator gar to be verified in Kentucky was in 1977 when a dead specimen was found floating in Kentucky Lake near the Cypress Creek embayment. 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. Annually, the KDFWR will receive alligator gar fry from the Private John Allen National USFWS Fish Hatchery. These fry will be reared at both the Pfeiffer Fish Hatchery and Minor Clark Fish Hatchery prior to being released into the wild. Alligator gar stocking sites will be those areas that have historically contained alligator gar and which still provide suitable habitat for optimal survival of alligator gar.



Juvenile alligator gar / Matt Thomas

In 2009 and 2010, a total of 4,726 and 8,851, alligator gar were stocked by the KDFWR, respectively. In 2009, Pfeiffer Fish Hatchery produced 4,476 gar, while Minor Clark Fish Hatchery produced 250 gar. In 2010, Pfeiffer Fish Hatchery produced 5,729 gar, while Minor Clark Fish Hatchery produced 3,122 gar. Size at stocking ranged from 7.3 to 13.6 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 Chein; (9) Mayfield Creek; (10)Ballard WMA; (11) Barlow Bottoms WMA; and (12) Doug Travis WMA. Sampling in September 2010 was successful in collecting an individual in the Clarks River. In 2010, Murray State University began an in-depth telemetry evaluation within the Clarks River. An additional twenty alligator gar were implanted with telemetry tag for the project. Preliminary results show sixteen of the twenty fish are still being actively tracked. The telemetry project will continue in 2011. This project is being funded in part by the State Wildlife Grants (SWG) Program.

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

KDFWR Strategic Plan. Goal 1, Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2; Class Actinopterygii and Cephalaspidomorphi: Priority Research Project #8.

Distribution, Habitat, and Conservation Status of Rare Fishes in Kentucky

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

Species of Greatest Conservation Need (SGCN) were recognized in the Kentucky Wildlife Action Plan (Kentucky Department of Fish and Wildlife Resources, 2005), based on levels of endemism, lack of knowledge of current population status, distribution, and life history characteristics, and potential importance as hosts to rare mussel species. Many fish species on this list are also included on the current List of Rare and Extirpated Biota of Kentucky (Kentucky State Nature Preserves Commission, 2005), as well as five species listed by the U.S. Fish and Wildlife Service as threatened or endangered. In 2010, the Kentucky Wildlife Action Plan was revised for the first time since its inception in 2005. Of the state's 241 native fish species, the Plan identifies 68 as in need of conservation action.

Within the political boundaries of Kentucky, a large portion (48% or 30 species) of fish SGCN are either entirely distributed or have the largest portion of their distribution west of the Green River basin. More than 80% of the available records for these species (based on vouchered specimens) are now more than ten years old, justifying the need for new surveys to determine the current status of populations. Periodic surveys at fixed locations within a species range are also necessary to assess population trends over time. Beginning in 2007, historic localities for selected fish SGCN from western Kentucky were surveyed to document current distribution and abundance of populations and habitat conditions.

The middle and upper Cumberland River drainage supports one of the most diverse and unusual assemblage of fishes in Kentucky, including 21% (13 species) of fish SGCN. Sampling in the South Fork Cumberland River drainage and Pitman Creek began in 2005 to evaluate the current distribution and status of the Sawfin Shiner (*Notropis* sp. *cf. spectrunculus*). In 2009, sampling began in portions of Buck Creek and Rockcastle River to evaluate the taxonomic status and distributional limits of the Striped Darter (*Etheostoma virgatum*). Also in 2009, a collaborative effort was initiated between Kentucky Department of Fish and Wildlife Resources, U.S. Fish and Wildlife Service, and Kentucky State Nature Preserves Commission to survey the upper Cumberland River drainage (above Cumberland Falls) to evaluate the current distribution and status of the Cumberland Arrow Darter (*Etheostoma sagitta sagitta*).

Sample localities for species of conservation need were chosen based on known historic records and other locations where habitat conditions might support those species. Field sampling was conducted between 1 August 2009 and 31 July 2010, using a backpack electrofisher, dip nets, and a 6 X 10' and 6 X15' (3/16" mesh) seines. At each site, all microhabitats within a 100-200m reach were worked thoroughly to ensure a representative sample. Additional emphasis was placed on specific habitats known to support the targeted species. 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. In Palustrine Systems (e.g., oxbows, wetlands, ponds), only seines and dipnets were used. Most fish collected were identified on site, enumerated, and released. A limited number of specimens were retained as vouchers that were fixed in 10% formalin, then transferred to 70% ethanol and archived in the Southern Illiniois University Ichthyological Research Collection. Species identification, gender (when possible), total lengths (when >20 individuals), and habitat condition were recorded and compared with previous records. Digital photographs were also taken to document species and habitats at all sample sites. Habitat variables are correlated with presence/absence and abundance data to assess levels of imperilment of populations of each species. Species distribution, abundance, and habitat data collected through this work are being used to inform implementation of conservation measures and identify suitable fixed long-term monitoring sites supporting healthy populations of fish SGCN.

Funding Sources: *State Wildlife Grant (SWG)*

Comprehensive Wildife Conservation Strategy: Appendix 3.9, Class Actinopterygii and Cephalaspidomorphi. Priority monitoring needs by taxonomic class (p.1). Establish protocols, schedules, and sites for long-term population monitoring to assess status and trends for priority species.

Description and Geography of Restricted Range Kentucky Fish Endemics

Lisa J. Hopman and Brooks M. Burr, Southern Illinois University Carbondale
KDFWR Contact:
Matthew Thomas

Stonecat (Noturus flavus)*, Cumberland River form / Matthew Thomas*

The Stonecat (*Noturus flavus)* is one of the most widely distributed members of the genus *Noturus*, commonly referred to as madtoms (family Ictaluridae). This species is found throughout Mississippi River tributaries ranging from southern parts of Canada to northern Alabama and from Montana to Vermont. In Kentucky, the Stonecat is restricted to the eastern half of the state with occurrences in the Ohio River, Licking River, Kentucky River, Salt River, and Cumberland River drainages. Madtoms can be distinguished from other catfishes in Kentucky by having an adipose fin that is joined to, or slightly separated from the caudal fin. The Stonecat is distinguished from other madtoms by its gray-brown coloration, posterior premaxillary tooth patch extensions, and pale marking at posterior dorsal fin base.

Preliminary observations, including pigment pattern scoring and body shape analysis have revealed diagnostic differences between Cumberland River and Kentucky River drainage (Ohio River basin) populations of Stonecat. A pale, small-eyed form has thus far been found to occur in the main channel of the Mississippi River from Cairo, IL, to the mouth of the Missouri River, and in the Missouri River upstream to Kansas City, Missouri. Whether the small-eyed form occurs in the Mississippi River below the mouth of the Ohio River is uncertain. The Stonecat population occurring in the Cumberland River drainage and part of the Tennessee River drainage have a unique color pattern on the top of the head that is absent in other populations throughout the Mississippi River basin. The Cumberland River Stonecats also appear more dorso-ventrally flattened anteriorly.

The primary objective of this research is to determine patterns of intraspecific variation in the Stonecat and the extent to which the Cumberland and Tennessee "upland" morphotype differs from other Stonecat populations. Thus far, 30 specimens of *Noturus flavus* from the Kentucky River drainage and 30 specimens of *Noturus flavus* from the Cumberland River drainage were obtained from the Southern Illinois University Carbondale Fluid Vertebrate Collection (SIUC FVC) for morphological analyses. To characterize body shape, 36 interlandmark measurements were taken with digital calipers to 0.1 mm precision. Dorsal head pigment and pelvic fin melanophore patterns were also scored using the categories created for this project. A preliminary analysis of body shapes using Principal Component Analysis (PCA) between the two morphotypes revealed a considerable degree of divergence, which emphasized the more flattened body of the Cumberland/Tennessee drainage specimens relative to Kentucky River drainage specimens.

