


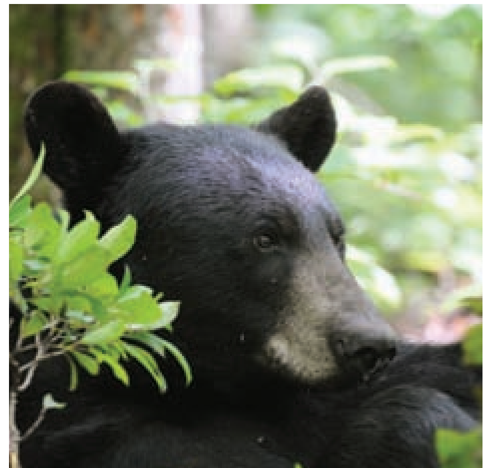

Kentucky Department of Fish and Wildlife Resources

Annual Research Highlights 2011

Volume V, Oct. 2012

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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

Collaring black bear / Obie Williams

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 all 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 (revised in 2010; *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 2011 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:

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

Dove banding/ John Brunjes

These federal programs provided approximately 19 million dollars to KDFWR in 2011 (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 2011, 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.

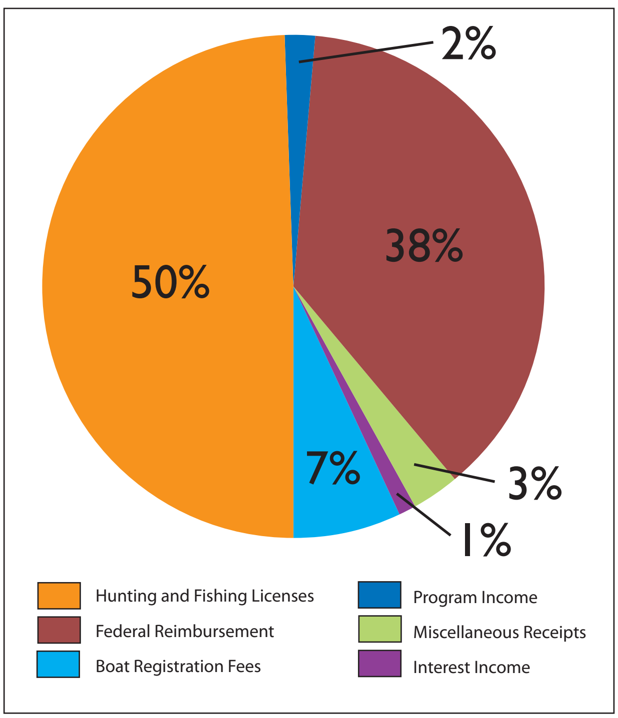

Figure 1. Kentucky Department of Fish and Wildlife Resources Funding Sources 2011. Total revenues for 2011 were $50,392,814.44

Please use the following citation when referencing this document:

Kentucky Department of Fish and Wildlife Resources Annual Research Highlights, 2011. Volume V. Publication of the Wildlife and Fisheries Divisions. October, 2012, 142 pp.

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Published Research

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

Culp, J.J., W.R. Haag, D.A. Arrington, and T.B. Kennedy. 2011. Seasonal and species-specific patterns in abundance of **freshwater mussel** glochidia in stream drift. Journal of the North American Benthological Society 30:436-445.

Eisenhour, D.J., A.M. Richter, and J.M. Schiering. 2011. Conservation status of the **longhead darter**, *Percina macrocephala*, in Kinniconick Creek, Kentucky. Southeastern Fishes Council Proceedings 53:13-20.

Frary, V.J., J. Duchamp, D.S. Maehr, and J.L. Larkin. 2011. Density and distribution of a colonizing front of the **American black bear** *Ursus americanus*. Wildlife Biology 17:404-416.

Reidy, J.L., F.R. Thompson III, and J.W. Bailey. 2011. Comparison of methods for estimating density of **forest songbirds** from point counts. Journal of Wildlife Management 75:558-568.

Shock, B.C., S.M. Murphy, L.L. Patton, P.M. Shock, C.Olfenbuttel, J. Beringer, S. Prange, D.M. Grove, M. Peek, J.W. Butfiloski, D.W. Hughes, J.M. Lockhart, S.N. Bevins, S. VandeWoude, K.R. Crooks, V.F. Nettles, H.M. Brown, D.S. Peterson and M.J. Yabsley. 2011. Distribution and prevalence of *Cytauxzoon felis* in **bobcats** (*Lynx rufus*), the natural reservoir, and other wild felids in thirteen states. Veterinary Parasitology 175:325-330.

Completed Projects

Fisheries

Wildlife

Project Highlights

These projects began in 2011

Fishes

Big Game

Furbearers

Migratory Shorebirds and Colonial Nesting Waterbirds

Habitat Management

Project Updates

This section includes brief updates for selected projects that began prior to 2011.

FISHES

Warm Water Fisheries

Urban Fisheries

Lake Investigations/ Cold Water Fisheries

Crappie fishing on Kentucky Lake / Obie Williams

Owl / Obie Williams

Completed Projects

Status and Life History of the Amblyopsid Cavefishes in Kentucky

Matthew L. Niemiller and Benjamin M. Fitzpatrick, Department of Ecology and Evolutionary Biology, University of Tennessee

KDFWR Contact: *Ryan Oster*

Introduction

The Appalachians and Interior Plateau support the highest aquatic subterranean biodiversity within the continental U.S. (Culver et al. 2003). However, over 95% of subterranean species in North America are vulnerable or imperiled (Culver et al. 2000) because of restricted geographic distributions (Culver et al. 2000, 2003) and a number of threats, such as groundwater pollution and habitat degradation (Elliott 2000; Danielopol et al. 2003; Boulton 2005). Unfortunately, the distribution and status of many species is incomplete or lacking entirely, making conservation and management decisions difficult. Here we investigate the distribution, ecology, conservation status, and threats to three cave-associated fish species in the family Amblyopsidae in Kentucky (Fig 1): the Northern Cavefish (*Amblyopsis spelaea*), Spring Cavefish (*Forbesichthys agassizii*) and Southern Cavefish (*Typhlichthys subterraneus*). Despite large distributions in central Kentucky, little is known regarding life history of these species, particularly of the obligate cave-dwelling *A. spelaea* and *T. subterraneus*. Pursuant with Kentucky's priority research and survey needs, the objectives of this study were to (1) conduct baseline surveys and status assessments of each amblyopsid species to determine their distribution and conservation status in the state, (2) obtain cavefish biology information, such as habitat requirements, ecology, and demography for each species, and (3) identify potential threats to existing and significant populations of each species and develop recommendations for

Cavefish / Matt Thomas

Figure 1: *Four species of amblyopsid cavefishes occur in Kentucky: the Spring Cavefish (Forbesichthys papilliferus) (top left), Northern Cavefish (Amblyopsis spelaea) (top right), Southern Cavefish (Typhlichthys subterraneus) (bottom left), and Kentucky Cavefish (bottom right).*

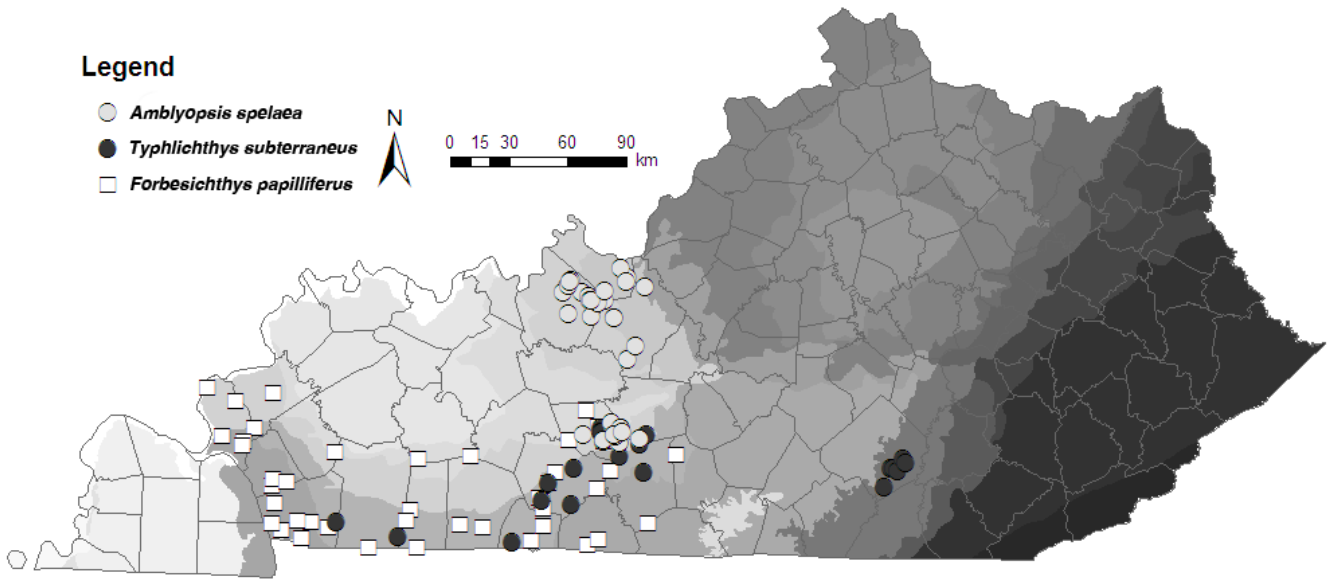

Figure 2: *The distributions of amblyopsid cavefishes in Kentucky are confined to cave- and karst- bearing regions. Ecoregions are colored.*

status evaluations and monitoring.

Methods

Field Surveys

We searched for Northern Cavefish, Southern Cavefish, and Spring Cavefish from May 2007 through September 2011 in caves, springs, and spring-fed streams throughout the Interior Plateau and along the Cumberland Plateau of Kentucky, including several historic localities. We conducted surveys during all months of the year, but concentrated during periods of favorable conditions in subterranean streams (i.e., shallow, clear water with little flow) or during spring when water levels were higher and Spring Cavefish can be found in surface habitats. Surveys for cave species (i.e., Northern Cavefish and Southern Cavefish) were temporarily discontinued in 2009 and 2010 because of concerns of the spread of White Nose Syndrome affecting cave-roosting bats.

To locate cavefish, we donned wetsuits and slowly walked along, waded through, or crawled in the cave stream channel and thoroughly scanned the streambed with the beams of our headlamps. We also carefully lifted flat rocks, small cobble, and detritus under which smaller individuals might seek refuge. Lifted rocks were returned to their original positions to minimize habitat disturbance. A similar approach was taken in surface springs, streams, and ponds while surveying for Spring Cavefish. We used large dipnets to search through aquatic vegetation and detritus where Spring Cavefish might seek refuge during the day. We also searched beneath rocks, logs, and other potential cover objects. A tally of each individual found was kept, and a concerted effort was made to capture, with small bait nets, each cavefish encountered.

Captured fish were placed in clear plastic bags until standard length (SL) was measured to the nearest mm using a small metric rule or digital calipers. Other data were gathered from each captured fish if possible, including sex, condition (e.g., injuries, growths, or presence of parasites), habitat (aquatic: stream pool, stream riffle, rimstone pool; terrestrial: mud bank, bank-cut, crevice), substrate (mud, sand, cobble, gravel, bedrock, organic debris, artificial), cover type (rock, log, crevice, organic debris), and other aspects of life history (diet, behavior, community associates). Additionally, we excised a small tissue sample from the right pectoral fin or caudal fin of one or more cavefish captured at each locality (up to 15 at a given locality) for subsequent genetic analyses.

Results and Discussion

Spring Cavefish Distribution

Within Kentucky, Spring Cavefish have been reported from at least 48 localities in 17 counties, including at least seven records from caves (Fig. 2). We did not observe Spring Cavefish during any cave surveys; however, the species has been reported from a few caves in the Western Pennyroyal Karst. Spring Cavefish occur in four ecoregions in Kentucky. This distribution extends through much of the southern Interior Plateau in the central part of the state, including the Western Highland Rim, Eastern Highland Rim, Crawford-Mammoth Cave Uplands and Western Pennyroyal Karst from the Mammoth Cave region in Edmonson and Hart counties south to the Tennessee border and west to Trigg, Lyon, and Livingston counties along the Cumberland River. At least six records exist within the Caseyville Hills of the Interior River Valleys and Hills. The highest density of Spring Cavefish localities occurs in the Land Between the Lake area in Lyon and Trigg counties, as well as south of the Bowling Green area in Warren County. Included in the distribution of the Spring Cavefish in Kentucky are nine HUC8 watersheds, including the Cumberland, Green, Lower Ohio, and Lower Tennessee basins. Spring Cavefish have the largest geographic extent of all amblyopsids in Kentucky with an extent of occurrence (EOO) of 14,786.2 km^2, and an area of occupancy (AOO) of 720.0 km^2 (based on 4 x 4 km grid cells). We discovered one new locality in Todd County in the Red River watershed.

Southern Cavefish Distribution

Within Kentucky, Southern Cavefish have been reported from at least 29 localities, including 27 caves, one spring, and one well in eight counties (Fig. 2). The highest density of Southern Cavefish localities occurs in Edmonson County. Southern Cavefish occur in four ecoregions in Kentucky. This distribution extends through much of the southern Interior Plateau in the central part of the state, including the Crawford-Mammoth Cave Uplands and Western Pennyroyal Karst from the Mammoth Cave region in Edmonson and Hart counties south to the Tennessee border and west to Trigg County. Southern Cavefish in this region have an EOO of 4,547.9 km^2 and an AOO of 320.0 km^2. A disjunct cluster of populations occurs in Plateau Escarpment ecoregion of the Southwestern Appalachians. Included in the distribution of the Southern Cavefish in Kentucky are five HUC8 watersheds. We documented several new populations in Pulaski County in the Upper Cumberland watershed. Prior to this study, *Typhlichthys* were confirmed from only Sloans Valley Cave (Cooper and Beiter 1972), which is partially inundated by Lake Cumberland. With the assistance of the Greater Cincinnati Grotto, we discovered new populations in three nearby cave systems with unconfirmed reports from two additional cave systems. All localities occur within the Plateau Escarpment of the Southwestern Appalachians and are isolated from other populations in both Kentucky and Tennessee. This set of populations only has an EOO of 38.3 km^2 and an AOO of 80.0 km^2.

Northern Cavefish Distribution

Within Kentucky, Northern Cavefish have been reported from at least 39 localities, including 38 caves and one spring in five counties (Fig. 2). Northern Cavefish occur in three ecoregions in the state: the Crawford-Mammoth Cave Uplands and Mitchell Plain of the Interior Plateau and the Caseyville Hills of the Interior River Valley and Hills (two localities). The highest density of Southern Cavefish localities occurs in the Sinking Creek valley in Breckinridge County and in the Mammoth Cave region in Edmonson County. Included in the distribution in Kentucky are three HUC8 watersheds: the Rough and Upper Green watersheds of the Green River Basin and the Blue-Sinking Watershed of the Lower Ohio River Basin. Northern Cavefish have an EOO of 2700.6 km^2 and an AOO of 432.0 km^2 in the state.

Relative abundance, population size and trends

Few studies have attempted to quantify population sizes and relative abundance of amblyopsids, and most of these studies have focused on caves that are known to contain relatively large populations. Other studies for which the most reliable estimates of abundance have been obtained have focused on the species of conservation concern. Additional demographic studies, including long-term censuses, are needed for both surface and subterranean populations.

Historically, Spring Cavefish has been considered rare to uncommon throughout much of its range. In Kentucky, this species has been widely reported but most localities yield fewer than ten fish during a single survey (Fig. 3). To our knowledge, Spring Cavefish have only been observed in excess of 25 fish at two localities: a ditch off of Morton Road in Todd County and Rich Pond in Warren County. Most surveys yield just a few fish; however, this likely is an artifact of habitats sampled, as many ichthyological surveys focus on streams and other larger bodies of water rather than spring runs and springs. Moreover, most springs are located on private property and consequently have been poorly sampled. Because Spring Cavefish return and persist in spring heads and underground waters when their surface habitats dry in late summer and autumn, the best chance of detecting this species occurs when water levels are high in late winter and early spring.

We discovered a new, significant population of Spring Cavefish in a spring-fed ditch off of Morton Road in Todd County (Fig. 4). This stream has been channelized for irrigation and averages ca. 2 m wide. It is full of aquatic vegetation, which provides ample cover for the species. During our first visit on 31 Mar 2010, we captured 77 fish in the 30 m stretch upstream of the road crossing and we estimated a population density of 12,833 fish per hectare at this locality. However, the number of fish dramatically decreased in subsequent weeks as water levels began to decrease and fish presumably moved upstream. By mid-June in both 2010 and 2011, we were unable to capture a single fish at this site. A similar phenomenon was observed at Rich Pond in Warren County. We surveyed a 50 m section of stream upstream of the road crossing on several occasions throughout the year. The stream at Rich Pond issues from a series of small springs then flows for a few hundred meters through an agricultural field before issuing into a large depression in an agricultural field. In the spring during high water levels, the water from the stream issues into this depression forming a large pond (up to 340 acres in size). However, as the season progresses, water levels drop and flow is usually reduced to a small stream that eventually goes completely dry by July or August. During our surveys, we observed as few as zero and as many of 203 Spring Cavefish in this 50 m section amidst aquatic vegetation. We estimated a population density up to 27,067 fish per hectare in the spring but dropping to 0 fish per hectare in the autumn when fish move underground and the stream dries.

Sixty-three percent of reported Southern Cavefish localities yield fewer than ten fish during a single survey. Only Hawkins River in Mammoth Cave, Hidden River Cave in Hart County, and L & N Railroad Cave in Barren County have historically produced 25+ fish during a single survey (Fig. 3). Although Southern Cavefish have been found in many portions of the Mammoth Cave system, the vast majority of cavefish observed are from the Proctor Cave section of the system, and more specifically Hawkins River. Pearson and Boston (1995) observed up to 104 *Typhlichthys* during several surveys in 1993 and 1994. We visited the Logsdon River section and observed 19 cavefish in 2010 even though water levels were slightly elevated from recent rainfall. Pearson and Boston (1995) observed up to 45 cavefish during several surveys of L & N Railroad Cave in 1993 and 1994. We visited the cave on four occasions and observed between 8, 15, 22, and 27 cavefish, respectively, in a ca. 300 m section of the stream. This population is unusual in that cavefish are found in the cave stream with considerable flow, often underneath rocks in the middle of the channel or under undercut ledges around bends and meanders. During two surveys, water levels were elevated with low visibility and we observed few cavefish. We estimated a population density of 450 cavefish per hectare in this section of stream. We discovered a new significant population of *Typhlichthys* in Pulaski County at Drowned Rat Cave. We searched ca. 400 m of stream passage on four occasions and observed 31, 17, 24, and 14 cavefish, including presumably young-of-the-year fish. We estimate a population density of 258 cavefish per hectare in this section of stream.

Like Southern Cavefish, most Northern Cavefish localities yield few cavefish, as ten or fewer cavefish have been observed from 64% of localities in Kentucky (Fig. 3). The largest populations exist in Breckinridge County, including Webster's Cave, Penitentiary Cave, Amblyopsis Cave, and Under the Road Cave where over 100 individuals have been observed during a single survey. This area and the Mammoth Cave system have been identified as population centers for *Amblyopsis* in Kentucky (Pearson and Boston 1995). Our surveys focused primarily on the northern population center in Breckinridge County where we observed significant numbers in several caves, including Under the Road Cave, which may have experienced a population decline (Pearson and Boston 1995). Webster's Cave

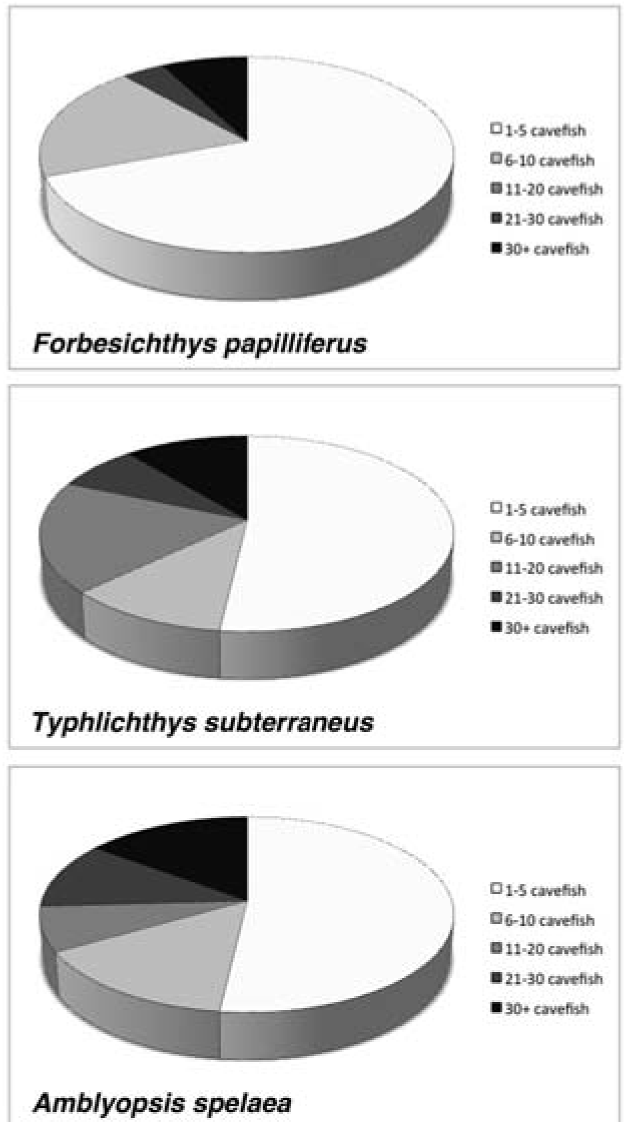

Figure 3: *Proportion of Spring Cavefish (top), Southern Cavefish (middle), and Northern Cavefish (bottom) localities in Kentucky categorized by the maximum number of cavefish observed during a single survey. Most localities yield few individuals.*

in Breckinridge County also supports a large population of *Amblyopsis*. Louis (1999) estimated a population size of 211 ± 37 individuals in a 2530 m section of stream passage at Webster's Cave using mark-recapture with visual implant elastomers. However, this estimate likely is conservative given that Pearson and Boston (1995) observed 162 individuals during a single survey and estimated a population size of 456 cavefish. We observed as many as 51 individuals during our surveys of the first 1200 m of this passage. Based on Pearson and Boston's (1995) data, we estimated a population density of 64 cavefish per hectare in the surveyed portion of Webster's Cave, but it should be noted that cavefish have been observed all throughout the cave system, including areas not subject to survey (Chris Anderson, personal communication).

Although these results might be a reflection of true abundance, the distribution and abundance of the cave-dwelling amblyopsids likely is greater than currently realized. Localities for which Southern Cavefish and Northern Cavefish have been reported represent but a fraction of total available habitat accessible to cavefish. This was clearly illustrated during a fertilizer pipeline break within the recharge zone of Meramec Spring that resulted in the death of at least 1,000 Southern Cavefish and likely many more. This unfortunate kill is informative because the drainage basin had no records for the species previously. The problem with inferring population densities from such fish kills is that we do not know the volume or extent of habitat impacted. Most observations of Southern Cavefish and Northern Cavefish are restricted to caves near the surface and there is some controversy as to whether even the best cavefish caves are sources or sinks (Niemiller and Poulson 2010). Habitats where few or no cavefish are observed likely represent population sinks and not sources. Wells and short stream segments encountered in an otherwise dry cave may not be representative of the habitat that most cavefish inhabit. Cavefish can disperse through and occupy submerged passages inaccessible to humans but these habitats are probably neither usual for the fish nor optimal. These habitats likely act as corridors for dispersal. Given their longevity, low metabolic rates, and foraging efficiency, cavefish likely can move relatively long distances but data are lacking to support this hypothesis.

Determining the actual population sizes of amblyopsid cavefishes is extremely challenging because of the difficulty and inaccessibility of the habitats that each species inhabits. Only a fraction of the actual census population likely is sampled during a given survey; however, even estimating that fraction sampled is not trivial. Here we apply an order of magnitude scaling factor for estimating population size, but recognize that actual population sizes could be lesser or greater than our coarse estimates. We estimate a minimal population size of over 12,000 individuals for Spring Cavefish, 3,200 individuals for Southern Cavefish, 500 individuals for new lineage of *Typhlichthys* in Pulaski County and 14,900 individuals for Northern Cavefish in Kentucky.

Trends refer to directional change over the short-term (within three generations) and long-term (within 100 years) in population size, EOO, AOO, or number of occurrences. There is no current evidence to suggest that there have been substantial changes in any of these factors over the short-term or long-term for amblyopsid cavefishes in Kentucky, although these factors should be reassessed every 5–10 years. The population of *Typhlichthys* at Sloans Valley Cave has not been confirmed since the late 1960s, but cavers have reported seeing white, blind fish in the same pools where Cooper and Beiter (1972) collected cavefish over the past two decades. If this population was extirpated, a significant reduction in EOO and AOO would occur for this lineage. Northern Cavefish may have experienced a population decline after excessive collections in the late 1800s (Niemiller and Poulson 2010) but there is no evidence to suggest that current population densities are any less than those in the mid 1800s when the species was first discovered in the Mammoth Cave system.

Management Recommendations

Several conservation measures have been proposed or implemented for populations of cave amblyopsids in Kentucky. Fencing or gating of cave entrances have been proposed or implemented to reduce and control human visitation to sensitive cave ecosystems, such as the many entrances to the Mammoth Cave system in Edmonson County, Thornhill Cave in Breckinridge County and Parker Cave in Barren County. Special bat gates are needed to allow entry and exit by bats but stop human entry. Bat Conservation International and The National Speleological Society have been leaders in the improvement and installation of such gates on an increasing number of bat caves. At other caves, such as Wells Cave in Pulaski County, signs have been posted to help reduce illegal visitation. Protection of cave surface and subsurface watersheds is probably the most important intervention for cavefish localities. Watershed protection has included establishing preserves as well as institution of best land management practices around sinkholes and sinking creeks, including reforestation. Indeed, a number of cave systems receive some protection by occurring on state or federally owned land or are owned or leased by conversation agencies. In other cases, water tracing has identified the source of pollutants and so allowed legal action that remedied the situation. Hidden River Cave in Hart County, Kentucky is one example. We suggest that demographic source caves deserve complete protection of their watersheds, such as Northern Cavefish localities located in Sinking Creek. Only a few caves have the vast majority of all Northern Cavefish ever censused. Attention to protecting these caves should be a top priority for the near future. Likewise, source populations of Spring Cavefish, such as Rich Pond, should be identified and protected. To this end, several management policies should be implemented in the immediate recharge basins of significant cavefish populations to protect the health and integrity of source populations: (1) alter land use practices and implement runoff control measures to reduce the input of sediments and runoff into cave systems, (2) reduce or eliminate the use of toxic pesticides and herbicides known to negatively impact the fragile subterranean ecosystem, (3) identify and protect critical input points (sinkholes and sinking streams) into cave systems, and (4) limit access to areas within cave systems that support large cavefish subpopulations.

In light of the current state of knowledge regarding amblyopsid populations in Kentucky, we offer the following recommendations for future research and conservation management:

Newly found cavefish habitat / Matthew Niemiller

Figure 4: *This spring-fed ditch off of Morton Road in Todd County contains a newly discovered population of Spring Cavefish (F. papilliferus).*

Spring Cavefish

1. Identify and survey springs located on private property located within the suspected distribution of the species to discover additonal significant populations.

2. Work to protect the Rich Pond population through purchase of the spring and surrounding area, implementing habitat protection strategies, or by obtaining a conservation agreement with the private landowner.

3. Additional population genetic analyses and long-term mark-recaptured are warranted to determine connectivity of populations and dispersal ability of the species in the Western Pennyroyal Karst. Although dispersal ability in amblyopsids is generally thought to be low, major flood events, such as the event during May 2010, may be important for long distance dispersal in this species.

4. Establish a yearly census at the two most significant localities (Morton Road in Todd County and Rich Pond in Warren County) during April or May to monitor population and demographic trends over time.

5. Delineate the recharge zone and conduct annual monitoring water quality at Rich Pond.

Southern Cavefish

1. Delineate the recharge zones of known localities of the undescribed species in Pulaski County, particularly the Coral Cave system and Hail Cave system.

2. Additional surveys are needed to document additional sites for the undescribed species in Pulaski and determine if the distribution extends to the southwest along the escarpment of the Cumberland Plateau in Wayne County.

3. Determine the point source of groundwater contamination at Friendship Cave in Warren County and initiate a chemical cleanup of the cave if possible.

4. Implement a public awareness program to inform landowners and others of the harmful impacts of dumping into sinkholes on groundwater and life it contains.

5. Remove the dilapidated pump house and other debris at the entrance of L & N Railroad Cave in Barren County to improve terrestrial and aquatic habitat in the cave.

Northern Cavefish

1. Surveys are needed of cave systems that occur between the main centers of distribution for *Amblyopsis spealea* in parts of Grayson, Hardin and Hart counties to determine if the two main population centers in Kentucky are continuous or isolated by the Hart County Ridge. Additionally, future genetic work should focus on determining with relationships of southern populations of *Amblyopsis* in the Mammoth Cave area with those to the north in the the Sinking Creek area of Breckinridge County. This latter recommendation is currently underway.

2. Because the populations in Sinking Creek in Breckinridge County represent the most significant population center of the species, efforts should be made to protect these populations through landowner agreements, the purchase of cave entrances and surrounding land within recharge zones, and measures to reduce development and construction activities in the area.

3. Implement a public awareness program to inform landowners and others of the harmful impacts of dumping into sinkholes on groundwater and life it contains.

4. Conduct *in situ* studies to determine if Rainbow Trout and Banded Sculpin successfully prey on subterranean fauna, including Northe Cavefish, in subterranean habitats and determine their influence on subterranean faunal abundance and behavior.

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Funding Source: *State Wildlife Grant (SWG) and University of Tennessee at Knoxville*

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

Kentucky Residents' Awareness of and Opinions on Elk Restoration and Management Efforts

Mark Duda, Responsive Management; Brian Clark and Tina Brunjes, Kentucky Department of Fish & Wildlife Resources

Introduction

The Kentucky Department of Fish and Wildlife Resources (KDFWR), in partnership with the Rocky Mountain Elk Foundation, established a 16-county elk restoration zone in 1997. Since the release of the first seven elk, which were captured in western Kansas and relocated, the number of elk in Kentucky has reached the target goal of 10,000. The restoration efforts have proven so successful that KDFWR achieved its elk population goals 11 years ahead of schedule and translocation efforts were discontinued in 2002. The elk population is thriving in Kentucky's restoration zone, and liberal hunting opportunities outside the restoration zone are helping to keep the population confined to the 16-county elk restoration zone (Figure 1). In fact, successful breeding, high calf survival rates, and a lack of predation have resulted in Kentucky boasting the largest free-ranging, wild elk herd east of Montana. This study was conducted to determine public perceptions regarding and support for the free-ranging elk herd that has been established across the 16-county elk restoration zone in southeastern Kentucky.

Methods

This study entailed a telephone survey of two groups of Kentucky residents: (1) residents in the 16-county elk restoration zone and (2) residents who do not reside in the elk restoration zone. Counties included in the restoration zone are: Bell, Breathitt, Clay, Floyd, Harlan, Johnson, Knott, Knox, Leslie, Letcher, Magoffin, Martin, McCreary, Perry, Pike, and Whitley. For the survey, telephones were selected as the preferred sampling medium because of the almost universal ownership of telephones among Kentucky residents (both landlines and cell phones were called). Additionally, telephone surveys (relative to mail or Internet surveys) allow for more scientific sampling and data collection, provide higher quality data, obtain higher response rates, are more timely, and are more cost-effective. A central polling site at the Responsive Management office allowed for rigorous quality control over the interviews and data collection.

The telephone survey questionnaire was developed cooperatively by Responsive Management and the Kentucky Department of Fish and Wildlife Resources. Responsive Management conducted pre-tests of the questionnaire to ensure proper wording, flow, and logic in the survey. Telephone surveying times were Monday through Friday from 9:00 a.m. to 9:00 p.m., Saturday from noon to 5:00 p.m., and Sunday from 5:00 p.m. to 9:00 p.m., local time. The survey was conducted in June 2011. Responsive Management obtained a total of 1,273 completed interviews. The software used for data collection was Questionnaire Programming Language. The sampling methodology entailed Random Digit Dialing (RDD), which ensures that all households with telephones have an equal chance of being called to participate in the survey. RDD is the best methodology for maintaining a representative random sample of households, taking into account such issues as those without landlines, those unlisted by choice, new numbers, and those numbers that have been disconnected due to a move or change in residence. The RDD sample was supplemented by cell phones in the proportion that matched the proportion of households that have cell phones only (i.e., households with a cell phone but no landline).

The sample was representative of all Kentucky residents age 18 and older. The sample also allowed for representative results for the two strata: Kentucky residents in the 16-county elk restoration zone and Kentucky residents who do not reside in the elk restoration zone. The analysis of data was performed using Statistical Package for the Social Sciences as well as proprietary software developed by Responsive Management. The results were weighted by demographic and geographic characteristics so that the sample was representative of residents in Kentucky as a whole. Throughout this report, findings of the telephone survey are reported at a 95% confidence interval (or higher). For the entire sample of Kentucky residents age 18 and older, the sampling error is at most plus or minus 2.75 percentage points. Sampling error was calculated based on a sample size of 1,273 and a population size of 3,046,951 Kentucky residents ages 18 years and older. Cross tabulations were run on many questions, including cross tabulations by residence. For this cross tabulation, respondents were categorized into two groups: elk restoration zone residents (respondents who lived in one of the 16 counties within the elk restoration zone) and non-zone residents (respondents who lived in Kentucky but do not live within the elk restoration zone).

Elk herd in eastern Kentucky / Brian Clark

Results

Awareness and Knowledge of Elk in Kentucky

About half of Kentucky residents (51%) are not aware that free-roaming, wild elk exist in the 16-county elk restoration zone in southeastern Kentucky. Not surprisingly, elk restoration zone residents are much more likely to be aware that wild elk exist in Kentucky than are non-zone residents: 76% of zone residents are very or somewhat aware wild elk exist in Kentucky compared to 45% of non-zone residents.

Those who have hunted *any* game species in Kentucky in the past 5 years are much more likely to be aware that wild elk exist in Kentucky than are those who have not hunted in Kentucky in the past 5 years: 73% of those who have hunted in Kentucky in the past 5 years compared to 42% of those who have not hunted in Kentucky in the past 5 years.

Most commonly, Kentucky residents indicated they know nothing (47%) about elk in Kentucky; however, about a third (32%) said they know a little. Although elk restoration zone residents are more likely than are non-zone residents to say they know about elk in Kentucky, zone residents most commonly indicated they know a little about elk in Kentucky. Most Kentucky residents do not know how many elk are in southeastern Kentucky; only 3% gave a response at or close to 10,000. Most Kentucky residents do not know which agency in Kentucky is responsible for the conservation of wildlife, including elk. About a quarter of respondents (24%) correctly named the Kentucky Department of Fish and Wildlife Resources, and another 6% gave a response that could be correctly identified as the Department.

Elk Encounters and Trips to View Elk

A large majority of Kentucky residents (75%) have never seen elk anywhere in Kentucky. A majority of elk restoration zone residents (57%) have seen an elk in Kentucky, but a large majority of non-zone residents (79%) have not.

Of Kentucky residents who have seen elk in Kentucky, 40% saw elk in southeastern Kentucky (captive elk are present in a few other locations, such as KDFWR's Salato Wildlife Education Center and in a prairie demonstration area at Land Between the Lakes National Recreation Area). Few Kentucky residents (5%) have taken a trip in Kentucky for the purpose of viewing elk. About half of Kentucky residents who have taken a trip in Kentucky for the purpose of viewing elk (53%) have done so in 2010 or 2011. The median amount spent on a trip to view elk in Kentucky is $50.

Values Associated with Elk

Large majorities of Kentucky residents rated values associated with the state's economy, the existence of elk, non-consumptive recreation related to elk, and hunting elk as very or somewhat important. Most Kentucky residents (90%) said it is very or somewhat important to them to know that Kentucky benefits economically from tourists who come to watch or photograph elk. Knowing that wild elk exist in Kentucky, that opportunities to watch or photograph elk bring tourists to Kentucky, and that people have the opportunity to watch or photograph elk in Kentucky were each rated as very or somewhat important by 88% of Kentucky residents. A large majority of Kentucky residents (70%) said it is very or somewhat important to them to know that people have the opportunity to hunt elk in southeastern Kentucky.

Awareness of and Opinions on Elk Restoration and Management

After being informed that the KDFWR is the agency responsible for conserving fish and wildlife resources and providing opportunities for fishing, hunting, and other wildlife-related recreation in Kentucky, a large majority (72%) said they are satisfied (very or somewhat) with the overall performance of KDFWR.

The most common reason given for dissatisfaction with KDFWR overall performance is poor management of wildlife or natural resources. The majority of Kentucky residents (58%) are not at all aware that KDFWR has restored elk in 16 counties in southeastern Kentucky. Nonetheless, a substantial percentage of Kentucky residents (40%) are aware elk has been restored in the area.

The majority of elk restoration zone residents are aware that the Department has restored elk, while the majority of non-zone residents are not at all aware. It is worth noting, however, that about a third of zone residents (34%) are *not at all* aware that KDFWR has restored elk in southeastern Kentucky where they reside.

The majority of Kentucky residents (54%) are not at all aware that KDFWR allows the regulated hunting of free-roaming, wild elk in southeastern Kentucky. Nonetheless, a substantial percentage of Kentucky residents (44%) are aware KDFWR allows elk hunting. A large majority of Kentucky residents (78%) support having free-roaming, wild elk in southeastern Kentucky, with much of that support being strong support; only 8% oppose.

The most common reason Kentucky residents oppose having elk in southeastern Kentucky is concern about elk-vehicle accidents (38% of those who oppose gave this response), followed by concern about crop or property damage (27%). The majority of Kentucky residents (61%) are satisfied with the management of elk in Kentucky.

After being informed that the current elk population is estimated at 10,000 elk and meets the goal set by the Department for the restoration plan, over half of Kentucky residents (56%) said the elk herd is about the right size; a substantial percentage (19%) said they do not know.

A large majority of Kentucky residents (80%) think the economic benefits of elk in southeastern Kentucky should be important to decisions about how the elk population is managed; 56% said it should be *very* important. The majority of Kentucky residents (68%) agreed that opportunities for both elk watching and elk hunting in southeastern Kentucky are compatible, with 39% *strongly* agreeing. Nearly half of Kentucky residents who disagreed that opportunities for elk watching and elk hunting are compatible (49%) said they disagreed because they were opposed to elk hunting, followed by 25% who have general safety concerns.

Opinions on and Participation in Hunting

A large majority of Kentucky residents (79%) supported legal, regulated hunting in Kentucky, with most support being *strong* support. The majority of Kentucky residents had never hunted. In their most recent year of hunting in Kentucky, the majority of respondents who had ever hunted in Kentucky hunted mostly on private land (64%).

Opinions on and Participation in Hunting

The majority of Kentucky residents (74%) supported legal, regulated hunting of elk in Kentucky, with over half (51%) strongly supporting elk hunting; nonetheless, a notable percentage (19%) opposed.

Kentucky residents were informed that between 800 and 1,000 elk tags are drawn in each year's elk hunting lottery, and a slight majority (54%) thought this is about the right number of tags for the lottery. The majority of those who have hunted in Kentucky in the past 5 years (69%) thought the number of elk tags drawn each year is about the right number.

Only 6% of Kentucky residents had personally applied for an elk tag to hunt elk in Kentucky since the elk hunt program began in 2001. About a quarter of those who had hunted any game species in Kentucky in the past 5 years (24%) had personally applied for an elk tag to hunt elk in Kentucky since the elk hunt program began in 2001.