Attempts will be made during the next year to obtain additional specimens for morphological and genetic data. Ultimately, the results of this analysis will determine whether formal recognition of the upland morphotype as a distinct species is warranted.

Regional patterns of variation exemplified by the Stonecat can be used to better understand processes that drive endemism in riverine fishes. Such information will help conservation managers identify and protect areas that are "hotspots" for diversification.

Funding Source: *State Wildlife Grant (SWG); Southern Illinois University Carbondale.*

KDFWR Strategic Plan. Goal 1, Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2; Class Actinopterygii and Cephalaspidomorphi: Priority Survey Project # 2.

Young Cumberland Darters being prepared for release / Matt Thomas

Propagation and Reintroduction of the Cumberland Darter *(Etheostoma susanae)* in the Upper Cumberland River Drainage.

Matthew Thomas and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources; Crystal Ruble, Patrick Rakes, Melissa Petty, and J. R. Shute, Conservation Fisheries, Inc.

The Cumberland Darter, *Etheostoma susanae*, has a limited range in the upper Cumberland River drainage, most of which is in Kentucky. A proposed rule is currently in review to federally list this species as endangered, because of recent range curtailment and fragmentation resulting from habitat degradation. Conservation Fisheries, Inc. (CFI), with support from Kentucky Department of Fish and Wildlife Resources (KDFWR), is developing captive propagation protocols for reintroduction of this species into streams within its native range to restore populations that have been extirpated. Because of the apparent rarity of this species, captive propagation and reintroduction is considered an appropriate tool for its recovery and eventual delisting. Artificially propagated individuals are being released within the watershed from which brood stock are taken, to avoid mixing potentially unique evolutionary lineages. Reintroduction sites are being chosen where habitat conditions are suitable and there is some level of protection (e.g., within wildlife management area or national forest boundaries). Survivability and movement patterns of released fish will be assessed through mark-recapture methods and through periodic monitoring using non-invasive methods, including visual census techniques.

On December 18, 2008, a total of 31 individuals were collected as broodstock from Barren Fork, Indian Creek watershed, in the upper Cumberland River basin. By the end of July, 2009, 60 juveniles were alive and being maintained in six 20 gallon tanks. These individuals were marked with visible implant elastomer (VIE) tags and released into Cogur Fork (Indian Creek-upper Cumberland basin) on August 25, 2009. On September 22, 2010, a total of 335 individuals were released into Cogur Fork. A week or so prior to release all the fish were marked with a visible implant elastomer tag (N=187 green, dorso-lateral right side of dorsal fin; N=148 green, dorso-lateral left side of dorsal fin) at CFI. The left-tagged fish were released in the downstream reach, which included the upper portions of the 2009 release reach (~150-250 m above KY 1045). Right-tagged individuals were stocked further up, ~350-450 m above KY 1045. A follow-up survey took place on November 9, 2010 with approximately 15 percent of individuals recaptured. Individuals displayed an overall trend of moving upstream with a minimal distance of 50 m and a maximum distance of 700 m. A single individual from the 2009 stocking was captured and was 61 mm in total length. Four unmarked individuals were also captured showing evidence of native individuals that immigrated into Cogur Fork from Indian Creek or a lack of tag retention. Another attempt at reintroducing individuals in Cogur Fork is anticipated for late summer 2011, depending on success of spring captive spawning efforts. Follow up surveys will also continue in 2011.

Funding Sources: *State Wildlife Grant Program (SWG), Conservation Fisheries, Inc.*

KDFWR Strategic Plan. Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Actinopterygii and Cephalaspidomorphi: Tax specific research project #1.

Propagation and Reintroduction of the Kentucky Arrow Darter *(Etheostoma sagitta spilotum)* in the Upper Kentucky River Drainage

Matthew Thomas and Stephanie Brandt, Kentucky Department of Fish and Wildlife Resources; Crystal Ruble, Patrick Rakes, Melissa Petty, and J. R. Shute, Conservation Fisheries, Inc.

Arrow darter release / Patrick Rakes

The Kentucky Arrow Darter, *Etheostoma sagitta spilotum*, has a limited range in the upper Kentucky River drainage, all of which is in Kentucky. Recent analyses of morphological and genetic data have shown that *E. s. spilotum* and *E. s. sagitta* (Cumberland River drainage) represent distinct evolutionary lineages and should be treated as separate management units for conservation management purposes. A status survey of *E. s. spilotum* in the Kentucky River basin has shown that populations have declined considerably during the past two decades. Kentucky Arrow Darters were detected in only 29 of 50 historic streams sampled in 2007 and 2008. This has led the U.S. Fish and Wildlife service to consider this taxon as a candidate for listing as threatened or endangered. Conservation Fisheries, Inc. (CFI), with support from Kentucky Department of Fish and Wildlife Resources (KDFWR), is developing captive propagation protocols for reintroduction of the Kentucky Arrow Darter into streams within its native range to restore populations that have been extirpated. Reintroduction sites are being chosen where habitat conditions are suitable and there is some level of protection (e.g., within wildlife management area or national forest boundaries). Survivability and movement patterns of released fish will be assessed through mark-recapture methods and through periodic monitoring using non-invasive methods, including visual census techniques.

Two gravid adult female Kentucky arrow darters and a smaller subadult were collected on 5 March 2010 from Big Double Creek, Clay County, Kentucky, near where the currently held brood stock were collected in 2008 and 2009. Active spawns were observed among the captively overwintered arrow darters after a male was introduced on 10 March. As observed in 2009, the female would select an area of fine sand and bury in it. The male would mount beside her and a brief vibration would take place where they would bury together deeper into the substrate and then exit. This happened multiple times throughout the day. After the end of these spawning activities and the observed termination of all females' receptivity (and battering by the male), the male was removed to allow the females time to recover. After spawning, most eggs were allowed to remain in situ to continue development undisturbed.

March 29 marked the first day of the appearance of larvae in the passive collection tub, but by 7 April only nine larvae had been captured by the set-up. This strongly suggested either very low numbers of eggs being deposited by the females, or that egg and yolk-sac larval survival was poor compared to 2009. We initially suspected the latter and that perhaps it might have been due to the new fine sand substrate becoming too compacted and inhibiting egg incubation, larval hatch, and/or passive collection.

Egg collections were performed and total passive collection of Kentucky arrow darter larvae remained low compared to the 2009 season.

Seining for darters in Big Double Creek / Stephanie Brandt

From the 25 eggs that hatched and 41 larvae captured, 32 survived to the early juvenile stage. Of these, 19 subadult fish remain. Most of these few Kentucky arrow darters that were produced will be released spring 2011 to Sugar Creek, Leslie County, Kentucky to continue efforts to restore the species to that stream. All the fish have been marked with a Northwest Marine Technologies elastomer tag (green, dorso-lateral right side of dorsal fin) in preparation for release. A portion of at least the females may be retained to add to the breeding population at CFI dependent upon the success of efforts to collect additional wild brood stock.

The causes behind the poor captive production observed this year are difficult to confidently explain. With the March-collected females, the large difference between the water temperature in the wild and that in the CFI facility, combined with a quarantine period, seemed to result in post-spawning condition of the fish with likely re-absorption of eggs and loss of receptivity. The four captively conditioned females spawned, but it was impossible to determine whether and how much all four contributed, and whether the low larval numbers collected were due to low egg production by the females or low survivorship of eggs and larvae in the suspect fine sand (which we have replaced for future efforts). We suspect both factors may have contributed and that the captively conditioned fish did not reach as high condition as those in the wild, whether due to temperature and photoperiod or nutritional issues. Finally, we have recently observed that even when held in same-sex groups, the females are highly territorial to one another, with one or several or every individual exhibiting ragged fins and wounds from fighting and a resulting decreased physiological condition. Instream territories for both sexes of this species may simply be larger than any of our aquaria, and forced captive confinement and exposure to the stress of (a) nearby conspecifics(s) may require individual isolation for optimal growth and conditioning in our facility. We are implementing tests of this hypothesis for efforts in 2011.

Despite monthly follow-up survey attempts, no tagged fish were recaptured, suggesting that either they did not survive or moved beyond the area of stream surveyed. Another attempt at reintroducing individuals in Sugar Creek anticipated for late summer 2011, depending on success of spring captive spawning efforts.

Arrow darter courting / Conservation Fisheries Inc.

Funding Source: *State Wildlife Grant Program (SWG), Conservation Fisheries, Inc..*

KDFWR Strategic Plan. Goal 1, Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2; Class Actinopterygii and Cephalaspidomorphi: Taxa specific research project #8.

Lake Sturgeon Restoration in the Upper Cumberland River Drainage in Kentucky

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

The Lake Sturgeon is considered critically imperiled in Kentucky, where it is currently limited to the Ohio and Mississippi rivers. In 2007, the Kentucky Department 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.

Since 2007, fertilized eggs have been obtained annually from the Wisconsin Dept. of Natural Resources taken from upper Mississippi basin stock (Wisconsin River). These eggs are hatched at the Pfeiffer Fish Hatchery in Frankfort, KY, and the young are reared to an approximate average of 7.5-8.5 inches total length. Since spring 2008, young Lake Sturgeon have been released annually at two locations in the upper Cumberland River drainage. The Cumberland River at the mouth of Laurel River received 959 fish (average 7.4-8.5 inches) in 2008, 2,004 fish (average 7.5 inches) in 2009, and 4,539 fish in 2010 (average 5.5-7.8 inches) . The Big South Fork Cumberland River at the Alum Creek access area received 716 fish (average 7.4 inches) in 2008, 1,973 fish (average 7.5 inches) in 2009, and 4,063 fish (average 5.5-7.8 inches) in 2010. Young Lake Sturgeon were 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, and left anterior scutes 3-4 for 2010. Local print media (Times Tribune, Corbin, KY) and Corbin High School students have been present at the Lake Sturgeon release events. Kentucky Afield television has also featured the reintroduction effort for this rare species in the Cumberland River.

Lake Sturgeon tanks at hatchery / Matthew Thomas

Five reports of Lake Sturgeon captured by anglers were received in 2009 and 2010, all of which were in the upper reaches of Lake Cumberland (mouth of Buck Creek and near Jasper Bend). Active and passive sampling procedures aimed at recapturing stocked Lake Sturgeon to estimate survivability and movement patterns will commence in 2011.

Juvenile Lake Sturgeon / Matthew Thomas

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2; Class Actinopterygii and Cephalaspidomorphi: Priority Research Project #8.

Genetic Characteristics of Restored Elk Populations in Kentucky

2009 Bull Elk Hunt / Photographer unknown

Virginia Dunn, Steve Demarais and Bronson Strickland, Mississippi State University; Randy DeYoung, Texas A&M University – Kingsville; Tina Brunjes, Kentucky Department of Fish and Wildlife Resources

Eastern Kentucky currently has a thriving elk (*Cervus elaphus*) population, thanks to restoration efforts by the Kentucky Department of Fish and Wildlife Resources (KDFWR) begun in 1997. Retention of genetic diversity is important to the success of wildlife populations, including elk. Genetic diversity is important to individual and population survival, adaptiveness, growth and reproductive potential. Future management decisions, such as hunting season regulations, need to be made with the genetic structure of the population in mind.

The KDFWR and Mississippi State University began a project in 2008 to evaluate the genetic makeup and physical characteristics of the eastern Kentucky elk herd. During fall and winter of 2008 and 2009, biologists, guides and hunters sampled tissue or hair and body and antler measurements from 373 harvested elk. We will use DNA taken from the tissue and hair samples to evaluate the genetic makeup of the elk across the restoration area and compare this to their source populations in western states. Comparing physical measurements allows us to evaluate the health of the population as it relates to genetic potential in restored and source populations.

A preliminary genetic analysis shows eastern Kentucky elk with high levels of genetic diversity throughout the restoration zone. Heterozygosity, or the characteristic of having two different forms of a certain gene, is an indicator used by geneticists to evaluate the genetic diversity in elk and other wildlife. Heterozygosity values can range from a low of zero to a high of 1, and the eastern Kentucky elk population has a fairly high average of 0.67. There is also indication of 2 genetically differentiated populations of elk within the restoration zone. This may change in the future, but it is important to document it at this stage of the restoration. A preliminary analysis of physical comparisons shows that eastern Kentucky elk are larger than some of their source state elk. Female elk in Kentucky were taller at the shoulder compared to females in Arizona, New Mexico and Oregon. Bulls in Kentucky have longer main beams than in New Mexico. By the end of summer of 2011, the final analysis will be complete and this information will allow the KDFWR to make future management decisions that will promote elk population health.

Genetic labwork at the Caesar Kleberg Wildlife Research Institute at Texas A & M University / Renee Keleher

Funding Source: *Pittman Robertson (PR) and Mississippi State University.*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Quail and Grassland Bird Response to Production Stands of Native Warm-Season Grasses

Andrew West, Patrick Keyser and David Buehler, University of Tennessee; John Morgan, Kentucky Department of Fish and Wildlife Resources; Roger Applegate, Tennessee Wildlife Resource Agency

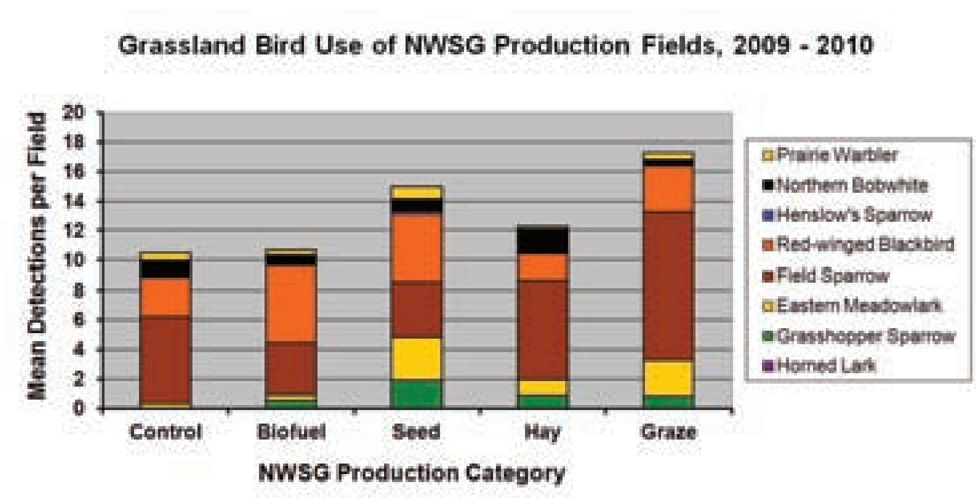
Grassland birds have declined more than any other guild of birds in the US. Much of this decline is attributed to the loss and fragmentation of grasslands. Urbanization, row crops, and non-native pastures now dominate the landscape that prairies once occupied. Despite substantial efforts to restore grassland habitat under the auspices of the Conservation Reserve Program (CRP), grassland bird populations have continued to decline. This may be due to the small amount of the landscape directly impacted by CRP. Other uses of native warm-season grasses (NWSG) such as, forage (grazing and haying), biofuel, and seed production have the potential to substantially increase NWSG on the landscape through market-based incentives provided to the landowner. Although the effects of such production fields on grassland birds have been examined in the Great Plains, comparable work in the eastern US is almost non-existent.

Therefore, this project examined grassland bird responses to production stands of NWSG in Kentucky and Tennessee during the 2009 and 2010 breading seasons. Treatments that we evaluated included control (fallow), forage (grazing and haying), seed, and biofuel production fields of NWSG. We monitored 102 fields across three sites: Hart (seed production and control) and Monroe Counties (haying, grazing, and control) in Kentucky, and McMinn County (biofuels, haying, and control) in Tennessee. Each field was visited three times to conduct a 10-minute point count to assess presence of 9 target species (dickcissel, eastern meadowlark, field sparrow, grasshopper sparrow, Henslow's sparrow, horned lark, northern bobwhite, prairie warbler, and red-winged blackbird) and a fourth time to measure vegetation (species composition, density, height, and litter cover and depth) each season.