Most commonly, Kentucky residents who had applied for an elk tag in Kentucky indicated that hunting elk for the meat is the single most important reason they applied for an elk tag. About 16% of Kentucky residents who had applied for an elk tag had personally hunted elk in Kentucky.

The large majority of Kentucky residents who had applied for an elk tag (81%) said they would be willing to pay for hunting access to private land that has elk if they were drawn for an elk tag. The majority of Kentucky residents willing to pay for hunting access to private land that has elk gave an amount less than $500. The median amount Kentucky residents are will-

ing to pay for hunting access to private land was $100.

Harvesting a trophy/large-antlered elk or a bull/male elk was important to those who had applied for an elk tag to hunt elk in Kentucky. When asked to indicate how important values related to elk hunting are, an overwhelming majority of Kentucky residents who had applied for an elk tag (91%) said being able to harvest a bull or male elk was very or somewhat important to them, followed by being able to harvest a trophy or large-antlered elk (89%) and being able to harvest any elk (86%). Kentucky residents who had applied for an elk tag were read three options for hunting elk in Kentucky and were asked to indicate which option they most prefer. Most commonly, those who had applied for an elk tag most prefer waiting for the opportunity to harvest a trophy elk: 33% gave this response. Substantial percentages preferred harvesting any elk (28%) or any bull (24%) in the first few hunting days or trips. The large majority of Kentucky residents who had applied for an elk tag to hunt elk in Kentucky also support management for trophy or large-antlered elk; support decreased only slightly when respondents were asked about management for trophy elk even if it meant that fewer hunters would be able to harvest a bull elk.

Land Ownership and Hunting on the Land

Nearly half of Kentucky residents (46%) owned land in Kentucky. Elk restoration zone residents were more likely than are non-zone residents to own land in Kentucky: 61% of zone residents compared to 45% of non-zone residents. Nearly half of Kentucky residents who owned land (49%) owned less than 5 acres. The median amount of land owned was 4 acres. Most commonly, Kentucky residents who owned land (9%) indicated that the largest tract of land they own is located within Jefferson County, followed by Hardin, Campbell, Fayette, and Warren Counties (3% each; these were some of our most populous and largest counties). Of those who owned land in Kentucky, 16% said their largest tract of land was located in one of the 16 counties included in the elk restoration zone. The majority of Kentucky residents who owned land in a county located within

Bull elk research / Joe Lacefield

the elk restoration zone (73%) had not seen an elk on the tract of land; nonetheless, nearly a quarter (23%) had seen an elk on the land.

Only 2% of Kentucky residents who owned land in a county located within the elk restoration zone personally hunted elk on the land. A slightly higher percentage (9%) allowed others to hunt elk on the land.

Problems with Elk and the Kentucky Department of Fish and Wildlife Resources' Response to Problems

Nearly all Kentucky residents had not experienced any problems with elk in the past 5 years; however, 3% of elk restoration zone residents had experienced problems with elk in the past 5 years. The majority of Kentucky residents who had experienced problems with elk in the past 5 years (61%) have had a vehicular collision with elk or damage to their vehicle caused by elk; approximately a third (35%) had experienced damage to their property, such as fences or other structures.

Discussion & Management Implications

This survey's results suggest that the primary management concern with respect to elk in Kentucky is public information. The level of public awareness about Kentucky's elk herd (58% not at all aware) was surprisingly low among Kentucky residents as a whole, and even among hunters a significant percentage was unaware of the elk. Predictably, knowledge of the elk program and hunting opportunities were much greater inside the elk zone, but even therein residents exhibited a substantial lack of knowledge about elk. KDFWR's statewide public information efforts and marketing related to the elk restoration program since its inception in 1997 have been largely targeted at hunters and viewers of *Kentucky*

Afield television program (although a variety of dispersed news releases, magazine articles, documentaries, and other media pieces have featured the elk program over the past 10 years). Whereas over one-third of Kentuckians view the department's TV program at least monthly, obviously many do not and have not seen the program, and only a small percentage attends outdoor expos where elk hunting is expressly promoted by KDFWR. Clearly a substantial percentage of the population has not learned about the elk restoration efforts through other sources.

Despite the lack of knowledge about Kentucky's elk, residents are overwhelmingly (78%) positive about the presence of elk in the Commonwealth. This is consistent with the virtual absence of negative experiences with elk—only 3% of elk zone residents had experienced problems with elk over the past 5 years. Interestingly, fears about elk-vehicle accidents and crop damage were prominent concerns among the 8% who opposed having elk in southeastern Kentucky. This is a concern that conservation educators and recreation planners should be prepared to address in their outreach efforts.

Only a small percentage of Kentuckians had personally invested in elk-related recreation, with 6% applying for elk hunts and 5% making elk-viewing trips. These findings further demonstrate that KDFWR still has a large unreached audience with whom to communicate about elk and to whom hunting and viewing opportunities relatively close to home can be marketed. With only 3% of Kentuckians aware of the general size of our elk population, significantly more widespread knowledge that Kentucky has 10,000 elk could translate into significantly more elk recreationists. A recent study revealed that as much as 27% of Americans are interested in hunting (Responsive Management 2011). Although Kentucky has a relatively low percentage of hunter churn (Responsive Management, unpublished data), identifying interested individuals who are not participating and providing them with accurate and helpful information about hunting opportunities may significantly improve hunter recruitment and retention efforts in the Bluegrass State (Responsive Management 2011).

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KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Bobcat Space use in the Paul Van Booven Wildlife Management Area, Southeastern Kentucky

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Introduction

Population estimation and trend analyses are critically important exercises for sustainable harvest and management of many game species. Animals that occur at low densities, exhibit elusive behavior, or are wide-ranging pose economic and logistical challenges to wildlife managers attempting to monitor them.

The bobcat (*Lynx rufus*) is a mesocarnivore and the only extant native felid throughout most of the U.S., including Kentucky, where it is an important furbearer and ecological component. Whitaker (1988), Penry (1988), and Painter (1991) used VHF radio-collars to examine bobcat space use patterns and habitat use in both eastern and western Kentucky. These studies examined the potential for a harvest season in light of known bobcat populations in Kentucky. As a result, an experimental quota season began in 1987. Since then, harvest of bobcats has increased, possibly indicating bobcats have increased in abundance and expanded their geographic range statewide. Other than habitat statistics, no data on bobcats in Kentucky have been collected since those collected in the 1980's, as reported by Frederick et al. (1989). We sought to re-evaluate the status of bobcats in Kentucky to improve and update current management strategies. The objectives of this study were to estimate home range sizes for a sample of bobcats in southeastern Kentucky and to assess core use areas and amount of overlap between individuals.

Methods

The Paul Van Booven Wildlife Management Area (PVB WMA) is a reclaimed surface mine characterized by deep v-shaped valleys and steep slopes, with elevations from 225 to 470 m. The dominant vegetation on the site is a mix of grain annuals, legumes, and trees that were planted as part of the post-mining restoration, though the broad landscape is part of the mixed mesophytic forest ecosystem. Much of the surrounding properties are privately held and large sections are active surface mines.

Bobcats were trapped according to the protocol outlined by Whitaker (1988) and KDFWR. Trapping began in February 2010 and continued through April 2010. Bobcats were captured by using number 2 double-coil spring steel padded leg hold traps (Schemnitz 1994). We used Telazol[R] to immobilize trapped animals, delivered by intramuscular injection; the dose was based on the in-field weight estimation (Kreeger 1996, Lovallo and Anderson 1996, Shindle and Tewes 2000). Handling of bobcats followed American Society of Mammalogists (ASM) guidelines (Gannon et al. 2007) and standard individual measurements, including sex, weight, total body length, ear length, and tail length were taken (Knick 1990).

A GPS/GSM radio collar was attached to 1 male bobcat; the collar weight was $\leq$3.85% of the cat's body weight (Gannon et al. 2007). The smaller female bobcats were collared with lighter VHF units. The GPS radio collar was programmed to record GPS coordinates once every 6 hours, producing 4 fixes per day. Bobcats were located approximately every five days over the course of 12 months (May 2010 through May 2011) by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) producing a total of approximately 65 points for the year per animal.

Minimum convex polygon bobcat home ranges, core use areas, and central core areas (Seaman and Powell 1996, Seaman et al. 1999), as well as home range overlap, were calculated from GPS and VHF data by using Biotas Software (Ecological Software Solutions LLC, Hegymagas, Hungary) and Hawth's Tools for ArcGIS 9.3 (ESRI, Redlands, CA; Benson et al.

Estimator	F1	F2	F3	F4	M1	Mean	SE
95%	9.23	22.41	25.29	12.48	4.92	14.87	3.89
50%	2.65	3.8	4.51	2.6	1.26	2.96	0.56
25%	0.79	1.14	1.23	0.47	0.63	.85	.15

Table 1: *Home range (95% MCP), core area (50% MCP) and central core area (25% MCP) size estimates (km2) for one male (M1) and 4 female (F1-F4) bobcats.*

Overlap Estimates (%)

Estimator	F1-F2	F1-F3	F1-F4	F1-M1	F2-F3	F2-F4	F2-M1	F3-F4	F3-M1	F4-M1	Mean	SE
95%	41.2	36.5	18.3	8.9	61.2	14.5	22	2.8	3.07	34.4	24.3	8.4
50%	0.00	0.00	0.00	0.00	62.9	0.00	0.00	0.00	0.00	48.5	11.1	10.6
25%	0.00	0.00	0.00	0.00	28.1	0.00	0.00	0.00	0.00	12.2	4	4.2

Table 2: *Estimates of home-range (95%), core-area (50%), and central-core-area (25%) overlap (%) between one male (M1) and 4 female (F1-F4) bobcats based on minimum convex polygon (MCP) estimators.*

2006, Diefenbach et al. 2006, Riley 2006, Tucker et al. 2008).

Results

Home Range, Core Area, and Central Core Area Size

Annual home range (HR) size estimated by the 95% MCP method (Fig. 1, Table 1) varied from 4.9 to 25.3 km^2 (n = 5, SE = 3.9, mean = 14.9 km^2) and mean female annual HR size was 17.4 km^2 (n = 4, SE = 3.9). We defined core areas as the inner-most part of the MCP that encapsulated 50% of locations; central core areas included the inner-most 25% of all locations. Annual core area size varied from 1.3 to 4.5 km^2 (n = 5, SE = 3.0), mean female core areas were 3.4 km^2 (n = 4, SE = 0.6). Annual central core area size ranged from 0.5 to 1.2 km^2 (n = 5, SE = 0.2), with a mean female central core area of 0.9 km^2 (n = 4, SE = 0.2).

Home Range, Core Area, and Central Core Area Overlap

Intrasexual and intersexual annual area overlap (Fig. 2, Table 2) was greatest at the home range scale, while core areas and central core areas remained fairly exclusive. Female-Female (F-F) annual home range overlap ranged from 2.8 to 61.2% (n = 6 pairs, mean = 29.1%, SE = 8.7), and Female-Male (F-M) HR overlap was from 3.1 to 34.4% (n = 4 pairs, mean = 17.1%, SE = 7.0).

Discussion

Because bobcats are a sexually dimorphic and polygynous species (McCord and Cardoza 1982), we expected to see males retaining larger home ranges than females to maximize encounters with females during the breeding season (Cochrane et al. 2006, Chamberlain et al. 2003). Numerous past studies have documented this pattern (Cochrane et al. 2006, Chamberlain et al. 2003, Lovallo and Anderson 1996b, Fuller et al. 1985), but we observed the opposite, with females having larger home range sizes than the male. Our sample size (4 females and 1 male), however, is too small to accurately portray space use by bobcats. The male's home range in our study overlapped multiple females and likely contained adequate resources to not necessitate a larger home range size.

Space use changes over time

In 1988, Whitaker reported on space use characteristics of bobcats in the PVB WMA vicinity (Table 3). During her study, much of the current-day management area was active mining property or in early stage reclamation (Whitaker 1988); during our study the PVB area was mostly a developing secondary growth reclamation area, surrounded by mining property at various stages of activity. Bobcat home range, core area, and central core area sizes were all consistently higher for males in the late 1980's, which follows most reported sizes for the southeastern region of the US (Cochrane et al. 2006, Chamberlain et al. 2003, Lovallo and Anderson 1996b, Fuller et al. 1985). When comparing our minimum convex polygon estimates to those of Whitaker (1988), we see that females in our study had consistently larger home range, core area, and central core area sizes than the male. When we compare the overlap data we also see an inverse pattern from that of Whitaker (1988), who reported females maintained exclusive home ranges. Assessing 95% MCP

Sex	HR (km^2)	CA (km^2)	CCA (km^2)
Mean Male	59.4	21.0	6.7
Mean Female	4.7	1.9	0.7
Mean Overall	37.5	13.3	4.3

Table 3: *Whitaker (1988) 95% home range (HR), 50% core area (CA), and 25% central core area (CCA) sizes based on the MCP method for bobcats in the PVB WMA and vicinity.*

percent overlap between the two studies, we see that female-male overlap decreased significantly, from 100% in 1988 to 17% in 2011, while female-female overlap increased significantly, from no overlap to 29% overlap for our study. Again, however, our low sample size prevents us from drawing conclusions from these data.

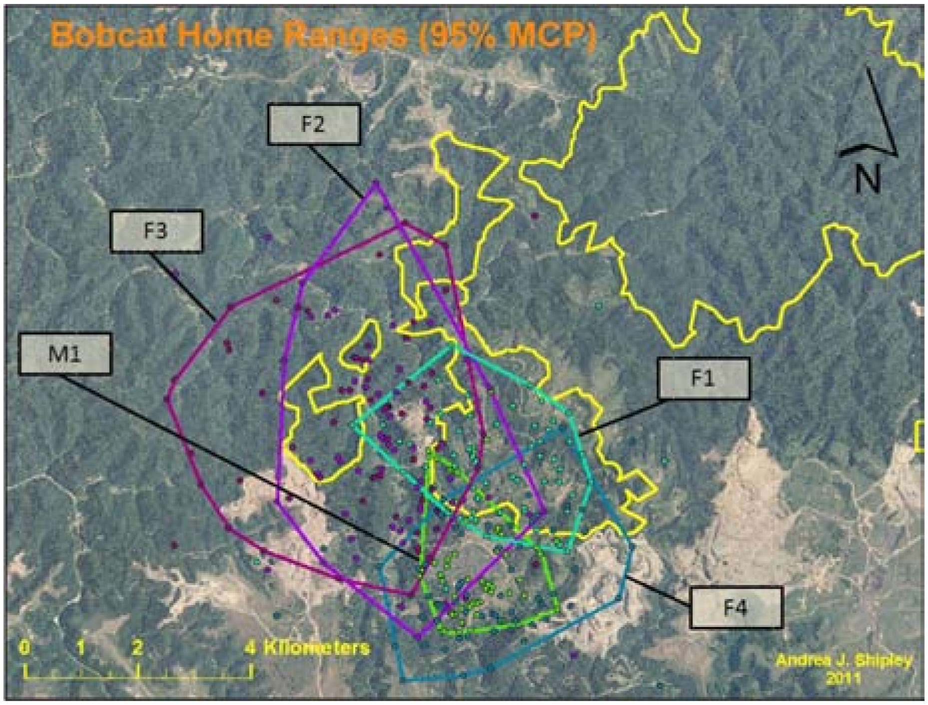

Figure 1: *95% Minimum Convex Polygon (MCP) home ranges of one male (M1) and 4 female (F1-F4) bobcats with their corresponding locations. The PVB WMA and Robinson Forest (upper right) borders are represented in yellow.*

Management Recommendations

Land use can have a great effect on the long term viability of bobcats (Riley et al. 2003), and continued study in areas of representative land uses, such as extractive industry, should continue in order to gain an understanding of the long term effects on bobcat populations. If active mining continues to increase, and reclaimed areas further dominate the landscape of eastern Kentucky, future wildlife studies should focus on these areas rather than avoid them. Requiring additional trapper information such as GPS coordinates as well as submission from hunters and trappers of bobcat samples (e.g., teeth, hair, and feces) would likely enhance the information on current bobcat populations over a broad area.

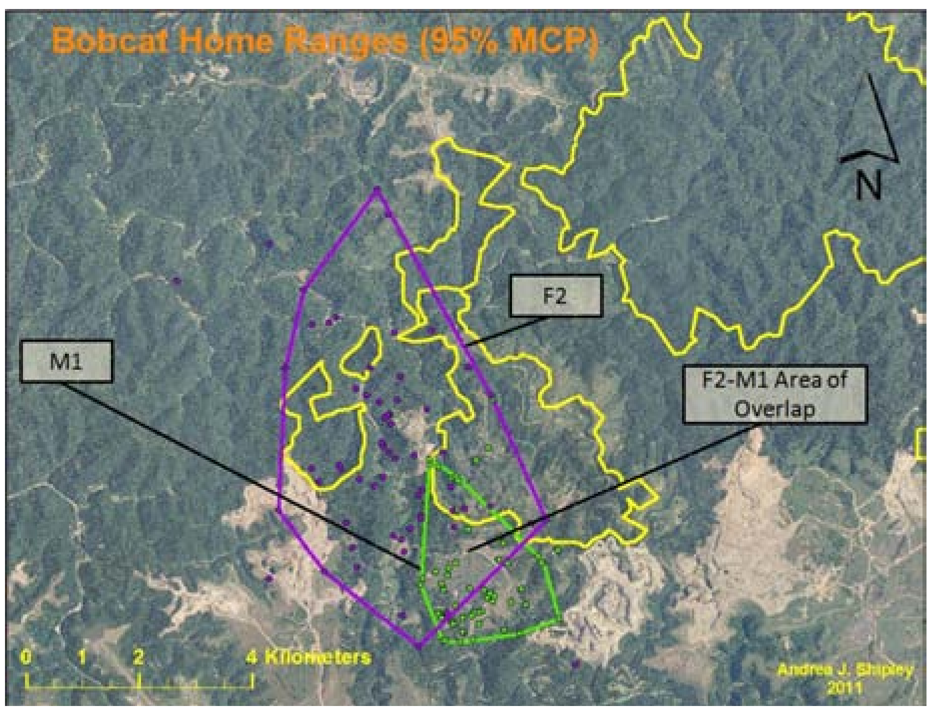

Figure 2: *Overlap of two bobcat home ranges, with their corresponding locations. The PVB WMA and Robinson Forest (upper right) borders are represented in yellow.*

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KDFWR Strategic Plan. Goal 1. Strategic Objective 5.


River Otter / Tim Daniel

Status, Distribution, Diet, and Reproductive Characteristics of River Otters in Kentucky

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Introduction

Prior to European settlement, river otters (*Lontra canadensis*) were distributed throughout Canada and the continental United States, from the arctic in Alaska to Texas and Florida (Hall 1981, Mason 1990). River otters were distributed widely in Kentucky (Barbour and Davis 1974, Toweill and Tabor 1982) and were likely found in every major watershed in the state during the early 1800s (Cramer 1995). Otter populations declined during the early 1900s, likely due to unregulated harvest and anthropogenic destruction of riparian habitat. In an effort to restore self-sustaining populations of river otters throughout suitable habitat in the state, the Kentucky Department of Fish and Wildlife Resources implemented a reintroduction program during the early 1990s (Cramer 1995). In the 16 years since restoration, river otter sightings and reports of damage to personal property and state fish hatcheries have increased. The increased frequency and quantity of reports of river otter occurrence and activity suggested a re-established population; however, no effort to assess the status of this population had been completed.

There have been few formal studies evaluating long-term status of reintroduced populations of river otters (Raesly 2001). Proper monitoring of this reintroduced species is necessary to implement appropriate management strategies, therefore, the overall objective of this project was to evaluate the current status of the river otter in Kentucky and facilitate development of appropriate management strategies for this species. The specific objectives were to: 1) describe the status of the river otter throughout Kentucky using damage reports, sign surveys, and harvest data; 2) present a statewide analysis of the winter diet of river otters in Kentucky, emphasizing predation on sportfish (i.e., Centrarchidae) and crayfish; and 3) describe age-specific reproductive traits of harvested river otters and input these data into models to project future population estimates of river otters in Kentucky

Methods

Distribution and Status Assessment

We used damage reports, sign surveys, and harvest data to evaluate the status of the river otter in Kentucky. Data on damage caused by river otters were gathered from annual reports submitted to the KDFWR by permitted Wildlife Control Operators and from KDFWR biologists and conservation officers from 2004-09. Data were tabulated as the total number of complaints/year. We stratified the state by the 12 watersheds, with sampling intensity within each watershed proportional to the relative percentage of the state that each watershed comprised. We randomly chose stream bridge-crossings as survey sites (for otter sign) in each watershed. We conducted surveys from May to October of 2006-08. Bridge-crossing protocol included walking 200-m transects of shoreline to search for sign of river otters. We recorded the type of otter sign (e.g., sightings, scat, tracks, slides, den sites, latrines), as well as standard location and seasonal data (e.g., geographic coordinates, date, ambient conditions). The number of scat and rolling places in an area is not always a good indication of the number of otters present, as a single otter may defecate and haul out many times in one area in a few hours (Melquist and Hornocker 1979); therefore, we used only presence/absence data in the analysis. A total of 65 surveys were completed. A subsample of sites (n = 13; 27%) where otter sign was not detected during the 2006 field seasons was selected and resurveyed during the 2007 field season to evaluate the reliability of otter absence from sites. Harvest data were gathered from a mandatory state telecheck system, in which trappers are required to report river otters hunted or trapped during the harvest season. The harvest data included the November-February 2004-05 and 2005-06 experimental hunting and trapping seasons held in the Jackson Purchase region of Kentucky, and the statewide hunting and trapping seasons for subsequent years from 2006-07 to 2009-10.

Carcass Analysis

We determined population demographics and reproductive parameters by carcass analysis. We obtained frozen otter carcasses from KDFWR and Kentucky trappers during three statewide harvest seasons (November-February), 2006-2009. To determine age of river otters a lower canine was pulled from each individual and age determined by cementum annuli examination (Matson's Laboratory, Milltown, MT; Johnson et al. 1987, Serfass et al. 1993, Stephenson 1977). We classified otters ≥ 2 years of age as adults, 1 year as yearlings, and <1 year as young of the year. For analysis, we grouped young of year and yearlings into a single juvenile category. Standard measurements including body mass, body length, and hind foot length were taken from all carcasses. Female reproductive tracts

Basin	% of state	harvest (*n*)	% of harvest	% survey effort	surveys (*n*)	% surveys positive
Mississippi	3	524	16	6	4	50
Tradewater	6	467	14	3	2	50
Licking	9	464	14	14	9	33
Lower Cumberland	5	433	13	5	3	67
Green	22	379	11	17	11	9
Tennessee	3	300	9	6	4	50
Kentucky	17	275	8	20	13	15
Salt	10	264	8	12	8	25
Upper Cumberland	13	157	5	9	6	17
Big Sandy	6	33	1	2	1	0
Tygarts	3	19	1	3	2	0
Ohio	3	16	<1	3	2	0

Table 1: *Relative area of Kentucky watershed basins, and harvest (2004-2009) and sign surveys of river otters (2006-2009).*

	Male	Female
n	95	75
Mean age (yrs)	1.35 ± 1.72	1.91 ± 2.33
Mean body mass (kg)	6.23 ± 1.56	5.41 ± 1.21
Mean body length (cm)	110.55 ± 9.69	109.31 ± 7.22
Mean hind foot length (mm)	54.41 ± 7.03	50.95 ± 3.95

Table 2: *Mean age, body mass, body length, and hind foot length of male and female river otters, 2006-2009. Data are mean ± SD.*

were removed from all carcasses (e.g. Docktor et al., 1987). We measured length, width and mass of ovaries, length of the bicornuate uterine horns, and inspected and flushed uterine horns for embryos and blastocysts. Ovaries were removed and 1 mm sections examined under a 25 x dissection scope for the presence of corpora lutea (CL). Placental scars, when present, were counted. Chi-square tests were used to evaluate sex ratio of harvested otters, Student's t-tests to evaluate body dimensions between males and females, and Mann Whitney U-tests to determine differences in reproductive characteristics of females from eastern and western portions of the state.

We evaluated population models for river otters using a modified life table approach (Hamilton 1998). These models were initially developed using reproductive characteristics (pregnancy rates and average litter sizes) from otter necropsies and survival data from radiotelemetry studies conducted on reintroduced otters in Missouri (Erickson and McCullough 1987). We calculated Kentucky-specific pregnancy rates and litter sizes from presence/counts of CL, blastocysts, embryos and placental scars. We then constructed a series of population models for otters in Kentucky using the Missouri model as a guide (Gallagher 1999, Hamilton 1998). We generated 4 models using Kentucky-specific reproductive characteristics taken from carcass analysis, including pregnancy rates and average litter sizes, and using adult survival rates from Tennessee (Griess 1987), Missouri (Gallagher 1999), Kentucky (Cramer 1995), and West Virginia (Tango et al. 1991). We evaluated predicted population growth using survival rates that ranged from a low of 0.60 (WV) to a high of 0.91 (TN). Because the first set of models contained survival rates that were calculated from non-harvested populations, we ran the 4 models again, this time with survival rate decreased by 5% to account for additive trapping mortality (Gallagher 1999, Hamilton 1998).

Food Habits Analysis

Stomachs contents from otter carcasses were identified to the lowest possible taxonomic group. We estimated percent volume (percentage of contents per stomach sample represented by a prey group) and percent occurrence (percentage of stomachs in which a prey group occurred), and calculated the average percent volume as the sum of individual volumes/number of stomachs x 100 for each prey group. We categorized scales of Centrarchidae into three groups: those which could not be identified beyond the family level (unknown); those which contained sunfishes, crappies, and rock bass (Group A); and, those which contained black bass such as largemouth bass, smallmouth bass, and spotted bass (Group B). Scales belonging to families other than Centrarchidae were identified to the lowest taxonomic group according to Daniels (1996) and verified with state geographic range information (KDFWR 2009). Crayfish remains were identified to the lowest taxonomic group with a 25x dissecting scope following Taylor and Schuster (2004). We analyzed data with Chi-square contingency tables and compared differences in food habits of male and female otters, juvenile and adult otters, and otters collected from eastern and western Kentucky.

Results

Distribution and Status

A total of 149 damage complaints were reported to the KDFWR from 2004-10. The majority of complaints were depredation of fish in farm ponds and damage to boats and docks. The number of damage complaints ranged from a high of 41 reports in 2005-06 to a low of 5 complaints reported in 2009-10. Damage complaints decreased dramatically after the statewide harvest of otters in the 2006-07 hunting and trapping season. River otter sign was found in 9 of 12 watersheds (Table 1). Otter sign was not found in the Big Sandy, Ohio, or Tygarts River watersheds; all are located in the far eastern portion of the state. Relative to sampling effort, a disproportionately high abundance of otter sign was found in the Licking, Lower Cumberland, Mississippi, Tennessee, and Tradewater River watersheds. A total of 3331 river otters were

	n	Mean/ female ± SD	Range
No. follicles	14	7.93 ± 10.3	1 - 36
No. corpora lutea	8	3.5 ± 1.31	1 - 5
No. placental scars	7	2.86 ± 1.46	1 - 4
No. embryos	6	2.67 ± 1.63	1 - 5
No. blastocysts	11	3.64 ± 1.36	2 - 6

Table 3: *Reproductive characteristics of adult female river otters (n = 32), 2006-2009.*

harvested in Kentucky from the 2004-05 to the 2009-10 hunting and trapping seasons. Of these, 2038 (61%) were males and 1293 (39%) were females. Harvest pressure was greatest in the Mississippi, Tradewater, Lower Cumberland, and Licking River watersheds. Moderate levels of harvest occurred in the Tennessee, Kentucky, Salt, and Upper Cumberland River watersheds, whereas few otters were harvested from the Big Sandy, Tygarts, and Ohio River watersheds. Relative to total area each watershed comprises in the state, a disproportionately high number of otters were harvested from the Mississippi, Lower Cumberland, and Tradewater River watersheds, whereas relatively low harvests occurred in Green, Kentucky, and Upper Cumberland watersheds.

Morphology, Reproduction and Population Growth

Our sample included 95 males (56%) and 75 females (44%), comprised of 111 juveniles (65%) and 59 adults (35%). The overall sex ratio (1.27:1.0) was not different ($\chi^2 = 2.35$, $P > 0.05$) from 1:1. Males had larger body mass ($t = 3.73$, $P < 0.05$) and longer foot length ($t = 3.78$, $P < 0.05$) than females, but body length did not differ ($t = 0.91$, $P > 0.05$) between the sexes (Table 2). Thirty-seven females (49%) showed sign of reproductive activity based on presence of follicles, CL, blastocysts, placental scars, or embryos (Table 3). Of these, 32 (86.5%) were adult females and 5 (13.5%) yearling females. The pregnancy rate for adult females was 0.72, with an average litter size of 3.14 ± 1.46(SD). We found no difference in number of follicles ($U = 15.5$, $P = 0.523$), CL ($U = 4.5$, $P = 0.241$), embryos ($U = 8$, $P = 0.797$), or blastocysts ($U = 8$, $P = 0.223$) between adult females collected from eastern and western Kentucky. The first set of models based on survival rates from Tennessee, Missouri, Kentucky, and West Virginia estimated the 2010 Kentucky population at 17,032, 4,632, 1,556, and 228 females, respectively. These estimates indicate densities of 1 otter per 614, 2,259, 6,726, and 45,903 ha of land, respectively. When 5% additive mortality was included in the model, the Tennessee, Missouri, Kentucky, and West Virginia models estimated the 2010 Kentucky population to be 14,670, 3,618, 1,110, and 140 females, respectively (Figure 1).

Family	*n*	% occurrence	% volume
Amiidae			
Amia calva	1	1	1
Catostomidae	14	21	14
Erimyzon **spp.**	2	3	3
Catostomus **spp.**	4	6	1
Moxostoma **spp. or** *Hypentelium nigracans*	3	4	4
Unknown	5	7	6
Centrarchidae	45	66	53
Group A	35	51	40
Group B	6	9	5
Unknown	8	12	8
Clupeidae			
Dorosoma **spp.**	9	13	12
Cyprinidae	14	21	12
Native minnow spp.	12	18	9
Eurasian carp spp.	2	3	3
Esocidae			
Esox spp.	3	4	2
Percichthyidae			
Morone **spp.**	4	6	5
Percidae			
Darters	1	1	0

Table 4: *Percent occurrence and volume of fish families identified in stomachs of river otters, 2006-2009. The number of stomachs containing prey items is indicated.*

Winter Diet

We examined 170 river otter stomachs: 90 carcasses were collected from the western region of the state and 80 from the east. Of the stomachs examined, 74% ($n = 126$) contained food item remains. Fish and crayfish were the most important winter prey of river otters, occurring in 86 and 27% of all stomachs examined which contained food items, respectively. *Rana* spp. (frogs), snakes, turtles, and *Anas platyrhynchos* (mallard) were also identified in the diet. There was no difference in the relative percentage of prey items taken between male and female otters ($\chi^2 = 5.04$, $P = 0.41$), juvenile and adult otters ($\chi^2 = 2.42$, $P = 0.79$), or otters collected from eastern and western regions ($\chi^2 = 10.62$, $P = 0.06$). We identified 8 families and 11 genera of fish in river otter stomach samples (Table 4). Centrarchidae were eaten most frequently, with Catostomidae (Suckers), Cyprinidae (Minnows) and Clupeidae (Shads) also common in the winter diet of otters. Group A fish (Sunfish and

Crappie species) comprised the majority of the Centrarchidae eaten, with Group B fish (Black Bass species) only occurring in 4.8% of stomachs that contained food items. There was no difference in the relative proportion of fish families taken between male and female otters ($\chi^2 = 13.05$, $P = 0.07$). We identified four genera and six species of crayfish in otter stomach samples. Crayfish in the genus *Orconectes* were eaten most frequently, with *O. rusticus* the most commonly recorded species of crayfish.

Discussion

River otters occurred in all 12 major watersheds in the state. Otters are abundant in the Jackson Purchase in west Kentucky and in the central reintroduction region of the state. An explanation for the lower occupancy of river otters in the eastern region, including the Cumberland Plateau and the Cumberland Mountains, is not immediately clear. We offer three suggestions for this difference. (1) Habitats in the eastern region are furthest from the Jackson Purchase (i.e., remnant source population) and reintroduction zone, and dispersing otters should be expected to take a longer period of time to reach and inhabit available habitats in the east; thus, numbers of otters are likely to increase in future years in the east. (2) The Cumberland Plateau and Cumberland Mountains are largely forested landscapes with pronounced changes in topography, often exceeding 300 m. These landscapes have fewer farm ponds and support streams that are shallower in depth and lacking in deeper pools of water, thereby providing less total acreage in available surface water. These differences result in habitat conditions supporting a lower potential carrying capacity of river otters than the fragmented and agricultural landscapes to the west; thus, numbers of otters are likely to remain at lower levels. (3) Watersheds in the eastern region are impacted in many stream reaches by resource extraction, particularly logging and/or surface mining. Resource extraction practices result in short and long-term changes in water quality and landform following reclamation. These changes lead to loss of original habitats, potentially limiting the establishment of river otters throughout the eastern region; thus, numbers of otters are expected to remain at lower levels. The small remnant population in the west has expanded and appears to have formed a contiguous population with the increasing numbers of river otters in the reintroduction zone. Populations of river otters in Kentucky are also likely to be affected by immigration of otters from surrounding states. Missouri (Beringer 2008), Illinois (Bluett et al. 1999), Indiana (Johnson et al. 2007), Ohio, and Tennessee have implemented otter reintroduction programs, and dispersal of otters is likely augmenting the expanding population in Kentucky.

Catostomids, cyprinids, and clupeids were commonly consumed by river otters in Kentucky, consistent with research in similar habitats where these fish assemblages occur (Anderson and Woolf 1987, Knudsen and Hale 1968, Manning 1990, Toweill 1974). Centrarchids were consumed most frequently of any family of fish, rejecting the null hypothesis that fast swimming fish species should occur less often in the diet of otters (Serfass et al. 1993, Stenson et al. 1984). Research on food habits of river otters in Illinois (Anderson and Woolf 1987), Massachusetts (Sheldon and Toll 1964), Michigan (Ryder 1955), Montana (Greer 1955), and Missouri (Roberts et al. 2008) also found Centrarchidae in the diet of river otters. The majority of centrarchid scales in river otter stomach samples belonged to Group A, or the sunfishes, crappies and rock bass. State agencies which have reintroduced river otters, including Kentucky, rarely receive complaints from anglers about declining populations of fish in Group A. Instead, complaints about river otters impacting Group B sportfish, such as *Micropterus* spp. (Black Bass species), are common (Beringer 2008; J. Ross, KDFWR, pers. commun.). Our data indicate that black bass species are not being taken by river otters to the same extent as the

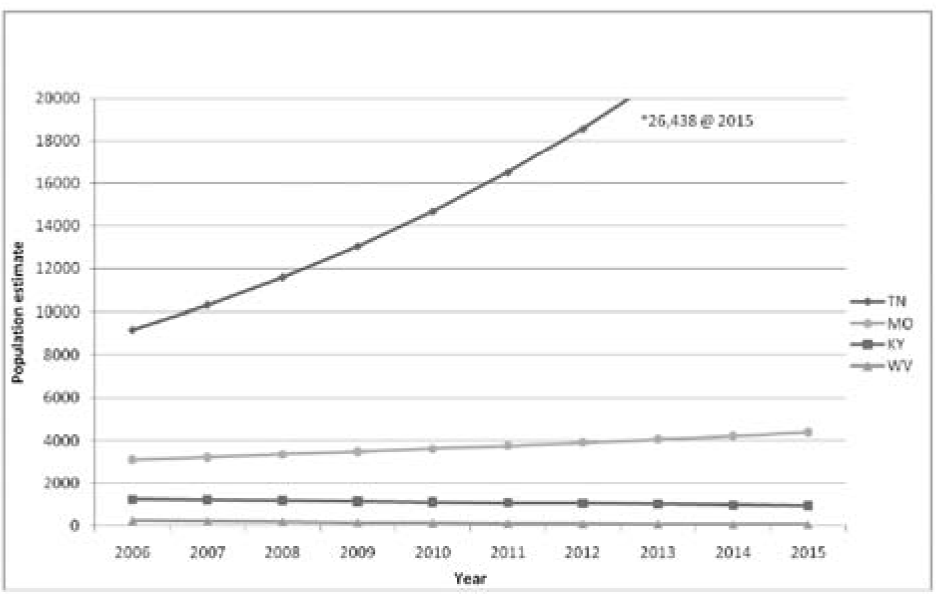

Figure 1: *Population estimates of river otters using survival data from 4 states, 5% additive mortality and Kentucky-specific reproductive parameters.*

sunfish/crappie group during winter months, and do not appear to represent a significant component of the diet of river otters in Kentucky. Regardless, observations from spring, summer and fall were not included in our analysis and shifts in the diet of river otters across seasons and among locations in the state are likely; thus, more data are needed on the level of predation by otters on Group B sportfish at other times of the year.

In areas where they are locally and seasonally abundant, crayfish are also important prey of river otters (Knudsen and Hale 1968, Manning 1990, Sheldon and Toll 1964, Toweill 1974), and occasionally replace fish as the most important food source during summer months (Noordhuis 2002, Roberts et al. 2008, Route and Peterson 1988). Crayfish (27%) were an important component of the winter diet of river otters in Kentucky, although many crayfish remains were reduced to minute fragments of exoskeleton and difficult to identify. We identified three genera (*Fallicambarus*, *Orconectes*, and *Procambarus*) and six species of crayfish previously unrecorded in the diet of river otters, along with *Cambarus*, a genus of crayfish common in the diet of river otters elsewhere (Grenfell 1974, Lagler and Ostenson 1942). Half of the classifiable crayfish were identified as *Orconectes* spp., the majority of which are common and widespread throughout Kentucky (Fetzner 2008). Members of *Orconectes* rarely burrow (Taylor and Schuster 2004) and may be more vulnerable to river otters compared with other crayfish genera (Taylor and Schuster 2004). We did record evidence of *O. cristavarius*, a species of concern (Fetzner 2008), in one stomach sample and *Procambarus viaeviridis*, a threatened species (KSNPC 2004), in another sample; thus, the possibility exists that river otters, in habitats where they are sufficiently abundant, could negatively impact rare and threatened species of crayfish. Given that crayfish contents in many stomach samples could not be identified beyond the genus, it is likely that predation is underestimated in our analysis.

A high ratio of males to females is often reported in harvested samples. Polechla (1987) reported an overall sex ratio of 1.38:1.0 in a summary of age data taken from otter carcasses and embryos gathered from 12 states. Male dominated sex ratios can be attributed to differences in trapping vulnerability. Males tend to form social groups, have larger home ranges, and travel more extensively during the breeding season than females; therefore, males have a higher probability of being captured (Blundell et al. 2002, Hamilton and Eadie 1964, Lauhachinda 1978, Melquist and Dronkert 1987, Melquist and Hornocker 1983). Chilelli et al. (1996) reported male dominated sex ratios in winter harvests for many northeastern states. Our sample sex ratio was very similar to the 1.27:1.0 ratio reported in New York by Hamilton and Eadie (1964), and slightly lower than those reported in other southeastern states. A higher percentage of females as compared to other states in the region may suggest a rapidly growing population. The average pregnancy rate and litter size calculated for Kentucky otters is very similar to rates reported in Missouri (Gallagher 1999, Hamilton 1998), and much higher than those reported in states with established populations. This suggests, as in Missouri (Hamilton 1998), the population of restored river otters in Kentucky is increasing and secure.