Average vegetation height and vertical density were greater in biofuel fields than other treatments. Control fields were greatest in percent of litter, forbs, and woody plants. Species abundance and richness was higher in seed production fields than other treatments. Dickcissels and eastern meadowlark appeared to select seed production fields and field sparrows appeared to avoid biofuel production fields. Other species showed no preference for any treatment type. This apparently broad adaptability to the NWSG fields we examined suggests that production fields may be able to make an important contribution to the recovery of grassland bird species. Models relating bird use to vegetation and landscape metrics are currently being developed.

Funding Sources: *The University of Tennessee, Kentucky Department of Fish and Wildlife Resources (NFA)*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2. Class Aves. Priority Research Project #2 and #8.



Population Ecology and Habitat use of Northern Bobwhite on a Reclaimed Surface Coal Mine in Kentucky

Ashley Unger, Evan Tanner, Craig Harper and Patrick Keyser, University of Tennessee; John Morgan and Eric Williams, Kentucky Department of Fish and Wildlife Resources

Bobwhite quail release / Ashley Unger

Northern bobwhite (*Colinus virginianus*) populations are rapidly declining because of range-wide loss of usable space. The decline has been attributed to deterioration of early successional habitat as a result of clean farming practices, lack of disturbance, and habitat fragmentation. An opportunity manage large tracts of potential wildlife habitat exists with reclaimed mined land. There are 1.5 million acres of reclaimed land in the eastern US, and more than 600,000 acres within Kentucky. Unfortunately, many of these reclaimed areas have been planted to invasive, non-native species, such as sericea lespedeza (*Lespedeza cuneata*) and tall fescue (*Schedonorus phoenix*), which may not provide suitable nesting or brooding cover.

To address potential habitat concerns for northern bobwhite on reclaimed mined lands, the Kentucky Department of Fish and Wildlife Resources (KDFWR) began implementing broad-scale habitat management strategies on the Peabody WMA in western KY in 2009. To quantify the effects of disking, planting flood plots, herbicide applications, and prescribed fire, we are monitoring movements, reproduction, and survival of northern bobwhite via trapping and radio telemetry. We are using an experimental design that incorporates treated and untreated areas on the 8,200-acre study site.

Since August 2009, we have trapped and collared 790 birds, with a 2.9% trapping success rate, which is comparable with other studies performed throughout the Southeast. Overall annual crude mortality rate averaged 49%. Using the collared birds, we have estimated the population using a fall covey-call survey. The fall 2009 estimate of 2,452 birds increased to 3,845 in the fall of 2010. During winter (October-March), birds were using annual food plots, native warm-season grass, and scrub-shrub vegetation types more than expected. During summer (April-September), birds were using native warm-season grass and open herbaceous (dominated by forbs and *Lespedeza cuneata*) vegetation more than expected. Birds frequently used disked areas during summer as well. This selection may be influenced by structural components of the vegetation, such as visual obstruction at ground level, litter depth, and species composition.

We will continue to monitor bobwhite response at Peabody as KDFWR continues to manipulate habitat. Our research should document the influence of these habitat management practices on northern bobwhite and provide wildlife managers information needed for sound decision making when managing reclaimed mined lands for the species.

Funding Source: *Pittman Robertson (PR) and The University of Tennessee*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2. Class Aves. Priority Research Project #2 and #3.

Using Non-Invasive Hair Sampling to Estimate the Size, Density, and Relatedness of a Reintroduced Black Bear Population in South-Central Kentucky

Sean M. Murphy, John J. Cox, John T. Hast and Songlin Fei, University of Kentucky, Department of Forestry.
KDFWR Contact: *Steven Dobey*

The once statewide black bear (*Ursus americanus*) was extirpated from Kentucky by the early 20th century. The species naturally recolonized a portion of extreme eastern Kentucky from the neighboring states of Virginia, West Virginia, and Tennessee. Additionally, in 1996-1997, a limited reintroduction occurred in Big South Fork National River and Recreation Area using 14 black bear translocated from Great Smoky Mountains National Park. Since the reintroduction, confirmed sightings, nuisance reports, and roadkills have increased in McCreary County, Kentucky, suggesting an increasing and expanding population. Recent findings confirmed the population is genetically distinct from other bear populations within Kentucky, although the population size remained unknown. We used a non-invasive hair snare approach in mark-recapture study design to estimate the size and density of the black bear population in south-central Kentucky. We sampled 126 ten km^2 blocks once per week for 7 consecutive weeks in late spring and early summer 2010. One hundred and fifty-six hair samples were collected from 30 different hair snares and subsequently sampled using $\geq$ 20 microsatellite loci. Preliminary genetic analysis identified 36 individuals from collected hair samples. Programs MARK, CAPTURE, and DENSITY will be used to estimate the size and density of the black bear population in south-central Kentucky. Additionally, a parentage analysis will be performed to determine genetic relatedness of extant individuals to the original founders translocated 14 years prior.

Sean Murphy pictured with sibling black bear cubs, one of which had a unique blonde color phase, in McCreary County, Kentucky / Ben Augustine

Funding Sources: *Pittman Robertson (PR) and University of Kentucky*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Mammalia: Taxa specific conservation project.

Population Dynamics and Movement Ecology of the Black Bear in Eastern Kentucky

Steven Dobey, Kentucky Department of Fish and Wildlife Resources; John J. Cox, University of Kentucky

Biologist Tristan Curry works up a black bear / John Hast

Since 2002, the KDFWR and University of Kentucky have been involved in cooperative research studying the population dynamics of black bears along Pine Mountain in the eastern region of the Commonwealth. The summer of 2010 marked the ninth consecutive year of trapping along Pine Mountain, and these findings have been crucial in managing Kentucky's growing bear population.

Bears were primarily captured using Aldrich spring-activated foot snares. Culvert traps were also employed for situations in which snares were not feasible. Estimates of annual and seasonal survival were determined from a radiocollared sample of the population. Den sites of radiocollared female bears were initially located by fixed-wing aircraft or location acquisition from GPS collar, and then visited on foot using ground telemetry. The reproductive status of radiocollared females was determined by visual inspection or listening for young at den sites. Median annual and seasonal 95% minimum convex polygon (MCP) estimates for home range size were estimated by sex by modeling the double log-transformed MCP area using linear regression.

During the summer trapping season of 2010, researchers on the Pine Mountain Study area captured 18 bears (8M:10F) on 21 (10M:11F) occasions. Fifty percent (n = 9) of individual captures were bears that had never been handled before, including 4 females. All captured females were equipped with a GPS (n = 8) or VHF (n = 2) radio collar.

Extensive biological data were collected from all bears handled. Those data included body measurements, reproductive status, as well as the collection of hair and tissue samples for genetic analyses. Mean weights for male and female bears captured on the Pine Mountain study area were 255.0 (n = 7) 138.3 (n = 9) pounds, respectively.

Annual survival for radiocollared male and female bears on the Pine Mountain study area were 0.74 (95% CI = 0.64–0.83) and 0.95 (95% CI = 0.90–0.98), respectively. Annual survival for subadult and adult male bears were 0.72 (95% CI = 0.56–0.83) and 0.85 (95% CI = 0.71–0.93), respectively. For radiocollared female bears, annual survival rates for subadults and adults equaled 1.00 (95% CI = 0.88–1.00) and 0.95 (95% CI = 0.88–0.98), respectively.

Den work from the 2010-2011 season documented the births of 22 (9M:13F) cubs from 10 litters. Inclusion of a tree den for which cubs could be heard but not counted resulted in a mean litter size of 2.75 cubs/female. Den sites for females with cubs were documented as downed logs or trees (n = 5), rock cavities (n = 4), and tree dens (n = 1).

Annual home range size for adult male and female bears on the Pine Mountain study area averaged 269.4 km^2 (n = 9; 95% CI = 116.9–718.9) and 23.4 km^2 (n = 25; 95% CI = 17.0–33.5), respectively. For subadult bears, male and female annual home range area averaged 296.2 km^2 (n = 10; 95% CI = 132.1–760.0) and 14.8 km^2 (n = 10; 95% CI = 10.0–23.3), respectively. Estimates of home range size differed by sex across age classes ($P < 0.0001$), but not by age classes within each sex ($P < 0.0001$).

Seasonal home range estimates were calculated for spring, summer, and fall. Overall, home ranges for Pine Mountain bears exhibited considerable variation in size across seasons. Among adult female bears, home ranges in spring ($\bar{x}$ = 6.8 km^2, n = 13, 95% CI = 4.3–12.7) were smaller than summer ($\bar{x}$ = 18.4 km^2, n = 23, 95% CI = 15.3–22.4) (P = 0.0006) and fall ($\bar{x}$ = 14.9 km^2, n = 22, 95% CI = 10.0–23.7) (P = 0.0037). No differences were detected between summer and fall home ranges (P = 0.3132).

As expected, summer home ranges for subadult male bears ($\bar{x}$ = 288.2 km^2, n = 9, 95% CI = 170.2–515.5) were largest among estimates across all age classes and seasons. The wide ranging nature of subadult bears was particularly demonstrated during the fall season when the home ranges of subadults ($\bar{x}$ = 217.7 km^2, n = 10, 95% CI = 105.7–501.2) were over twice the area of those for adult bears ($\bar{x}$ = 81.4 km^2, n = 7, 95% CI = 40.9–184.5).

Further, ongoing analyses of locational data indicated important movement patterns in relation to human-related food sources. In particular, open garbage dumpsters appear to strongly influence seasonal movements and placement of home ranges. Further analyses on this topic will yield important management implications with regard to human-related attractants to bears.

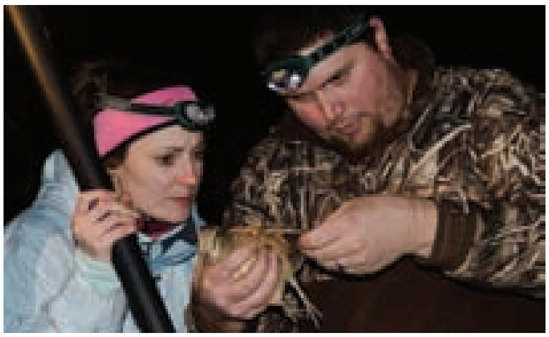
Collectively, data collected from this research project has yielded invaluable biological information regarding the expanding black bear population in eastern Kentucky. Research clearly illustrates continued population growth as annual trapping efforts continue to document bears that have never been handled before. As additional demographic data are collected from his study, population modeling efforts using these data will provide the KDFWR with an estimate of population growth. These modeling analyses will prove critical as they will allow the KDFWR to predict expansion patterns and long-term growth rates of bears.

Funding Source: *Pittman Robertson (PR) and University of Kentucky*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.9; Class Mammalia: Taxa specific conservation project.

American Woodcock Nocturnal Field Usage During Spring Migration in Central Kentucky

Andy Newman and Charles Elliott, Eastern Kentucky University, John Brunjes, Kentucky Department of Fish and Wildlife



Processing woodcock / John Brunjes

American Woodcock (*Scolopax minor*) are small migratory shorebirds that range throughout the eastern United States. A majority of woodcock winter in the southeast and coastal states and breed in the northern part of their range. They prefer dense thickets of young growth forest for diurnal cover and nesting. At dusk they often fly into fields for roosting, feeding, and courtship during spring. Since the inception of woodcock monitoring in the late 1960's, populations have exhibited long-term declines. Removal of bottomland forest and mechanized farming practices has reduced amount of wintering habitat available. In northern breeding areas, changes in forest management has resulted in fewer tracts of early-successional habitat that woodcock prefer for nesting and roosting. While woodcock do breed in Kentucky, a majority of the birds pass through the state during migration in early spring and late fall. Limited research documenting habitat preferences for migrating woodcock has been conducted.

During the springs of 2009 and 2010 potential nocturnal roosting habitats were searched for woodcock on the Miller-Welch Central Kentucky WMA and the Blue Grass Army Depot. ATVs equipped with spotlights were used to locate birds. If possible birds were captured, banded, sexed, and aged. Flagging was used to mark locations of birds in fields. Habitat type, dominant vegetation, distance and composition of dense cover, percent cover, and field size were recorded. Differences in habitat preferences between sex and age classes were analyzed using the two-sample t-test. A stepwise regression using Akaike's information criterion values was used to compare relative woodcock densities between fields.

In two field seasons over 400 woodcock were located and 110 were banded. Woodcock were located in a variety of fields, e.g., managed old fields (bush hogged), mowed, native grasses, hayed, burned, and pasture. There was no significant ($P=0.05$) difference in habitat variables assessed at roost sites and woodcock sex and age. Stepwise regression analysis indicated the best model for predicting woodcock density per field incorporated percent litter at roost site, litter depth, distance to escape cover, visual obstruction of escape cover from 0-20cm, and visual obstruction of escape cover from 50-100cm. Dominate species that comprised overhead cover consisted of blackberry (*Rubus spp*.), goldenrod (*Solidago spp*.), dogwood (*Cornus spp*.), and sumac (*Rhus spp*.).

The results of this study indicate that American woodcock migrating through central Kentucky are selecting for nocturnal fields that contain specific habitat characteristics. Immediate cover at roost sites was often sparse with residual shallow grass litter, patches of bare soil, and short vegetation. Herbaceous and woody cover that offered protection from both predators and inclement weather was in close proximity of lightly vegetated areas. Similar habitat selection have been noted on both wintering and breeding grounds. Fields that exhibit heterogeneous vegetation heights and composition allow woodcock to satisfy basic ecological needs during migration by providing foraging, resting, mating, and predator avoidance habitat.

Managers and landowners wanting to enhance suitability of fields for nocturnal woodcock habitat within Kentucky should focus on the following: (1) increase residual woody vegetation in fields (i.e., blackberry, saplings, goldenrod), (2) create openings in taller vegetation, (3) focus manipulation efforts on fields located close to diurnal habitat (forested areas), and (4) use of burning to remove dense ground cover. The implementation of these practices will provide quality stopover sites for woodcock allowing more birds in better body condition to reach the northern breeding grounds each spring.

Funding Source: *State Wildlife Grant (SWG) and Eastern Kentucky University*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2. Class Aves. Priority Survey Project #3.

Foraging and Roosting Ecology of Rafinesque's Big-eared bat in Kentucky

Joseph S. Johnson and Michael J. Lacki, Department of Forestry, University of Kentucky
KDFWR Contact: *Brooke Slack*

Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) is one of North America's rarest bat species, and is listed as a species of concern by the state of Kentucky. Due to the species' rarity, there is an increasing need to identify habitat features which are important to reproductive populations during the summer maternity season. Two of the basic needs of summer colonies are roosting and foraging habitats. Previous research has shown that Rafinesque's big-eared bat roosts in hollow trees, caves, buildings and other man-made structures. Rafinesque's big-eared bat, like other big-eared bat species, primarily feeds on moths and possesses several adaptations that help it capture preferred moth prey. Forest types known to be used for roosting and foraging activities are diverse, and include bottomland as well as upland forested habitats.

While much has been learned about these bats, the majority of studies have focused on populations in regions south of Kentucky where available habitats, and therefore habitat use, likely differ from that present in the Commonwealth. To investigate these potential differences, we embarked on a three-year study funded by the Kentucky Department of Fish and Wildlife Resources during the summer of 2009. The goal of this project is to help land managers better understand the behaviors and habitat requirements of Rafinesque's big-eared bat in two different habitats where they occur in Kentucky. The first study area is located in Ballard Wildlife Management area in western Kentucky. The management area is a bottomland hardwood forest, where roosting and foraging habitats differ dramatically from the second study area located in Mammoth Cave National Park, an upland forest environment.