Lauhachinda (1978) suggested that because the movement of young animals is restricted due to the tendency to stay with family during early life, juveniles tend to be underrepresented in trapped samples. Our sample contained a high percentage (63%) of juvenile otters, providing insight into the contribution that yearlings have to the population growth of this restored population of otters (Figure 2). Increasing populations tend to have a high proportion of young animals, stable populations have a more even age distribution, and decreasing populations have a high proportion of adults (Krebs 1972). Our data indicate that the Kentucky otter population likely is expanding. The

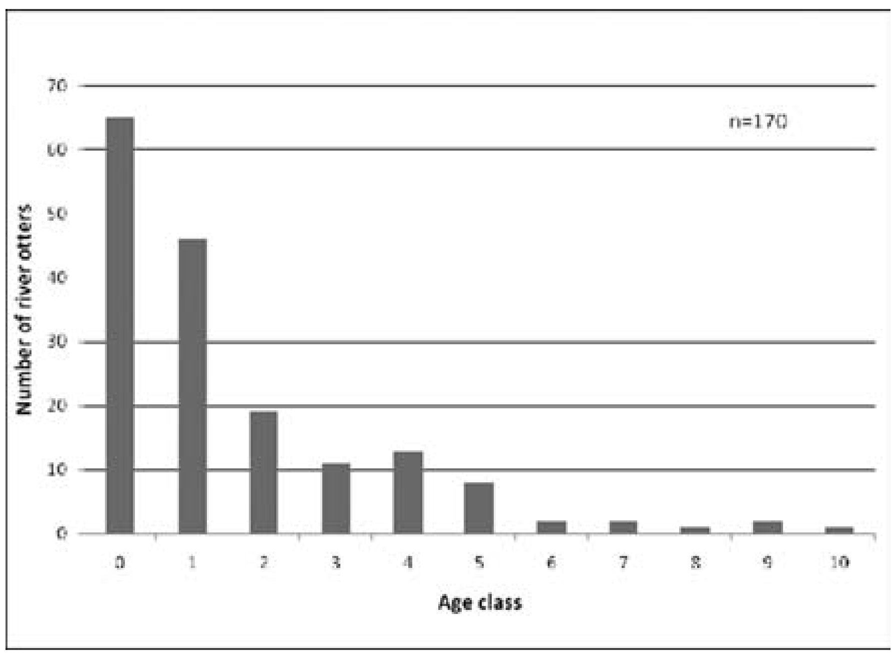

Figure 2: *Age class distribution of river otters as determined by cementum annuli examination, 2006-2009.*

oldest otter from our sample was aged at 10 years, which is the also the oldest recorded in Arkansas (Polechla 1987). River otters are induced ovulators (Polechla 1987) and do not produce CL unless they have mated. Most accounts of yearlings breeding have been regarded as anomalous (e.g. Chilelli et al. 1996). Regardless, we found evidence of reproduction (CL, blastocysts, embryos, or placental scars) in 36% of yearling females, suggesting that juvenile females are contributing measurably to the overall reproductive output of the statewide population. Other states reporting successful reproductive effort of yearlings include Maine (Docktor et al. 1987), Minnesota (Liers 1958) and Missouri (Gallagher 1999).

Our mean population estimates using survival rates from Tennessee, Missouri, Kentucky, and West Virginia indicate a density of 1 female otter per 614, 2,259, 6,726 and 45,903 ha of land in Kentucky, respectively. Our population density estimates are much lower than those reported in other states. Otter densities tend to be relatively high in habitats that offer a rich diversity of food and cover such as coastal marshes. Shirley et al. (1988) reported a density of 1 otter per 86 ha in Louisiana while Foy (1984) reported a density of 1 otter per 106 ha in Texas. These estimates are based on telemetry data and the presence of scat, and represent total population estimates whereas our estimates included only females. Regardless, density estimates for breeding females are more important because they reflect the immediate reproductive potential of the population (Melquist and Hornocker 1983).

The adult survival rate reported (0.90) in Tennessee (Griess 1987) is unrealistically high for a reintroduced population. Nevertheless, we included this survival rate into the series of models to serve as a maximum possible rate or benchmark to estimate the upper end of population densities. The topography and habitat available in eastern Kentucky is very similar to West Virginia, and we suggest that adult survivorship reported by Tango et al. (1991) may be a more representative estimate for otters in the eastern mountain region of Kentucky. The West Virginia population model predicts that otter populations in eastern Kentucky may be extirpated if current harvest protocol is maintained in that region. We believe that Kentucky should consider a more conservative harvest level for the eastern watersheds until more accurate estimates of otter survival are obtained.

Management Implications

Relative to total area that each watershed comprises in the state, there was disproportionately high numbers of otters harvested and positive sign detected in the Jackson Purchase area and the Licking River watershed in

River Otter / Tim Knight

the reintroduction zone. In contrast, a disproportionately low number of otters appear to be occupying the eastern watersheds. These results suggest that a zonal harvest strategy may be warranted for Kentucky, with higher bag limits allowed in the Jackson Purchase and some portions of the central region of the state, such as the Licking River watershed in northern Kentucky. While the harvest data throughout most regions in the state currently demonstrate a relatively uniform harvest pressure, harvesting of river otters in the Licking River watershed remains high relative to total acreage this watershed comprises in the state.

Investigation into the relationship between river otters and prey populations, particularly sportfish, should be a consideration in setting goals for harvest levels. Data indicate that conflicts potentially exist between reintroduced river otters in Kentucky and predation on sportfish of the family Centrarchidae and rare and threatened crayfish. Of particular concern is the impact on Centrarchids, as this family includes many popular sportfish such as black bass (*Micropterus* spp.), rock bass (*Ambloplites rupestris*), sunfishes (*Lepomis* spp.), and crappies (*Pomoxis* spp.). KDFWR has received reports from fisherman in northern Kentucky alleging decreased populations of bass where otter densities were high; however, no study has been conducted to verify whether this decrease is related to river otters or a combination of other factors, and there are no data on the summer diet of river otters to further evaluate the potential for conflicts. We encourage continued monitoring of sportfish and crayfish populations, especially in watersheds with high river otter densities. Should sportfish populations or the abundance of rare crayfish exhibit declining trends, adjustments to river otter harvests may be warranted for watersheds supporting high otter densities. The establishment of a Licking River harvest zone could be a management response if further reports of damage and decreasing sportfish populations continue in this area of the state.

Data indicate that juvenile females are contributing measurably to the overall reproductive output of the statewide population. The average pregnancy rate and litter size calculated for Kentucky otters is comparable to rates reported in Missouri, and much higher than those reported in states with established populations. This suggests that the population of restored river otters in Kentucky is increasing and likely secure. Because topography and available habitat differ greatly between eastern and western portions of the state, a zonal harvest is currently recommended for Kentucky with more conservative harvest protocols in the eastern watersheds. KDFWR should consider maintaining a conservative approach to the overall statewide harvest until more accurate estimates of otter survival across the state can be obtained.

We encourage further monitoring of the river otter population in Kentucky, including statewide catch per unit effort (CUE), with special attention paid to obtaining more data on survival and pregnancy rates. Any population models used for river otters in Kentucky will be improved with additional data, leading to improved accuracy of input parameters. Because river otters may give birth between late winter and early spring, more accurate pregnancy rates could be obtained by extending the harvest season by one month (through March) for consecutive harvests, with the requirement that all carcasses be turned in to KDFWR biologists for necropsy and analysis. Furthermore, both age and area-specific survival rates would allow for more accurate population estimates of otters in both the eastern and western regions, allowing for more appropriate regional management strategies for river otters in Kentucky.

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KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

At a Glance

We recommend a zonal harvest in Kentucky, with more conservative harvest in the eastern watersheds.

Status of a Reintroduced Black Bear Population in the Big South Fork Area of Kentucky

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Collaring black bear / Mike Strunk

Introduction

Reintroduction is a frequently used tool for wildlife management that has led to the successful reestablishment of animal species across the globe (Griffith et al. 1989). The majority of wildlife reintroductions in North America have focused on mammal conservation (Fischer and Lindenmayer 2000), the most frequently reintroduced mammal species being large carnivores (Hayward and Somers 2009). Large carnivores have often been considered keystone species, and reestablishment of these species may increase natural biodiversity and allow recovery of ecosystem processes (Seddon 1999).

The goal of any reintroduction is to establish a population that persists without intervention (Seddon 1999). Determining reintroduction success, however, can be difficult with no definitive protocol to aid researchers in the confirmation process (Seddon 1999, Fischer and Lindenmayer 2000, Gusset 2009). Success of most reintroductions has been evaluated based on the establishment of a self-sustaining population (Swaisgood 2010). Currently, the IUCN Species Survival Commission (SSC)/Re-introduction Specialist Group (RSG) requires >1000 mature individuals to be present in a population for a species to be listed as vulnerable or better (IUCN 2001), and Griffith et al. (1989) defined reintroduction success as a self-sustaining population of >500 individuals. Many naturally-occurring wildlife populations, especially large carnivore populations, however, do not meet these criteria, and would require augmentation had populations resulted from reintroductions (Hayward and Somers 2009).

Long-term monitoring of reintroduced populations is crucial to assess population status and reintroduction success, and to determine if management intervention is needed (De Barba et al. 2010). Demographic information such as population abundance, growth rate, reproduction, mortality, immigration, and genetic diversity should be monitored at pre-defined time intervals following reintroductions (Seddon 1999, De Barba et al. 2010). Additionally, knowledge of ecological characteristics, such as patterns of range expansion, dispersal, and connectivity with nearby populations, are critical for management. Many researchers, however, often do not implement long-term monitoring strategies for reintroduced populations, despite the known importance of such programs (Sarrazin and Barbault 1996, De Barba et al. 2010). As a result, numerous reintroductions have either failed or resulted in very small populations (Frankham 2009, Hayward and Somers 2009).

Currently, two genetically differentiated black bear subpopulations occur in Kentucky, and evidence suggests limited or no connectivity between them (Hast 2010). One subpopulation, considered most abundant (Frary 2008, Hast 2010), is located in extreme southeastern Kentucky counties along the borders of Virginia, West Virginia, and Tennessee. This subpopulation (hereafter referred to as Pine Mountain population; PMP) resulted from a natural recolonization event over the last half-century from the aforementioned border states

(Unger 2007, Frary 2008, Hast 2010), and likely forms the western-most extent of a regional metapopulation (Hast 2010). A separate subpopulation (hereafter referred to as Big South Fork population; BSFP), located in McCreary County, Kentucky, along the Tennessee border, resulted from a limited reintroduction into the Big South Fork National River and Recreation Area (BSF) in Kentucky and Tennessee (Figure 1).

In 1996 and 1997, the National Park Service (NPS) reintroduced black bear into the BSF by translocating 14 adult female black bear with 16 cubs from Great Smoky Mountains National Park (GSMNP) (Eastridge 2000, Eastridge and Clark 2001). Of 6 total release sites in the BSF, 3 were located in McCreary County, Kentucky (Eastridge 2000). By November 1999, 3 adult founders had left the BSF and never returned, and an additional 4 founders had died (Eastridge 2000). Van Manen and Pelton (1997) had recommended 40 individual bears be released in the BSF over a 6-7 year period to ensure persistence of the population. Concerns voiced by the public, however, resulted in the Fentress County, Tennessee Chamber of Commerce passing a resolution that banned all further releases of black bear. Although population modeling suggested extinction would occur without further supplementation of individuals (Eastridge and Clark 2001), no supplementation occurred following the original reintroduction (Eastridge 2000), and no long-term monitoring strategies were devised.

Bear were assumed to still be confined within the BSF until recently (M. Strunk, KDFWR, pers. comm.). Since 2004, biologists from KDFWR have received multiple reports of black bear sightings, including adult females with cubs, in areas outside the boundary of the BSF in McCreary County, Kentucky (KDFWR, pers. comm.). Additionally, nuisance complaints and bear-vehicle collisions increased in McCreary County, Kentucky, over the past 6 years (KDFWR, unpublished data). Collectively, observations of black bear in the BSF area since 2004 suggest the population has grown and expanded, but empirical evidence to support this assumption is lacking. Multiple natural resource agencies and the general public have expressed interest in better understanding the current status of the black bear in the greater Big South Fork area. Although some stakeholders have expressed interest in expanding the Kentucky black bear hunt to McCreary County, there also appears to be widespread public sentiment in the Commonwealth for ensuring black bear persistence in the BSF population and elsewhere in the state. Given the potential deleterious impacts that overharvest can have on small bear populations (Clark et al. 2010), estimates of population parameters, such as abundance and density, for black bear in the BSF population were clearly needed.

To investigate the status of black bear in McCreary County including the BSF (henceforth BSF), we used non-invasive hair sampling in a capture-mark-recapture study design to estimate abundance and density of this population. We used individual genotypes of black bear to investigate relatedness of extant individuals in the BSF by employing parentage analysis. We quantified genetic diversity of black bear in the BSF by calculating expected heterozygosity (H_E). We also investigated range expansion using non-invasive genetic sampling and program ArcMap (Environmental Systems Research Institute - ESRI, Redlands, CA). We used these results to evaluate long-term success of the black bear reintroduction in the BSF, and to provide wildlife managers with data applicable to management of black bear in this area.

Methods

Study Area

The study area encompassed 1,260 km^2 of the western edge of the Cumberland Plateau physiographic region in south-central Kentucky at the Tennessee border (Figure 1). The study area was bordered to the northeast by the Cumberland River, to the south by Scott County, Tennessee, and was bisected by highway U.S. 27. Research was conducted in all 1,118 km^2 of McCreary County, and in neighboring portions of Laurel, Pulaski, Wayne, and Whitley counties.

Approximately 81% (906 km^2) of McCreary County is owned by the federal government. The Stearns Ranger District of the Daniel Boone National Forest (DBNF) and the National Park Service's Big South Fork National River and Recreation Area (BSF) managed approximately 63% (705 km^2) and 18% (201 km^2) of lands in the county, respectively. An additional 6% (69 km^2) is state government land in the Beaver Creek Wildlife Management Area, managed by KDFWR. The remaining 12.8% (143 km^2) of McCreary County is privately owned.

Non-invasive genetic sampling

A non-invasive hair trap sampling grid composed of 126 contiguous cells was created using ArcMap 9.3 Geographic Information Systems (ESRI, Redlands, CA) and superimposed across a map of the 1,270 km^2 study area (Figure 1). Each sampling cell encompassed 10 km^2; an area equivalent to the average annual spring home range (*i.e.* smallest annual home range) of adult female black bear in Kentucky based on ~3 years of Global Positioning Systems (GPS) radio-collar data (University of Kentucky, unpublished data). One baited, barbed-wire hair trap was

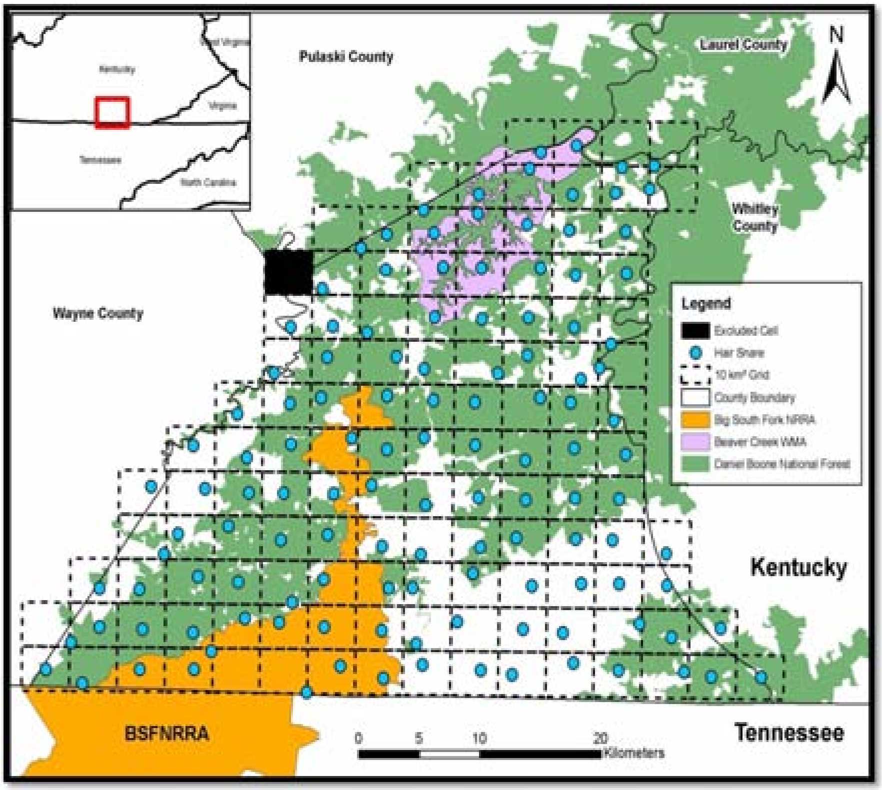

Figure 1: *2010 black bear study area, McCreary County, Kentucky, illustrating hair trap sampling grid of 126 10 km2 cells. Each hair trap was checked and baited every 7 days for 7 consecutive, week-long sampling sessions.*

constructed in each 10 km^2 sampling cell to collect black bear hair for DNA analysis (Woods et al. 1999). Hair trap placement was restricted to locations between 100-250 m from roads to enable efficient access; however, if campgrounds, picnic areas, or residential areas were present, a minimum buffer of 500 m was used to mitigate human-bear conflict.

All hair traps were checked and re-baited every 7 days for 7 consecutive, week-long sampling sessions from 23 May 2010 to 11 July 2010. Weekly duration hair-trapping sessions were chosen to maintain equal trapping effort, and to reduce the risk of DNA degradation in the humid environment of the study area (Shaw and Wofford 2003). Traps were not moved between or during sampling sessions. All collected hair samples were shipped to Wildlife Genetics International (Nelson, British Columbia) for DNA extraction and amplification using the polymerase chain reaction (PCR). Twenty-two black bear-specific microsatellite loci were used to identify individual bears, delineate gender, obtain capture histories, and investigate genetic diversity and relatedness of extant individuals.

Abundance and density

To estimate abundance (*N*), closed-population CMR models (Otis et al. 1978) were used in program MARK (White and Burnham 1999). To address sources of variation in equal capture probability, models that account for temporal variation, behavioral variation, and individual heterogeneity were constructed (Otis et al. 1978, Huggins 1989, Pledger 2000). Akaike's Information Criterion (AIC - Akaike 1973), corrected for small sample size (AICc - Burnham and Anderson 2002), was used to select models that best-fit the data within 7 ΔAICc values to provide a conservative abundance estimate (Burnham et al. 2011). Best-fit models were averaged according to the methods outlined in Burnham and Anderson (2002) to produce a final, model-averaged abundance estimate. Finally, sex-ratios were calculated using abundance estimates for each gender, and a chi-square test was used to investigate whether sex-ratios differed from 1:1 ($P < 0.05$).

Density was estimated using the traditional method, which divides the model-averaged abundance estimate by the effective sampling area: $D = N/A$. The effective sampling area was estimated by extending the sampling grid by 5 km (radius of average annual spring home range of females in Kentucky; University of Kentucky, unpublished data) to create a buffer (Dice 1938).

Relatedness

To investigate relatedness of extant individuals, a parentage analysis was performed with program PARENTE (Cercueil et al. 2002) using the categorical allocation method (Jones et al. 2010). Categorical allocation uses a likelihood-based approach to assign an offspring to a particular parent (Jones and Arden 2003). Data sets from this study, Hast (2010), and live-captures (University of Kentucky, unpublished data) were pooled to create a single data set for black bear in the BSFP (2009-2010). Genotype data at ≥ 20 microsatellite genotypes was used for parentage of individual bear identified in the BSF.

Results

Non-invasive genetic sampling

During the 7 sampling sessions, 156 black bear hair samples were collected. Bear visited a total of 23 sample sites (mean = 3.3 visited sites/ sampling occasion). All female hair captures occurred ≤15 km from original release sites in the BSFP, whereas only male hair captures occurred outside of this range (Figure 2). A total of 29 individual bear (16M:13F) were uniquely identified by genotyping with 22 microsatellite markers.

All individuals sampled during the 7 capture-mark-recapture sessions (n = 29) were successfully genotyped for 22 microsatellites with no missing loci present. Genetic diversity indicated by expected heterozygosity (H_E) was 0.709. The pooled data set from this study, Hast (2010), and live captures (University of Kentucky, unpublished data) totaled 48 individuals in the BSFP (2009-2010), which were successfully genotyped for ≥ 20 microsatellite markers with no missing loci. Overall genetic diversity in the BSFP from pooled data (2009-2010), as indicated by expected heterozygosity (H_E), was 0.698 (Table 1).

Abundance and density

The top 5 sex-specific models were model-averaged to produce a male abundance estimate of N_{male} = 21 (95% CI = 16-56), and a female abundance estimate of N_{female} = 17 (95% CI = 13-36), totaling N = 38 individuals. Sex ratio favored males, but was not statistically different from 1:1 (21M:17F, X^2 = 0.003, P = 0.95). Average capture probability of males was p_{male} = 0.30, and average capture probability of females was p_{female} = 0.27. The top 5 non-sex-specific models were model-averaged to produce an overall abundance estimate of N = 40 (95% CI = 30-113). Average capture probability throughout all 7 sessions was p = 0.22, and average probability of recapture was c = 0.23.

Because samples were acquired from hair traps in only a portion of the 1,270 km^2 sampling area (Figure 2), the effective sampling area was reduced to avoid underestimation of density. The reduced effective sampling area, which included a 5 km buffer, totaled 1,208 km^2. Estimated density (D) was 0.03 bear/km^2.

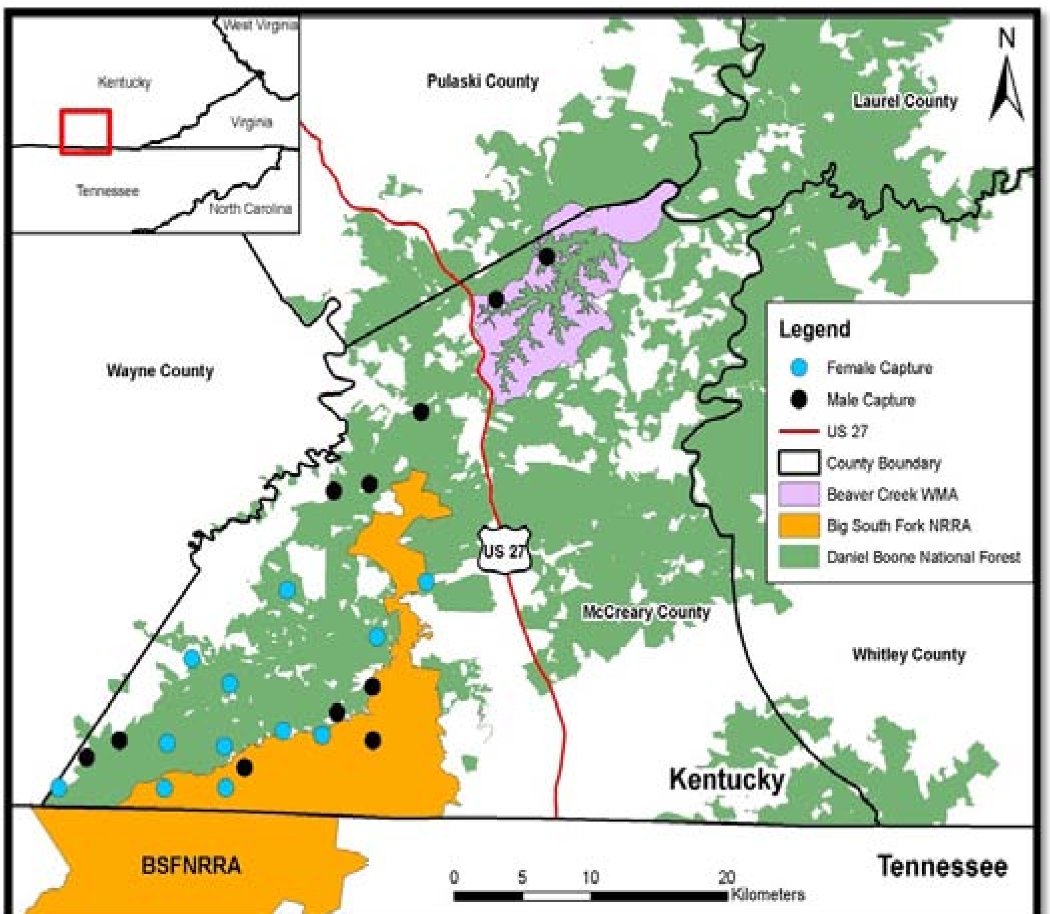

Figure 2: *Locations of 23 hair traps visited by black bears in McCreary County, Kentucky, 2010. All female hair samples were captured at hair traps ≤ 15 km from reintroduction release sites, suggesting minimal range expansion.*

Relatedness

All 48 individuals identified in this study, Hast (2010), and live captures (University of Kentucky, unpublished data) from 2009-2010 with ≥ 20 microsatellite genotypes were analyzed in program PARENTE (Cercueil et al. 2002)(Figure 3). Fourteen mother-father-offspring triads were discovered, totaling 14 known reproductive pairs that produced 15 offspring. Six mother-offspring dyads were identified and 10 father-offspring dyads were identified. Three matrilines and 3 patrilines were discovered. Additionally, parentage analysis suggested female bears 664 and 025 may be original founders, or direct offspring of original founders. Finally, 15 individuals (*i.e.* 30% of all sampled bear) were identified as descendents of male 622 (Figure 3).

Discussion

Reliable estimates of demographic parameters are necessary for effective management and timely conservation actions. Frary (2008) produced the only abundance estimate for black bear in Kentucky (*N* = 130), and suggested this estimate was representative of all black bear in the state. This statement, however, was not valid because the Big South Fork area, including McCreary County, was not included in the study area (Frary 2008). Therefore, this study provided the first ever abundance estimate for black bear in the BSF.

The abundance estimate reported by this study (*N* = 40) indicated the BSFP is much smaller than the neighboring Pine Mountain population (*N* = 130; Frary 2008), and comparable in size to threatened black bear populations in Florida (Maehr et al. 2001, Brown 2004, Dobey et al. 2005) and Louisiana (Triant et al. 2004, Lowe 2011) that currently have conservation protection. Additionally, the density estimate for black bear in the BSFP (0.03 bear/km^2) is in the lower-range of reported densities for black bear populations in the southeastern United States.

While population size in the BSFP has increased since reintroduction, range expansion appears to have been minimal. All female bear hair samples were collected from hair traps ≤15 km from original release sites, whereas, all hair samples collected >15 km from release sites were from male bear (Figure 2). This pattern of range expansion is typical of black bear populations still in the early stages of colonization, as females are highly philopatric and establish home ranges adjacent to or near mothers, whereas, males are typically dispersers that exhibit long-ranging movements (Clark 2009). Furthermore, the estimated sex ratio in the BSFP (21M:17F), although not significantly different from 1:1, appears to favor males. Most bear populations that have moved beyond the initial stages of colonization typically exhibit female biased sex ratios and higher population densities (Unger 2007, Frary 2008).

The BSFP remains small (*N* = 40) and at low density (0.03 bear/km^2), and has colonized very little new range within the last decade, suggesting a slow population growth rate. Clark et al. (2002) characterized black bear as poor colonizers, and results from this study appear to support this description. There have been documented observations of bear poaching in this area since reintroduction (J. Plaxico and M. Strunk, KDFWR, pers. comm.), however, suggest that poaching may have been an important factor in retarding population growth and expansion. Buchalczyk (1980) identified illegal poaching of brown bears in Poland as the primary cause of population loss 25 years post-reintroduction. Therefore, it is certainly possible that continued illegal poaching, coupled with other sources of mortality, such as bear-vehicle collisions, could have substantial deleterious consequences on the already small BSFP.

Relatedness is a useful biological characteristic to evaluate, especially in small populations that may be isolated. Since the BSFP originated only 14 years prior to onset of this study, a unique opportunity was presented to investigate relatedness, family lineages, and breeding structure of this small, recently reintroduced black bear population. The identification of two females, 664 and 025, as original founders is plausible based on available known ages of select descendents (Figure 3). For example, M504, which was the first-order offspring of female 664 and male 622, was 9 years of age when live-captured in 2010 (Figure 3). Based on the average earliest breeding age of female bear in Kentucky (*i.e.* 3 years of age), female 664, whose exact age remains unknown as she has not been live-captured to-date, was likely born no later than 1998, one year following reintroduction. A similar inference can be made for female 025, whose second-order offspring was M509, a 5 year-old individual in 2010 (Figure 3).

Perhaps the most revealing discovery from parentage analysis was male 622's lineage. Approximately 30% (15 individuals) of bears sampled from 2009-2010 shared male 622 as a common ancestor (Figure 3). The age of this individual remains unknown as he has not been live-captured to-date. Male 622, however, was not identified as a migrant by Hast (2010), and was comprised of a genotype similar to

Year	# Individuals	# Markers	H_E	Study
2002	16	8	0.819	KDFWR
2009	19	20	0.77	Hast (2010)
2010	29	8	0.758	This study
2010	29	22	0.709	This study
2009-2010	48	20	0.698	This study

Table 1: *Estimated genetic diversities (expected heterozygosity) of black bears in the Big South Fork area of Kentucky since reintroduction, 2002-2010.*

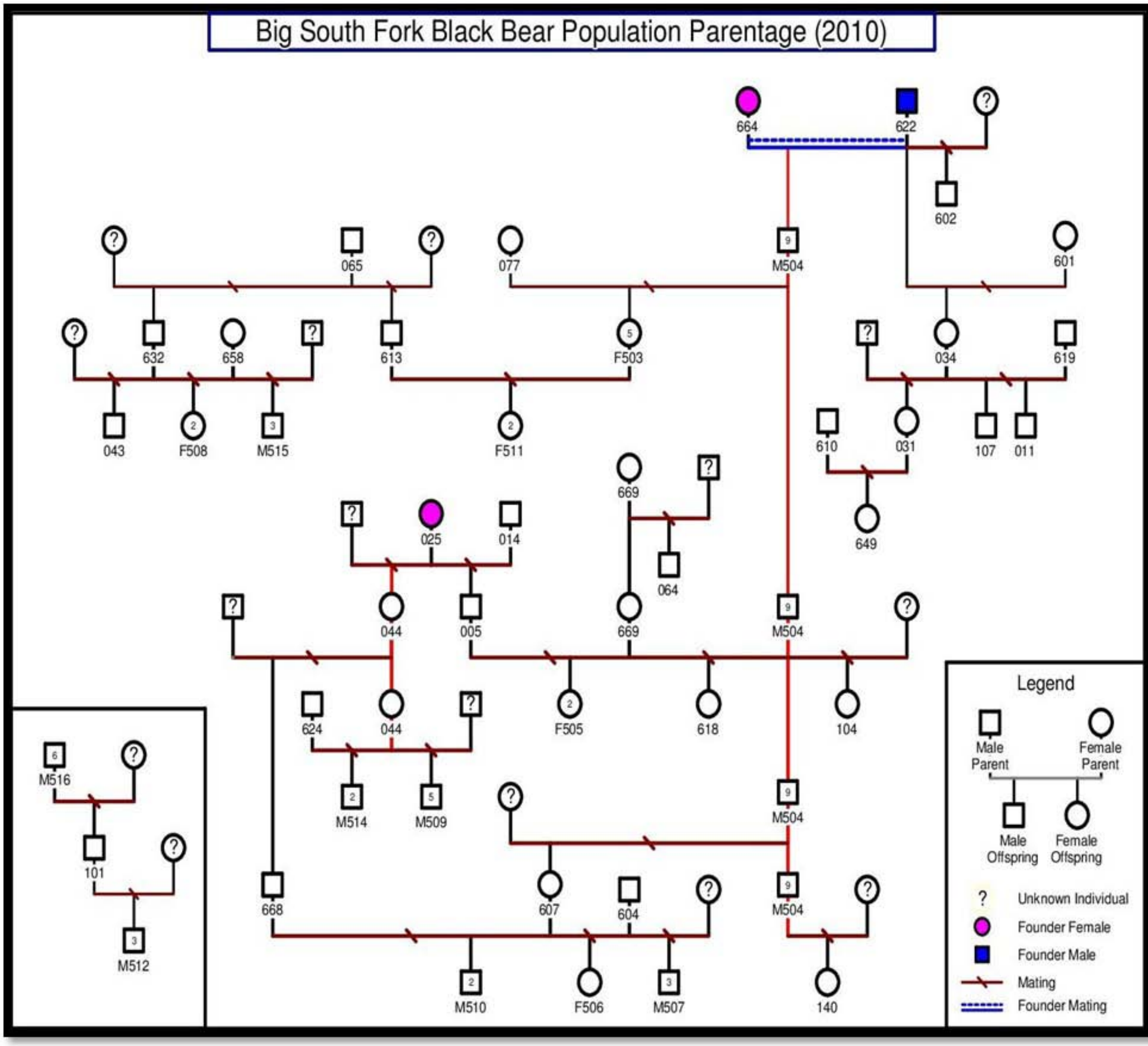

Figure 3: *Lineage results from parentage analysis of the Big South Fork black bear population using data from this study, Hast (2010), and live-captures. Females 664 and 025 were likely founders in the Big South Fork population, and approximately 30% of sampled individuals (2009-2010) shared male 622 as a common ancestor.*

other individuals in the BSFP and the Great Smoky Mountains (Hast 2010). Furthermore, because one of male 622's first-order offspring was M504, male 622 was likely either a founder cub or was present in the Big South Fork area prior to reintroduction. Cumulatively, results from parentage analysis suggest many individuals in the BSFP are closely related.

Hast (2010) suggested the BSF population may be isolated from nearby subpopulations, including the neighboring Pine Mountain population. Isolated populations are vulnerable to deleterious genetic effects such as genetic drift, genetic bottleneck, and inbreeding depression (Hartl 2000, Boersen et al. 2003). Additionally, reintroduced populations that remain isolated typically exhibit reduced levels of genetic diversity over time (Maudet et al. 2002). Genetic diversity in the BSFP based on pooled data at ≥ 20 microsatellites was $H_E = 0.698$ (Table 1), which suggests a declining trend, and linkage disequilibrium was detected, which could indicate the presence of genetic drift (Boersen et al. 2003). The proportion of closely related individuals identified by parentage analysis, a decline in genetic diversity, and minimal gene flow into the BSFP as suggested by Hast (2010) support the possibility of genetic drift and founder effects caused by isolation.

If the BSFP is in fact isolated from nearby populations to the east, the Interstate 75 barrier posited by Hast (2010) may be impeding movement between the BSF and Pine Mountain populations. To date, no radio-collared bear originating in the BSFP are known to have crossed Interstate 75 (University of Kentucky, unpublished data). Additionally, range expansion in the BSFP displays a movement westward and northward, away from Interstate 75 and the PMP. Therefore, establishing connectivity between the BSFP and populations to the east may be delayed until resident female bear in the BSFP establish home ranges east of highway U.S. 27 or female bear in the PMP establish home ranges west of Interstate 75. Such expansion rates, however, will likely require many years.

This study represents the first evidence of successful reintroduction and associated expansion of black bear in Kentucky. Seddon (1999), however, warned that reintroduction success may only be representative of the time at which assessments are made, and that momentary self-sustainability is not synonymous with long-term population persistence. Seddon's (1999) admonition is further supported by the multiple reintroduction projects that have been initially declared successful, only to have declining populations years or decades later (e.g. Buchalczyk 1980, Wolf et al. 1996). As such, declaring the reintroduction of black bear in the BSF area a success does not imply the BSF population will persist in the future, especially since this small population, comprised of numerous closely-related individuals, appears to have declining genetic diversity, and may be substantially influenced by human-induced mortality.

Management Implications

This study provided an important post-reintroduction status assessment of black bear in the BSF area, including the first population abundance and density estimates. While the population currently appears to be small, but stable, the future of the BSF black bear remains unpredictable based on current information and known problems with reintroduced populations. Empirical data from this study and Hast (2010), however, indicate the population may be vulnerable. The BSF black bear population exhibits numerous characteristics of small, isolated populations that are susceptible to deleterious genetic effects and overexploitation. Many individuals in the population appear to be closely related, genetic diversity demonstrates a declining trend, and the population may be experiencing isolation-induced genetic drift. As such, we recommend that black bear in the BSF population should not be considered for inclusion in the Kentucky bear hunt given the potential detrimental effects on the population, including a further reduction of a presumed slow population growth rate, risk of overharvest, and possibly extinction.

Results from this study demonstrate the critical need for continued monitoring and immediate research of this small black bear population. Because the status and number of bears in the BSF population in neighboring Tennessee remains unknown, we suggest investigating it to further characterize bears in this area. Despite the difficulties of monitoring small populations, future research should begin to examine population growth rate, a parameter that is often more useful for black bear population management than abundance estimates (Clark et al. 2010). In addition, we strongly recommend repetition of this study within 5-10 years to evaluate changes in abundance, density, and range expansion. These studies should also allow continued monitoring of the genetic health of this small population to assess changes in genetic diversity, and provide a landscape genetics perspective into whether connectivity becomes established between the BSF and Pine Mountain populations.

We also recommend that survival rates of bears in the BSF population be investigated. Although limited data exists, unexplained cub mortality has been documented in the BSF population (University of Kentucky, unpublished data), and cub survival and population recruitment may be low. Additionally, cases of illegal poaching of all age classes of black bear have been confirmed in McCreary County, Kentucky, but the true extent of such occurrences remains unknown. Therefore, future research should also investigate causes of mortality. We suggest development of a comprehensive black bear monitoring plan for the BSF population that includes said research recommendations, along with pre-defined time intervals for implementation. This measure will be important for natural resource agencies challenged with ensuring the long-term persistence of the black bear in the Big South Fork area.

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

? / Jeremy Williams

The Return of the Black Bear to Eastern Kentucky: Conflict and Tolerance Between People and Wildlife

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Introduction

Bear populations appear to be increasing both in the U.S. overall (Siemer et al. 2009) and in Kentucky specifically (Unger 2007). As bears and humans occupy more and more overlapping space, the likelihood of human-bear interactions increases. At the same time, traditional paradigms for wildlife management are shifting. While wildlife managers once served a fairly narrow constituency of hunters, anglers, and trappers, they are now called upon to meet the needs of a much more diverse collection of constituents (Decker et al. 1996). Stakeholders with an interest in Kentucky bears and their management currently encompass not only hunters, and wildlife managers themselves, but also researchers, wildlife watching recreationists, residential nuisance sufferers, and community leaders. Knowing what people think about wildlife, what they expect from managers, and how they would like problems resolved is an important first step in designing a management plan. Understanding where stakeholder needs conflict and where compromise is possible is also vital in moving forward towards a comprehensive management strategy.

A primary challenge for wildlife professionals is in reducing the potential for conflict between people and bears. Conflict often begins with an "anthropogenic" or human-source food attractant. Foraging black bears can destroy an apiary, or damage agricultural crops, e.g. by trampling cornfields or breaking limbs in apple orchards. Bears may also prey on pets and livestock (Mattson 1990). Residential garbage is by far the most common attractant leading to nuisance complaints (Spencer et al. 2007). Food left out for pets and bird feeders are also frequently associated with bear nuisance behavior.

Access to non-natural foods affects bears both physically and behaviorally, as they forage less, grow larger, and live at higher densities than they would under natural conditions (Beckman and Berger 2003). Bears may even aggregate in the urban-wildland interface to take advantage of these resources, leaving natural areas depopulated (Beckman and Berger 2003). Maintained at artificially high densities by garbage, male bears come into contact with lactating females and may kill young cubs.

Black bears now have widespread access to anthropogenic food sources in eastern Kentucky. They routinely raid trashcans in picnic areas and campgrounds. They have foraged in a school dumpster in the town of Cumberland, and are regularly seen during daylight. Wild bears that have been intentionally fed by residents have subsequently damaged property in search of more food, and some are being killed illegally by residents who find their behavior threatening. Artificial provisioning, illegal feeding, and poaching are important human behaviors for wildlife managers to understand and monitor (Hristienko and McDonald 2007), yet they are exceedingly difficult to study or quantify using traditional research techniques such as surveys because people are reluctant to admit illegal activity, and nuances of motivation and behavior may be lost (Tope et al. 2005).