Our work at both locations encompasses many facets of the species' ecology. By following bats tagged with radiotransmitters to day-roosts across the summer season we are gathering data on the characteristics of these roosts, including features of the roosts themselves, characteristics of adjacent forests, and conditions (including temperature, humidity and light levels) inside the roosts. We are also tracking bats during their nighttime foraging bouts and investigating connections between the habitats used while foraging and the abundance of available insect prey in habitats used and not used by bats. This task includes a dietary analysis of fecal samples coupled with sampling of insect populations with light traps distributed across the landscape.

In our first two years of study we have tracked 85 Rafinesque's big-eared bats to 101 day-roosts between the two study areas. Temperature, humidity and light levels have been monitored at approximately 40 of these roosts to date. Nighttime foraging data have been collected for 66 of the radio-tagged bats, and thousands of insect samples have been collected from potential foraging habitats to help determine if bats are foraging in habitats with higher densities of preferred prey species. These data, combined with data to be collected in 2011, will allow us to quantitatively describe daytime and nighttime habitat use of Rafinesque's big-eared bat and develop management recommendations aimed at protecting and enhancing habitat for the species across the state.

Rafinesque's Big-eared bat / Joe Johnson

Funding Source: *State Wildlife Grant (SWG) and University of Kentucky*

Comprehensive Wildlife Conservation Strategy: Appendix 3.2, Class Mammalia, Prioritized Research Projects 1 and 4, and Survey Project 1.

A gravid western mud snake / Will Bird

Inventory, Monitoring, and Management of Amphibians and Reptiles in Kentucky

Will Bird and Phil Peak, Kentucky Herpetological Society; John MacGregor, Kentucky Department of Fish and Wildlife Resources

In the course of developing Kentucky's Comprehensive Wildlife Conservation Strategy(CWCS) it was determined by KDFWR that more baseline data needed to be collected in order to execute effective conservation action plans for our native reptile and amphibian species. While general distributions for reptiles and amphibians in Kentucky have been determined, more detailed distribution and abundance records need to be collected so that the populations of these animals can be monitored over time. Many of the records that we have in our current database are decades old and very vague. Species for which baseline data is most needed from all groups of reptiles and amphibians have been identified, as have the regions within Kentucky where this information should be gathered.

Locating reptiles and amphibians can be difficult. We begin the process by identifying locations where we believe targeted species can be found. These locations are on state, federal, and even private lands. Once permission is granted to conduct surveys we use different methods for locating specimens based on their biological requirements. Because they are ectotherms we are able to utilize Artificial Cover (AC) to locate many of the animals we search for. Heavy metal objects that absorb heat from the sun's rays and provide protection from the elements are set out at our study sites. We also deploy large wooden boards which retain moisture even during the drier months and provide refuge for many of the herpetofauna that might otherwise stay far below the surface of the ground where they could remain undetected. There are species of reptiles and amphibians for which AC has proven less effective. When targeting these species we use box style funnel traps to assist in their location and also search natural forms of cover such as rocks and logs.

The information about where specimens are located is recorded in a very precise manner so that these locations can be visited and monitored into the future in order to continue to monitor populations and dynamics. Since the project began we have secured many new survey locations in areas targeted by the CWCS and continue to gather information and data for species of interest.

Funding Source: *State Wildlife Grant (SWG)*

Comprehensive Wildlife Conservation Strategy: Appendix 3.4, Class Reptilia: Prioritized Survey Projects 1 and 2. Class Amphibia: Priority Survey Projects #1 and #2.

Effects of *Phragmites* Removal on Species of Greatest Conservation Need at Clear Creek WMA

Howard Whiteman and Tom Timmons, Murray State University
KDFWR Contact: *Danna Baxley*

Common reed (*Phragmites australis*) is an aquatic plant that has successfully invaded numerous wetland habitats beyond its native range. *Phragmites* has been implicated in dramatic habitat changes, causing shifts in plant and animal communities. Aerial herbicide spraying of *Phragmites* is considered effective for population control, but herbicides can have unforeseen consequences toward non-target organisms and ecosystem processes. Few studies have determined the effects of *Phragmites* eradication on wetland animal communities, although species such as fish, reptiles, and amphibians are likely to be affected, due to susceptibility to toxicants, dependence on wetland habitats, and/or limited dispersal.

Phragmites is particularly noxious at the Clear Creek WMA (CCWMA), where it dominates the landscape, has likely altered wetland hydrology, and has caused numerous access problems, particularly for waterfowl hunters. Numerous SGCN inhabit Clear Creek, and may also be affected by large-scale *Phragmites* removal. However, no formal survey work had been conducted to determine the effects of large scale *Phragmites* eradication on SGCN. The goal of this study was to use aerial herbicide treatment in an effort to eradicate *Phragmites*, and to understand the effects of such management on SGCN, as well as fish, amphibian, and reptile diversity.

On 22-August-2009 KDFWR and Ducks Unlimited carried out a chemical treatment of *Phragmites australis* on the CCWMA. An aerial application of a glyphosate herbicide was conducted on approximately 300 of the 858 acres. These 300 acres comprise our experimental site. A site on the WMA that is invaded by *Phragmites* but did not receive chemical treatment serves as a control site. Another site on private land near the WMA where *Phragmites* has not yet been established serves as a non-*Phragmites* control site.

Using a variety of sampling techniques, including hoop traps, minnow traps, seines, electroshocking, automated recording devices (frogloggers), water chemistry analysis, and stable isotope analysis, we have sampled these three sites repeatedly since July 2009. Thus far, we have recorded several SGCN within the CCWMA, including western lesser sirens (*Siren intermedia*), bird-voiced treefrogs (*Hyla avivoca*), copperbelly water snakes (*Nerodia erythrogaster neglecta*), diamondback watersnakes (*Nerodia rhombifer rhombifer*), western cottonmouth (*Agkistrodon piscivorus leucostoma*), the lake chubsucker (*Erimyzon sucetta*), American black duck (*Anas rubripes*), the least bittern (*Ixobrychus exilis*), great egrets, (*Ardea alba*), solitary sandpiper (*Tringa solitaria*) and the American bittern (*Botaurus lentiginosus*).

A total of 26 species of fish have been collected from these sites, across 2525 individuals, and thus far we have observed few effects of *Phragmites* management on fish diversity or abundance. There were no differences between sites in terms of diversity or the Kentucky Index of Biotic Integrity. However, there were differences in the similarity of the fish community across sites, suggesting that management efforts may have affected the distribution and abundance of some fish species, at least temporarily.

Phragmites australis at the CCWMA. / Amy Krzton-Presson, WSI

Aerial view of the CCWMA, with sampling sites marked. The red area in the southeastern portion of the WMA is Phragmites that has died from herbicide management (experimental area). / Jane Benson, MARC/WSI

Currently 152 hours of ambient sound has been recorded per treatment using frogloggers. Eight months worth of recordings have been analyzed, documenting nine frog species. Thus far we have observed no differences in anuran diversity across sites, suggesting *Phragmites* presence and management do not have an impact on frog diversity.

Four species of turtles have been recorded from these sites, across 659 individuals, but red-eared sliders (*Trachemys scripta*) and common snapping turtles (*Chelydra serpentina*) were by far the dominant species within these wetlands. Turtle diversity is higher in the presence of *Phragmites*, but thus far we have detected no effects of *Phragmites* management on turtle abundance or behavior. We have observed dispersal between the study area by several individuals of the two dominant turtle species, but there has been no pattern to this dispersal that would suggest either immigration or emigration from the *Phragmites* management area. We have detected differences in the sizes of turtles inhabiting *Phragmites* versus non-*Phragmites* control areas, suggesting that resource limitation in the presence of *Phragmites* may be reducing turtle growth rates, and thus *Phragmites* management may aid turtle populations.

Five species of snakes have also been recorded from these sites, but no pattern of effects from *Phragmites* management is currently evident. Data collection will continue on all of these parameters through June 2011. Because the effects of *Phragmites* management may not be detectable for several years, continued monitoring of these sites is warranted.

Additional studies have allowed us to better understand the potential impacts of *Phragmites* invasion and management on SGCN and the CCWMA ecosystem. Using DNA analysis, we have confirmed that the *Phragmites* at CCWMA is not native to the North America. We are analyzing stable isotopes throughout the CCWMA food web to detect the implications of the death of a dominant wetland plant on ecosystem function (e.g., nutrient cycling and energy flow), and thus far have found that the presence of *Phragmites* produces significantly different isotopic signatures from area without this invasive plant. Finally, we are conducting an in-depth study of lake chubsucker diet in each study site to detect the potential for cascading effects of *Phragmites* management on the invertebrate and fish community.

Because removing *Phragmites* via herbicide spraying is a critical management goal with unknown consequences toward the CCWMA environment and the SGCN within it, our project will be an important step in understanding the ecological effects of removing *Phragmites* from wetlands where it dominates, and of utilizing herbicides for such manipulations. By understanding the effects of this management on SGCN at Clear Creek, wildlife biologists in Kentucky will have the necessary insight to prescribe future *Phragmites* removal at this site, other WMAs, and other important state lands.

Funding Sources: *State Wildlife Grant (SWG), Watershed Studies Institute and Department of Biological Sciences, Murray State University, and Ducks Unlimited.*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2, Class Reptilia. Priority Research Project #1, Priority Survey Project #1. Class Actinopterygii and Cephalaspidomorphi. Priority Research Project #1.

Development of *In Vitro* (Artificial) Laboratory Culture Methods for Rearing Juvenile Freshwater Mussels

Christopher Owen and Jim Tidwell, Kentucky State University; Monte McGregor, Kentucky Department of Fish and Wildlife Resources

Propagation of freshwater mussels has been somewhat limited to species for which we know the host. For these species, host fishes may be unknown or difficult to handle and/or collect in adequate numbers for conventional fish-host propagation methods. Despite availability of glochidia and hosts, even under the best laboratory conditions, transformation rates to the juvenile stage are variable and mostly unpredictable.

Over the years, *in vitro* metamorphosis of glochidia has been successful with only a few common species, including *Ligumia recta, Lampsilis siliquoidea* and *Utterbackia imbecillis*, all of which are host-generalists that utilize a broad range of fish hosts. Host-specific or threatened and endangered species had not been successfully metamorphosed *in vitro*. In addition, no literature existed describing the 'fitness' of individuals metamorphosed *in vitro*, using various metrics as percent transformation, lipid reserves, and survival rate for comparison.

Control of microbial contamination composes the single largest hurdle with *in vitro* mussel culture. Improvements to the *in vitro* culture medium and protocol have proved effective in controlling microbial contamination and resulted in the successful metamorphosis of sixteen mussel species. Of the twenty-seven species to metamorphose, twelve represent new species to be successfully metamorphosed *in vitro*. These twelve species include: *Anodonta suborbiculata* (Flat Floater), *Alasmidonta viridis* (Slippershell mussel), *Alasmidonta atropurpurea* (Cumberland Elktoe), *Cyprogenia stegaria* (Fanshell), *Epioblasma brevidens* (Cumberland combshell) *Epioblasma capsaeformis* (Oyster Mussel), *Lampsilis abrupta* (Pink Mucket), *Lasmigona costata* (Fluted-shell), *Strophitus undulatus* (Creeper), *Toxolasma parvus* (Lilliput), *Villosa ortmanni* (Kentucky Creekshell) and *Villosa taeniata* (Painted Creekshell). Of these twelve species, *A. Atropurpurea, C. stegaria, E. Brevidens, E. capsaeformis* and *L. abrupta* are the first reports of federally listed endangered species to successfully metamorphose *in vitro*.

This artificial culture technique will allow KDFWR wildlife managers and others mussel propagators a new and more effective method for the conservation of freshwater mussels. The development of the *in vitro* culture technique not only allows mussel propagators to bypass the need for a fish host, but the technique has the potential to create significantly more juveniles than propagation techniques involving fish hosts. This ability is important particularly for species of the most dire conservation need, including endangered or threatened mussel species found in limited population size, with threatened or endangered fish hosts or skewed sex ratio (availability of gravid females).

With the successful elimination of deleterious effects of microbial contamination, research is now focused on the nutritional requirements of the culture medium in addition to the investigation of the effectiveness of the *in vitro* method with new species. Species investigated this current year include *Alasmidonta atropurpurea, Actinonaias ligamentina, Actinonaias pectorosa, Epioblasma brevidens, Fusconaia flava, Lasmigona costata, Pyganodon grandis, Strophitus undulatus, Villosa ortmanni, Ligumia recta* and *Utterbackia imbecillis*. All species successfully metamorphosed *in vitro*, with no species exhibiting less than 80% metamorphosis. To date, >600,000 juveniles of the combined species have been successfully propagated using the *in vitro* metamorphosis technique. Experiments with *U. imbecillis* have investigated the role of fatty acids as an energy source in the production of mussel tissue. Fatty acid profiles were analyzed through lipid extractions and gas chromatography. Additionally, the effects of brood stock conditioning on larval metamorphosis and pediveliger survival was investigated.

Research will continue to focus on the role of fatty acids in mussel development *in vitro*, as well as in brood stock conditioning. Brood stock condition may be a significant factor in the successful metamorphosis of glochidia. The *in vitro* method will continue to be tested with new species as they become available.

Funding Sources: *State Wildlife Grant (SWG), Kentucky State University, University of Louisville*

KDFWR Strategic Plan: Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2, Class Bivalvia. Priority Research Project #1.

Natural Grassland Survey of the Original Barrens-Prairie Region of Kentucky

Brian Yahn, Kentucky State Nature Preserves Commission
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At the time of early settlement, Kentucky had an estimated 2.5 to 3 million acres of natural grasslands (prairies) and open woodlands (barrens) that were common in the Pennyroyal/ Mitchell Plain and the Coastal Plain regions and scattered throughout surrounding areas (including the Eastern and Western Highland Rim and Shawnee Hills). These prairies and open woodlands supported a wide diversity of wildlife species. Many of these species are now rare or declining in Kentucky due to the destruction of the grassland habitat that supported them. This includes species such as the Henslow's sparrow, Lark sparrow, Short-eared owl, Northern Harrier, Eastern corn snake, Eastern slender glass lizard, and Six-lined racerunner, as well as many others. (These species are listed by KDFWR as species of greatest conservation need (SGCN)).

Our project includes identifying the remaining natural grassland and woodland habitats that harbor and sustain these rare and declining wildlife species (SGCN). We will focus this inventory within the Interior Low Plateau Karst Priority Conservation Area (ILPCA) over a 3 year period (2008 – 2011). Identifying grassland habitats will take a 4-step approach. First, existing data on grassland sites will be collected and entered into a GIS database. Second, color aerial photography will be analyzed to select potential areas not previously identified. Third, sites selected in steps 1 and 2 will be organized into a flight plan. These sites will be flown-over (via helicopter) and inspected. Fourth, only selected sites from step 3 will be ground-truthed. Qualitative ground surveys will further identify the highest quality habitat remaining and provide information to refine and delineate regions of conservation focus.

The project started in mid-August of 2008 and focused in Hardin, Larue and Grayson counties. The flight plans included 58 sites which were surveyed by air. After inspection, 36 of these sites were visited on the ground. These sites were then scored by evaluating 6 factors: habitat quality, species rarity, invasive species abundance, size, landscape context and woody species encroachment. After scoring all the sites visited, six scored high enough to be considered of higher-quality prairie/ glade/barren habitat. So far, these 6 were mostly small (< 50 acres) with thin, forested buffers. Outside of the thin, forested buffers, most sites were surrounded by crop agriculture (of low restoration potential).