This project was developed to expand on a mail-out public opinion survey conducted by KDFWR in 2002, as well as an ecological study of the Kentucky black bear begun at the same time. The intent was to improve understanding of the concerns, interests, and behavior of the people living in bear habitat, as well as the impact of this interaction on the bears themselves in the hopes that this information could be used to develop community-sensitive wildlife management plans, educational outreach strategies, and nuisance bear mitigation techniques.

Methods

Site Description

The primary study area for this project was the Tri-Cities region, comprising the cities of Cumberland, Benham, and Lynch, total population of 4,100 people, located along Highway 119, which runs alongside Pine Mountain in Harlan County. Cumberland is officially "the Black Bear Capital of Kentucky" and includes Kingdom Come State Park (KCSP). Bears are seen regularly in the area, especially within the park, often feeding on garbage and handouts left for them by park visitors. The presence of bears has dramatically increased park attendance and hundreds of people come to KCSP in the hopes of seeing a black bear.

We observed bears and conducted interviews in the Tri-Cities and throughout Harlan County, as well as the eastern portion of Letcher County. Data from bear trapping efforts in neighboring Bell and Pike Counties were included in this analysis as well.

Database

This project utilized information on bears gathered from trapping records and notes as well as from a database created by KDFWR and provided to UK, which detailed relevant bear handling events between 2002 and 2006 including first captures, repeat captures, den visits, and mortalities. At each handling event, bears were rated as being in poor, fair, good, or excellent condition based on observation of their body fat and overall appearance. For this analysis we condensed the condition categories into poor/fair and good/excellent in order to minimize issues of rating subjectivity.

These data formed the basis of our analyses of bear demographics and condition across capture areas, and allowed us to compare bears with known anthropogenic feeding behavior to those not known to engage in this behavior. We also used these datasets to calculate mean litter size for collared female bears and compare these findings to data collected in other states. We used SAS (SAS Institute, Cary NC) for all statistical analyses. Differences were considered significant at the $P < 0.05$ level.

We also examined 56 nuisance reports that were filed with KDFWR officials within the study area and provided to UK as well as eight additional cases of nuisance activity identified on site. The reports were collected opportunistically as they were made available and do not represent the total number of reports filed by nuisance complainants with KDFWR during that period.

Bear observation

Using witness reports and radiotelemetry, we periodically located and monitored the behavior of nuisance bears from June through October each year of the study. We obtained approximate locations of collared bears by aerial telemetry (see Eastridge 2000), but as the error rate for radiolocations obtained in this manner can exceed 1500 m (Eastridge and Clark 2001), we used this information only as a general guideline for where to begin the search for a bear on the ground. We located bears from the ground both by triangulating on their collar's signal and by pinpointing the direction of the loudest signal (Springer 1979).

Between June 1 and September 1 in 2004, 2005, and 2006 we conducted behavioral observations of marked and unmarked bears at KCSP as well as at private residences two to three nights per week. We observed bears engaged in nuisance activities and documented characteristics of behavior including: the time of approach, proximity to people and to other known bears, vigilance behavior, and reactions to human interference. We noted frequency of garbage visitation at the park, and, where possible, recorded what the bears ate and what they left behind.

Participant observation

Participant observation is a technique, more commonly used in anthropology and sociology, where researchers improve their understanding of a situation by observing people's behavior and participating in related activities. It helps researchers understand the perspectives of the people being studied (Mack et al. 2005) and uncovers previously unknown factors that could have an impact on the research questions (Gans 1999); the more cryptic the behavior of interest, the more important this becomes. It is the best way to study illegal or taboo behavior that would be impossible to examine via a survey or other method. In this project, participant observation was integrated into the larger project as researchers spent time in the community, engaging with other people while observing bears, and assisting with bear-related projects and events.

Interviews

We conducted both formal and informal interviews with a variety of people involved with bears and bear-related issues in the region. Interviewees were selected as representatives of eight stakeholder groups, each of which was identified as having some vested interest in black bears in Kentucky and KDFWR's management of them. The stakeholder groups included: Bear oriented wildlife watchers, KCSP park staff, people involved with local tourism, residential nuisance bear complainants, commercial nuisance bear complainants, government officials, people involved with coal mining, and anti-bear residents (with no other affiliation).

Formal interviews were semi-structured; we used an interview guide with a list of topics, questions, and follow-up probes. The interview covered topics such as personal experience with black bears, knowledge of their behavior and natural history, opinions about the management of bears in Kentucky, the availability of information about them, and reactions to several hypothetical management scenarios. The questioning followed the guide but was open-ended and participants were free to raise topics not covered by the guide.

We collected 42 interviews for in-depth analysis, including 32 taped and 10 untaped. All taped interviews were later transcribed verbatim. Following untaped interviews, we took field notes using a Dictaphone, which were also transcribed. The transcripts were entered into the qualitative analysis software NVivo, which allows for the importation of both text and images. This information was then coded, allowing the researcher to explore trends and relationships. We analyzed the data using open coding in which text is examined line by line to find recurrent and significant categories (Strauss and Corbin 1990).

Results

There were a total of 94 different bears (excluding newborn cubs) processed during 167 handling events between 2002 and 2006 described in the KDFWR database and in data gathered during this study. There were 32 mortalities processed, all of which appeared to be human-caused, including bears struck by vehicles, bears euthanized because of recurrent nuisance activity and associated safety concerns, bears killed illegally, and marked Kentucky bears killed legally during hunting season in Virginia.

Of the 94 individuals, 74 were male, 17 were female, and 3 were of unknown gender. There were 84 bears whose age could be confirmed with reasonable certainty, of these 84.5% were ≤ 3 years of age when first captured during the study period, and included 2 cubs, 22 yearlings, and 47 subadults (bears aged 2-3 years). Only 21 bears were classified as adults at first capture and 8 of these were estimates, unconfirmed by tooth analysis. At the other end of the spectrum, 8 bears reached the age of 8 years or older during the study period. Of these, 5 were female and 3 were male. There were 3 bears for which no age estimate was recorded.

Fifty-eight (61.7%) of the bears were confirmed to use anthropogenic food sources, as established by a nuisance capture history and/or personal observation. The feeding habits of the remaining animals were unknown but may also have included anthropogenic foods so this percentage is a minimum value. Of the bears known to use anthropogenic foods, 44 were rated as good or excellent at all captures; 7 were rated as poor/fair at one capture but good/excellent subsequently; 1 was rated as poor/fair at her only capture; and 6 were not rated. Of the 33 bears for which anthropogenic feeding was unknown, 25 received condition ratings; 15 were rated as poor/fair at all captures and 10 as good/excellent. Of this latter group, 4 were suspected of nuisance feeding based on telemetry locations and 3 were one-time handling events of mortalities for which feeding behavior could not be assessed. We used a chi-square and Fisher's exact test to compare the condition of bears known to consume anthropogenic foods and those for which feeding behavior was unknown. Even though the bears suspected of anthropogenic feeding and the one-time mortality handling bears were included in the unknown feeding habits group, statistical analysis confirmed that the rated conditions of the two groups were still significantly different ($\chi^2 = 35.56$, d.f. = 2, $P < 0.0001$) (Fisher's exact test $P < 0.0001$).

Overall, 87.9% of confirmed anthropogenic feeding bears were rated good/excellent at one or more captures and 1.9% rated poor/fair across all captures. In contrast, 40% of bears with unknown anthropogenic feeding histories were rated as good/excellent at one or more captures and 60% were rated as poor/fair across all captures. We examined 66 cases of nuisance activity of which 16 pertained to commercial or public sites, though two sites accounted for 11 of the 16 reports. We received three reports of agricultural damage. The remaining 46 cases of reported nuisance activity were residential. All complaints were categorized by the type of damage experienced or attractant involved: garbage, pet food, garden, bee hive, orchard/nursery, livestock, bird feeder, and other.

Garbage-related conflict accounted for the greatest number of complaints examined, at 68% of all complaints and 61% of residential problems. Due to the historic absence of bears, garbage handling in the area was not designed to be resistant to wildlife. At the inception of most issues, garbage was freely accessible to the bears. Anthropogenic food was integral to the KCSP bear watching situation. Although there are variably occurring natural foods such as blackberries and acorns within the park, with one exception, observed bear visitation was a result of access to garbage, picnics, and associated handouts.

Data and observations from this study indicated that females who used the park had larger than average litters and reproduced at a younger than average age which is consistent with anthropogenic feeding bears studied elsewhere (Rogers 1976; Beckmann and Berger 2003). However, long-term data about the survival and recruitment success of bears using the park was not available and at least some food conditioned bears died and/or were relocated as a result of their use of anthropogenic food, so the benefits of anthropogenic food usage were not unequivocal.

People experiencing recurrent bear visitation were divided into three categories: 1) people who were intentionally (even if passively) provisioning bears so that they could see them; 2) people who were intolerant of bears generally, or became so after initially tolerating them, but who were not altering their behavior sufficiently to reduce visitation; and 3) people who immediately removed attractants but continued having problems because of neighbors and area attractants over which they had no control. Regardless of their ultimate level of tolerance and/or risk perception, the primary reaction of those interviewed following their initial bear nuisance experience was fear. Concern for children was a common theme, followed by personal safety, and concern about pets or livestock.

Many of the residents interviewed initially saw bear visitation as a novelty and were intrigued with the bears. They did nothing to discourage their presence, instead watching and photographing the bears in a similar manner to those who observe birds at backyard feeders. In four cases, opportunistic scavenging evolved into intentional feeding as dog food or other treats were left out specifically for bears.

A majority of participants appeared at least initially interested in and sympathetic to bears and for each perceived "nuisance bear" that generated complaints, there were typically other people in the same vicinity who did not find the bear behavior problematic or at least not at first. However, many residents eventually became disenchanted, especially if they experienced property damage. The tipping point for those that moved from tolerant to intolerant was typically when bear visitation increased so that residents were picking up trash >2 times per week. At that level of visitation, tolerance decreased markedly and a majority of people wanted the problem resolved.

The preferred alternative for the majority of people suffering from recurrent bear visitation was the removal of the nuisance bears from their property and relocation to some other area far away from human habitation. Few showed any desire for the bear to be harmed; they simply wanted it removed and the problem resolved. Many bears were indeed relocated by KDFWR but this management strategy proved ineffective and problematic as relocated bears either returned, were killed while trying to return, or initiated nuisance activities elsewhere.

Nuisance bear activity / Jeremy Williams

Discussion

A majority of the Kentucky bears studied, and on which current knowledge is based, appear to be using anthropogenic foods at least some of the time. If these bears are representative of the larger Kentucky black bear population, as is likely given the widespread availability of these resources, then a majority of black bears in Kentucky consume anthropogenic foods. The behavior and appearance of bears captured elsewhere in the state are consistent with this conclusion. This has important ramifications because the use of human-derived food sources has been repeatedly demonstrated to affect bear biology, ecology, and behavior, though the exact impact varies.

Research in other regions indicates that while anthropogenic feeding bears may have greater cub production than non-anthropogenic feeding females (Rogers 1989), their overall cub survival is lower (Beckmann and Lackey 2008). Bears that use anthropogenic foods often have negative population growth, and regions where this behavior is widespread may represent a population sink, only maintained by immigration from outside (Beckmann and Lackey 2008). Like anthropogenic feeding bears studied elsewhere, the female bears studied thus far in Kentucky have produced larger than average litters and several have had a very early first age of reproduction. However, the survival rate of these cubs is unknown. Long term studies of individual animals are needed to explore these issues in Kentucky.

All known mortality of adult black bears in Kentucky appears to be human-caused, which is typical of studies throughout the U.S. (Rogers 1987; Hellgren and Vaughan 1989; Costello et al. 2001). Both poaching and vehicle collisions are significant sources of mortality for this small population. These factors may also be related to anthropogenic feeding if nuisance activity results in illegal kills, food conditioned bears being euthanized, or the relocation of bears which are subsequently hit by cars. Bears that became habituated to humans and food conditioned as a result of feeding at coal mines suffered almost 100% mortality by the time they were 2 years old.

At this time, bear related tourism in Kentucky depends heavily on the accessibility of anthropogenic foods. People who supported non-natural feeding of bears or were opposed to bear-proofing existing garbage cans offered two primary reasons: 1) they enjoyed seeing the bears and realized that without these anthropogenic attractants and food conditioned/habituated animals, those opportunities would be severely limited; 2) they believed that without the supplemental feeding the welfare, reproductive success, and survival of the bears would suffer. Consequently, none of the arguments commonly offered to discourage non-natural food provisioning resonated with these residents or changed their behavior.

Most management strategies for problem bears during this study were ineffective, in large part because of the widespread and continued availability of anthropogenic foods such as garbage, as well as food conditioning and habituation. Although problems ceased while the attractants were temporarily removed, when residents replaced bird feeders or went back to storing their garbage in an accessible manner, the bears returned, often the same night. This suggests that bears continued to patrol the area unseen in search of possible food sources.

The efficacy of targeted removal of problem bears depended in large part on the nature of the nuisance complaint. The removal of highly habituated coal mine bears, for example, did result in a reduction of area nuisance activity and associated complaints. However the removal of less habituated bears, for example those feeding at backyard bird feeders or on garbage at night, is not likely to be effective over the long term because, although one bear is gone, the food resource will be discovered subsequently by other bears. Even in the case of coal mine bears, if the mine is discovered by another bear, which is then habituated in a similar fashion, area nuisance problems will continue.

The only mitigation measure that had any discernable impact at reducing nuisance bear visitation was the effective removal of attractants. However, as discussed above, the impact of anthropogenic food removal is multifaceted, and incomplete removal is likely to exacerbate existing problems rather than relieve them. Anthropogenic food sources likely represent an important resource for foraging bears, especially following the total loss of many stable food sources such as American chestnuts, they may also compensate for episodic shortages of natural foods when they occur (Mattson 1990). Over the long term any type of supplementation may allow population growth and individual bear size beyond what the environment could support naturally (Stringham 1986; Robbins et al. 2004). If bears experience a sudden and dramatic loss of food availability, both the amount and severity of nuisance activity should be expected to increase (Ziegltrum 2004) resulting in more property damage and bear deaths and an overall bear population decline.

Management recommendations

Monetary and logistical constraints to bear-proofing were an insurmountable problem for many residents suffering unwanted bear visitation. Bear resistant garbage receptacles may need to be provided free of charge to people who want them if nuisance activity is to be diminished. Where financial problems are not the issue, and voluntary bear proofing is rejected, regulatory recourse may be required. This approach is not recommended for private landowners as it may precipitate the illegal killing of bears, but in cases such as housing developments or coal mines where owners can afford to provide bear-resistant dumpsters they should be required to do so. Although residents and workers at these sites often intentionally provision bears, their opportunities for close contact and subsequent bear habituation would be greatly diminished if access to the initial attractant were removed.

Hazing by either KDFWR or local police is too sporadic to be effective. An alternative approach would be to provide nuisance complainants with capsaicin (pepper) spray and instructions on how to haze a bear themselves. Capsaicin spray may be a more effective deterrent than other hazing techniques because it can be used by home owners and therefore applied as a negative reinforcer more frequently and consistently than aversives that require wildlife manager participation. In addition, the conditions under which the bear is sprayed more closely resemble the conditions in which the bear engages in nuisance activity troubling to the residents, without the addition of extraneous cues, such as certain vehicles or culvert traps, perceptible to the bear. Psychologically, giving homeowners some alternative to shooting the bear may be helpful in promoting a sense of control and reducing the number of illegal kills (Bjerke and Kaltenborn 1999). Sue Mansfield of the Wildlife Research Institute reports good success discouraging nuisance activity and instilling renewed fear of humans when residents sprayed visiting bears with capsaicin spray which their group provided (pers. comm. July 2006). This product results in extreme local irritation but no lasting ill-effects (Jenkins and Hayes 1962). No bear attacks have ever been associated with the use of this spray and it does not appear to cause aggression (Rogers 1984; Herrero and Higgins 1995).

Wildlife managers should emphasize the manner and attitude of first responders to nuisance bear issues as this seems to be a more important determinant of complainant satisfaction than actual resolution of the problem. In addition, educational material about non-controversial topics such as bear biology or natural history may be more effective than "dos and don'ts" lists. Where mitigation suggestions are offered, they must be exceedingly clear, with site-specific suggestions for removing attractants. The cases where responding wildlife officers came up with specific and site-based solutions were more successful and resulted in a higher level of caller satisfaction. Although sometimes requested by homeowners, relocation should be considered a last resort as an alternative to euthanasia or an immediately dangerous situation. When relocating, managers should consider bear demography and focus on bears least likely to return, e.g., young males rather than adult females.

KDFWR should consider encouraging community-based or collaborative management strategies such as neighborhood watch groups. Where intentional feeding is occurring in residential areas, a citizen task force or neighborhood watch group will likely be more effective in deterring this activity than KDFWR or law enforcement personnel who may be believed to have a conflicting agenda (Petty and Cacioppo, 1979). Similarly, messages about bear-related issues should be promoted through alternative channels, for example through the newspaper or community leaders. It is important that messages are relevant to the target audience and do not run counter to firmly held beliefs. Arguments that point towards desirable outcomes are more likely to lead to favorable thoughts than those pointing to negative outcomes (Petty et al. 1997).

Community leaders and members could occasionally be included in bear trapping and handling experiences to promote ownership over the larger bear conservation effort. Many people want to interact and connect with wildlife in some manner and substituting a less damaging activity for a more damaging one may be a more effective means of reducing conflict than trying to convince them not to want to interact with wildlife at all. Similarly, education programs are most effective when there is a receptive audience. Investing in an education program designed to change the behavior of people who do not see any reason to change their behavior is potentially a waste of money. The funds would be better spent by taking a step backward and working to convince people of the need for change or enlisting their assistance in a mutually beneficial project.

There is no solution that will perfectly address the demands of all stakeholders, but there is certainly the potential for common ground if different stakeholders are willing to approach the situation with an open mind and a willingness to collaborate.

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KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.4. Class Mammalia: Priority taxa-specific conservation action #3.

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 Resources

Woodcock with chick / Andy Newman

Introduction

The American Woodcock (*Scolopax minor*) is a small migratory game bird that ranges throughout the eastern United States. The species typically breeds in the northern part of their range and winters in the southeast and Gulf States (Sheldon 1967). The species has suffered long-term declines at a rate of 1.1% per year (Cooper and Parker 2009). Woodcock declines are attributed to extensive habitat loss on breeding and wintering grounds, as well as along migration routes. Drainage and clearing of forested wetlands throughout the woodcock's range reduces daytime cover and impedes feeding by allowing surrounding soil to harden quickly; thus becoming inaccessible to the foraging woodcock's bill (Sheldon 1967). Mechanized farming has also played a major role in habitat declines in all areas inhabited by woodcock. Brooks and Birch (1988) suggested changing landowner and social attitudes, farm abandonment, increased fire suppression, changing management techniques, and increased urbanization have resulted in fewer stands of young growth forest vital to nesting woodcock.

Woodcock are relatively early spring migrants with initiation dates beginning in late January and early February (Sheldon 1967, Straw et al. 1994). Several factors influence departure timing; gonadal recrudescence (Roberts 1980, Olinde and Prickett 1991), photoperiod (Coon et al. 1976, Meunier et al. 2008), moon phase, and weather (Krementz et al. 1994). Krementz et al. (1994) concluded there are no sex- or age- specific constraints upon migration initiation. Birds begin arriving on northern breeding areas in late March to early April; often experiencing snow cover and adverse weather (Sheldon 1967, Straw et al. 1994). Extreme weather exposure during migration, courtship, and nesting can result in higher metabolic rates, which can lead to poor body condition and increased mortality (e.g. Mendall and Aldous 1943). Early migration places bioenergetic strains on birds, yet arrival on breeding grounds at this time generally coincides with increased earthworm availability during nesting and brood rearing periods (Rabe et al. 1983).

The nocturnal use of fields by woodcock during winter, spring (breeding), and summer has been well documented (e.g. Mendall and Aldous 1943), though rates of use may vary between season and sex (e.g. Owen and Morgan 1975). Woodcock use fields for the following functions: feeding, breeding, roosting, predator avoidance, and thermoregulation, with varying patterns based on season (Krohn 1970, Sheldon 1967, Stribling and Doerr 1985, Krementz et al. 1995, Berdeen and Krementz 1998). Birds rarely fly greater than >1 km to nocturnal fields (Krementz et al. 1995, Berdeen and Krementz 1998).

Field types utilized by woodcock during winter include clear cuts, fallow fields, pastures, agriculture, and pine plantations. Glasgow (1958 *cited in* Straw et al. 1994) suggest that a majority of fields used during winter consist of herbaceous or brushy canopy (0.5-1m high) with sparse ground cover and enough soil moisture to keep earthworms in the upper soil strata. Wintering woodcock in Texas exhibited increased foraging rates in response to the following habitat variables: increased foliage density at 0.25-0.75m, increased bare soil, light ground litter, soil moisture, and low foliage density at 0.0-0.25m (Boggus and Whiting 1982 *cited in* Berdeen and Krementz 1998). In the Georgia Piedmont during the winter, Berdeen and Krementz (1998) found higher densities of woodcock in medium to large-sized seed tree-clearcuts and fallow-old fields that exhibited the following habitat conditions: greater foliage volumes at the 0.8-2.0m strata, more bare soil, and proximity to diurnal habitat. Moderately broken canopies and exposed soil appears to allow for ease of walking and foraging by woodcock while enhancing predator avoidance, especially from owls (Straw et al. 1994). Connors and Doerr (1982 *cited in* Krementz et al. 1995) and Horton and Causey (1979) both observed non-random distribution of woodcock in fields and noted that birds prefer edges which likely allow quick movement into dense cover.

In northern breeding areas, field usage during the spring is primarily for the establishment of woodcock singing grounds and courtship. Male territories have been noted in clearcuts, forest openings, gravel pits, roads, pastures, agricultural fields, lawns, and fallow fields (Mendall and Aldous 1943, Sheldon 1967, Straw et al. 1994). Field sizes exhibit great variability during spring with single males using openings as small as <10m in width (Straw et al. 1994). Gutzwiller et al. (1983) speculated that structural rather than compositional vegetation features dictate singing ground site selection. Potential vegetation structural components determining singing ground selection may include: amount of litter cover, density of small and large woody shrubs, distance to water, and age of vegetation (Kinsley et al. 1982 *cited in* Straw et al. 1994). Tall vegetation surrounding openings may reduce or negate certain field usage (Gutzwiller and Wakeley 1982 *cited in* Straw et al. 1994). Proximity to quality nesting and brooding habitat may be vital in the establishment of singing ground locations (Dwyer et al. 1988). Males stay on singing grounds all night, and will display throughout the night during peak breeding season if sufficient moonlight is available (Sheldon 1967). Females visit singing grounds frequently prior to nesting and sporadically once a nest has been initiated (McAuley et al. 1993).

There is relatively little known about habitat preferences, migratory routes, and rates of migration for spring migrating woodcock. All studies thus far have focused on fall migration by investigating band return data (Sheldon 1967, Krohn et al. 1977, Myatt and Krementz 2007a) and by determining migration initiation by analyzing radio-telemetry data (Coon et al. 1976, Sepik and Derleth 1993, Meunier 2005). Krementz and Myatt's (2007b) study of large scale migratory patterns during fall migration suggested woodcock often select mature stands of upland forest for stopover sites. Their study also suggested that due to the low soil moisture of diurnal roosts, woodcock might have been feeding extensively during nocturnal periods. This study represents the first investigation of habitat use by woodcock during spring migration in Kentucky. There have been only three woodcock studies conducted in Kentucky, which mainly focused on nesting (Russell 1959, Abel and Ritchison 1999, Harris et al. 2009). The purpose of this study was to investigate spring nocturnal habitat preferences used by migratory woodcock in central Kentucky

Methods and Materials

Study Area

This study was conducted in central Kentucky at the 747 ha Central Kentucky Wildlife Management Area (CKWMA) and the 5,907 ha Bluegrass Army Depot (BGAD). Both sites are located in Madison County, Kentucky. The CKWMA is managed by the Kentucky Department of Fish and Wildlife Resources and the BGAD is operated by the United States Army. The two study sites are located in the southern edge of the Bluegrass Region in the foothills of the Kentucky Knobs (Quarterman and Powell 1978). The area is composed of broad flats and gentle slopes along wide ridge tops with moderately steep slopes along some drainages (Norment 1991).

The CKWMA land cover consists of small deciduous woodlots and thickets interspersed with managed fields. A majority of fields are maintained for upland games species through a series of management techniques including herbicide application, strip mowing, and prescribed burning. The BGAD land cover consists of 70% pasture, 12% bottomland forest, 12% upland forest, and 6% development and open water (Jones 2000). The BGAD is managed for agriculture, wildlife, and timber harvest.

Woodcock Distribution

Myatt and Krementz (2007b) recorded average stopover duration of woodcock during fall migration to be 4 days, so I searched individual fields for woodcock every 3 to 4 days. To search for roosting woodcock, crews of two or three people drove ATVs in study fields at night and used a spotlight (Q-beam, 500,000 candle power). Roosting woodcock were considered any bird that selected a field to carry out basic biological needs, e.g. foraging, resting, reproduction. Woodcock roost sites were flagged with surveyors tape and the location was determined using a global positioning system (GPS) unit. Flushed birds were followed and resulting location noted to prevent recounting individuals. If possible, woodcock were captured with a fish net (hoop diameter >1m and handle >3m). Captured birds were sexed and aged via morphological characteristics [i.e. wing chord, bill length, body weight (Sepik 1994)], banded with U.S. Fish and Wildlife Service bands. Stribling and Doerr (1985) suggest that moist soil on the bill is an indicator of soil probing and foraging, so I recorded the presence or absence of moist soil on the bill of each captured bird.

Habitat Conditions

A series of landscape and vegetation characteristics were assessed at each woodcock roost site. The following landscape measurements were determined for each field: habitat type, field size, and soil type. I used ARCVIEW GIS version 9.3 (ESRI 2008) to determine distance from roost site to field edge. Vegetation characteristics measured at roost sites included ocular percent cover using a PVC 1m^2 plot [cover categories= bare soil, grass/graminoids, forbs, woody (shrub/sapling/vine), and litter], litter depth measured at the center of the plot, dominant plant height (based on dominant species in plot), dominant plant species in plot, and distance to escape cover. Percent vertical cover (visual obstruction) was determined using a Robel pole [divided into heights of 0-20cm, 20-50cm, 50-100cm, and 100-150cm (Toledo et al. 2008)] placed 1m into escape cover at the closest perpendicular distance from the center of roost plot. Escape cover was defined as any vegetation that offered sufficient vertical and horizontal cover to conceal a woodcock. Dominant plant species, determined by percent aerial coverage, were recorded at escape cover locations. Random plots (n = 136) were established in study fields at CKWMA using ARCVIEW GIS's random point script (ESRI 2008). The same criterion of vegetation characteristics for roost plots were used to sample random points. Random points were not measured at BGAD due to logistical constraints related to access.

Data Analysis

Soil moisture on the bill was used to approximate the percentage of woodcock that were actively feeding; i.e., earthworm biomass increases in upper soil strata during nocturnal periods (Duriez et al. 2006). Dominant plant species at roost sites and escape cover sites were used to determine species associated with nocturnal habitat. Differences in habitat preferences between sex and age classes were analyzed using the two-sample t-test.

All statistical modeling was generated by R Project version 2.13.1 (R Development Core Team 2008). To test for differences in habitat characteristics between individual used roost sites and random unused sites, I used step-wise logistic regression to model presence (roost)/ absence (random) data. A logistic regression built on a binary system assigns variables a given value of 0 or 1; an event happened or did not (in this analysis a 0 was assigned for woodcock absent from a point and 1 for presence of woodcock at a point). A logistic curve is built from presence/absence data and the model allows for the prediction that the point should have a roosting woodcock present. Roost/random point data from 2011 were used to test the model. These points allowed for the testing of the accuracy of the resulting prediction model and number of correct/incorrect predictions recorded. The strength of the model was gauged by its ability to correctly predict presence/absence of 2011 collection data.

To explain relative woodcock densities, I used multiple linear regression to explain the variation in density (response variable) among study fields using habitat variables (explanatory variables) collected from the same fields. Relative woodcock densities were determined by summing all woodcock recorded in each field and dividing this number by the total area of the field yielding a woodcock per hectare measurement. Akaike Information Criterion (Akaike 1974) values (herein AIC) were used to determine a best fit model(s). Lower AIC values indicate a model of better fit than higher ones. The final models of the logistic regression and multiple linear regression were compared to identify consistent patterns between the models.

Results

During the 2010 field season, a total of 254 woodcock were flushed from field sites. Seventy-three woodcock were captured, sexed, aged, and presence of moist soil on the bill noted. Of the 73 birds captured, 40 were males (18 after second-year birds, 20 second-year, and 2 of unknown age) and 30 female (16 after second-year, 12 second year, and 2 of unknown age). Three birds were recorded as unknown sex and age. Moist soil on the bill was present on 42 out of 65 (64%) birds examined for this attribute. The first woodcock observed was on February 21, 2010; with peak numbers recorded the second week of March 2010. During the 2011 field season a total of 115 woodcock were flushed. No age or sex data was collected in 2011 due to unfavorable weather conditions for trapping (i.e. full moon).

A total of 211 woodcock roost locations and 136 random locations were assessed for landscape and vegetation characteristics during the 2010 field season. A total of 115 woodcock roost sites were assessed for vegetation characteristics during 2011. Random locations were not assessed in 2011 due to limited amount of field time available. Fescue (*Festuca* sp.) exhibited the highest percent occurrence (62%) at roost sites; while blackberry (39%) exhibited the highest percent occurrence at escape cover sites. Of the woodcock roost sites located in this study (n=254), the majority (63%) occurred on moderately well-drained to well-drained soils.

There was no significant differ-

Banding woodcock / Andy Newman

ence in habitat variables assessed at roost sites between woodcock sexes or age classes. Multiple linear 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. Because of security and access issues no random sites were sampled at the BGAD study area; hence, only roost sites at the CKWMA were used in the logistic regression model. Logistic regression analysis indicated the best predicators of woodcock presence were percent bare, grass, graminoids and woody vegetation, litter depth, dominant height of vegetation at the roost site, distance to escape cover, visual obstruction of escape cover from 0-20cm, and distance to field edge. The logistic regression based on 2010 data correctly predicted 111 of 115 (96.5%) roost sites from the 2011 field season.

Discussion

American woodcock migrating through central Kentucky during spring roosted in fields that exhibited specific vegetative and habitat characteristics. Woodcock density increased in fields exhibiting woody/ herbaceous species interspersed with patches of lightly vegetated areas. The highest concentrations of birds observed in this study were located in old fields that had been managed via strip mowing and spring/ fall burning; whereas hayed and pasture land were used less frequently.

In this study, woodcock roosting in short vegetation were in close proximity to herbaceous and woody cover. Similar to Glasgow (1958 *cited in* Straw et al. 1994) and Boggus and Whiting (1982 *cited in* Straw et al. 1994), I found the tall herbaceous and woody vegetation around roost sites exhibited lower foliage densities from 0-20cm and much denser vegetation in the upper strata (>20cm). The sparse vegetation from 0-20cm probably allows for ease of mobility underneath a dense canopy. Berdeen and Krementz (1998) noted the importance of the structure of vegetation between 1 to 2m in determining the use of fields at night by woodcock. Similarly, I found roost sites were generally located in close proximity to woody and herbaceous vegetation that provided a degree of cover for woodcock.

I found a majority of birds located in the center of old fields; with birds only utilizing edges if fields contained short (<4 in), mowed grass. Connors and Doerr (1982 *cited in* Krementz et al. 1995) and Horton and Causey (1979) observed woodcock in close proximity to field edge, speculating birds would rapidly walk or fly into diurnal cover if disturbed. Berdeen and Krementz (1998) documented use of field edge in pastures and hayfields. Any woody vegetation located in the interior of a field was readily used as roosting cover by birds observed in this study. Larger fields have been postulated to be attractive to woodcock because they provide more interior area to occupy (Berdeen and Krementz 1998). Woodcock exhibited similar preferences for field interior in this study. The use of field interior may decrease predator encounter rates, as larger fields increase a predator's time and effort in searching for prey items.

Tall herbaceous/woody vegetation within the interior of a field or along field edges may provide several advantages for woodcock utilizing fields at night Overhead horizontal cover likely provides better protection from raptors, specifically owls. Horizontal cover may also aid in predator avoidance by allowing birds to walk away from mammalian predators or to avoid detection with their cryptic pattern. Vegetation capable of reducing the influence of wind may provide a microclimate which enhances the ability of woodcock to conserve energy on cold nights. In absence of herbaceous/ woody vegetation, such as in pastures and hayed fields, bunch grasses (i.e., *Andropogon* spp., *Schizachyrium* spp. and *Sorghastrum* spp.) can provide horizontal and vertical cover. Cool-season, sod-forming grasses do not exhibit the same structural characteristics as bunch grasses, and so woodcock will probably avoid this habitat type.

Several woodcock in this study where observed in dense stands of blackberry and saplings during diurnal periods. Abel and Ritchison (1999) noted woodcock nesting in dense sapling thickets in old-field habitat at the CKWMA. While nests in northern breeding areas are often located in dense, hardwood cover (Mendall and Aldous 1943), woodcock exhibit a wide variation in nest site selection (Sheldon

1967). Olinde (2000) observed increased gonadal recrudescence by mid- to late- February, and increased nesting along migratory routes during warm springs. In this study, old fields were readily used by migrating woodcock as nocturnal roosting habitat; however, these same areas may also be utilized as diurnal and nesting habitat.

While soils noted at woodcock roost sites in this study varied in terms of drainage classification, most soils consisted of a silt loam composition. Hendrix et al. (1998) and Guild (1951 *in* Edwards and Bohlen 1996) suggest the type and structure of soil influences earthworm abundance, with loams and silt soils often-exhibiting higher concentrations of earthworms. Smith et al. (2008) found higher numbers of earthworms in old fields than in disturbed agricultural areas. Stribling and Doerr (1985) suggested the presence of residual litter may increase earthworm populations by providing organic forage and favorable microclimates during periods of freezing temperatures. In this study, I noted the presence of moist soil on the bills of roosting woodcock as an indicator of foraging during spring migration. Sixty-four percent of woodcock captured exhibited moist soil on their bills. In North Carolina, Stribling and Doerr (1985) noted that 12 of 14 woodcock that exhibited moist soil on their bills had earthworms in their proventriculus and or stomach. Earthworm availability increases in the upper soil strata during nocturnal periods, especially during periods of low ambient temperatures (Owen and Galbraith 1989, Duriez et al. 2006). During this study, it appears that a large number of woodcock actively foraged during nocturnal periods to coincide with increased availability of earthworms in the upper soil strata.

While rates of nocturnal feeding vary amongst seasons, higher rates of feeding are required during spring due to increased basal metabolic rates resulting from migration, low ambient temperatures, and reproductive effort (Rabe et al. 1983). Vander Haegen (1992 *cited in* Vander Haegen et al. 1994) observed female woodcock became active in both diurnal and nocturnal periods, apparently in an attempt to build up nutrient reserves required for nesting. Due to their larger body size, females are more capable of withstanding sub-zero temperatures and low food abundance (Gregg 1984 *cited in* Longcore et al. 2000). Yet, use of lipid reserves by females to cope with these hardships often delayed nesting by 3-4 weeks (Vander Haegen et al. 1993). Additional lipid reserves acquired during spring migration could help off-set adverse weather on breeding grounds and increase reproductive fitness. The combination of short vegetation, shallow litter, and favorable soils for high earthworm abundance appear to be factors influencing nocturnal roost selection by woodcock migrating through Kentucky in the spring.

Management Recommendations

Although two very different birds in aspects of their natural history, some of the management approaches useful for maintaining or enhancing habitat used by migrating American woodcock in Kentucky are very similar to the techniques proposed for managing bobwhite quail (*Colinus virginianus*) in the Commonwealth (Morgan and Robinson 2008). The maintenance of fields interspersed with plant communities in early-to-mid stages of plant succession appear to be of greatest value as nocturnal roosting habitat to woodcock migrating through Kentucky in the spring. Several management practices (e.g., prescribed burning, strip mowing, and grazing), can be utilized to create the mosaic of desired plant assemblages important to woodcock and quail. Prescribed burning in the spring can benefit woodcock by removing excess litter. This would allow for greater access to feeding and courtship areas. Strip mowing would provide roost areas while the un-mowed portions could serve as escape cover. Short-duration grazing could be used to thin out thick stands of grass and create openings for feeding. Implementing these management practices in fields near undisturbed areas would provide woodcock access to woody vegetation and the vertical and horizontal cover needed for predator avoidance. Since woodcock rarely fly long distances to nocturnal habitat, field management efforts should be focused on larger fields within 300m of appropriate diurnal habitat. Management efforts focused in central and northern Kentucky would be beneficial to woodcock that migrate across the predominately agricultural areas of western Ohio and Indiana where appropriate habitat is currently scarce (Myatt and Krementz 2007b).

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

At a Glance

American woodcock will benefit from a habitat matrix including open areas for courtship (utilize prescribed fire), and woody vegetation for escape cover (leave some unmowed/unburned areas)

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

Introduction

Grassland bird populations have declined more than any other guild of birds in the United States due to the loss of grassland habitat (Johnson and Igl 2001, Peterjohn 2003). The area enrolled in the Conservation Reserve Program (CRP; 1.15 million ha or 1% of landscape) within the southeastern USA is limited, and only 3.9% of that acreage is in native warm-season grasses (NWSG; Burger 2000). In contrast, biofuel feedstock and forage production have the potential to influence habitat on millions of hectares (McLaughlin et al. 1999, Barnes 2004). To date, research regarding bird responses to biofuel (Murray and Best 2003, Roth et al. 2005) and forage (Coppedge et al. 2008, Powell 2008) production have been conducted in southwest Wisconsin and Oklahoma; only two studies east of the Mississippi River have examined bird responses to any of these practices (Walk and Warner 2000, Giuliano and Daves 2002) and none in the southeastern US. Therefore, we examined NWSG in Kentucky and Tennessee managed as biofuel feedstock, seed, and forage (grazing and haying) production. Specifically, we assessed how species abundance, total abundance, species richness, and diversity for grassland birds during the breeding season were affected by these management practices. We also examined how vegetation composition and structure differed among these same production practices and how these vegetation patterns influenced avian community metrics.

Study Area

Study sites included McMinn and surrounding counties (MCMINN), in southeastern Tennessee and Hart (HART) and Monroe Counties (MONROE), both in south-central Kentucky. All three sites had unmanaged NWSG fields that were in CRP, or the Conservation Reserve Enhancement Program (CREP), or managed similarly to fields enrolled in those programs, and remained undisturbed during the course of the study and served as a control (CONTROL). CONTROL were predominately planted in a mixture of big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*). MCMINN included switchgrass (*Panicum virgatum*) being grown as a biofuel feedstock (BIOFUEL) and hay fields (HAY) planted in a mixture of big bluestem, indiangrass, and/or switchgrass. We examined fields being managed for commercial NWSG seed production (SEED) including, big bluestem, indiangrass, and little bluestem, at HART. MONROE featured eastern gamagrass (*Tripsacum dactyloides*) that was hayed (HAY) or grazed (GRAZE). To minimize any biases associated with area-sensitive species, we constrained our sample to 2–12 ha fields. HAY fields were harvested during June each year, SEED during August - October,

Native grass managed for grazing / Andrew West and BIOFUEL during early winter (November – January). All GRAZE fields were rotationally grazed and had at least one rotation during May – June. While intensity and duration varied with landowner, all fields were managed for production.