The project continued in 2009 using the same methodology. Over 115 sites were surveyed by air focusing on Hart, Edmonson, northern Barren, northern Warren and eastern Butler Counties. One flight was conducted in mid-August and two more in the middle of September. Ground visits were conducted in parts of Barren, Edmonson and Grayson and throughout Hart County. Thirty two sites (with 24 sites in Hart County) were visited on the ground. Nine of these sites are being considered of higher-quality prairie/glade/barren habitat, with a couple showing larger restoration potential.

Many of the sites that were flown in the fall of 2009 were ground visited early the next summer (2010). By late summer/fall, an additional 80 sites were surveyed by air in two flights, one in September and one in October. Most of the survey work was conducted in Logan, Warren, Edmonson and Butler Counties. Forty eight sites were visited on the ground. Twenty of these sites are being considered of better-quality prairie/glade/barren habitat, with many of marginal conservation priority and needing intensive restoration.

By the summer of 2011, an assessment of the counties surveyed will be conducted. A few of the highest quality sites can be discussed with a KDFWR vertebrate zoologist. With information provided by the project leader (KSNPC), the vertebrate zoologist can evaluate the sites to select the areas with the highest potential for SGCN. Criteria will include the overall extent of habitat available, the quality of the natural communities and faunal information. (High-ranked sites can be surveyed by KDFWR for SGCN).

Prairies and the species that depend on them have become scarce in Kentucky. Many of the remnants are small and easily overlooked on the landscape. By identifying the best of these remaining prairies, we hope to help KDFWR more efficiently target conservation and restoration efforts for prairie-dependent species.

Funding Sources: *State Wildlife Grant (SWG) and Kentucky State Nature Preserves Commission*

Kentucky's Wildlife Action Plan: Appendix 3.8, Terrestrial habitat guild (Grassland/agriculture), Objectives 1, 3, 4 and 5.

Published Research

Barding, E.E., M.J. Lacki, and L.L. Patton. 2010. Recovery of the **river otter** to Kentucky. Proc. Annu. Conf. S.E. Assoc. Fish and Wildlife Agencies (*In press*).

Britzke, E.R., B.A. Slack, M.P. Armstrong, and S.C. Loeb. Effects of orientation and weatherproofing on the detection of **bat echolocation** calls. 2010. Journal of Fish and Wildlife Management 1(2):136-141.

Corn, J.L., M.E. Cartwright, K.J. Alexy, T.E. Cornish, E.J.B. Manning, A.N. Cartoceti, and J.R. Fischer. 2010. Surveys for disease agents in introduced **elk** in Arkansas and Kentucky. Journal of Wildlife Diseases 46(1):186-194.

Culp, J.J., A.C. Shepard, and M.A. McGregor. 2009. **Fish hosts** and conglutinates of the pyramid pigtoe *(Pleurobema rubrum)*. Southeastern Naturalist 8(1):19-22.

Dzialak, M.R., K.M. Carter, M.J. Lacki, D.F. Westneat, and K. Anderson. 2009. Activity of post-fledging **peregrine falcons** in different rearing and habitat conditions. Southeastern Naturalist 8(1):93-106.

Edmonds, S. T., D. C. Evers, D. A. Cristol, C. Mettke-Hofmann, L. L. Powell, A. J. McGann, J. W. Armiger, O. P. Lane, D. F. Tessler, P. Newell, K. Heyden, and N. J. O'Driscoll. 2010. Geographic and seasonal variation in mercury exposure of the declining **Rusty Blackbird**. The Condor 112(4):789-799.

Harris, D., C. Elliott, R. Frederick, and T. Edwards. 2009. Habitat characteristics associated with **American woodcock** (*Scolopax minor* Gmelin) nests in central Kentucky. The Journal of the Kentucky Academy of Sciences 70(2):114-144.

Hartman, P.J., D.S. Maehr, and J.L. Larkin. 2009. Habitat selection by **cerulean warblers** in Eastern Kentucky. The Wilson Journal of Ornithology 121(3):469-475.

Heyden, K.G. 2010. 2010 Barn Owl (*Tyto alba*) inventory and current management for the species in Kentucky. The Kentucky Warbler 86(4): 79-85.

Heyden, K. G. 2010. Current status of nesting **Bald Eagles** (*Haliaeetus leucocephalus*) in Kentucky. The Kentucky Warbler 86(4):85-89.

Hopkins, R.L. 2009. Use of landscape pattern metrics and multiscale data in aquatic species distribution models: a case study of a **freshwater mussel**. Landscape Ecology 29:943-955.

Hopkins, R.L., M.D. Burns, B. Burr, and L.J. Hopman. 2008. Building a centralized database for Kentucky fishes: Progress and future applications. Journal of the Kentucky Academy of Science 69 (2): 164-169.

Hopkins, R.L. and B.M. Burr. 2009. Modeling **freshwater fish** distributions using multiscale landscape data: A case study of six narrow range endemics. Ecological Modeling 220:2024-2034.

Larkin, J.L., D.S. Maehr, J.J. Krupa, J.J. Cox, K. Alexy, D.E. Unger, and C. Barton. 2008.
Small mammal response to vegetation and spoil conditions on a reclaimed surface mine in eastern Kentucky. Southeastern Naturalist 7(3):401-112.

Lynch, W.L., and C.N. Moreira. 2008. Nest arrival vocalizations of the **Turkey Vulture** *Cathartes aura* (Cathartidae: Falconiformes). Vulture News 59:3-6.

Owen C.T., J.E. Alexander, Jr., and M.A. McGregor. 2010. Control of microbial contamination during *in vitro* culture of larval **unionid mussels**. Invertebrate Reproduction and Development. 54 (4):187-193

Owen, C.T., M.A. McGregor, G.A. Cobbs, and J.E. Alexander Jr. 2010. Muskrat predation on a diverse **unionid mussel** community: Impacts of prey species composition, size and shape. Freshwater Biology 56(3): 554-564.

Patton, L.L, D.S. Maehr, J.E. Duchamp, S. Fei, J.W. Gassett and J.L. Larkin. 2010. Do the **golden-winged warbler** and **blue-winged warbler** exhibit species-specific differences in their breeding habitat use? Avian Conservation and Ecology 5(2).

Ruder, M.G., A.B. Allison, D.L. Miller, and M.K. Keel. 2010. **Pathology** in practice. Journal of the American Veterinary Medical Association 237(7):783-785.

Vukovich, M. and G. Ritchison. 2008. Foraging behavior of **Short-Eared Owls** and **Northern Harriers** on a reclaimed surface mine in Kentucky. Southeastern
Naturalist 1(1):1-10.

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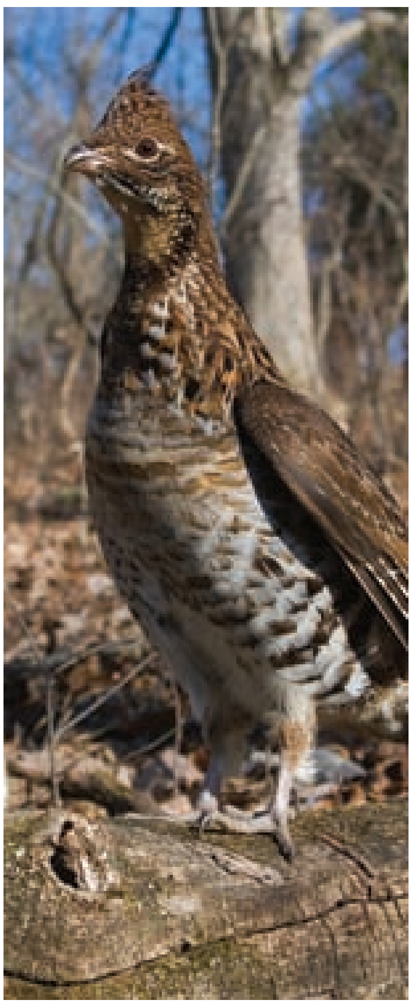

Ruffed grouse / Joe Lacefield

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