Methods and Materials

Grassland Bird Surveys

We surveyed each field three times during the breeding season annually, once during each of three periods: 10 – 30 May, 1 – 15 June, and 16 June – 1 July, 2009 and 2010. We used 10-minute 100-m fixed-radius point counts for target bird species. Due to field size, and to ensure equal sampling effort, each field had one point only. We recorded 12 focal species, nine of primary interest (dickcissel (*Spiza americana*), eastern meadowlark (*Sturnella magna*), field sparrow (*Spizella pusilla*), grasshopper sparrow (*Ammodramus savannarum*), Henslow's sparrow (*Ammodramus henslowii*), horned lark (*Eremophila alpestris*), northern bobwhite (*Colinus virginianus*), prairie warbler (*Dendroica discolor*), red-winged blackbird (*Agelaius phoeniceus*)) and three of secondary interest (Bachman's sparrow (*Aimophila aestivalis*), bobolink (*Dolichonyx oryzivorus*), loggerhead shrike (*Lanius ludovicianus*)), during the survey period. Primary species seen or heard within a 100-m radius were recorded using a removal method (Farnsworth et al. 2002) while secondary species were recorded as present only.

Vegetation Measurements

We measured vegetation annually between 1 June – 11 July to reflect habitat conditions of the field during the breeding season. Hay fields that were harvested before vegetation measurements were taken and grazed fields that were never grazed in a given year were dropped for that year.

We measured vegetation along a systematic grid centered on the point-count location that included 12 vegetation plots per field. At each plot, we sampled herbaceous species, litter depth, ground cover, average vegetation height, and cover density.

Statistical Analyses

We calculated bird diversity for each visit during each year using a Shannon-Wiener diversity index (Shannon and Weaver 1949). Means for vegetation measurements were taken across all 12 sampling points within each field. We calculated means for bird detections across all three visits for each field in each year. We used averages in subsequent analysis unless otherwise stated.

Because not all treatments were at all site locations, we used an incomplete block design (Bose 1942) to account for the fact that our sites had different treatments. We analyzed means for vegetation variables under a randomized block model using a one-way analysis of variance (ANOVA) with a split-plot (year) with replication of the whole plot (production type). Total bird detections (relative abundance), species richness, species diversity, and relative abundance for individual species were examined using the same model. Site was a blocking factor in both analyses.

Results

We sampled 90 fields in 2009 and 87 in 2010 for 102 total fields that ranged from 1.6-12.1 ha (mean 4.1 ha). Due to management changes or access restriction, 12 fields used in 2009 were not available in 2010. None of the secondary species were detected in either year. Due to the low occurrences of Henslow's sparrows and horned larks, ANOVA's were not conducted for these individual species; however, they were included in relative abundance, species richness, and species diversity analyses.

Avian

We detected 919 and 1230 birds of all species during 2009 and 2010, respectively. Field sparrow was the most frequently detected species (42%) followed by red-winged blackbird (27%) in both years. SEED had the greatest relative abundance, species richness and diversity among all treatments ($P < 0.05$); the remaining four categories were not different with respect to any of these measures (Table 1). Field sparrow, eastern meadowlark, and dickcissel were the only species for which we detected differences among treatment types ($P < 0.05$). Both eastern meadowlark and dickcissel were more abundant on SEED fields, while field sparrows were less abundant in BIOFUEL fields. Only relative abundance for all species and for field sparrows had a year effect ($P < 0.05$) with 2010 having more detections in both cases. No year-by-treatment interactions were detected for any of the species or community metrics ($P > 0.01$).

Vegetation

Average vegetation height and vertical density were greatest ($P < 0.0001$) in BIOFUEL and lowest in GRAZE. CONTROL had the highest percent litter, forbs, and woody plants ($P < 0.0001$). Litter depth and cover for other species did not differ among treatments.

Among vegetation measures, only litter depth (greater in 2010) and vegetation height (greater in 2009) differed between years. Year-by-treatment interactions were detected for vertical density ($P < 0.01$), average height ($P < 0.001$), and forb cover ($P < 0.05$). Vegetation in SEED was taller and denser in 2009 than HAY, where HAY was taller and denser in 2010 than SEED. Forb cover was greatest for HAY in 2009 and for CONTROL fields in 2010. GRAZE forb cover was lower in 2010 than in 2009, dropping below BIOFUEL.

Discussion

Overall, our results showed little variation among the five treatment types we examined with respect to relative abundance, species richness, and species diversity for all species or for four of the seven individual species with large enough sample sizes to test. On the other hand, vegetation varied among treatments, but those differences did not seem to impact bird use.

The undisturbed CONTROL was intermediate for all individual species and for all species combined with respect to relative abundance, species richness, and species diversity. CONTROL had the most litter, forb, and woody cover among all treatments. This was an expected result considering these fields were not disturbed, thus allowing thatch to accumulate and succession to proceed unabated; in other treatments, disturbance retarded succession and litter was removed through harvests.

Field sparrows were the only species that had lower relative abundance in BIOFUEL than in the other production categories; all other bird metrics for BIOFUEL were similar to other treatments. Due to dormant-season cutting (November – January), grassland birds were not disturbed during the breeding season, which may explain why few differences were found for most species in our study. BIOFUEL fields had the tallest and densest vegetation of all the treatments. Lowland varieties of switchgrass, the primary species in BIOFUEL, are taller than other NWSG. Furthermore, BIOFUEL was treated annually with nitrogen (67 kg ha^{-1}) to increase biomass and, therefore, vegetation density, as a normal part of production practices.

Species richness, diversity, and relative abundance for all species combined and for eastern meadowlark and dickcissel were all greater in SEED than other treatments. In the case of dickcissel, the greater relative abundance may be explained by the fact that they are generally more common at this study site because it is located well within the species' range whereas the other sites were more peripheral to that range. Horned lark was only located on SEED, again, perhaps as a function of species' range. Eastern meadowlark favors greater percentage of NWSG (Roseberry and Klimstra 1970) which may be why their relative abundance was greater for SEED. The late harvest in SEED, like BIOFUEL, allows for grassland birds to breed all season without disturbance (unlike HAY). Skinner (1975) found fields combined for seed had more species and individuals than control fields. SEED fields were lowest in amount of litter and forb cover. The low amount of forb cover is not surprising given the operational application of herbicides to minimize contamination of harvested NWSG seed by those of weeds. Annual burning after seed collection eliminated thatch left in seed production fields.

In GRAZE, bird metrics were similar to all other treatments although the standard error was greater for GRAZE, probably due to the limited availability of this treatment type or the

Table 1: *Means and standard errors (SE) for relative abundance, species richness, and species diversity for all species combined and relative abundance for seven species of grassland birds detected during the breeding season in production stands of native warm-season grasses in Kentucky and Tennessee, 2009 – 2010.*

Variable/Species	CONTROL		BIOFUEL		SEED		GRAZE		HAY		
	x̄ (S.E)		x̄ (S.E)		x̄ (S.E)		x̄ (S.E)		x̄ (S.E)		P[a]
Mean relative abundance	3.52 (0.31)	B[b]	3.57 (0.50)	B	5.32 (0.60)	A	4.07 (0.62)	B	3.99 (0.44)	B	<0.001
Species richness	1.54 (0.10)	B	1.51 (0.13)	B	2.46 (0.24)	A	1.90 (0.37)	B	1.88 (0.17)	B	<0.001
Shannon-Weiner Diversity Index	0.36 (0.04)	B	0.34 (0.05)	B	0.70 (0.09)	A	0.40 (0.14)	B	0.49 (0.07)	B	<0.001
Field Sparrow	1.94 (0.16)	A	1.16 (0.21)	B	1.25 (0.02)	AB	2.33 (0.46)	A	2.17 (0.23)	A	0.002
Red-wing blackbird	0.91 (0.21)		1.74 (0.44)		1.54 (0.23)		0.73 (0.32)		0.57 (0.17)		0.512
Eastern Meadowlark	0.10 (0.03)	B	0.14 (0.05)	B	0.96 (0.21)	A	0.57 (0.25)	B	0.36 (0.13)	B	<0.001
Northern bobwhite	0.35 (0.07)		0.24 (0.07)		0.25 (0.08)		0.10 (0.07)		0.51 (0.12)		0.066
Grasshopper sparrow	0.03 (0.01)		0.18 (0.07)		0.64 (0.17)		0.20 (0.13)		0.29 (0.09)		0.498
Dickcissel	0.00 (0.00)	B	0.01 (0.01)	B	0.32 (0.10)	A	0.03 (0.03)	B	0.00 (0.00)	B	<0.001
Prairie warbler	0.18 (0.04)		0.10 (0.04)		0.30 (0.10)		0.10 (0.05)		0.07 (0.03)		0.156

[a] *Results of ANOVA comparing five production types.*

[b] *Means within rows with the same letters are not significantly different (P >0.05, Fisher's least significant difference test).*

high variability inherent with grazing. It also may be due to the fact that the dominant grass in GRAZE was eastern gammagrass where others studies have examined more complex mixtures of NWSG (i.e., big bluestem, indiangrass, and switchgrass). Gammagrass grows in larger clumps than other NWSG and may not provide the same structure. GRAZE had the lowest vegetation height and vertical density. The active grazing during the season kept grasses shorter than other treatments. Forb cover was intermediate between that for CONTROL and SEED treatments.

HAY did not differ from CONTROL for any bird metrics. However, hay fields may be a sink for grassland birds (Giocomo et al. 2008, Luscier and Thompson 2009). Luscier and Thompson (2009) examined hay cuttings in northwestern Arkansas for cool-season grasses and found early cuttings (26 – 31 May) were detrimental to nest survival for field sparrows, red-winged blackbirds, and dickcissels and resulted in decreased grassland bird densities. However, they reported that impacts associated with late cuttings (17 – 26 June) were trivial. These dates coincide with cutting dates of NWSG in our study; NWSG also are typically harvested at higher residual height than cool-season hay fields, a practice that may result in reduced impact on active nests (Walk and Warner 2000, Giuliano and Daves 2002). In comparison to CONTROL, HAY had less vertical density, litter cover, and woody cover due to the yearly cutting and removal of grasses.

Management Recommendations

There are two important implications in using NWSG in production stands. The first is disturbance. Historical disturbance regimes in natural tall-grass prairie were based on both fire and grazing. Although contemporary managers commonly use fire in fallow NWSG stands, grazing is still lacking as a widespread disturbance agent in NWSG managed primarily for wildlife habitat. Harvesting in the other production types (biofuels, seed, and hay) may slow woody encroachment while also removing litter. The second major implication is that production-based uses of NWSG provide landowners incentive to not only plant NWSG, but also to maintain it in a manner that provides regular disturbances. Use of NWSG based on markets can also reduce uncertainty associated with Farm Bill funding and improve the efficiency of delivering wildlife habitat on a large scale.

The use of market-based NWSG production fields could potentially impact an extensive area. If just 10% of pastures in the southeastern USA were converted to NWSG, that would create 1.5 million ha (U.S. Department of Agriculture 2009) compared to 1.2 million ha of CRP (only 3.9% of which is in NWSG). In addition, biofuel feedstock has been predicted to result in as much as 7.8 million ha, much of which would be in the southeastern USA (Ugarte et al. 2003). This vast acreage could make an important contribution to stopping or even reversing the decline in grassland species.

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At a Glance

Production stands do not appear to negatively impact grassland bird populations, as long as mowing does not occur in the prime breeding season. Early cuttings of hay (26-31 May) have been shown to be detrimental to nest survival of grassland birds.

The Common Raven in Cliff Habitat: Detectability and Occupancy

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Raven on snag / Josh Felch

Introduction

The cliff-nesting common raven (*Corvus corax*) is of conservation interest in Kentucky and currently listed as state threatened and as a Species of Greatest Conservation Need in Kentucky's State Wildlife Action Plan (Kentucky's Comprehensive Wildlife Conservation Strategy 2005). The raven appears to have been widespread throughout the Commonwealth during early European settlement (Mengel 1965). However, the raven may have been most common in the eastern portions of the state characterized by the rugged Pine, Cumberland, and Black Mountains, as well as the Cliff Section of the Cumberland Plateau (Mengel 1965, Palmer-Ball 1996, Cox and Larkin 2004). As settlement increased, the common raven population fell and the species was nearly extirpated in the eastern U.S. by the mid 1900's (Mengel 1965, Hooper et al. 1975, Palmer-Ball 1996). Mengel (1949) listed 1935 as a tentative date for extirpation of ravens in Kentucky with a small population possibly persisting up until that time in Powell County. Persecution by humans, loss of forest habitat due to timber harvest and agricultural needs, and likely the absence of large mammal carrion have been attributed as the main factors leading to this population decline (Harlow 1922, Jones 1935, Sprunt 1956, Mengel 1965, Cox et al. 2003). The remaining ravens were largely restricted to high elevation strongholds in the most remote rugged reaches of the Appalachians (Cox and Larkin 2004). Today, portions of its range have been recolonized by remnant populations including southeastern Kentucky, where sightings and a handful of nests have been observed during the past three decades (e.g. Croft 1970, Smith and Davis 1979). Raven recovery has been credited to the regions' shift away from an agrarian society and the resultant reclamation and maturation of forests, behavioral adaptations to anthropogenic environments, and a resurgence of large herbivore populations that have supplied more carrion through vehicle collisions and hunting (Buckelew and Hall 1994, Boarman and Heinrich 1999, Cox et al. 2003). The Commonwealth appears to have extensive suitable breeding habitat, but Kentucky's ravens have remained relatively rare and unstudied, thus little is known about the local ecology or population status of this often reclusive corvid (Palmer-Ball 1996, Cox and Larkin 2004).

The objectives of our study were threefold: to quantify factors that affect our ability to detect ravens in cliff habitat; to quantify landscape attributes of breeding locations at multiple scales; and to develop and initiate protocols for monitoring the occupancy of key potential breeding habitats in Kentucky.

Methods and Materials

Detectability

We identified known raven breeding locations on natural cliffs in Kentucky and neighboring states through coordination with biologists, naturalists, birders, and others throughout the region. All work conducted outside of Kentucky was funded from additional grants. A subset of these nest sites were then chosen to be visited based on ease of access to a suitable observation point, travel time, and whether the site was occupied during the present year. At each of the chosen occupied sites (n=23; NC-1, KY-2, WV-4, VA-16), an observation point was chosen in a location that enabled visual survey of as large of a portion of the cliff as possible (Figure 1). In some cases, the observation point was located on top of the cliff being surveyed due to best view/easiest access. Auditory and visual surveys with binoculars and spotting scope were conducted at each site three times during the 2009-2010 breeding seasons (late January-early May) until first detection and/or occupied detection or two hours had elapsed. First detection was defined as first sight/sound of a raven in the survey area, and occupied detection defined as detection of a pair or of a single individual exhibiting territorial or breeding behavior (*i.e.* territorial calls, territorial chases, pair flights, carrying nesting material, 3 or more visits to the same cliff site, *etc.* (Boarman and Henrich 1999)). Factors thought to affect our ability to detect raven occupancy were recorded (i.e. time-of-day, sky conditions, predominant aspect, wind, percent cloud cover, precipitation, temperature, percent

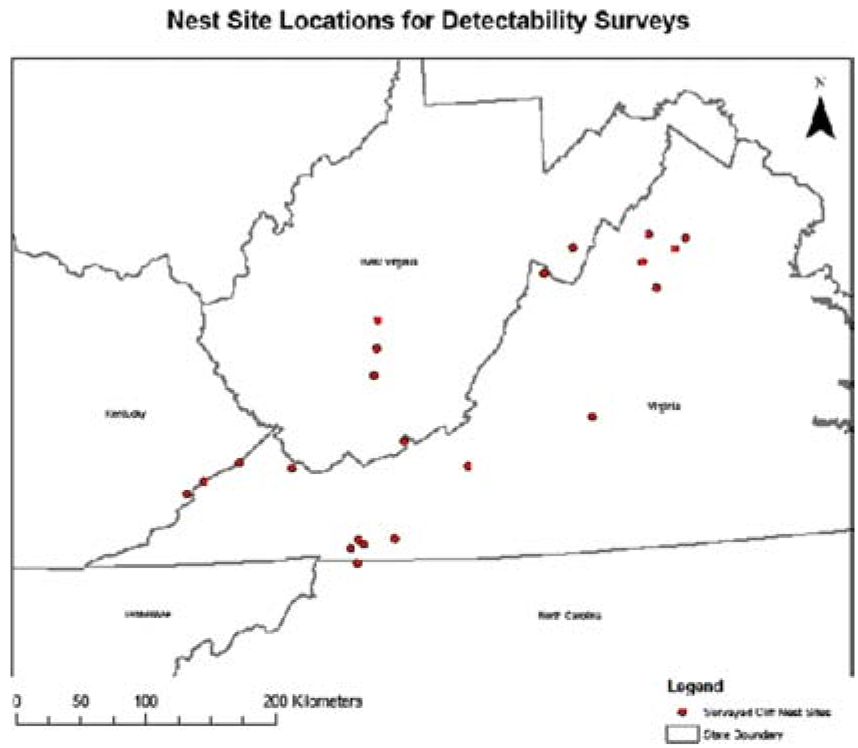

Figure 1: *Known raven cliff nest sites surveyed tor detectability during the 2009 and 2010 breeding season. Each site was surveyed three times.*

forest cover, and distance of observation point from site) and defined as a small set of models likely explaining detection probability (Bernatas and Nelson 2004). Times were recorded for each detection category as well as distance at first detection. To minimize variation in detection probability due to time of day, surveys were only conducted between 0600 and solar noon during the breeding season and were not conducted during times of inclement weather (i.e. high winds, fog, snow other than light flurries, and rain greater than a very light drizzle). Detection probabilities for half hour time intervals up to a maximum of two hours were estimated using logistic regression in SAS 9.2.

Breeding Habitat

For each known occupied cliff site, an equal number of unoccupied cliff sites (n=26; KY-20 and VA-6) were identified and visited providing the basis for a site-attribute model that quantified breeding habitat in the eastern region of Kentucky (Flesch 2003, Dzialak et al. 2007). Habitat data associated with local cliff physiography (i.e. cliff length, cliff height, degree of occlusion, orientation of strata, degree of access, cliff situation and general prominence, predominant aspect) was collected in the field similar to Watts (2006) and additional land feature data (i.e. percent forest cover, road density, proximity to roads, proximity to human habitation, elevation) was obtained using ArcGIS 10. Again, logisitic regression in SAS 9.2 was used to analyze the data.

Monitoring

The detection probabilities for each half hour time interval were used in the probability model proposed by McArdle (1990) and used by Kèry (2002):

$$N\,min = \log(\alpha) / \log(1 - p)$$

where ($N\,min$) is the minimum number of visits and (p) is the estimated probability of detection at any one visit. This was done to ascertain the necessary allocation of survey effort needed to determine the minimum number of visits and length of time required to infer absence of ravens with a high level of confidence.

A preliminary list of areas where ravens were most likely to breed in Kentucky was created based on historical observations, recent sightings, and areas containing suitable nesting substrate. These areas included cliffs associated with Pine, Black, and Cumberland Mountains, Paintsville Lake area, and natural cliffs and high walls associated with strip-mining. Due to limited resources, we were only able to conduct monitoring surveys on Pine, Cumberland and Black Mountains during the 2010 and 2011 breeding seasons. Monitoring consisted of auditory and visual surveying with binoculars and a spotting scope as well as periodic use of a wildlife caller to elicit vocal or territorial responses from ravens that may be occupying or passing through the area.

Results

Detectability

When ravens were detected at a site, the average time until first detection was 14.0 minutes, and 23.6 minutes until occupied detection. The estimated probability for first detection ranged from 0.80 to 0.99 for a half hour and two hour survey, respectively (Figure 2). The estimated probability for occupied detection was the same as first detection at the hour and a half and two hour surveys, but differed at the half hour and one hour survey with probabilities of 0.65 and 0.90, respectively (Figure 3). We were unable to detect any statistically significant factors influencing detectability.

Breeding Habitat

Occupied cliff sites differed little

from unoccupied breeding sites with the exception of predominant aspect. Only three out of the 25 nest cliffs that were located (two of these were not included in the detectability surveys) had an easterly aspect and only one of those faced true east.

Monitoring

During the Fall of 2009, preliminary detection probabilities were used to determine the appropriate allocation of effort for monitoring occupancy of ravens in eastern Kentucky. Analysis showed that surveying a given cliff site two times for duration of one and a half hours is required to determine occupancy by these species with a confidence level of 99 percent. With this knowledge, we conducted monitoring surveys at 25 cliffs on Pine and Cumberland Mountains during the 2010 breeding season. These occupancy surveys yielded detection of ravens at five sites; four in Harlan County (south side of Pine Mountain southwest of Kingdom Come State Park, Stone Mountain WMA, Cranks Creek WMA, and Martins Fork WMA) and one in Bell County (Shillalah Creek WMA). Three of these sites appeared to have territorial breeding adults at them (Stone Mountain WMA, Cranks Creek WMA, and just outside of Shillalah Creek WMA and Hensley Settlement at Cumberland Gap National Historical Park) but no actual nests were located. The cliff sites where ravens were not detected were used as unoccupied sites listed above in Objective 2. We also located two other sites that held territorial pairs on Pine Mountain (Rebel Rock vicinity and Jenkins, KY). An active nest was located at the latter.

For the 2011 breeding season, more precise detection probabilities using data collected during the 2010 breeding season reduced the necessary survey effort to two, each lasting one hour, thus enabling the occupancy of a given cliff site to be determined with a 95% confidence level. Future surveys should be conducted using this survey effort as is outlined in the monitoring protocol that was submitted to KDFWR. We monitored 54 cliff sites on Pine and Cumberland Mountains with detection of ravens in five areas: Hensley Pine Mountain WMA, Pine Mountain State Park, Cranks Creek WMA, Martins Fork WMA, and just outside of Shillalah Creek WMA and Hensley Settlement at Cumberland Gap National Historical Park. Four of the locations contained definite territorial breeding pairs (Hensley Pine Mountain WMA, Pine Mountain State Park, Martins Fork WMA, and just outside of Shillalah Creek WMA and Hensley Settlement at Cumberland Gap National Historical Park). We failed to find the actual nest locations except for the site just outside of Pine Mountain State Park located on a highwall in a nearby quarry. We also opportunistically confirmed an active nest and a pair of old nests at two other quarries (Harlan County and Letcher County), an active nest in Elkhorn City (Pike County) (D. Raines pers. comm.), an active nest on an old highwall near Starfire Mine (Knott County), and likely the same active nesting pair in the Rebel Rock vicinity (Harlan County).

Discussion

Our findings show that common ravens in the southern Appalachians are highly detectable at known occupied cliff sites. This is the first study to look at detection probabilities of ravens, so comparison to other work is difficult. However, the species' large stature, loud and often frequent vocalizations, and territorial behavior towards other ravens and potential predators near breeding sites support these findings (Boarman and Heinrich 1999).

Evaluation of suitable habitat for ravens produced similar findings to those of Hooper (1977) with ravens preferring cliffs with at least one suitable ledge for a nest with an associated overhang above and a precipitous rock face below to deter land predators. Boarman and Henrich 1999 also noted that ravens tend to use east facing cliffs less than cliffs facing the other cardinal directions.

Prior to this study, there were only five confirmed nests within Kentucky: Bad Branch State Nature Preserve, two

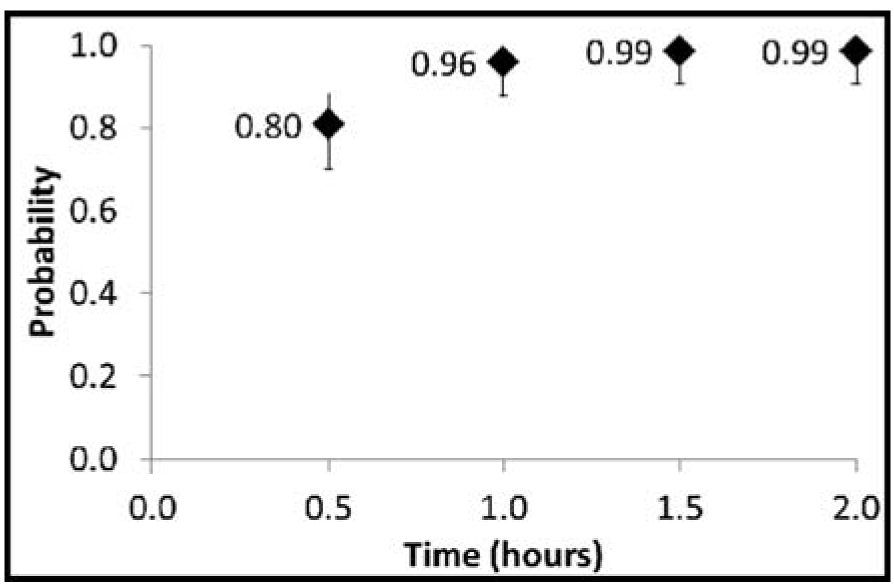

Figure 2: *Detection probabilities for first detection of common ravens at 23 known cliff breeding sites at half hour increments with a 95% confidence interval.*

nests on stripmine highwalls in Knott and Breathitt Counties, Paintsville Lake, and Rebel Rock (Fowler et al. 1985, Larkin et al. 1999, Cox et al. 2003, Palmer-Ball and McNeely 2004, Palmer-Ball and McNeely 2006). In the past three years, the number of known breeding pairs in the state has effectively tripled. In talking with quarry staff, it appears that ravens have nested in eastern Kentucky quarries for at least the last few years, and perhaps as early as the mid-1980's as suggested by one manager (M. Roark pers. comm.). It is very possible that ravens may have nested in eastern Kentucky prior to being first seen again in 1969 (Croft 1970).

The majority of observed raven nests in the southern Appalachians are on cliffs. However, we observed one nest located in a tree in late January at Shenandoah National Park, Virginia. Other tree nests have been found throughout the region, but nests on cliffs are much more prevalent (Harlow 1922, Hooper et al 1975, Hooper 1977). These tree nests, nests on highwalls and in quarries, and particularly those observed in human constructs (e.g. radio towers, buildings, billboards, train tressels) in Appalachia, suggest that the notoriously reclusive ravens in this region appear to have become increasingly tolerant of humans and their artifacts (Boarman and Henrich 1999, Larkin et al. 1999., Cox et al. 2003, Shedd and Shedd 2004).

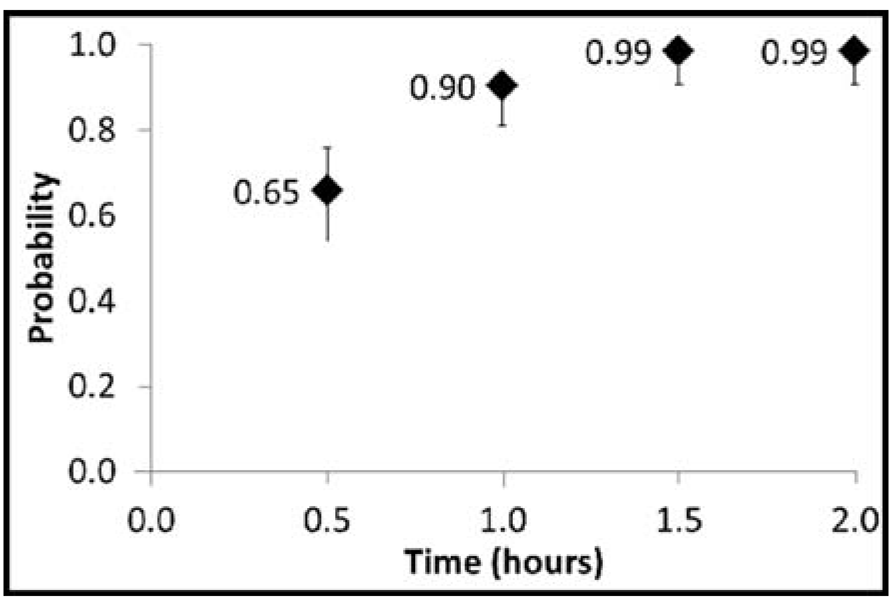

Figure 3: *Detection probabilities for occupied detection of common ravens at 23 known cliff breeding sites at half hour increments with a 95% confidence interval.*

Management Recommendations

Although ravens can adapt, live, and nest in close proximity to humans (Knight 1984, White and Tanner-White 1988, Boarman and Heinrich 1999), we suggest that wildlife managers limit human encroachment in areas where ravens are known to nest for the immediate future. We also suggest that wildlife managers and land stewards adopt the Hooper (1977) guidelines concerning human activity near active raven nest sites: hikers and general foot traffic should be restricted within 200 meters of an active nest when said traffic is visible to ravens on the nest cliff, and not permitted within 100 meters when concealed from view; vehicular traffic at 100 meters or more from a nest could be permissible as long as a parking area was not situated within 200 meters; road construction within 200 meters and building of overlooks above nest cliffs should be avoided to reduce the risk of abandonment; and prohibition of rock climbing at active nest cliffs from January 15th until all young have fledged in late April or early May. We propose that lengthening the rock climbing ban to the end of May as there is variation in the timing of nests in the region and some fledging has taken place later than early May.

In some cases, these guidelines may not be fully applicable. Case in point, two active nests were located on highwalls at active limestone quarries on Pine Mountain and one active nest was observed within 25 meters of a road in Knott County. In situations where ravens appear to be conditioned to repeated disturbance (e.g. strip-mine highwalls, and other quarry locations), the guidelines could be relaxed. Heavy machinery and blasting in these areas appear to be of little deterrence to ravens choosing these locales for nesting. Ravens choosing more remote breeding sites seem to be less tolerant of such disturbance. Of greatest importance is the preservation of the highwall in which the nesting pair has chosen. This may be plausible in cases where the highwall in question is an older one that is not being actively mined, but may be impossible when the highwall is still in operation. Due to common raven pairs increasingly using highwalls as a nesting substrate in the region, leaving some old highwalls that are suitable for nesting in place even after reclamation would be greatly beneficial to the species. Larkin et al (1999) stated that unreclaimed highwalls may serve as significant landscape features promoting range expansion of ravens to other parts of the state and suggested that further surveys investigating ravens use of these manmade cliff-lines should be conducted.

Ravens are easily confused with their morphologically similar, but

Raven nestlings / Josh Felch

smaller relative, the American Crow. As such, we suggest that at minimum, educational outreach should be an important management strategy for recovery of this species. This could be done in a myriad of ways with a few being information about the species in KDFWR publications and educational outreach with schools, and online reporting devices that allow sightings to be documented. Educational programs should target hunters, quarry staff, strip mine employees, and even agency field personnel. Furthermore, research examining survival and cause-specific mortality of ravens, particularly estimation of accidental take during crow hunting season, could inform managers as to whether prohibiting crow hunting in areas where ravens occur is warranted.

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

Comprehensive Wildlife Conservation Strategy: Appendix 3.4; Class Aves: Taxa specific conservation action #1.

At a Glance

On mineland, leaving old highwalls that are suitable for nesting in place after reclamation would greatly benefit the species.

Development of In Vitro (artificial) Laboratory Culture Methods for Culturing Freshwater Mussels

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

Introduction

Propagation of freshwater mussels has been somewhat limited to species for which we know the host and can artificially infest glochidia onto the gills and fins of the host fish. For many freshwater mussel species, host fishes are unknown or difficult to handle and/or collect in adequate numbers for conventional fish-host propagation methods. Despite the best efforts under laboratory conditions with species with abundant glochidia and hosts, transformation rates to the juvenile stage are low, variable and generally unpredictable. For rare mussels and species that possess a short-term brooding strategy, the chances of successful propagation are reduced even further.

Ellis and Ellis (1926) first experimented with metamorphosing glochidia using artificial media in the early 20th century with some success; however, they never published their methods. Later, Isom and Hudson (1982) reported findings of a nutrient medium that could be used to bypass the fish host in rearing juvenile mussels. The medium consisted of unionid physiological salts, amino acids, glucose, vitamins, antibiotics, and fish blood plasma. They furthered their own recipe for metamorphosing glochidia *in vitro,* substituting the nutrient medium with modern cellular culture recipes. Keller and Zam (1990) improved upon Isom and Hudson's work demonstrating successful metamorphosis with new and different species and having increased percent transformation using commercially available media components. Similar studies performed in Thailand on the Asian unionoidid *Hyriopsis myersiana* (Uthaiwan et al. 2001, 2002, 2003) and European unionid *Anodonta cygnea* (Lima et al. 2006) have demonstrated successful metamorphosis of glochidia *in vitro*.

Initially, the *in vitro* metamorphosis of glochidia was consistently successful with only a handful of species, including *Ligumia recta*, *Lampsilis siliquoidea* and *Utterbackia imbecillis*, all of which are host-generalist brooders that utilize a broad spectrum of fish hosts. Until recently, host-specific species, rare and imperiled species and species that possibly require special pH, ionic or gaseous conditions (changes in the partial pressure of O_2 and CO_2 specific to the external cells of fish) had not been successfully metamorphosed *in vitro*. In addition, only one study described the growth and survival of individuals metamorphosed *in vitro* (Hudson and Isom 1984), and none compared cohorts of animals that metamorphosed *in vitro* versus *in situ* using various metrics such as percent transformation, fatty acid reserves, growth rate and survival.

The research detailed in this report demonstrates the advances in the potential for *in vitro* metamorphosis, compares the physiological condition of *in vitro* and *in vivo* cultured animals and evaluates the potential for the use of *in vitro* artificial propagation in the management of freshwater mussels.

Methods and Materials

Methods below describe the long-term investigation of the improvement of the *in vitro* culture method, the comparison of the physiological condition of mussels cultured *in vitro* vs. *in vivo* and the evaluation of the effectiveness of the *in vitro* culture method for propagation. Additionally, an opportunistic evaluation of recovery of juveniles

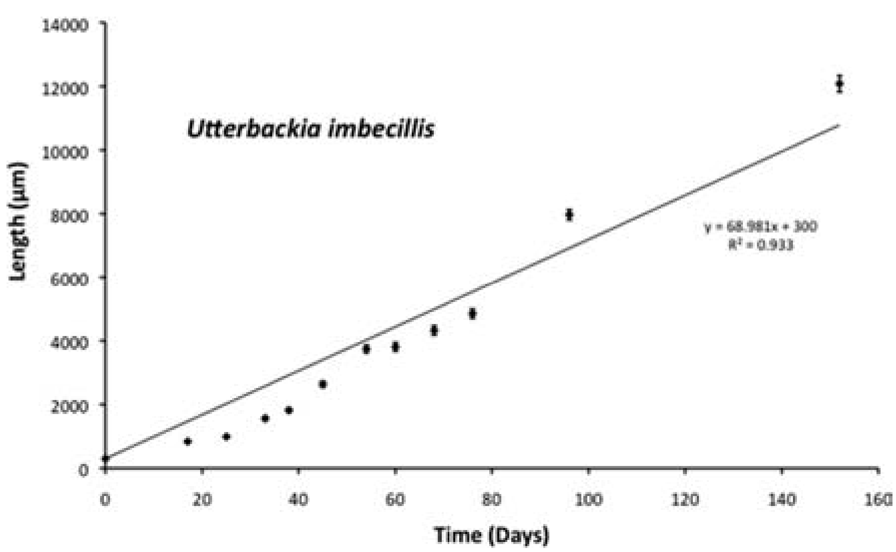

Figure 1: *Growth of U. imbecillis metamorphosed in vitro.*

Family	Geographic Distribution	Species	Owen (UL and KSU)	T&E Species
Unionidae	Europe	*Anodonta cyngea*	NA	NA
	North America	*Actinonaias ligamentina*	+	
		Actinonaias pectorosa	+	+
		Alasmidonta atropurpurea	+	+
		Alasmidonta viridis	+	+
		Amblema plicata		
		Anodonta suborbiculata	+	
		Cyprogenia stegaria	+	+
		Dromus dromas	+	+
		Elliptio angustata	(+)	
		Elliptio complanata	+	
		Elliptio crassidens		
		Elliptio dilatata		
		Elliptio lanceolata		
		Elliptio steinstansana	(+)	
		Elliptoideus sloatianus	(+)	
		Epioblasma brevidens	+	+
		Epioblasma capsaeformis	+	+
		Fusconaia ebena		
		Fusconaia flava	+	
		Lampsilis abrupta	+	+
		Lampsilis cardium	+	
		Lampsilis fasciola	+	
		Lampsilis ovata		+
		Lampsilis siliquoidea	+	
		Lampsilis teres	+	
		Lampsilis ventricosa		
		Lasmigona costata	+	
		Ligumia recta	+	
		Megalonaias nervosa		
		Pleurobema cordatum		
		Ptychobranchus fasciolaris	+	
		Pyganodon cataracta		
		Pyganodon grandis	+	
		Strophitus undulatus	+	
		Toxolasma parvus	+	
		Utterbackia imbecillis	+	
		Villosa delumbis	(+)	
		Villosa iris	+	
		Villosa lienosa		
		Villosa ortmanni	+	+
		Villosa taeniata	+	
Hyriidae	Asia	*Hyriopsis myersiana*	NA	NA
	South America	*Diplodon greeffeanus*	NA	NA
		Diplodon rotundus gratus	NA	NA

(+) denotes assistance with, but did not perform at the CMC

Table 1: *In vitro propagated species*

from the cysts of dead host fish was recorded.

Development of Method

Development of the *in vitro* culture method consisted of 1) testing new species using the current *in vitro* protocol established by Owen (2009, 2010); 2) evaluating the new protocol with species previously reported to metamorphose *in vitro*; and 3) testing the current *in vitro* method with glochidia that were previously encysted on fish and transferred to culture media.

New species tested using the current protocol include the Mucket (*Actinonaias ligamentina*), the Pheasantshell (*Actinonaias pectorosa*), the Wabash Pigtoe (*Fusconaia flava*), the Cumberland Combshell (*Epioblasma brevidens*), the Cumberland Elktoe (*Alasmidonta atropurpurea*) and the Kentucky Creekshell (*Villosa ortmanni*). Species re-tested using the current *in vitro* protocol include the Giant Floater (*Pyganodon grandis*), the Slippershell (*Alasmidonta viridis*), the Fatmucket (*Lampsilis siliquoidea*), the Flutedshell (*Lasmigona costata*), the Creeper (*Strophitus undulatus*) and the Paper Pondshell (*Utterbackia imbecillis*) Percent metamorphosis was recorded with all species and fasting survival at two weeks was recorded with *L. siliquoidea, L. costata, P. grandis, S. undulatus* and *U. imbecillis*

Individuals of *A. atropurpurea* were collected and encysted on host fish (Northern Hogsucker, *Hypentelium nigricans*). During the course of the infestation, several fish died before glo-

Figure 2: *Broodstock of Utterbackia imbecillis (Paper Pondmussel) used for research. / Christopher Owen*

chidia had developed into pediveligers. The carcasses of 18 recently deceased hogsuckers were collected and the larval cysts were identified. Under a stereoscope, larval cysts were removed and the surrounding tissue removed from the fish. Once removed, as much surrounding tissue was excised as possible, leaving only the glochidium and a thin layer of host epithelial cells. The freed cysts were washed in sterile unionid river water (URW) followed by a rinse in sterile minimal essential media (MEM) to remove potential microbial contaminants as well as the trophozoites, tomonts, theronts of the protozoan parasite *Ichtyopthirius* from the *in vitro* cultures. Cysts were then placed in cultures dishes using the established *in vitro* protocol.

Physiological Condition

Individuals of *U. imbecillis* were used to compare the physiological condition of newly metamorphosed individuals. The larvae of 14 gravid individuals were split between host fish infestation and *in vitro* metamorphosis. The average lipid measurement per demibranch, number of viable larvae, number of sloughed larvae and total number of newly metamorphosed individuals were recorded. After metamorphosis, juveniles were analyzed for total lipid and fatty acid content using a modified Folch (1957) method using a methanol:chloroform extraction followed by methylation of fatty acids. A subsample of animals were fasted and sampled for 12 days post-metamorphosis and percent fatty acids were analyzed over time. Comparisons of the left demibranch and right demibranch were made to evaluate possible variation within an individual animal.

Evaluation of effectiveness of in vitro mussel culture

Several cohorts of mussels were evaluated to see if the *in vitro* method produced healthy and viable pediveligers at an aquaculture scale. Over two years, species were placed in culture dishes using the current *in vitro* protocol, however, animals were also placed in larger petri dishes and at higher densities than normal. Most cultures consisted of animals in excess of 1000 glochidia per ml of media in 105mm petri dishes, sometimes as high as 5000 animals per ml. Generally, 10-15 105mm petri dishes or 30-40 60mm petri dishes would be set up at a time to produce a large cohort of mussels. After metamorphosis, animals were taken to the CMC for grow out. Effectiveness of the method was evaluated using a combination of percent metamorphosis, growth, 30 day survival and fasting survival at two weeks. Some cohorts were limited in the ability to evaluate their growth and survival due to food and space limitations.

Results

Development of Method

All new species tested using the *in vitro* protocol successfully metamorphosed. Several new species were added to the list of mussels that successfully metamorphose *in vitro*, including *A. pectorosa, A. ligamentina, E. brevidens, A. atropurpurea* and *V. ortmanni* (Table 1). Species previously reported to be cultured *in vitro* also successfully metamorphosed using the current *in vitro* method, with most species improving in percent metamorphosis (when data available). These species include *A. viridis* (92%), *F. flava* (60%), *L. siliquoidea* (81%), *L. costata* (98%), *P. grandis* (97%), *S. undulatus* (86%) and *U. imbecillis* (98%) (Table 1). All cultures tested for two-week fasting survival exceeded 91% survival (see Table 1). Glochidia recovered from dead hogsuckers successfully metamorphosed *in vitro* and averaged 76% metamorphosis. See Table 2 for a complete summary.

Physiological Condition

Starting values for lipids significantly varied between cohorts of *U. imbecillis* (F=13.44, P=0.009). No differences were observed between larvae collected from the left demibranch or right demibranch (F=0.227, P=0.661). *In vitro* cultured animals had lower concentrations of fatty acids per gram of total glochidia weight (F=57.2, P=0.0001) than *in vivo* cultured animals. Animals fasting over time initially consumed up to 50% of their larval fatty acid reserves (F=17.1, p=0.0002) within three days. Lipid and fatty acid values with the current *in vitro* protocol, however, were increased over total lipid values from previous published works.

Evaluation of effectiveness of in vitro mussel culture

Large scale cultures successfully metamorphosed without the additional contamination problems typically observed with high density cultures. Percent metamorphosis did not seem to change between 500 gloch/ml and >1000 gloch/ml. Successful large-scale culture batches were observed with *A. ligamentina, A. pectorosa, E. brevidens, A. viridis, L. siliquoidea, L. costata, P. grandis, S. undulatus* and *U. imbecillis*. No dishes were lost due to microbial contamination with the current *in vitro* culture protocol. With *U. imbecillis*, 75% of larvae did not successfully attach to a host fish once fish were added to a bucket containing aerated larvae. Of the 25% to attach, 15% successfully metamorphosed; the overall portion of this cohort to successfully attach and metamorphose was approximately 4%. Using the fish host method, 96% of the larvae were either sloughed before metamorphosis was complete or they failed to attach to the host. Using the *in vitro* method, 27% of the larvae snapped shut on other larvae and were unusable for culture. Of the remaining 73% of *U. imbecillis* larvae, 98% successfully metamorphosed. Using the *in vitro* culture method, 71% of the total larvae successfully metamorphosed. Lastly, a growth curve was also established for *U. imbecillis* using *in vitro* cultured animals (Fig 1). See Table 2 for a complete summary.

Discussion

Significant improvements were made in the effectiveness of *in vitro* mussel culture. The known species to metamorphose increased by six species, including two federally endangered mussels (*A. atropurpurea* and *E. brevidens*) and two state listed species (*A. pectorosa* and *V. ortmanni*). Six species previously reported to metamorphose *in vitro* demonstrated improved metamorphosis with the current protocol.

The physiological condition of newly metamorphosed individuals was improved

Table 2:

Mussel Status	Species Name	% Metamorphosis (average)	% Survival (fasting)	# Propagated (total)
Endangered Species	*Alasmidonta atropupurea*	59%	NA	1,538
	Epioblasma brevidens	92%	NA	53,170
State Listed Species	*Actinonaias pectorosa*	84%	NA	104,042
	Alasmidonta viridis	92%	NA	27,560
	Villosa ortmanni	67%	NA	2,345
Non-listed Species	*Actinonaias ligamentina*	88%	NA	128,835
	Fusconaia flava	60%	NA	450
	Lampsilis siliquoidea	81%	91%	43,066
	Lasmigona costata	98%	98%	157,020
	Pyganodon grandis	97%	95%	122,197
	Strophitus undulatus	86%	92%	76,386
	Utterbackia imbecillis	98%	96%	313,880

significantly over previously reported levels. Fisher (2001, 2002) reported a concentration of less than 100 ug/g of total lipids in newly metamorphosed *in vitro* animals and animals metamorphosed with the current protocol contain approximately 15 mg/g of total lipid and 3 mg/g of fatty acids. While this remains lower than the physiological condition of *in vivo* cultured animals, levels appeared sufficient to not impose a survival limitation based on lipid reserves. Often, animals collected from the *in vivo* culture were collected 12-24 hours after they excysted from the fish, giving them some time to feed on the bacteria and DOC from the fish aquarium, possibly enriching their lipid reserves relative to the *in vitro* animals. Thus, the increased lipid reserves of the *in vivo* animals may be biologically insignificant. Additionally, two week fasting survival of all species tested indicated that survival was not limited by the concentrations of fatty acids and lipids, and that the lipid concentrations that accumulate during metamorphosis were adequate for their survival.

Experiments with large scale *in vitro* cultures indicated that this was an effective and efficient means of producing large number of healthy, viable juvenile mussels. Using the current protocol, the negative effects of microbial contamination were eliminated, despite increased densities in culture dishes. Using a split batch of larvae pooled from 14 gravid individuals of *U. imbecillis*, ~13,500 pediveligers were recovered from host fish, while ~252,000 pediveligers were produced *in vitro*. Overall, significantly fewer larvae were wasted and more animals were produced using the *in vitro* method over fish host propagation methods.

Management Recommendations

The *in vitro* method is capable of producing newly metamorphosed mussels of proper development and nearly equal viability as with host fish propagation methods. The potential for producing juveniles exceeds the fish host method by nearly 20 fold. Roughly two-thirds of the freshwater mussel hosts in North America are unknown and the *in vitro* method is an effective and efficient way of bypassing fish hosts in propagating freshwater mussels. The *in vitro* method constitutes the greatest chance of successfully culturing mussels with limited larvae or for exceedingly rare occurrences of some species. While some clades are largely understudied using this propagation method and require further

Figure 3: *1 year old juveniles of Lampsilis siliquoidea (Fatmucket) metamorphosed in vitro. / Christopher Owen*

investigation, it is recommended that *in vitro* culture be utilized by mussel managers for the conservation of freshwater mussels.

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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.

At a Glance

Invitro mussel propagation constitutes the greatest chance of successfully culturing exceedingly rare mussels.

Big Sandy crayfish / Roger Thoma

The Conservation Status of *Cambarus veteranus*, Big Sandy Crayfish and *Cambarus parvoculus*, Mountain Midget Crayfish

Roger Thoma, Midwest Biodiversity Institute
KDFWR Contact: *Danna Baxley*

Introduction

This goal of this project was to determine conservation status, distribution, habitat preferences, and life history of two crayfish species found in Kentucky: The Big Sandy Crayfish, *Cambarus veteranus*; and the Mountain Midget Crayfish, *Cambarus parvoculus*. The principle areas of focus for the study were the Big Sandy River basin in Pike, Floyd, Martin and Letcher Counties where *C. veteranus* is found and the Cumberland River basin of Whitley, McCreary, Wayne and Clinton Counties where *C. parvoculus* has been reported.

Materials and Methods

Field work:

One year's field work was conducted in Pike, Floyd, Martin Letcher, Whitley, McCreary, Wayne and Clinton Counties, Kentucky. Two allopatric species of crayfish were studied. Sample site selection for each species is detailed as below.

Cambarus (P.) veteranus

Known areas of occurrence were sampled first, then third order or larger tributaries to streams with existing populations were sampled. Sampling focused on the Big Sandy River basin (Pike, Floyd, Martin and Letcher Counties) where museum and literature records indicated the presence or possible presence of the species in Kentucky. Thirty collections were made in July and September.

Cambarus (J.) parvoculus

This species is known to favor small, headwater streams so sampling focused on the most upstream reaches of streams and nearby areas downstream. A recent study (Thoma & Fetzner, 2008) indicated that the Cumberland River basin (Whitley, McCreary, Wayne and Clinton Counties) is the only remaining stream system reported to harbor this species in Kentucky.

Each sample site was georeferenced with a hand held GPS unit. Locality information and habitat quality were recorded on Ohio EPA QHEI (Qualitative Habitat Evaluation Index) data sheets and OSUMC (Ohio State University Museum of Biological Diversity Crustacean Collection) Stream Inventory field data sheets. The QHEI records data on stream substrate composition, in-stream cover, channel morphology, riparian zone & erosion, and pool/glide & riffle/run quality.

Data analysis was conducted with Statistica 8 and ArcView 9.0 computer programs. Statistical analysis employed principle component analysis, correlation analysis, regression analysis, and t-test.

Lab work:

Voucher samples were collected at each site and identities verified in lab. All collected material was deposited at OSUMC.

Results

Reproduction:

Cambarus (P.) veteranus

First form males, second form males, juveniles, and females were present in both months sampled. Females carrying eggs (ovigerous) were recorded in the month of September. *Cambarus veteranus* has a late summer reproductive cycle (Thoma 2009). Thoma (2009) reported in Virginia the species primarily laid eggs and reared young from July through October. The results of this study conform to that observation. Thoma (2009) also observed mating related behavior in June.

Cambarus (J.) parvoculus

Only one collection of *C. parvoculus* was made during this study in Clinton County, the most western portion of the State sampled. The collection came from Pickens Branch of Illwill Creek, a tributary of the Obey River system. All males observed (5) were first form. Also observed were 2 females and 2 juveniles (female). A male and female were observed in amplexus (mating). Three ovigerous females (housed at The National Museum of Natural History (USNM) and The Ohio State University Museum of Biological Diversity (OSUMC)) have been recorded in March and April. First form males have been recorded from March through November (USNM & OSUMC). It is likely first form males are present year round. These data indicate *C. parvoculus* likely mates in the fall and early spring (as seen in its closest relative *Cambarus jezerinaci*) and lays eggs in early and mid spring.

Habitat Preference:

Cambarus (P.) veteranus

The Big Sandy crayfish has been found to show strong correlations with habitat measurements in Virginia (Thoma, 2009). In Kentucky background habitat conditions are similar to those seen in Virginia but with a greater influence of strip mining on stream habitats. *Cambarus veteranus* has responded to this negatively. The species' aversion to elevated sediment levels is evident when sampling sediment impacted streams. As in Virginia, the species was most strongly associated with clean, third order or larger streams, low in bedload sediments, with moderate gradient, and an abundance of boulder/cobble substrate. Many of the streams visited were high in bedload sediments and were not sampled. Principle component analysis of habitat data collected in this study showed a strong relationship between *C.veteranus* abundance and general habitat quality (QHEI), riffle quality, and percent boulders. These two factors explain 65.55% of variation seen in the data. Those sites lacking *C. veteranus* had statistically significantly lower riffle embeddedness scores than those with *C. veteranus*. The other statistically significant relationship with abundance was Substrate score, a number reflecting general quality of riffle habitat. Correlation analysis results show Riffle Embeddedness to be the only habitat variable significantly correlated with *C. veteranus* abundance.

Cambarus (J.) parvoculus

Due to the fact that only one site harboring *C. parvoculus* was found in this study, it is not possible to analyze the habitat preferences of this species in Kentucky. Discussion of habitat preferences will be based on observations of Tennessee populations previously studied by the author. In Tennessee, the center of the species' distribution, it is found in small cool water streams with closed canopies, moderate to high gradients, abundant cobble/ boulder substrate originating from sandstone bedrock. The Kentucky site fits this description.

Kentucky Distributions

Cambarus (P.) veteranus

Taylor and Schuster (2004) reported *C. veteranus* from 4 sites in Kentucky, one in Knox Creek of Tug Fork, one in Levisa Fork and two in Russell Fork. This study confirmed continued existence at all four sites and added seven more localities. Most significant is a new population recorded in Shelby Creek of Pike County. The 4 other new sites were: two additional tributaries of Tug Fork (Blackberry Creek, Peter Creek), 1 more Levisa Fork site (between the historic most downstream site and the confluence of Russell Fork), and the remains of a dead individual in the lower portion of Elk Creek.

Cambarus (J.) parvoculus

As stated previously, only one site harboring a population of *C. parvoculus* was found during this study. *Cambarus parvoculus* sites previously reported by Taylor and Schuster (2004) from the Cumberland River basin in the vicinity of Pine Mountain and upstream have been found to be most closely related to *Cambarus jezerinaci* (Thoma and Fetzner, 2008). The areas sampled in this study were those sites reported for the Big South Fork basin and Cumberland River basin downstream Pine Mountain and its western flank. The most commonly encountered species was *Cambarus distans* (17 sites), a close relative of *C. parvoculus* and *C. jezerinaci*. The three sites reported to be *C. parvoculus* within the 4 county study area were sampled and found to harbor *C. distans*.

Discussion

Cambarus (P.) veteranus

Thoma (2009) reported on the life history of *C. veteranus and* found the species' reproduction was focused on mid summer to late fall with some late spawning females still carrying young in early spring. In general, mating occurs in mid summer, egg laying occurs in late summer and fall, and young are independent by early spring of the next year. Observations in this study conformed to that scenario. It was also reported that fresh molted individuals were very common in late spring/early summer. Kentucky populations also show this phenomenon. It appears the general life cycle pattern for *C. veteranus* is 2 to 3 years growth, maturation in the 3rd year, and first mating in mid summer of the 3rd or 4th year. After mating, a series of years characterized by mid summer mating, late summer/fall spawning, spring release of young, and late spring/early summer molting ensues. How many years of reproduction an individual can experience is not clear. It is speculated (using best professional judgment) that at least 2 or 3 years minimum could be expected. In early spring samples during previous studies/sampling efforts dead individuals were more commonly found. These individuals were almost always the largest individuals from the previous summer. *Cambarus veteranus* likely lives 5 to 7 years though it should not be discounted that fortunate individuals may live approximately 10 years.

Other crayfish species collected with Kentucky *C. veteranus* populations were *Cambarus (C.) sciotensis*, Teays River crayfish, *Cambarus (C.) angularis*, angled crayfish, *Cambarus (P.) robustus*, big water crayfish, and *Orconectes (P.) cristavarius*, spiny stream crayfish.

Cambarus (J.) parvoculus

Because there are very few *C. parvoculus* collections it is difficult to draw an accurate picture of the species' life history. It appears the species' reproductive cycle is similar to that observed in many other headwater stream species: mating in late summer and fall, egg laying in late fall and early spring, and fledging in late spring and early summer. This is the pattern observed in *C. jezerinaci*, the most closely related species. In describing *C. jezerinaci,* Thoma (2000) referred to it as a sister species of *C. parvoculus.* Thoma and Fetzner (2008) confirmed this relationship.

Other crayfish species collected with the one Kentucky *C. parvoculus* population were *Cambarus* (*E.*) *tenebrosus*, cavespring crayfish, and *Orconectes* (*P.*) *placidus*, bigclaw crayfish.

Kentucky Distributions

Cambarus (P.) veteranus

It is reasonable to assume all of the Big Sandy River basin upstream the Tug Fork - Levisa Fork confluence was once occupied by *C. veteranus*. This is an area of 3,974 square miles (includes all 3 states). The Kentucky portion of this drainage basin is approximately 2,975 square miles. Much of this area is no longer occupied by the species. In the Tug Fork basin *C. veteranus* is confined to 3 tributaries. No populations could be found in Tug Fork proper. The stream was severely polluted and heavily impacted by excess sediment. Very few crayfish were found inhabiting the stream and all were tolerant species of *Orconectes* (*O. cristavarius* & *O. rusticus*). The survival of the Tug Fork tributary populations is highly tenuous. They are confined to the lower portions of the streams and display low abundance.

In Levisa Fork proper, the species is found in very low numbers. The populations of the stream are obviously stressed and specimens collected were in poor condition. Any increase in pollution load could easily eliminate the species (similar to Tug Fork). Only 2 tributaries of Levisa Fork harbored populations of *C. veteranus*. Shelby Creek in Pike County has one of the healthiest populations in Kentucky. Populations in the lower and upper portions of the stream are very healthy while the middle section of the stream's population is stressed, primarily by nearby strip mining and associated sediment loads. Russell Fork, just upstream Shelby Creek, is the last stream with *C. veteranus* populations. The populations of Russell Fork are healthiest upstream near the Virginia State line. In the Levisa Fork basin, upstream of Russell Fork, no extant populations could be found.

Cambarus (J.) parvoculus

It is not surprising that *C. parvoculus* was found in the Obey River system. The type locality of the species is from the Hurricane Creek basin, a tributary of the Obey River. The surprising result of this study was the lack of *C parvoculus* found in the remaining portions of the Cumberland River basin. It was tacitly assumed at the beginning of this project that *C. parvoculus* would be found in the study area and likely at numerous new locations. Half way through the collecting effort it became apparent that this would not be the case. All of the localities reported by Taylor and Schuster (2004) turned out to be occupied by *C. distans*. Two sites in the Spring Creek basin of Clinton County were reported to harbor *C.*

distans. Collecting at two Spring Creek sites failed to yield any members of the subgenus *Jugicambarus*. At the time of collecting, the area was experiencing very dry conditions and most of the small headwater streams (all on limestone bedrock) suitable for the subgenera's occupation were dry. This stream system may harbor *C. parvoculus*. Further collecting will have to be conducted to make this determination.

Conservation Status

Cambarus (P.) veteranus

Current conservation designations are IUCN: Vulnerable, Taylor et al. (2007): Threatened, Kentucky: Special Concern. This report recommends Kentucky elevate *C. veteranus* to Endangered conservation status. This recommendation is made based on the extreme loss of range within Kentucky and the fact that only two populations have been found to be healthy (Shelby Creek & upper Russell Fork) one of which (Shelby Cr.) is experiencing stress from strip mining activities within its basin.

Recommended conservation actions are, in order of importance, control of activities and conditions resulting in increased erosion and sedimentation, rehabilitation of habitats damaged by stream modification, and reduction of nutrient inputs. Many area streams are currently overwhelmed with heavy bed loads of sand and silt. If some of these in-stream sediments could be removed, downstream reaches could be spared future impacts and impacted stream could recover sooner. In habitat modified streams, riffle structure has been damaged by removal of slab shaped boulders. Habitat for *C. veteranus* in these areas would be greatly enhanced by placing slab boulders in the riffles of these streams (as long as bed load sediments are not excessive). The downstream reaches of Russell Fork and Levisa Fork were noticeably impacted by elevated nutrient levels. This enrichment is impacting much of the streams ecological structure. At those sites with high enrichment impacts, few individuals of *C.veteranus* were observed and those seen appeared to be stressed. Also, few, if any, young individuals were seen.

Cambarus (J.) parvoculus

Current conservation designations are IUCN: Least Concern, Taylor et al. (2007): Currently Stable, Kentucky:Threatened. This report recommends Kentucky consider elevating *C. parvoculus* to Endangered conservation status. This recommendation is made based on the finding that the species has a highly restricted range within Kentucky.

Recommended conservation actions are establishing conservation easements or other conservation measures in the Illwill Creek basin of Clinton County. Though the species was not recorded there, consideration should be given to the Spring Creek and Sulpher Creek basins of Clinton County. Little other action seems needed at this point in time.

Other Findings

The finding of *C. angularis* in Kentucky was the most significant unintended finding of this study. This is the first record of the species in Kentucky. The species has also been documented in the Big Sandy River basin of West Virginia by Mr. Zac Loughman (personal communication). It may be that this population forms a unique genetic pool. A study of its relationship to the population in the Clinch and Powell Rivers of Virginia should be undertaken. Because of the limited range and the high levels of environmental stress in the Tug Fork Basin, the species should be classified as Endangered by Kentucky.

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Funding Source: *State Wildlife Grant (SWG) and Midwest Biodiversity Institute*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Response of crayfish populations to restored stream habitats in disturbed portions of East Fork Little Sandy River basin, Lawrence & Boyd Counties, Kentucky

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KDFWR Contact:
Danna Baxley

Introduction

Kentucky Department of Fish and Wildlife Resources (KDFWR) selected the East Fork Little Sandy River (EFLS) for stream restoration efforts in 2010. To better understand the influence of restoration efforts, KDFWR initiated a pre- and post- restoration survey project to determine potential site-specific impacts of stream restoration on crayfish populations. The East Fork Little Sandy project is located within the boarders of Lawrence County, Kentucky within the Western Allegheny Plateau Ecoregion (WAP) and the Ohio/Kentucky Carboniferous Plateau (OKCP) sub-ecoregion.

East Fork Little Sandy River / Roger Thoma

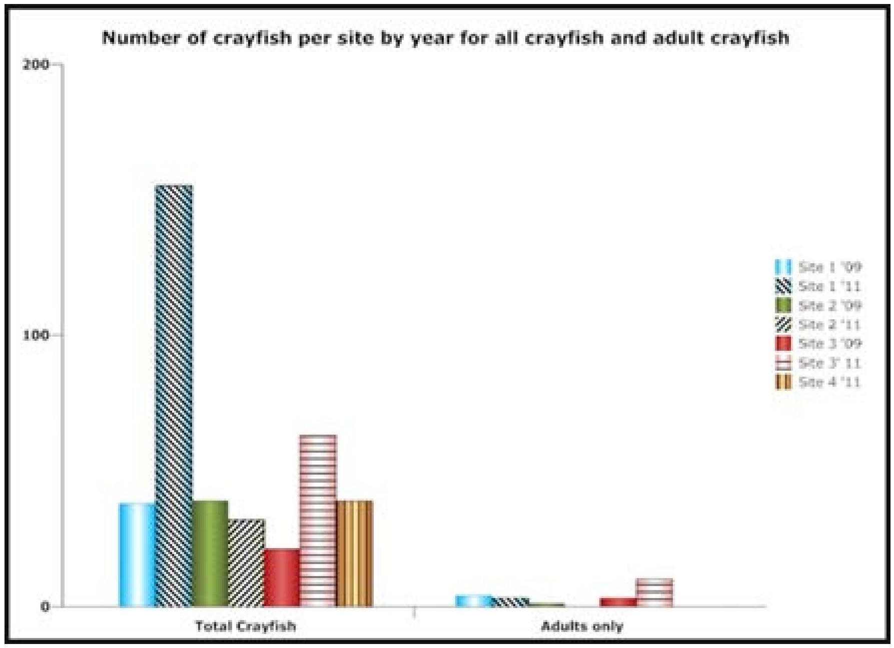

Figure 1: *Number of crayfish captured by site, by year for all crayfish observed (left) and adult specimens only (right).*

Methods

Site selections were made in consultation with KDWR personnel. Three sites on EFLS were sampled in 2009 and four in 2011 (Figure 1). Sampling methods involved the use of a 4'X6' seine and/or dip-nets in waters 20 cm deep or deeper. In shallower waters crayfish were collected by hand. Area sampled (square meters) was measured and recorded on field datasheets. For each year's sampling, all sites were sampled within the same week.

Since crayfish occupy a wide variety of habitats, a variety of habitat types were investigated for the presence of crayfish. The primary habitat investigated was surface water of streams. When sampling a stream site, rocks, logs, and undercut banks were disturbed by flipping, kicking, rocking, or sweeping with the foot to dislodge and disturb any crayfish hiding in the area. Deep areas were swept by dragging the seine through the deepest sections. Kick seining was employed in riffle areas. Kick seining consists of placing a seine downstream in a fast flowing riffle area and kicking the upstream area with the wader boot to turn and disturb rocks and send crayfish downstream into the net.

All crayfish burrow to some degree. Three burrowing styles were present in the EFLS study area; primary burrower (a species that digs an extensive burrow complex and spends most of its life within the burrow), secondary burrower (a species that digs a streamside burrow or burrows under a large flat rock coming out frequently to forage in the vicinity of the burrow entrance), and tertiary burrower (a species that digs a shallow excavation sufficient only for hiding and spends most of its time in the open). Secondary and tertiary burrowers are associated with surface waters such as streams and ponds/lakes. Primary burrowers are associated with ground water and spring/seep areas. Ground water burrows can frequently be found associated with wetlands and stream floodplains. In the EFLS area, burrows were found associated with stream banks, ditches, and a broad seep area in a hayfield. To examine burrows and capture species, one must excavate, to some degree, the upper area of the burrow. Frequently, a crayfish can be induced to come to the top of its burrow, but if it cannot, one must dig the burrow until the resident crayfish is found. Excavation is conducted with a small shovel or by hand depending on the hardness of the substrate the burrow is located in.

Three sites were sampled in 2009 (EFLS sites 1, 2, & 3) and sampled again in 2011. Site 3 was reclaimed in fall, 2006, site 1 in fall, 2009, and site 2 in winter, 2010/2011 (Table 1). An additional site (EFLS #4) was added in 2011 in the downstream reaches of the project. Site 4 was reclaimed in summer, 2010. The area of the fourth site could not be sampled in 2009 because of water depth. Two additional, non-EFLS, were sampled in 2009; Bolts Fork and an unnamed tributary of Left Fork Trace Creek. Bolts Fork was not restored, therefore it was not sampled in 2011. The unnamed tributary had already been restored in 2007 and was sampled in 2009 and again in 2011 to gauge recovery progress.

Results

A total of 366 individual crayfish were captured in EFLS during the course of this study. Three of the 6 species reported for Boyd and Lawrence Counties by Taylor and Schuster (2004) (*C. b. cavatus, C. thomai, O. cristavarius*) were documented in this study. An additional species (*Cambarus dubius*) was also documented. In 2009, four species were encountered in the system; *C. b. cavatus* (Appalachian Brook Crayfish), *C. dubius* (Upland Burrowing Crayfish), *C. thomai* (Little Brown Mudbug), and *O. cristavarius* (Spiny Stream Crayfish). One species is a secondary burrower (*C. b. cavatus*), one a tertiary burrower (*O. cristavarius*), and two are primary burrowers (*C. dubius*, *C. thomai*). In 2009 *C. dubius* was captured some distance from the EFLS project Footprint; however, effort to recollect it in 2011 was not made. Two species were recaptured in 2011

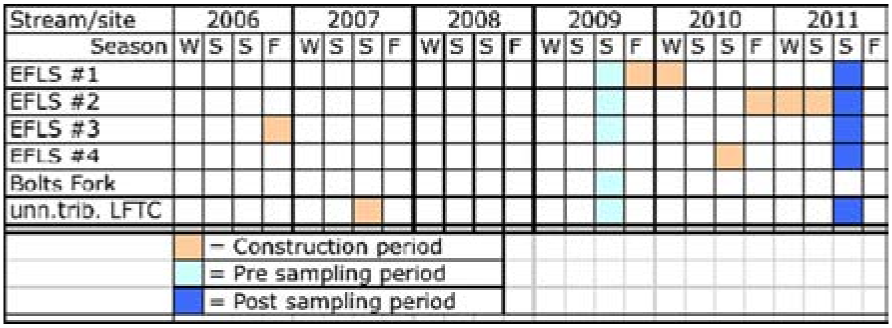

Table 1: *Timeline of activity in the East Fork Little Sandy River project area by season (Winter, Spring, Summer, Fall respectively) and by year. Tan represents the period of stream restoration construction, light blue the first (Pre) crayfish sampling period, and dark blue the second (Post) crayfish sampling period.*

(*C. b. cavatus* and *O. cristavarius*). Total catch in 2009 was 77 and 250 in 2011. The fourth 2011 site harbored 39 specimens. *Cambarus thomai* was not found in EFLS during 2011 collections.

In the unnamed tributary of Left Fork Trace Creek 3 species were captured in 2009 (*O. cristavarius, C. b. cavatus,* & *C. thomai*) and 2 in 2011. *Cambarus b. cavatus* was not recaptured in 2011. Total numbers were 13 (2009) and 23 (2011). In Bolts Fork 3 species were captured in 2009 (*O. cristavarius, C. b. cavatus,* & *C. thomai*). The system was not sampled in 2011.

Discussion

Sampling in 2009 indicated impacts from low quality habitat present throughout the system. Few refugia for crayfish were present in the area as a result of excess sand/sediment bedloads and lack of hard substrates. Crayfish communities in other streams of the ecoregion with intact habitat have been observed to harbor greater numbers of individuals with numbers dominated by adults (personal observation R.F. Thoma). In 2009, the dominance of crayfish populations in EFLS by juveniles and the overall low number of individuals was a clear sign of impacts from low quality habitat. It was anticipated that post-restoration community structure would improve with increased overall numbers and a domination by adult crayfish. The 2011 follow up sampling effort yielded variable results, of which, restoration maturity played an important role. Numbers of individuals did increase at sites 1 and 3 but the increases were primarily due to high numbers of young of year *O. cristavarius*. Only site 3 showed an increase in adults. Site 3 was reclaimed in 2006 and had subsequently experienced several years of recovery.

Two factors are responsible for our variable results: construction activity took place in the winter of 2010 for site 2, just prior to the 2011 sampling season, and a major flooding event occurred in the EFLS system just after completion of construction and prior to the new system reaching stabilization. Heavy rains damaged some of the newly restored stream segments during mid-winter of 2011 and precipitated the need to rework the impacted sections of the EFLS channel in early summer 2011. Resultantly, crayfish populations sampled in 2011, in the most recently restored sections, did not have sufficient time to recover from disturbance associated with stream restoration work. The winter flood affected the most recently restored subset of sample sites, while results from more mature sites, not as affected by flooding, demonstrate how habitat improvements can enhance crayfish communities.

Some indication of the potential recovery that could be achieved can be gleaned from sites 1 and 3. These two sites did not experience the full disruptions of the 2010 flooding events. Both sites displayed large increases in population numbers with site 3 showing increases in adult numbers. The results from sites 1 & 3 demonstrate the positive effect of habitat restoration on crayfish populations. Decreasing bedload sediments and increases in hard substrates are the factors most responsible for the improvements seen. As the EFLS continues to recover and bedload sediments decrease further it is anticipated the crayfish communities in the system will return fully to their pre-impact state.

In the unnamed tributary of Left Fork Trace Creek (ut-LFTC) habitat conditions remained stable during the study period. Habitat rehabilitation had been conducted prior to 2009 and the stream continued to recover prior to 2011. No flooding damage was incurred in the winter of 2010/11. In 2009 three species were recorded (*O. cristavarius, C. b. cavatus,* & *C. thomai*) and a total of 13 individuals were captured. In 2011 two species (*O. cristavarius* & *C. thomai*) and 23 individuals were recorded. It is not clear why *C. b. cavatus* was not reencountered. All 2011 individuals collected were juveniles, and it appears the stream is primarily being used as a nursery area. Sampling was difficult and an effort was made to not overturn rocks that were serving as bank protection. This is likely why no adult *C. b. cavatus* were encountered but it does not explain the absence of juveniles. The absence of adult *O. cristavarius* in ut-LFTC is not readily evident. The species is normally associated with large to mid sized streams and this tributary may be too small to retain adults. No adult *C. thomai* were capture as no effort was made to dig burrows on the floodplain. Since adults had been captured previously, numerous fresh burrows were observed in the area, and numerous young of year were captured, the habitat disturbance resulting from excavation of burrows was deemed not worth the potential results. It is assumed adult *C. thomai* are still present. There is the possibility that summer drying has been occurring for the stream, reducing the number of adult crayfish in the habitat. The reduced sampling effort is likely a large part of the explanation for the differences between 2009 and 2011. The stream is thought to be progressing in its recovery.

Bolts Fork, sampled only in 2009, possessed a healthy crayfish community. Ten adults and 42 juveniles were recorded. Ten adult crayfish is the most collected at a site during this study. EFLS #3 also had 10 adults in 2011. Bolts Fork had high gradient within the sample area (a ditched stretch of stream). There was abundant rock/ rubble substrate and a lack of soft sand bed load sediments. It is thought that restoration of Bolts Fork to its original channel would result in even better crayfish communities.

In examining the 2011 data it is evident that primary and secondary burrowing crayfish occurrence was much reduced from 2009. There are two explanations for this phenomenon, first, burrowing crayfish from outside the immediate project footprint were not searched for, i.e. the site harboring *C. dubius* was not specifically visited. Secondly, burrowing crayfish colonies are very slow to recover from disturbance. When stream banks, where most burrowing crayfish are found, are disturbed at least 2 years time is needed for such species to reappear in sufficient numbers to have a presence. It is likely *C. b. cavatus* and *C. thomai* will eventually return to the sampling sites but how long that will take is not clear.

Management Implications

It is recommended another sampling effort be conducted on EFLS in summer 2013. To draw firm conclusions about the effects of habitat restoration on crayfish communities based on this study is unwise. Though there are indications that habitat improvements can enhance crayfish populations, more data is needed to support such a conclusion and an actual 2-year recovery period should be observed.

Infield observations of crayfish occurrences indicated the importance of hard substrates (especially those comprised of flat rock slabs) to the presence of in stream crayfish. It is recommended that future restoration projects employ a dressing of flat slab rock in reconstructed riffles. It would be beneficial to select one of the EFLS sites to add flat slab rock to and consequently monitor its effect.

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Funding Source: *State Wildlife Grant (SWG) and Midwest Biodiversity Institute*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.3. Priority Conservation Action #80, #120, #164, and #185.

At a Glance

Stream restoration projects in high-priority crayfish areas should incorporate flat slab rocks in reconstructed riffles.

Effects of Phragmites Management on the Ecology of Clear Creek Wildlife Management Area

Howard Whiteman, Thomas Timmons, Amy Krzton-Presson, Brett Davis, Christopher Mecklin, Kirk Raper, and Katlyn Hitz, Murray State University

KDFWR Contact:
Danna Baxley

Introduction

Invasive species have been severely impacting habitats and communities worldwide for decades (Gratton and Denno 2006, Simberloff 1996). Wetland ecosystems are particularly susceptible to invasion because they are watershed “sinks”, accumulating materials resulting from terrestrial and wetland disturbances (nutrients, sediments, excess water), which supply invasive plants with the resources they need to outcompete native plant communities (Zedler and Kercher 2004). There are 412 exotic plant species established in Kentucky, 10 of which are considered invasive wetland species (Mahala 2008). Of these 10 species, *Phragmites australis* (common reed) is one of Kentucky’s most noxious invasive wetland species with prevalent populations throughout the western part of the state and along the Ohio River (Mahala 2008).

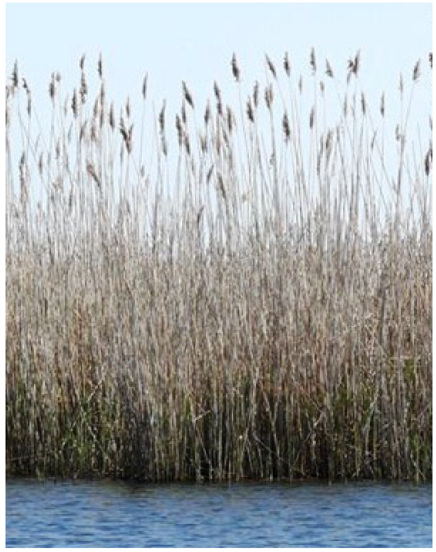


Figure 1: *Phragmites australis at CCWMA. / Amy Krzton-Presson.*

Phragmites australis is a coarse perennial wetland grass that grows in dense colonies, spreading laterally through subterranean rhizomes in circular growth patterns (Ailstock et al. 2001). This species is native to North America, but the *Phragmites* that is rapidly invading wetlands comes from a haplotype from Eurasia (Marks et al. 1994). Communities consisting of monoculture stands of *Phragmites* are considered poor wildlife habitat with low faunal diversity (Paxton 2007, Roman et al. 1984), through both a decrease in palatable vegetation and alterations in the structure of the habitat. Invasive *Phragmites* alters hydrologic and chemical cycles in wetlands where it becomes monotypic, replacing the more diverse native flora. This not only changes the structure, but also the function of the wetland (Meyerson *et al*. 2000). For example, Armstrong and Armstrong (1988) found that *Phragmites* can limit the cycling of phosphorus and other nutrients by having increased rhizosphere oxidation, which can bind these molecules in the sediments.

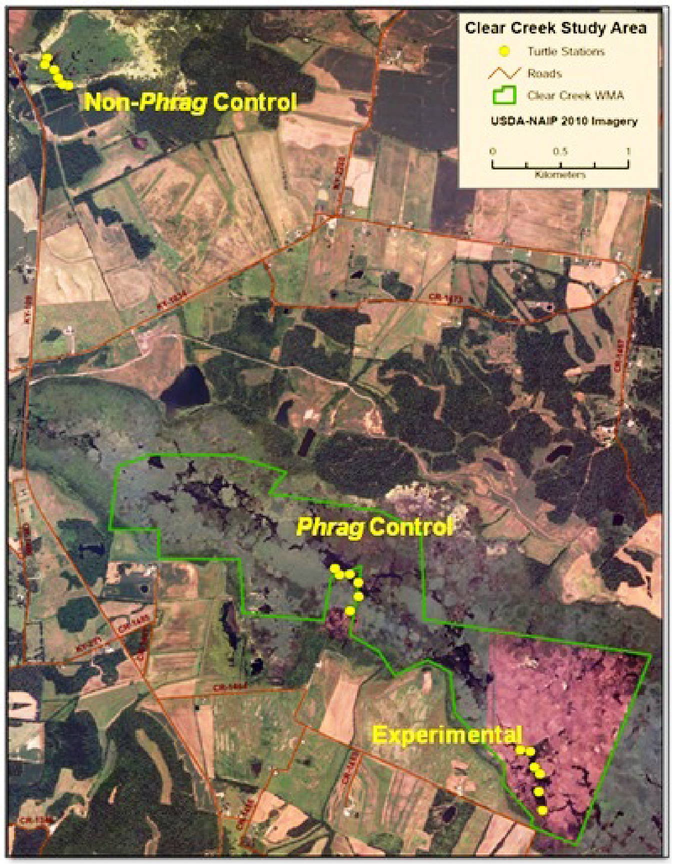
Because of the invasive nature and ecological damage caused by *Phragmites*, the control and eradication of this plant is important for biologists who wish to return affected wetlands to their pre-invasion state. Options for *Phragmites* reduction and/or removal include chemical, mechanical, and biological controls (Ailstock *et al*. 2001, Haslam 1971). Regardless of the method used, the destruction of a plant that has such a large presence in a community is likely to have an impact on the surrounding fauna by changing community composition and habitat structure.

Phragmites invasion has been particularly nocuous at the Clear Creek Wildlife Management Area (CCWMA; Fig. 1), a Kentucky Department of Fish and Wildlife Resources (KDFWR) property located in Hopkins County, KY. In an effort to increase access to this public area and to begin restoration of this vital wetland ecosystem, the KDFWR, Ducks Unlimited, and Murray State University collaborated to manage 300 acres of *Phragmites* on the CCWMA. Our goal was to study the effects of herbicide management on the fish and herpteofaunal communities as well as Species of Greatest Conservation Need (SGCN) and develop recommendations for future management of *Phragmites.*

In this study, we focused our efforts on two questions: 1) What effect does *Phragmites* and its management have on fish, reptile, amphibian, and SGCN populations?; and 2) What impact does *Phragmites* and its management efforts have on the ecosystem as a whole? Our efforts were thus aimed at monitoring the effects of *Phragmites*, as well as herbicide treatment of *Phragmites*, on fish and herpetofaunal diversity, the presence or absence of SGCN, and water quality.

Previous research suggested that *Phragmites* would have negative effects on wetland fauna, and that vegetation removal would result in an alteration of the fish and herpetofaunal communities. Therefore, we hypothesized that areas impacted by *Phragmites* would have reduced diversity and altered community structure, and provide less quality habitat for SGCN than non-impacted areas. We also hypothesized that *Phragmites* management would result in an increase in species richness and abundance in the fish and herpetofaunal community composition when compared with control areas where *Phragmites* remained. Finally, we hypothesized that *Phragmites* would impact the entire ecosystem by lowering nutrient availability. This study was designed to provide the data necessary for effective management of this invasive wetland species.

Figure 2: *Clear Creek Wildlife Management Area (green outline) and associated experimental sites. Sample locations are represented by yellow circles. Dead Phragmites, the result of herbicide application, is apparent in the experimental area. Map created by Jane Benson, Mid-American Remote-sensing Center (MARC), Murray State University.*



Materials and Methods

Site Description and Phragmites Management

Clear Creek is a 5th order stream approximately 50.8 km long draining an area of 15,661 ha, of which 858 acres makes up the CCWMA. Historically, this area consisted of an infrequently flooded bottomland hardwood swamp (B Kik, pers. comm.); it is now a more permanently flooded emergent vegetation wetland. It is characterized by a low gradient, clear water, and loose bottom composition consisting of detritus, vegetation, large woody debris, and silt. Currently the landscape at Clear Creek is dominated by the presence of *Phragmites* (Fig. 1). Concurrent genetic analysis of the *Phragmites* at Clear Creek WMA revealed that this population is the exotic, more invasive genotype (Croteau *et al*., unpublished data). Additionally, there are many native plants that occur at lower densities, including duckweed (*Lemna minor*), yellow water lily (*Nuphar advena*), coontail (*Ceratophyllum demersum*), arrow arum (*Peltandra virginica*), pond weed (*Potamogeton sp.*), and cattail (*Typha latifolia*). As part of this study, an adjacent non-*Phragmites* wetland was surveyed as a comparison to Clear Creek. This site, located on private land in the Weir Creek drainage, is a 3rd order tributary of Clear Creek and drains an area approximately 6,133 ha and is 17.6 km long. The predominant plant species in Weir Creek include yellow water lily (*Nuphar advena*), duckweed (*Lemna minor*), cattail (*Typha sp.*), and coontail (*Ceratophyllum demersum*). Weir Creek is characterized by low gradient, discolored water, and loose bottom composition consisting of detritus, vegetation, large woody debris, and silt.

On 22-August-2009 KDFWR and Ducks Unlimited carried out a chemical treatment of *Phragmites australis* on the experimental section of the CCWMA. An aerial application of a glyphosate herbicide (AquaMaster®) was conducted on approximately 300 of the 858 acres at a rate of ten gallons per acre via helicopter to spray the *Phragmites* and avoid the native aquatic plants (Fig. 2). This area served as our experimental treatment (EX), an untreated area invaded by *Phragmites* downstream served as our *Phragmites* control (PC), and the Weir Creek wetland served as our non-*Phragmites* control (NPC).

Sampling Methods

Fish were sampled according to the standardized methods of the KIBI (Kentucky Index of Biotic Integrity; see below; KDOW 2002), including seining and electrofishing (Fig. 3). Beginning in September 2009, fish sampling occurred every third week until October 16, after which cold weather and duck hunting season prevented sampling. Sampling resumed March 15th 2010 and continued until August 14th 2010. Fish were identified using keys in Etnier and Starnes (1993). Differences in KIBI and Shannon diversity

Family	Species	Common Name	EX	PC	NPC
Amiidae	*Amia calva*	bowfin	13	11	5
Lepisostidae	*Lepisosteus oculatus*	spotted gar	0	0	1
	Lepisosteus osseus	longnose gar	3	3	19
Esocidae	*Esox americanus*	grass pickerel	32	82	29
Clupeidae	*Dorosoma cepedianum*	gizzard shad	1	0	0
Catostomidae	*Erimyzon succeta*	lake chubsucker	161	272	44
Cyprinidae	*Cyprinus carpio (exotic)*	common carp	0	3	0
	Notemigonus crysoleucas	golden shiner	43	51	85
Atherinopsidae	*Labidesthes sicculus*	brook silver side	0	0	1
Ictaluridae	*Amerius melas*	black bullhead	4	6	2
	Amerius natalis	yellow bullhead	11	7	0
	Noturus gyrinus	tadpole madtom	5	1	0
Fundulidae	*Fundulus olivaceous*	blackspotted topminnow	1	0	0
Poeciliidae	*Gambusia affinis*	mosquito fish	32	23	498
Aphredoderidae	*Aphredoderus sayanus*	pirate perch	78	114	88
Centrarchidae	*Centrarchus macropterus*	flier	2	0	28
	Lepomis cyanellus	green sunfish	8	14	1
	Lepomis gulosus	warmouth	18	7	13
	Lepomis macrochirus	bluegill	64	83	311
	Lepomis megalotis	longear sunfish	0	2	0
	Micropterus salmoides	largemouth bass	5	8	79
	Pomoxis annularis	white crappie	0	1	31
	Pomoxis nigromaculatus	black crappie	0	0	6
Elassomatidae	*Elassoma zonatum*	banded pigmy sunfish	37	38	6
Percidae	*Etheostoma squamiceps*	spottail darter	1	0	3

Table 1: *Total number of captures for each fish species by sampling location. EX = experimental; PC = Phragmites control; NPC = Non-Phragmites control.*

among sampling locations and dates were evaluated using ANOVA. Additionally, similarity of fish communities was evaluated using the Jaccard similarity index and analyzed using a permutational MANOVA to test for significance among sample locations and dates.

Turtles were trapped at each site using hoop traps throughout the summers of 2009, 2010, and early summer 2011. Traps were checked daily and removed from the water at the end of a trap period to prevent mortality. Each site was sampled consecutively throughout the summer. Measurements of captured turtles include carapace length, carapace width, carapace height, plastron length, and mass. Adult turtles were sexed and marked with a unique code composed of holes drilled in marginal scales on the carapace (Gibbons 1990, Dustman 2010). Turtle capture data was used to analyze movement patterns, size density relationships, and species diversity. The Shannon diversity index and an ADONIS analysis of similarity was used to compare turtle diversity between study sites. Turtle measurements were compared across sites using MANOVA.

To sample frogs and toads, a Wildlife Acoustics, Inc. Song Meter1™ automated recording device (ARD) was utilized to record ambient sound for two minutes every hour. The ARD's were placed at each site to record breeding male frogs' songs and downloaded regularly to identify frog species and estimate relative densities. Semi-quantitative densities were estimated using the North American Amphibian Monitoring Program (NAAMP) ranking system (Bridges and Dorcas 2000, Royle and Link 2005). A Gower's measure of dissimilarity was used to statistically measure the level of dissimilarity of both species richness and ordinal densities. An ADONIS analysis was performed to identify significant dissimilarities in the Gower's results.

Lesser sirens (*Siren intermedia*) were trapped at each site simultaneously during the spring and fall, and consecutively in correspondence with turtle trapping during the summer. Six modified trashcan traps (Luhring and Jennison 2008) were set at each station within each sample site, baited with sardines, and checked daily. Traps were opened and upended after each trap period to allow captured organisms to escape and prevent mortality. Snout-to-vent length, total length, and mass were measured for each captured siren. Four minnow traps were set at each of the six trashcan trap locations and baited with dry dog food. All other organisms (snakes, frogs, tadpoles, fish and invertebrates) captured in the minnow and trashcan traps were identified to the lowest taxon and released. All SGCN that were captured or casually observed during fish and herpetofaunal sampling were recorded.

Water Chemistry

To evaluate water quality, three replicate water samples were taken from each site every month. These samples were analyzed for nitrate/

Figure 3: *Murray State graduate students Kirk Raper and Brett Davis seining the CCWMA for fish. Note the abundance of Phragmites in the background. / Amy Krzton-Presson.*

nitrite, phosphorus-phosphate (SRP), total particulate phosphorus (TPP), and total particulate nitrogen (TPN) using a Lachet Quick Chem 8000 at the Hancock Biological Station (HBS). Water samples filtered through 42.5mm glass microfiber filters were analyzed for total organic carbon (TOC). Turbidity, temperature, pH, conductivity, and dissolved oxygen (DO) were measured using a handheld YSI 650 MDS water meter sonde. MANOVA was used to compare overall water quality across sites, with individual ANOVA analyses on each parameter.

Results

Over the course of this study, 26 species of fish representing 14 families and 2,525 individuals were captured and recorded at all three sites. The presence of *Phragmites* affected the distribution of captured fish, but *Phragmites* management did not (Table 1). Of the 15 fish species with more than 15 total individuals captured among all three sites, 12 showed a pattern of similar capture numbers among the *Phragmites* sites (EX, PC) that were substantially different from the non-*Phragmites* control (NPC; $\chi^2 = 5.4$, $p = 0.02$, d.f. = 1; Table 1). This pattern was confirmed by the Jaccard similarity index: permutational MANOVA analysis showed significant dissimilarity between the non-*Phragmites* control and *Phragmites* sites (EX and PC; both $F_{1,12} > 2.42$, both $p = 0.001$), but not between the experimental and control *Phragmites* sites ($F_{1,12} = 0.77$, $p = 0.75$).

The average KIBI for each site across all sampling efforts were NPC = 22, PC = 19.33, and EX = 16.75. The KIBI of each site fluctuated over the course of the study, with scores increasing during 2010 and reaching their maximum values on July 15, 2010 (NPC = 34, PC = 34, EX = 38). There were no significant differences in the KIBI among sites ($F_{2, 36} = 0.88$, $P = 0.42$) and only marginal differences in the KIBI across sites over time ($F_{2,24} = 3.16$, $P = 0.064$). Similarly, there were no differences in the Simpson's diversity index among sites or when controlling for time (both $F < 0.5$, both $P > 0.61$).

Of particular interest among the fish samples is the lake chubsucker, *Erimyzon sucetta*. *E. sucetta* is threatened in the state of Kentucky and a SGCN (Table 2), and was found at all three sampling locations. A total of 477 individuals of this species were collected among all three sites, the second highest abundance of all species collected (Table 1). The majority of these individuals (57%) were collected at the *Phragmites* control site.

Over two field seasons each site was trapped for 288 trap days resulting in 661 turtle captures, consisting of 328 common snapping turtles (*Chelydra serpentina*), 330 red-eared sliders (*Trachemscripta elegans*), 2 musk turtles (*Sternotherus oderatus*), and 1 midland painted turtle (*Chrysemys picta margenata*). The painted turtle was captured at the *Phragmites* control along with one of the musk turtles. The other musk turtle was captured at the experimental site. Turtle biodiversity, as measured by the Shannon diversity index, was found to be significantly lower at the non-*Phragmites* treatment than either of the two *Phragmites* sites ($F_{2,99} = 3.59$, $p < 0.01$). The experimental and *Phragmites* control site did not differ significantly.

MANOVA comparisons of overall body sizes showed significant differences among both common snapping turtles and red-eared sliders. Juvenile outliers were removed from the analysis. Turtles of both species were significantly larger at the non-*Phragmites* control than either of the two sites with *Phragmites* (both $F > 3.4$, both $p < 0.01$); the experimental site and the *Phragmites* control site did not differ significantly.

The ARDs recorded for ten months at each site; of that, over 360 hours of sound were analyzed. Twelve anuran species have been identified across the three sites including three SGCN: bird-voiced tree frog (*Hyla avivoca*), the crawfish frog (*Rana areolata circulosa*), and the southern leopard frog (*Rana sphenocephala*) (Table 2). Gower's measure of dissimilarity showed no trends and the subsequent ADONIS analysis showed no significant differences in anuran biodiversity across the sites ($F_{2,21} = 0.54$, $p > 0.05$).

Sirens and other SGCN

Each treatment was trapped for approximately 654 trap days over the two-year period for the western lesser siren. This resulted in only seven siren captures, only one of which was at the experimental site. In addition to sirens, diamondback water snakes, copperbelly water snakes, and western cottonmouths were also occasionally captured in these traps.

With the exception of the western lesser siren (*Siren intermedia nettingi*) and the western cottonmouth (*Agkistrodon piscivorus leucostoma*), other SGCN were observed at all three sites (Table 2). A western mud snake (*Farancia abacura reinwardtii*) was found dead on the road directly adjacent to the non-*Phragmites* control indicating both their presence in at least that site and also the presence of undetected *Siren intermedia nettingi* as that is the mud snakes' primary food source.

Water Chemistry

Five of the eleven water quality parameters varied significantly among treatments. All of the variation coincided with the presence of *Phragmites*; the experimental treatment never differed significantly from the *Phragmites* control and in five of the parameters the non-*Phragmites* control differed significantly from both the experimental and the *Phragmites* control. The DOC, SRP, TP, and TN were higher at the non-*Phragmites* control (all $F_{2,38} > 8.0$, all $p < 0.01$). In contrast, conductivity was significantly lower at the NPC treatment than the other two treatments ($F_{2,38} = 76.27$, $p < 0.01$). DOC, TP, turbidity, ORP, TN, and conductivity showed significant seasonal variation ($F_{1,38} \geq 4.75$, $p < 0.05$), but only conductivity exhibited a significant interaction between treatment and month. This interaction was driven by variation at the two *Phragmites* treatments while the NPC treatment remained relatively stable. NO_3/NO_2, temperature, pH and DO did not differ significantly across treatments or over time.

Discussion

While actual removal of *Phragmites* stands did not occur as a result of this study, the herbicidal treatment of the experimental site was a successful management step toward restoring 300 acres of Clear Creek WMA to a pre-invasion condition. The return of arrow arum (*Peltandra virginica*) and cattail (*Typha latifolia*) to the treatment area provided evidence that managing *Phragmites* can allow native species to re-establish in the region. Although herbicide spraying can be costly, continued management of *Phragmites* is an effective treatment that should be weighed against the ecological disturbance caused by *Phragmites* invasion, which as this study shows can be considerable. The successful management of this invasive could also benefit waterfowl hunters, anglers, and non-game recreational wildlife enthusiasts as the quality of the Clear Creek habitat increases with native plant restoration.

Fish, Herpetofauna, and SGCN Effects

Our results do not support the hypothesis that the CCWMA fish community was affected by *Phragmites* management. The lack of difference between the experimental and control sites could be attributed to the similar habitat that still exists at these two locations. While the treatment of *Phragmites* at the experimental site resulted in the elimination of green plant tissue in adult individuals, the dead plant stems still remained standing during our study, and the amount of open water habitat remained the same as before *Phragmites* treatment. The short duration of the present study may not be a reflection of the long-term changes in the fish community that could result from *Phragmites* management. For example, the fish community at the non-*Phragmites* control was made up of a significantly different assemblage than those at either of the *Phragmites* locations (Table 2). This supports the hypothesis that the native plant community at the non-*Phragmites* control provides habitat for a different fish community than those sites dominated by *Phragmites*. As the remaining *Phragmites* stems decompose and herbicide treatment of *Phragmites* continues, open water habitat and native plant species should increase at the CCWMA. Future research at CCWMA may thus reveal significant differences in the fish community as the habitat changes.

Phragmites presence, but not management, also affected turtle species. More large turtles of both dominant species were found at the non-*Phragmites* site than at either of the two *Phragmites* sites. There are large numbers of native yellow water lily (*Nuphar lutea*) and duckweed (*Lemna minor*) at the non-*Phragmites* site, both of which are commonly consumed by red-eared sliders (Gibbons 1990). Although snapping turtles are much more carnivorous than sliders, both species are omnivorous. Our observation that large turtles of both species were more common at the non-*Phragmites* control site when compared to the two *Phragmites* sites suggest there may be habitat selection by age and size according to their different needs. Invasion by an exotic plant such as *Phragmites* lowers plant diversity and palatable plants may be limited in the two *Phragmites* sites. Additionally, our fish community results and invertebrate samples (not shown) suggest that there were no significant differences in overall prey availability among sites. Thus, all three areas had adequate food sources for younger and smaller turtles that typically have a more protein-based diet, suggesting that larger turtles may have been more concentrated in the non-*Phragmites* site because of the vegetation differences.

The non-*Phragmites* control site was found to have lower turtle biodiversity than either of the two *Phragmites* sites primarily because of low

Species	Treatment observed	Frequency Observed
Lake Chubsucker *(Erimyzon sucetta)*	EX, PC, NPC	Common
Western Lesser Siren *(Siren intermedia nettingi)*	EX, PC	Uncommon
Bird-voiced Treefrog *(Hyla avivoca)*	EX, PC, NPC	Common
Northern Crawfish Frog *(Rana areolata circulosa)*	EX, PC, NPC	Uncommon
Southern Leopard Frog *(Rana sphenocephala)*	EX, PC, NPC	Common
Diamondback Water Snake *(Nerodia rhombifer rhombifer)*	EX, PC, NPC	Common
Copperbelly Water Snake *(Nerodia erythorogaster neglecta)*	EX, PC, NPC	Common
Western Cottonmouth *(Agkistrodon piscivorus leucostoma)*	EX, PC	Common

Table 2: *Fish, amphibian, and reptile SGCN observed at the CCWMA, the treatments in which they were observed, and the frequency of observations. EX = experimental; PC = Phragmites control; NPC = Non-Phragmites control.*

species evenness. The two *Phragmites* sites did not differ significantly from each other. The ratio of common snapping turtles to red-eared sliders was much higher in the non-*Phragmites* site as opposed to either the experimental or *Phragmites* control (~4:1 versus ~1:2, respectively). These results suggest that *Phragmites* has species-specific effects on turtle distribution and population size. It is possible that turtle species differ in habitat selection, either preferring or avoiding *Phragmites*; alternatively, the more aggressive snapping turtles may outcompete sliders and other less aggressive turtle species for access to the high quality resources at the non-*Phragmites* locality. Further research will be required to evaluate these disparate hypotheses.

We found no significant difference in anuran diversity based on both species richness and ordinal densities using the NAAMP ranking. This result supports the null hypothesis that anurans are not affected by the presence of *Phragmites* and may therefore show little reaction to *Phragmites* management. Although *Phragmites* does not grow in deep water, there is standing water within and throughout the *Phragmites* stands in Clear Creek. Our results suggest that this provides adequate habitat for the frog species of this area.

The presence of western lesser sirens was confirmed at both the experimental site and the *Phragmites* control site. Although they were not captured at the non-*Phragmites* site, a western mud snake, a siren-specialist predator and a SGCN, was found nearby suggesting both species are present in that area. Of the ten aquatic reptile and amphibian SGCN that are listed as confirmed in Hopkins County, Kentucky (KDFWR 2005), eight were observed at or directly adjacent to the study sites. This speaks highly of the quality of Clear Creek despite the invasion of *Phragmites australis*. Some of these species, particularly the western lesser siren, were rare and might benefit from the successful management of this invasive plant.

Water Chemistry Effects

All of the significant variation seen in the water chemistry analysis paralleled the presence or absence of *Phragmites*, strongly suggesting that this plant is impacting the nutrient cycling in Clear Creek. The land use surrounding all three treatments is very similar; agricultural activity and strip mining are adjacent to every site (Davis 2011). With the exception of nitrogen, the differences across treatments included the major nutrients involved in aquatic ecosystems. An increase in dissolved organic carbon can reflect the faunal community that the ecosystem can support. Sources of dissolved organic carbon include excretion of waste materials by fauna, cell breakdown, and microbial decomposition (Lampert and Sommer 2007). An increase in DOC, as well as other more limiting nutrients such as phosphorus and nitrogen, can be indicative of an increased trophic state of an aquatic habitat (Lampert and Sommer 2007).

Reactive phosphorus (SRP) is typically the most limited nutrient in a wetland (Cole 1994). More available phosphorus could benefit the algal community at the base of the aquatic food web. *Phragmites* has been shown to have a higher net primary productivity than the native plants it displaces (Ehrenfeld 2003); this combined with the increased plant biomass seen in *Phragmites* could be contributing to the lower levels of phosphorus seen at the EX and PC treatments and coincidentally limiting available phosphorus for other macrophytes. The decrease (but not total elimination) in living *Phragmites* at EX due to management may have a small, or thus far undetectable, effect on nutrients such as SRP; however, nutrient cycling in a stream ecosystem has a longitudinal (downstream) element (Newbold 1992). *Phragmites* still exists upstream and may be impacting the influx of nutrients.

Conductivity varied significantly over time at both *Phragmites* treatments, while levels at the NPC treatment were much more stable. The fluctuations seen in PC and EX coincide (inversely) with discharge data from a USGS station on the Tradewater River just downstream from the confluence of Clear Creek and the Tradewater River. The NPC treatment remained stable throughout rain events and a drought. This suggests the flow of minerals into Weir Creek is much more constant and stable than that entering Clear Creek. Conductivity is related to total dissolved solids, and these solids are often minerals capable of conducting electrical current through the water (Cole 1994). High mineral content in watersheds is often a result of the erosion of rocks and soils (Golterman et al. 1975), which could be affected by local strip mines in Hopkins County. These three study treatments are all surrounded by strip mines (Davis 2011), but the increased levels and variation in conductivity suggest Clear Creek may be more heavily impacted than Weir Creek. Drainage from strip mines is often characterized by a low pH and increased heavy metals (Robb and Robinson 1995). *Phragmites* has been shown to increase sediment deposition (Rooth and Stevenson 2000), and this may be impacting the transport of conductive dissolved solids in Clear Creek. The pH levels did not indicate increased acidity; *Phragmites* is known to increase the pH of runoff from mines by adding alkalinity through gas exchange in the substrate (Robb and Robinson 1995), and this process may be stabilizing the pH at CCWMA. Other water chemistry parameters (besides conductivity) varied over time, but the treatments had had similar trends showing they had similar seasonal effects.

Alternatively the differences seen in conductivity across treatments could be site-specific characteristics independent of the presence *Phragmites*. In this scenario, drainage from strip mines that increased conductivity may have degraded Clear Creek making it difficult for native plants to survive, thereby reducing competition for *Phragmites* and making it easier for it to invade CCWMA. Peverly et al. (1995) documented *Phragmites* thriving and expanding in high concentrations of metal leachate from an adjacent strip mine, the roots acting as filters to absorb metals while the rhizosphere released oxygen to form metal precipitate. If this is the case, Clear Creek may be more difficult to restore as *Phragmites* is providing an ecological buffer for strip mine drainage. Even after the invasive plant is removed, native species may have difficulty reestablishing in a degraded habitat.

Conclusions and Management Recommendations

This study demonstrates the complex and variable nature of invasive species treatment in a wetland ecosystem. Because an increase in invasive species abundance can alter wetland ecosystem function (Meyerson *et al.* 2000), invasives demonstrate how individual species can make a difference on an ecosystem level. Additionally, many authors agree that long term monitoring of invasive species treatment and standardization of methods is critical for evaluating management techniques and recommending future strategies (NRC 1992, Kondolf 1998, Blossey 1999). The use of both ecological and statistical population metrics in the present study resulted in an effective method for monitoring effects of invasive species management on fish and herpetofaunal community dynamics. Because plant invasions generally affect all levels and processes within an ecosystem, multi-disciplinary and cross-taxa monitoring research is important for understanding the ecological implications of invasive species management (Blossey 1999). This inter-disciplinary approach is reflected in the management goals and monitoring strategies at Clear Creek WMA.

Our findings of differences in fish community structure and turtle sizes suggest that continued management of *Phragmites* may be beneficial toward both taxonomic groups. The increased biomass of *Phragmites* may be reducing nutrient levels such as phosphorus at the two invaded treatment sites. Isotopic signatures of individuals of various species show more utilization of macrophytes at NPC as well as higher densities of tertiary consumers (Krzton-Presson 2011). Although *Phragmites* impacted some species more heavily than others, this study supports the idea that it is a lower quality food resource, alters available nutrient levels, and these combined effects influence the organisms capable of being supported by this system.

The ability of *Phragmites australis* to quickly dominate marsh plant communities (Roman et al. 1984) makes it an invasive capable of altering wetlands on an ecosystem level. This study illustrates the complexities of wetland dynamics and fluxes, some of which originate from the bottom of the food web and manifest in top predators. The successful management of this plant and any subsequent effects on the wetland community may not be apparent unless long term monitoring in conjunction with continued management is performed. Successful habitat restoration attempts to re-establish communities to a state that is both physically and functionally similar to the pre-invasion habitat (Palmer et al. 1997). The use of complimentary research techniques (i.e. fish diversity, turtle population ecology, anuran diversity, SGCN, water chemistry, etc.) allowed for a deeper understanding of how this invasive plant and its management are affecting this wetland.

Our results suggest that future management of *Phragmites* at the Clear Creek WMA is warranted, and that continued monitoring of plant, fish, herpetofauna, and SGCN will be necessary to adequately determine the long-term consequences of such management.

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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 Actinopeterygii and Cephalaspidomorphi. Priority Research Project #1.

At a Glance

Managing Phragmites in the manner can allow native species to re-establish. Both arrow arum and cattail re-established onsite.

Natural Grassland Survey of the Interior Low Plateau Karst Priority Conservation Area

Brian Yahn, Kentucky State Nature Preserves Commission

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Introduction

At the time of early settlement, Kentucky had an estimated 2.5 to 3 million acres of natural grasslands (prairies), open woodlands (barrens) and rocky glades that were common in the Pennyroyal/ Mitchell Plain and the Coastal Plain regions and scattered throughout surrounding areas (Abernathy et al. 2010). This system in Kentucky was an outlying part of the once vast Prairie Peninsula that existed in central North America prior to European settlement (Ladd 1995). The natural communities of this ecosystem supported a wide diversity of plants and animals, very different from the surrounding and prevailing forests. Such species were adapted to drought, fire and grazing pressures. But in this modern era, most of the original grassland system in Kentucky has been eliminated from the landscape, converted to agricultural fields, mined land and urban cities and highways. Many species associated with native grasslands are now rare, declining or extirpated.

Today, only a number of small and a few larger natural grassland remnants are known to still exist. They are widely scattered and often in isolated patches. Most are in poor ecological condition from decades of misuse, over-grazing and lack of fire. It is important to identify remaining parts of this grassland ecosystem and develop long-term conservation plans to provide protection and management to sustain grassland associated species into the future. These areas include the original grassland flora of the region as well as the habitat structure and food plants that support grassland/woodland wildlife species. Restoration of remnant grasslands and woodlands/barrens (i.e. with prescription fire, non-native species management and cedar removal) is critical to the continued existence of these unique species and communities in Kentucky. Large-scale restoration is most successful when remnant grasslands and woodlands, with a diverse native flora, are embedded within the

Limestone prairie Crooked Creek / Dave Skinner area to be restored. The native plants growing in these areas provide the seed bank necessary for successful restoration. These natural populations can also supply the seed source for more intensive restoration (i.e. seed drilling) on adjacent lands.

Natural grassland communities are highly diverse and have developed this variation over relatively long periods of time (ca 8,000 years ago) with fire and grazing (i.e. large herbivores) as natural disturbance factors (Ladd 1995). It is just a matter of time before these natural grassland remnants are converted to development, agriculture or other uses and the opportunity to protect both natural communities/habitats and the unique species that rely on them will be gone. To this end, identification of the remaining pieces is needed to support the diverse and unique flora and fauna associated with these grassland systems.

Table 1: **Summary of Sites Surveyed and Remnants Identified**

	Sites Surveyed	Sites Surveyed: Acres	Surveyed Areas by Quality*
Total	**392**	**46,900**	**452**
Eliminated	**304**	**36,423**	**349**
Moderate to High Quality	**88**	**10,477**	**103**
	Best Quality Ranks	**Sites Surveyed: Acres**	**Surveyed Areas by Quality***
	State Significant	**4,138**	**13**
	State Notable	**1,359**	**21**
	County Notable	**4,242**	**58**
	Restoration Potential	**738**	**11**

** Surveyed sites were divided into areas based on quality*

In past years, conducting systematic inventories for native grassland remnants has been difficult and time consuming. The results lead plant ecologists to assume that the best and largest grassland, woodland and glade habitats had already been found in Kentucky. But in perspective, these "best" sites were few and, on a landscape scale, relatively small, isolated and separated by enough distance that gene flow between populations was restricted or completely shut-off. A new approach was needed to identify more remnants within the landscape and to make conservation decisions based on the remaining distribution.

The goal of this project was to identify and document remaining natural grassland, woodland and glade habitats that support native flora and fauna (from grasses and forbs to insects, snakes, lizards, birds and mammals). Once identified, focus areas could be established, allowing for KDFWR to narrow their surveys, monitoring and protection for wildlife species of greatest conservation need (SGCN). Examples of such wildlife species which directly utilize or depend on native grasslands include: Henslow's Sparrow, Lark Sparrow, Short-eared Owl, Northern Harrier, Eastern Corn Snake, Eastern Slender Glass Lizard, and Six-lined Racerunner.

Methods and Materials

The project area (Figure 1) was selected to provide additional biological information on the conservation areas described in Kentucky's Wildlife Action Plan (KDFWR 2005). This area, known as the Interior Low Plateau Karst Priority Conservation Area (ILPKCA), also coincided with a significant part of the pre-settlement prairie and barrens region of Kentucky.

With the recent use of color and black and white aerial photography (USDA-NAIP/KY EPPC color digital orthophotography (2004, 2006, 2008, 2010) and USGS/KY EPPC digital orthophoto quadrangle (1995/1997)), KSNPC ecologists are now able to distinguish areas dominated by native (warm season) grasses and forbs from areas dominated by non-native (cool season) grasses and forbs (e.g. old fields dominated by fescue). A color aerial photo taken sometime in summer through fall will usually show darker brownish color signature for warm season plants and a greenish color signature for cool season plants.

In combination with the above method, an older method of inventory that identifies natural areas (simply called Natural Areas Inventory or NAI) was developed in the mid-1970s and conducted by the University of Illinois. This approach, adopted in the late1980s by KSNPC, still involved using aerial imagery (but past image quality was poor or limited). Using this imagery and other information (soils, topography, geology, etc), sites were selected and then systematically flown over in search of natural areas (e.g. looking for natural features (cliffs, natural ponds, waterfalls, etc.), low-disturbance communities, large expanses of mature forests, etc.). Such a survey required that the aircraft fly slowly, be able to spin in tight space and hover over precise locations. Helicopters were the best choice to perform such surveys.

Selecting sites from aerial photos and then completing a rapid inventory by helicopter is a very efficient and productive method to achieve a reliable assessment of large study areas like the ILPKCA. These steps help to quickly filter out the sites that need ground vis-

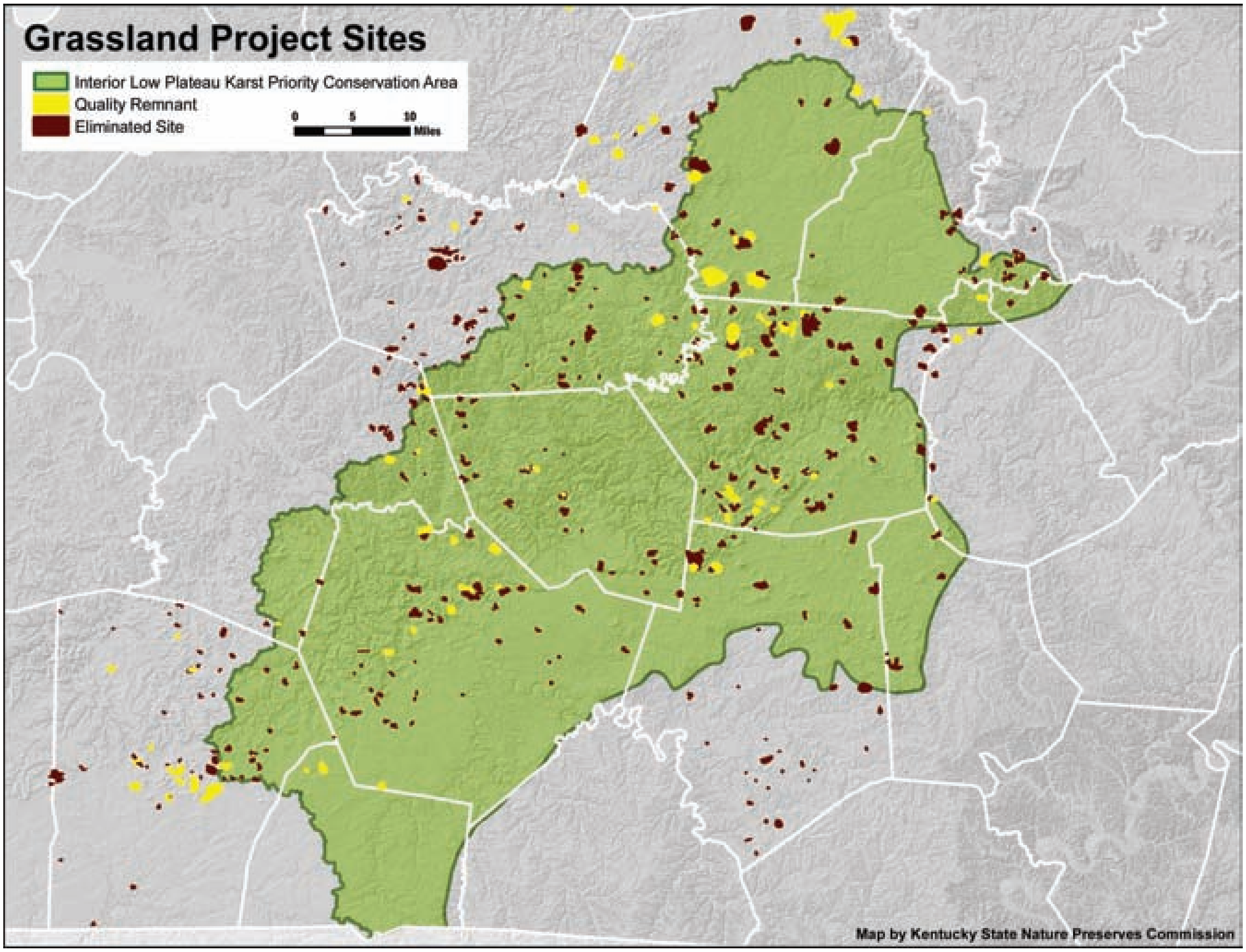

Figure 1: *Study Area, see inset key for details.*

its. Many grassland sites can be evaluated quickly in one flight whereas the same number of sites (not flown over) might take weeks or months to eliminate/inspect on the ground.

All sites visited on the ground were scored by evaluating six factors: habitat quality, species rarity, invasive species abundance, size, landscape context and woody species encroachment. Values were given to each factor on a 1 to 5 scale, with 1 most favorable and 5 the least favorable. An overall site or community rank was also determined.

The step by step inventory process was completed as follows:

1. Organized relevant grassland sites in the ILPKCA that had been identified/surveyed in the past (using the KSNPC Natural Heritage Database, KSNPC NAI database, etc.)
2. Systematically inspected the aerial photography, selecting areas for potential grassland sites (using ArcGIS software). A grid system of quarter quads was used to keep the imagery in order.
3. Organized potential sites into a flight plan. A crew (usually two ecologists, along with the pilot) then assessed the potential sites through aerial surveys (via helicopter). Sites were either kept for closer inspection or eliminated due to low quality appearance (e.g. logging, bulldozing, invasive species presence, overall weedy appearance, etc.).
4. Sites that were kept for closer inspection, especially those that ranked as higher priority, were surveyed on the ground. Detailed vegetation data was collected and included: qualitative data regarding composition, data describing community structure, presence of weeds and other signs of anthropogenic disturbance.
5. The data collected from

ground visits was entered into two separate forms. One form was used for documenting site conditions and species presence and abundance. Another form was used for ranking the quality and conservation potential of the site. The form that ranks quality and conservation potential was a first step approach to separate the best sites from the worst and to assess the sites based on several factors

Results

Surveys in Barren, Butler, Edmonson, Metcalfe and Simpson Counties resulted in fewer high quality remnants discovered (Figure 1). Most of the sites surveyed, particularly in Butler Co., were low to moderate quality, many with sandy, dry, eroded soils. Grayson and LaRue Counties had a few high quality remnants found but most were isolated, without other nearby remnants. The highest concentrations of new remnants found were in Hardin and Hart Counties, particularly in two regions: southwest and southern Hardin County extending into northwestern Hart County. Both of these areas have been selected as conservation focus areas. Warren and Logan Counties also had a high number of remnants, but many of these were found during the original NAI surveys in the late 1980s. Some of these sites have been further fragmented or degraded or destroyed since their discovery (due to new roads, logging and other development pressures). This being an unfortunate confirmation that high quality grassland habitat continues to disappear from the landscape.

A total of 392 sites were either surveyed during this project or through past natural area inventories. Of these, 88 sites were considered of moderate to high quality remnants and 304 were eliminated (Table 1). Thirteen sites have the highest rank of State Significant (covering over 4,000 acres). However, seven of these thirteen are protected areas (such as State Nature Preserves or other conservation/managed lands) and make up 59% of the total acreage. The remaining notable sites are mostly privately owned with little to no protection or grassland management.

Focus Areas:

As a result of this study, four Conservation Focus Areas have been delineated within the project area. These Focus Areas have been created based on three main factors: 1) high-quality grassland remnants occurring at high density, 2) the high occurrence and abundance of SGCN and KSNPC-listed species and 3) predominance of native vegetation on the landscape (including large forest tracts, significant natural areas (especially other native grassland sites), etc.). These Focus Areas have been created to help the conservation community center their attention on particular areas for conservation and restoration of native grasslands.

Selecting Focus Areas was not without bias but the three factors listed above guided the decision making process. Sources of information to complete the process include Kentucky Rarity-weighted Richness Index Analysis (RWRI) (Abernathy et al. 2010), KSNPC Kentucky Natural Heritage Database (2011a), KSNPC NAI database (2011b), KSNPC Conservation Lands Database, and KSNPC Kentucky Large Forest Tracts (Evans 2009).

The four Conservation Focus Areas are:

Focus Area 1: *Rough River and Meeting Creek Focus Area (Southwest Hardin County)*

Focus Area 2: *Nolin River & Round Stone Creek Focus Area (S. Hardin & Northern Hart Co.)*

Focus Area 3: *East Mammoth Cave Focus Area (Southern Hart and Northwest Barren County)*

Focus Area 4: *Pennyroyal Karst Plain Focus Area (Southern Warren County)*

Discussion

Land use and persistence of native grasslands (prairies/barrens/glades)

Most natural grassland remnants persist because private landowners never converted the land to pasture (e.g. cool season non-native grasses) or crop fields (e.g. corn, soybean, etc.) - or converting the native grassland to non-native pasture was attempted but the effort was unsuccessful. In general, where there are remnants, landowners probably used the areas as native pasture for livestock, the land was grazed (sometimes heavily) and kept open. In a heavily grazed situation, if the livestock were removed and the land had time to recover, native grassland plants could spread from native patches or could re-colonize from edge habitats. Another scenario: if the land was left idle or abandoned, woody species would invade the area (especially without repeated fire and/or grazing). In time, the woody forest species would grow up and shade out the native grassland species, reducing grassland density and diversity.

In situations where woodlands (barrens) were common, conditions were likely degraded over time. Trees were likely removed or reduced by long-term grazing, or the woodland was suppressed without fire and allowed to close in, or it was logged and left to re-grow. Woodland re-growth and maturity was often without fire, and tree species aggressively competed for light to establish dominance in the canopy. With fire being suppressed and grazing pressures changing from natural to human-induced, the stability of the woodland system began to unravel. Today, on many dry, rocky slopes and knobs of the Interior Low Plateau, grassland-prairie plants are found but only in small open pockets within a dry but closed or dense canopy forest. These plants, growing in a sea of shade-loving forest species, point to a pre-settlement condition where a prairie-woodland mosaic existed and changed gradually with disruptions from natural fire and grazing cycles. Today the native grassland system is broken and severely fragmented, with dysfunctional natural cycles.

Over-grazing, erosion, woody invasion or repeated mowing over time cause a significant reduction in grassland species diversity and this depauperate condition is evident in most remnants on the landscape today.

Completeness of surveys for the ILP-KCA

Selecting sites from the aerial imagery is, by nature, partly subjective. Also, when flying over sites, the decision to keep or eliminate them is made very quickly. Aside from identifying the dominant sod-grasses on a site, the distant view from the helicopter only allows for a few other species to be identified (usually those of large populations) or large species with large flowers, leaves and/or tall stems). To account for this, sites assessed as marginal quality (that seemed weedy or of lower quality but had some potential) were not eliminated.

Prior to this grassland project, it was thought that barrens-woodlands remnants would need to be semi-open to support grassland vegetation. But during this study a few nearly-closed cedar-oak woodlands were found with a diverse grassland understory. These were small barrens communities along south and west-facing slopes of forests. The woodlands blended in to where openings were minor, often scattered, thin and/or linear. The openings were virtually undetectable with the current imagery used and were very difficult to spot during helicopter surveys.

Additional surveys or other studies needed

The information gathered via this project helps to advance the goal of providing biological data needed in order to make decisions about rare and declining communities, habitats and species. Although effort has been made to visit all sites in the project area, many sites are still left to survey. Additional surveys may provide information on areas that could not be fully assessed as part of this effort.

Although this project area covered an important section of Kentucky's original grasslands, similar projects are needed throughout the Highland Rim, the East Gulf Coastal Plain and through parts of the Shawnee Hills. It is hoped, that these types of projects can be combined to improve conservation of Kentucky's natural systems.

Rarity in communities vs. species

Sometimes the rarity of a type of grassland community will greatly increase the importance of a site (e.g. rank, score), even though the species found are not rare, the size of the community is relatively small and/or the surrounding landscape context is degraded. Native grassland remnants of rare community types, even if disturbed, will always receive high conservation values. Examples include Tallgrass prairie and Limestone flatrock glade.

Management Recommendations

A. Recommended sites for protection through restoration (enhancement) and expansion

This study identifies native prairie-woodland remnants in need of restoration management. Each management recommendation is site specific; brief management recommendations have been listed on the grassland forms where applicable (see full report). Prescription fire, cedar thinning/removal and herbicide application for invasive species will probably be the first action in restoring or improving most native grassland habitats. These activities often require years of work before desired results are achieved (i.e. a diverse native composition and open habitat structure).

Tractor mowing (i.e. bushhog) is recommended in situations where prescription fire cannot be achieved (this can be applied to old fields as well as woodlands or remnants on steeper slopes). Mowing once a year in very late summer to fall will promote better grassland conditions (this allows warm season plants to flower and produce seed). Many low quality remnants are thick with native grass (e.g. near monocultures of little bluestem) and have little abundance or diversity of grassland forbs. Some of this is due to mowing an area multiple times in the growing season. Also, mowing high and leaving a low duff (litter) layer should be attempted to encourage cover for wildlife populations. If mowing is desired more than once per year, a spring mow and late summer/fall mow, in most conditions, would still promote grassland vegetation and encourage plant diversity (grassland bird nesting is also a concern here). Mowing during dry periods is highly recommended as soils remain firm and less disturbed when under pressure of heavy equipment. Many invasive grassland species will take advantage of soil disturbed by tire ruts and trampled vegetation that tend to occur more in wet soils than dry.

Be cautious when removing oaks from native remnants as several species were naturally abundant in Kentucky's fire-dependent woodlands. In general, oaks are good trees for wildlife too (especially acorns) so leaving wide-spaced trees is recommended. If there are dense thickets or tightly-grown young forests, steps to reduce their coverage is usually necessary. Furthermore, oak woodlands dominated by dense (native) grass-herb understories are rare in Kentucky (oak barrens) and fire-managed stands are needed. Also be cautious to remove other mature hardwoods, cedars and pines because many of these are an important component of Kentucky barren-woodland communities.

Native plant seed drilling within natural remnants is not recommended as this often results in a reduction of diversity (i.e. most plantings are low diversity and the composition depauperate compared to natural remnants). Establishing native grass plantings/fields in close proximity to native remnants is also not recommended, as this can lead to introduction of non-local genotypes. But if an adjacent planting already exists, such as a CREP field previously established, the planted field could help develop a reliable grass-herb layer that structurally, burns more complete. With the right conditions, seed from the natural remnant overtime could disperse into the CREP field, blending the two more fittingly. With undesirable conditions, aggressive grasses (like Indian Grass) from the CREP field could overrun the native remnant.

B. Recommended sites for protection through acquisition

This study provides a list of the highest quality grassland sites within the four selected focus areas. Those sites may be further evaluated as to the potential for SGCN. Criteria will include the overall extent of habitat available, the quality of the natural communities and faunal information. (i.e. High-ranked sites can be surveyed by KDFWR for SGCN).

The opportunity exists to survey and collect more species level information, and over the next couple of years, determine if the focus areas need minor or major adjustments. It can also be recommended now (through discussions by conservation agencies) that these areas are of greatest importance in the ILPKCA and need immediate conservation attention.

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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.

At a Glance

Four Grassland Focus Areas were established to facilitate conservation of this rare habitat type:

- *Southwest Hardin County*
- *Southern Hardin and Northern Hart County*
- *Southern Hart and Northwest Barren County*
- *Southern Warren County*


Collecting catfish from hatchery pond to stock FINs lakes / Dave Baker

Project Highlights

Exploitation Rates of Stocked Channel Catfish and Rainbow Trout in Fishing in Neighborhoods (FINs) Lakes

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

Tagged rainbow trout awaiting release / Dane Balsman

The Fishing in Neighborhoods (FINs) program provides fishing opportunities to cities of all sizes across the Commonwealth. These lakes require routine stockings of catchable-size fish to maintain quality fishing opportunities to a diverse group of anglers. To assess angler utilization and current stocking rates at FINs lakes, an exploitation study began in late 2010.

An angler exploitation study of rainbow trout was conducted at Upper Sportsman's Lake (6 acres) in Franklin County from 8 November 2010 – 31 May 2011. Tagged rainbow trout ranged in size from 8.3 – 11.4 inches and averaged 0.36 pounds. Fish were tagged with yellow Floy FD-94 anchor t-bar tags below the dorsal fin. In total, 688 rainbow trout were tagged and stocked into Upper Sportsman's Lake (183 on 8 November 2010, 293 on 7 February 2011, 212 on 16 March 2011). Tags from a total of 525 fish were returned. The uncorrected exploitation rate was 24% with an uncorrected catch rate of 76%. Exploitation rates were corrected for non-reporting, tag loss and tagging mortality with a 28% corrected harvest rate. The corrected catch rate was 88%. The average number of days the trout were at large before being caught was 23 with a median of 18 days.

A channel catfish exploitation study was also conducted at Upper Sportsman's Lake from 8 March 2011 – 31 October 2011. The dates of the study coincide with the date of the first stocking through the end of the anticipated fall fishing season. No catfish tags were returned after 31 October 2011. Tagged channel catfish ranged in size from 10.0 – 21.5 inches and averaged 0.77 pounds. Fish were tagged with yellow carlin-dangler tags. The tags were attached to the fish using stainless steel wire threaded through the fish below and anterior to the dorsal spine. A total of 600 channel catfish were tagged from March – May 2011 (200 on 8 March 2011, 200 on 11 April 2011, and 200 on 23 May 2011). Tags from a total of 409 fish were returned. The uncorrected exploitation rate was 25% with an uncorrected catch rate of 68%. Exploitation rates were corrected for non-reporting, tag loss and tagging mortality with a 32% harvest rate. The corrected catch rate was 85%. The average number of days the tagged fish were at large before being caught was 19 days with a median of 7 days.

From the exploitation study we conclude the catfish are caught quickly after stocking, but less than one out of three fish are initially harvested. Trout are not caught as quickly as catfish likely due to fewer anglers fishing during the cool weather months. The exploitation rate is similar for trout with about 1/3 of caught fish being harvested the first time they are harvested. When we view the creel survey, the estimated catch for catfish far exceeds the number of stocked fish, while the number of harvested fish mirrors the number of stocked fish. It appears the catfish are caught multiple times before ultimately being harvested by anglers. The exploitation study fails to capture the estimated higher harvest rate due to the tag being removed the first time the fish is hooked and likely being harvested on subsequent catches. The creel survey data for trout also estimates the catch to be larger than the number of stocked fish indicating stocked fish are caught multiple times by anglers.

Stein Community Park Lake (7 acres) in Campbell County and Middleton Mills Shelterhouse Lake (1 acre) in Kenton County both have ongoing exploitation studies. The exploitation study in conjunction with creel and attitude surveys are necessary for assessing the fisheries. This work helps ensure stocking rates are adequately meeting the needs of the anglers.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Lake Sturgeon Telemetry in the Cumberland River

Sara Tripp, David Baker, Nick Keeton, Steve Marple, and Nick Skudlarek, Kentucky Department of Fish and Wildlife Resources

Lake sturgeon were once native to the Mississippi, Ohio, and Cumberland Rivers in Kentucky, but since the 1950's lake sturgeon have been extirpated from the Cumberland River due to destruction of habitat and loss of range due to barriers. Because of this, the Kentucky Department of Fish and Wildlife Resources (KDFWR) has committed to a twenty-year stocking program to restore lake sturgeon populations in the Cumberland River Basin. One major component to the success of this reintroduction program is to assess the survival, movements, and habitat use of stocked sturgeon and document their transition into the natural environment. A telemetry project can provide insight into survival, movements, and habitat preferences of stocked lake sturgeon, leading to initial measures to quantify the success of the hatchery stocking program.

As part of the telemetry project, thirty lake sturgeon will be tagged with ultrasonic transmitters and held in the hatchery for 15 days to observe recovery and potential mortality from the tagging process. Prior to stocking, twelve stationary receivers will be deployed at locations upstream and downstream of the two stocking sites (Noe's Dock and Alum Ford) in the Big South Fork and Cumberland rivers, as well as local tributaries to determine movement out of the stocking areas. Department staff will also manually track stocked lake sturgeon at least once a month, recording surface water temperature, depth, velocity, substrate, and habitat type (i.e., main channel, channel border, tributary mouth, tributary) to determine habitat use and preference. With the combination of manual tracking and the stationary receivers we will be able to quantify movement (specifically seasonal and temporal patterns), site fidelity, and determine the home ranges of the transmittered fish.

Since it is crucial to understand survival and condition of stocked lake sturgeon through the first year after stocking, we will attempt to recapture tagged sturgeon at the end of the transmitters' battery life. To increase our probability of recapture a combination of three gears (experimental gill nets, mini-Missouri trawl, and trotlines) will be used in concert with tracking equipment. At the end of the first year, we will hopefully have substantial data on stocked lake sturgeon survival, movement, and habitat use throughout the first year. If recapture attempts are successful, we will also quantify condition and growth rates, which may be predictors for successful adaptation to the wild and potential recruitment into adulthood in the Cumberland River. If reintroduction is a success and a self-sustaining population is established, we can begin to manage for a unique sport fishing opportunity.

Funding Source: State Wildlife Grant (SWG)

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

Lake sturgeon telemetry / Matt Thomas

Evaluation of a Smallmouth Bass Stocking Program at Paintsville Lake

Smallmouth bass fingerlings / Gerry Buynak

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

Smallmouth bass (*Micropterous dolomieu*) are among the most popular sportfish in Kentucky. Populations are doing well in many of the state's rivers and streams, but they thrive in few of its reservoirs. As past research has suggested, a potential reason for this is that smallmouth bass possess specific habitat requirements. Aside from their preference for lower trophic levels and year-round cool water habitat, other characteristics (i.e. mean depth & exchange rate) have been identified that coincide with self-sustaining smallmouth bass populations.

Soon after it was impounded in 1983, Paintsville Lake was stocked with smallmouth bass fingerlings. A fishery was then developed that became quite popular with local anglers, despite the fact that sampling results showed that the smallmouth bass made up only 5% of the black bass population in the lake. When their abundance did not improve after stocking efforts in the 1990's, the smallmouth bass stocking program was suspended. Eventually, the fish management objectives for Paintsville Lake changed, and the dam began releasing cooler, oxygenated water in favor of conserving the warmer, fertile water preferred by largemouth bass. Although some sportfish species benefited from this water release schedule, smallmouth bass abundance declined as the cool water habitat faded from the lake during summer months. Consecutive years with high amounts of rainfall compounded the habitat problems. Smallmouth bass numbers continued to drop until they were no longer found in sampling efforts or the anglers' creel.

Paintsville Lake has since been recognized as one of the few lakes in Kentucky where a smallmouth bass fishery could be re-established. A relatively undeveloped watershed has allowed the lake to maintain a lower trophic level. Also, the water release at Paintsville Lake has been altered once again so that more of the deeper, cooler water is conserved. With minimal impacts to other sportfish species, the cool oxygenated water (≤ 74.3°F) that smallmouth bass need during the summer months made a return to the lake by 2005. Unfortunately, this critical habitat is still unstable and seems to diminish during longer periods of heavy rainfall. Nevertheless, the KDFWR chose to resume the stocking of smallmouth bass in 2010 while hoping that the rainfall totals will remain at normal levels.

This project was initiated to determine if a 3-year (2010-2012) smallmouth bass stocking program is able to re-establish a fishery at Paintsville Lake. The target stocking density for smallmouth bass fingerlings was 20 fish/acre, but the actual density varied each year depending on the maximum number of fish that were available. Fingerlings were marked prior to being stocked so biologists could distinguish them from any native smallmouth bass. Marked smallmouth bass will be identified during regular black bass sampling that occurs twice a year and during the less frequent creel surveys. Water quality parameters will also be monitored to ensure that suitable smallmouth bass habitat is available, especially during summer months.

Biologists have started looking for smallmouth bass in 2011 and some early results indicate that only 3 were collected during the regular black bass sampling efforts. Luckily, all 3 smallmouth bass have turned out to be marked fish. A much bigger concern is that despite the recent changes in the water release, the high rainfall totals endured in both 2010 and 2011 pushed more of the colder water out of Paintsville Lake than was originally anticipated. If the critical habitat continues to be threatened, smallmouth bass stocking efforts at Paintsville Lake could be suspended again after 2012. Regardless, biologists will continue to look for marked fish in the years to come and hopes are that smallmouth bass will once again be a regular occurrence at the lake.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Investigation of the Restoration of Native Walleye in the Upper Levisa Fork

Dave Dreves and Paul Wilkes, KDFWR

Native walleye in the Upper Levisa Fork / Dave Dreves

Walleye is a freshwater fish native to most of the major watersheds in Kentucky, including the Levisa Fork watershed located in extreme eastern 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 Levisa Fork in 1915. 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). Since there are no known recent reports of walleye from the Levisa Fork or Fishtrap Lake, it is suspected that the "northern" strain fry stockings in 1915 were not successful and the native population in the river had been lost.

Although portions of the Levisa Fork are impounded by Fishtrap Lake, there is approximately 15 miles of unimpounded mainstem of the Levisa Fork between the lake and the Virginia state line and at least that many more miles beyond. The broad goal of this project is to re-establish a reproducing native "southern" strain walleye population to this section of the Levisa Fork. An established population of native walleye in the Levisa Fork 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 Levisa Fork. In order to accomplish these restoration goals, beginning in 2010, native strain walleye were collected from Wood Creek Lake and the Rockcastle River in the spring and transported to Minor Clark Hatchery to be used as broodfish. Walleye are spawned and the resulting fry are reared to fingerling size (1.5 in.) in ponds, then stocked in the Levisa Fork 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 at least 2015. 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. All stocked fingerlings are marked with oxytetracycline (OTC) to determine recruitment of stocked fish. Beginning in 2016, small walleye may be sacrificed and otoliths removed for examination for OTC marks. We also have PIT tagged captured walleye to determine movement and growth rates. Walleye sampling in the Barren River is slated to continue through 2020 to allow for the reproductive potential of the stocked walleye population to reach a point where natural recruitment is possible and detectable.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Can body Condition and Select Physiological Indicators Predict Survival of Elk Post-Translocation?

Aaron Hildreth, John J. Cox, John T. Hast, and Alejandra Betancourt, University of Kentucky Department of Forestry

KDFWR Collaborators:
Kristina Brunjes, Gabriel Jenkins, Will Bowling, Dan Crank, and Aaron Hecht

Elk being processed / John Cox

States began reintroducing elk (*Cervus elaphus*) only a few decades after extirpation from the eastern United States in the mid-1800s. The majority of these reintroduction attempts were failures, although the causes were often unknown or misunderstood. It is well-established that elk and many other ungulates are susceptible to stress and physical injuries that can lead to death during capture, processing, captivity, translocation, and shortly after release. Despite these problems, little is known about what factors determine the relative susceptibility of individuals to injurious or lethal conditions from capture through final release.

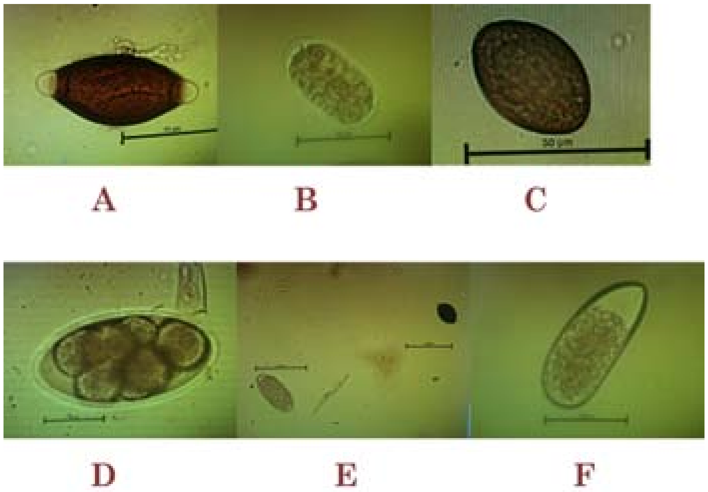
With a reintroduced elk population now exceeding 10,000 individuals, the Kentucky Department of Fish and Wildlife Resources (KDFWR) is now able to serve as a source state to other states desiring elk. In 2011, Missouri became the first recipient of Kentucky elk, with the goal of moving 50 per year over the next several years. We took advantage of this opportunity to work with captive elk to characterize and monitor body condition and select physiological parameters during a 90-day holding period, and to model whether one or more of these factors are predictors of elk survival post-translocation (all elk are fitted with GPS collars and will be monitored by University of Missouri upon release). A successful predictive survival model could inform wildlife managers as to characteristics of individual elk most likely to survive future capture and translocation efforts.

In 2012, KDFWR captured a total of 58 elk (37 cows, 13 calves, 8 spike bulls) with either corral traps (46) or chemical immobilization (12) and will quarantine them for a period of 90 days before translocation to Missouri. Upon arrival to the holding facility, the elk were ear-tagged, weighed, given antibiotics, vitamin B_{12}, and separated into one of 3 different pens based on gender and age. The elk will be tested twice for tuberculosis (TB) during the holding period. We will weigh, draw blood, collect ticks, and a fecal sample for each individual elk on all 4 days handled in the processing corral. In addition to the fecal samples collected during each workup, we will collect fecal samples from each pen throughout the quarantine period. We will also measure rump fat and loin thickness with the aid of an ultrasound during each workup.

Fecal samples will be analyzed for parasite load by performing a fecal float and assayed to determine fecal glucocorticoid levels. Fecal glucocorticoid levels will help us understand how elk respond to quarantine and handling stressors. We will perform a total panel blood test on each blood sample to look for indicators of capture-related stress. Ultrasound measurements of rump fat thickness will be used to determine the overall body condition of each elk and how it changes throughout quarantine. Loin thickness measurements will be compared from the first workup to the second to look for signs of protein catabolism. Morphometric and physiological data collected will be used to construct a model to determine factors predictive of elk survival post-translocation.

Funding Sources: *Rocky Mountain Elk Foundation, University of Kentucky, and Pittman-Robertson*

KDFWR Strategic Plan. Strategic Goal 1. Strategic Objective 5.



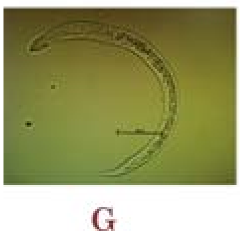


Figure 1: *Photographs of parasite eggs and larvae from elk in southeastern Kentucky. A) Trichuris, B) Strongyloides, C) trematode egg, D) Nematodirus, E) Capillarid spp. (left) and pseudoparasite (right), F) Trichostrongylid-type, G) Dictyocaulus viviparus larvae*

Prevalence of Select Parasites of Elk in Southeastern Kentucky

Alejandra Betancourt, John J. Cox, John T. Hast, and Aaron Hildreth, University of Kentucky Department of Forestry

KDFWR Collaborators:
Kristina Brunjes, Gabriel Jenkins, Will Bowling, Dan Crank, and Aaron Hecht

Parasitological information is often underutilized in wildlife management. The consequences of parasite infections are frequently overlooked, but can have an impact on individual, as well as herd health. As part of translocation health protocols, ungulates are often treated with anthelmintics before being moved to prevent the transport of parasite species that could be inadvertently introduced into the new environment. Treatment is not always completely effective, so it is quite possible that parasites are brought in with translocated individuals and cause important impacts to naïve ecosystems and individual species.

With the elk herd in Kentucky now being one of the largest and newest, our research will document the prevalence and incidence of common parasite species, including ones that may have been introduced during translocation and that could impact herd health. In addition, parasite prevalence has long been used to establish a population density index for white-tailed deer. Data from this study will be evaluated to determine whether various metrics of parasite burden can be used as a population index for elk.

In fall 2011, we began collecting samples from harvested elk to perform fecal egg counts and abomasal parasite counts. The abomasum, or the fourth-chamber of the ruminant stomach, was collected to look for lumenal parasites in the abomasal contents; the liver was collected and dissected to examine whether the animals were infected with liver flukes (*Fasciola hepatica*), and fecal samples were collected to quantify the number of gastrointestinal parasite eggs found in feces.

After bull and cow hunts of 2011, samples were collected from 81 elk. In some cases, abomasums, livers and/or fecal samples were unable to be collected due to sample destruction from harvest. To date, fecal egg counts have been performed on samples from 74 individual elk. The most common parasite eggs found in the fecal samples have been overwhelmingly Trichostrongylid-type (*Haemonchus, Ostertagia*, Trichostrongylus, *Cooperia* and *Oesophagostomum*) from different species of gastrointestinal nematodes (Figure 1). Capillarid spp., *Trichuris, Strongyloides, Nematodirus* and some trematode (fluke) eggs were also found in the samples. Lungworm (*Dictyocaulus viviparus*) larva was found in one sample (Figure 1). Though some trematode eggs were found in the fecal samples, no liver flukes were found in any of the dissected livers. Abomasums were collected from 76 elk and the remnants will be examined for lumenal parasites. Abomasums, additional fecal and organ samples, as well as ticks will be processed in the near future.

Funding Sources: *Rocky Mountain Elk Foundation, University of Kentucky, and Pittman-Robertson*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Exploring Methods for Monitoring Bobcats in Kentucky

Laura Patton, Danna Baxley, Brian Gray, Gary Sprandel, and Steven Dobey, Kentucky Department of Fish and Wildlife Resources

KDFWR Technician Andrew Butler sets up trail camera / Laura Patton

The successful recovery of bobcats has been well documented as they have expanded back to their original North American range. A recent range-wide assessment of bobcat populations estimated 2,352,276 to 3,571,681 bobcats in the United States, a substantial growth since 1981 estimates of 725,000 to 1,017,000 bobcats (Roberts and Crimmins 2010). Harvest of bobcats has occurred for several years in Kentucky; the first regulated season opened in 1987 in several eastern counties and resulted in the take of 113 bobcats (13 of these were road-killed). The harvest zone has since been expanded statewide and annual harvests have exceeded 2,000 bobcats. Field observations from Kentucky hunters and trappers indicate that bobcats are abundant throughout much of the Commonwealth, and the Department often receives requests to increase harvest opportunity.

Bobcat in cage trap / Laura Patton

While reports of abundant bobcats and increased harvest may legitimately reflect true population status, it is important to have state specific data quantified from various methods to substantiate reports and compare with harvest data. Bobcats are a valuable furbearer; monetarily to fur trappers and in the taxidermy market, as well as to hunters and trappers as a trophy harvest. Consequently, the market and popularity make this a much sought after species requiring responsible management through regulated harvest.

Monitoring bobcats is challenging for resource agencies considering the secretive nature of the species. We will explore various techniques for detecting and monitoring bobcats. These methods include estimating densities using scat detector dogs, using camera traps to individually identify bobcats, and traditional trapping and radio-collaring. Population characteristics will also be studied from carcasses submitted from hunters and trappers. Litter sizes will be determined from placental scar counts and age structure by cementum analysis. Information from this project will be used to update and adjust current bag limits and season lengths of bobcats.

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

KDFWR Strategic Plan. Goal 1.

Literature Cited

N.M. Roberts and S.M. Crimmins. 2010. Bobcat Population Status and Management in North America: Evidence of Large-Scale Population Increase. Journal of Fish and Wildlife Management 1(2):169–174.

Monitoring Migrating and Wintering Sandhill Cranes in Cecilia

Erin Harper, Kentucky Department of Fish and Wildlife Resources

The Eastern Population (EP) of greater sandhill cranes (*Grus canadensis*) primarily breeds in the Great Lakes region of the United States and Canada and winters in Kentucky, Tennessee, Alabama, Georgia, and Florida. After being extirpated from most of its breeding range in the 18th and 19th centuries, the EP has made a substantial recovery. The US Fish and Wildlife Service estimated the EP to be at least 71,975 cranes in the fall of 2011. The increasing size of the EP has resulted in increasing numbers of sandhill cranes wintering and stopping in Kentucky.

With increasing occurrence of sandhill cranes in Kentucky, KDFWR began collecting abundance data from the two major use areas (Cecilia and Barren River Lake Wildlife Management Area) during the winter of 2007-2008. Both sites are important stopover areas for SACR migrating through Kentucky.

KDFWR implemented a habitat use and availability study in the winter of 2011-2012 in the Cecilia area. Monitoring consisted of counting cranes twice weekly and recording habitat use and behavioral patterns. The number of SACR in each flock was estimated using a 15-60x spotting scope. Habitat type, location, weather, and time of day were recorded for each flock encountered. Instantaneous observation of flocks recorded the proportion of cranes observed in each of 6 behaviors; feeding, locomotion (flying and walking), resting (loafing), comfort (stretching, bathing, preening, wing flap, and scratching), social (alert, courtship, aggression, play), and other (all other activities not previously listed). Surveys were conducted weekly with the route being sub sampled 3-4 times daily to determine temporal variation. In addition to these surveys, a sunrise count was conducted late in each survey week to monitor abundance. These surveys are being used to develop a chronology of migration through Kentucky and to determine changes in abundance and distribution. The time-activity budget study will provide information on habitat use and preferences and factors that influence that use by sandhill cranes.

A peak count of 6900 SACR in the Cecelia area occurred during the last week in January. This peak was one to two weeks earlier than in previous years. The number of cranes remained high through the end of February. Between 60 and 1700 SACR were present in Cecilia during mid-December thru mid-January counts. This differed from previous years where few observations were made during this period. The increased number of cranes in this midwinter period was consistent with other states observations and could have been due to a warmer than normal winter in 2011-2012. Monitoring of migrating and wintering sandhill cranes will continue for the next two years to examine potential changes between wintering periods and further evaluate effects of environmental variables on time activity budgets and habitat use in the Cecilia region.

Funding Source: *State Wildlife Grant (SWG)*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2. Class Aves. Prioritized Research Projects 2 and 4, Priority Survey Projects 1, 2, and 5; Appendix 3.9. Class Aves. Terrestrial Monitoring Projects

Sandhill Cranes / Erin Harper

Managing Rank Native Warm Season Grass Stands in Kentucky

Native warm season grass research plot / Don Pelly

Danna Baxley, Ben Robinson, Brian Gray, Curt Divine, Scott Buser, Bill Mitchell, and John Morgan, Kentucky Department of Fish and Wildlife Resources; Don Pelly, Shaker Village of Pleasant Hill

Extensive research has been conducted to determine which methods are most efficient for converting cool season grass fields to native warm season grass stands. After establishment, if NWSG fields are not managed, succession occurs and these fields become thick and overgrown, holding little value for wildlife. Maintaining high quality native warm season grass stands is an important and understudied aspect of wildlife management. Despite the importance of this issue, there have been very few research projects aimed at assessing efficiency of post-conversion management techniques. Information on post-conversion management and maintenance of native warm season grass fields is scarce, particularly for Kentucky. As native warm season grass fields become more prevalent on the landscape, it is increasingly important to understand how management efforts impact these vegetative communities. The goal of this multi-year study is to assess the value of three different herbicides (Sahara, Glyphosate, and Arsenal) as a management tool to thin native warm season grass stands.

Beginning in 2011, we established research plots on Green River Wildlife Management Area, Higginson Henry Wildlife Management Area, Taylorsville Lake Wildlife Management Area, and Shaker Village of Pleasant Hill. Research plots are four acres in size and contain a 1-acre control plot, 1-acre Sahara plot, 1-acre Glyphosate plot, and 1-acre Arsenal plot. All plots were burned prior to the onset of the project. Vegetation data is collected in the summer and fall of each year. Data collection efforts will continue through 2013, and the resulting management recommendations will guide future efforts to thin native warm season grass stands in Kentucky.

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

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Processing juvenile bald eagle for tracking project / Ray Stainfield

Project Updates

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

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

Despite their popularity, crappie (*Pomoxis* sp.) can be frustrating to both anglers and resource managers. The status of a fishery can change rapidly, especially because successful crappie spawns rely heavily on the alignment of specific biotic and abiotic factors. Subtle differences in the habitat requirements of white (*P. annularis*) and black crappie (*P. nigromaculatus*) also allow these factors to influence which species will dominate the fishery. Some of Kentucky's most popular crappie lakes have seen a shift from a fishery of mostly white crappie to one where black crappie are the most abundant.

The two crappie species have habits that vary enough to require anglers to use different techniques to be successful. Black crappie have a tendency to move shallow earlier in the year and stay there longer, so anglers often use methods and baits that are similar to those used in bass fishing. In contrast, white crappie are shallow for a shorter time period and spend most of the year occupying deeper habitat. This is why they are caught with different techniques that are most commonly associated with "crappie fishing". When white crappie numbers decline, anglers using traditional methods are most likely to experience decreases in catch rates. Anglers become concerned when lower catch rates occur for several years in a row, and they often request that KDFWR take a proactive approach solving the issue.

Since regulations are already in place at most crappie fisheries in Kentucky, KDFWR has turned to supplemental stocking as a way to help white crappie populations. Crappie stocking often has mixed results, so this project sought to evaluate the latest white crappie stocking program and identify ways to help increase its success. After four reservoirs were initially chosen for the project, the number was reduced to three in order to focus efforts and allow stocking rates to be increased. Prior to being delivered to any lake, white crappie fingerlings were marked so they could be identified many years after being stocked. In the fall of 2009, the first official white crappie fingerlings were produced at a Kentucky hatchery and stocked into Carr Creek Lake, Taylorsville Lake and the Blood River embayment of Kentucky Lake. This process was repeated in 2010 and 2011 when white crappie fingerlings were marked and transported to the same three reservoirs. The only notable change was the stocking rates, which increased substantially in 2011 when a Missouri hatchery began assisting in fingerling production.

Preliminary results from 2011 indicate that, although stocked white crappie are being collected annually, their level of contribution to the natural population varies substantially by reservoir. For instance, fall trap net samples from Taylorsville Lake and the Blood River embayment of Kentucky Lake both contained stocked crappie. At Taylorsville Lake, the samples contained 34 white crappie that were from the same year-classes as those fingerlings stocked in 2009 and 2010. When aged even further and checked for marks, it was estimated that 16 out of the 30 (53.3%) age-1 white crappie and all 4 (100%) of the age-2 white crappie were stocked fish. In contrast, a total of 59 age-1 and age-2 white crappie were collected from the Blood River embayment of Kentucky Lake, but only 8 of them, or 13.6%, were marked fish. It was interesting to discover that the stocked fish made an almost identical contribution to the age-1 (13.6%) and age-2 (13.3%) year-classes of white crappie.

In 2012, white crappie populations at all three reservoirs will continue to be monitored. Stocking, which resumes in the fall, will involve fingerlings produced by both Kentucky and Missouri hatcheries. A special study will be conducted in 2012 to address concerns of over stocking mortality and identify the best ways to minimize stress the crappie fingerlings endure while being transported and stocked. As in the past, crappie populations will be sampled with trap nets and electrofishing. Increased use of bottom trawling is also planned for 2012 as some experimental runs conducted in 2011 showed promising results for collecting younger crappie. In all, biologists hope to see the white crappie fisheries at these reservoirs continue to improve.

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

KDFWR Strategic Plan. Goal 1,Strategic Objective 5.

Bass tournament / Gerry Buynak

Black Bass Tournament Results in Kentucky

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

KDFWR samples black bass (*Micropterus* sp.) populations annually at lakes throughout the state, but creel surveys are conducted on only a handful of these water bodies. The high costs associated with creel surveys make it difficult to use them on the same lake for consecutive years, which would be necessary to identify trends in the relationship between bass populations and angler catch. Thus, in 1999, the KDFWR began to tap into another source of angler data when it started collecting results from black bass tournaments. This invaluable data on fishing pressure, catch and success rates of tournament anglers can be used to build a long-term database and monitor trends in black bass fisheries by lake and on a statewide basis. By combining the tournament results with data collected through annual sampling efforts, resource managers have an increased ability to explain and forecast changes to the black bass populations. The summarized data should also prove useful to anglers when planning future fishing trips and to help them understand the normal fluctuations that occur in their favorite bass fisheries.

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 was developed and has made this process much more efficient. Participation in the project has grown significantly since its inception because of the ongoing efforts of researchers and tournament organizers who are constantly passing on information to their peers. Catch data is analyzed at the end of each year and summarized in a way that provides tournament anglers with invaluable information, but offers biologists another source of data for the bass fisheries in their lakes and rivers. Beginning in 2010, organizers were not only asked to report their catch data, but to provide detailed information on the tournament's format. In the past decade, team tournaments have grown in popularity and the change was necessary as treating teams like a single unit rather than two individual anglers would greatly increase the accuracy of the results. These results are published in an annual report that is first mailed to all participating tournaments and then made available to the public via KDFWR's website.

In 2011, tournament catch data was reported from 30 different water bodies throughout Kentucky. There were a total of 350 participating tournaments, which was a drop from the 376 reporting catch data in 2010. In fact, this was the first time in many years that the number of tournaments participating in the project has decreased. It was not surprising as countless tournaments were forced to cancel when many areas of Kentucky received record amounts of precipitation in 2011. The decline in number of participating tournaments did not, however, translate into decreases in the catch data. In 2011, 17,093 anglers, or 10,630 angling-units (individual anglers + teams), brought in 26,440 bass to the scales for a total weight of 61,853.3 pounds (lbs). Tournaments in 2011 experienced a modest improvement over the 16,410 anglers that participated in 2010, but there was a more substantial increase (16.8%) from the 22,009 bass that were weighed in that year. The average winning weight for a tournament in 2011 was 13.62 lbs, which was also up from 13.11 lbs in 2010. The highest winning weight for a 1-day tournament in 2011 was 27.7 lbs at Kentucky Lake and the biggest bass caught in a tournament was 8.45 lbs. Other tournament catch data has been analyzed to produce statistics that illustrate how water bodies differ in the number/size of bass and the success of anglers that target them. These statistics have also been used to effectively identify trends at many of Kentucky's more popular lakes and rivers. Because of its continued success and the importance of expanding and maintaining the database, this project has been converted into a long-term program that should always be there to serve as a 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

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

Cedar Creek Lake largemouth bass / Chris Hickey

As the most sought after sport fish in Kentucky, KDFWR manages black bass (*Micropterus* sp.) populations to achieve a quality fishery in every region of the state. Prior to 2002, Kentucky lacked what would be classified as a "trophy bass" lake. Cedar Creek Lake, a 784-acre reservoir built in 2002, was identified as offering the best opportunity to establish a highly-coveted trophy largemouth bass (*Micropterus salemoides*) fishery. Previous studies indicate that a lake's productivity level is usually highest during the years immediately following its construction. It was the high productivity and plenty of ideal fish habitat that would give this largemouth bass fishery the best chance of reaching a trophy status. KDFWR established regulations that would limit the largemouth bass harvest and allow Cedar Creek Lake to be promoted as the state's first trophy bass fishery. The 20-inch minimum length limit and 1 fish daily creel soon became the focus of this research project as biologists monitor fish populations at Cedar Creek Lake in an effort to gauge the bass fishery's response to highly restrictive regulations.

The largemouth bass population at Cedar Creek Lake has been sampled with nocturnal electrofishing every spring and fall since 2003. Data collected during these sampling efforts provide insight into the density, length frequency, size structure, condition, and reproductive success of bass. Sampling is also conducted in the summer with the sole purpose of examining the stomach contents of largemouth bass to keep track of their diet. Every few years various methods are utilized to check both age & growth of the largemouth bass and satisfaction levels of anglers using the fishery. Electrofishing is also used annually to assess other fish populations (i.e. bluegill) that might serve as forage for the largemouth bass.

In 2006, biologists documented the first ≥ 20.0 in largemouth bass and they have been found in Cedar Creek Lake every year since. Though catch rates of the larger size classes have fluctuated quite a bit over the years, there has been a general increasing trend, which indicates that the regulations are likely protecting the bass until they reach 20 in. In spring of 2011, 15 bass measuring 20 inches or more were sampled, which was identical to that found in 2010. However, the overall catch rates of largemouth bass during these 2011 sampling efforts had generally declined from previous years. The primary reason for this may have less to do with the bass population and more to do with sampling conditions. Early in 2011, Kentucky received heavy amounts of precipitation causing water levels in many of it lakes and rivers to increase drastically. Cedar Creek Lake was no exception as high water postponed spring sampling efforts for nearly a month, and the turbid water made it difficult to collect fish even when biologists were finally able to get on the lake. Sampling will be conducted again in 2012 and, hopefully, better conditions will result in largemouth bass catch rates comparable to previous years.

Age and growth analysis in both 2007 and 2010 indicated that it took 4 years for largemouth bass at Cedar Creek Lake to reach 15 inches, which is the length limit at many of Kentucky's other high quality bass fisheries. On average, they grow 3 – 4 inches a year until reaching about 15 in, which is when the bass begin to put on more weight than length. Food habit analysis in 2011 matched previous results showing that largemouth bass feed primarily on crayfish and smaller forage fish. Fishing pressure estimates from the latest creel survey have indicated that, on an acre-by-acre basis, Cedar Creek Lake is one of the more heavily fished waterbodies in Kentucky. The high satisfactions rates of bass anglers also indicate that this largemouth bass fishery has become extremely popular even though it may have a while to go before reaching a true "trophy" status.

Funding Sources: *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

Supplemental stocking is a common management tool that has been used in Kentucky to enhance largemouth bass (*Micropterus salemoides*) fisheries, but the increasing demand on the state's only two hatcheries requires the smart use of its limited resources. One way to do this is to develop a system that predicts abundance of age-1 largemouth bass, enabling resource managers to respond appropriately. 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. On the other hand, if there was a below average spawn, the system would predict a low abundance of age-1 bass for the following spring and stocking in the fall could offset these numbers. Kentucky's Largemouth Bass Stocking Initiative (BSI) attempts to do just that by developing a protocol that successfully predicts a below average number of age-1 largemouth bass next spring by looking at abundance of age-0 bass in the fall.

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 age group in the following spring. Two predictive equations and 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 of ≥ 5.0 inches. The regression equation with the lowest p-value is then used to predict the density of the year class at age-1. The catch rate of age-0 bass that are determined during each lake's annual fall sampling is inserted into this equation and the prediction is checked against the lake's average age-1 density. If the predicted value is below the average, then it could be stocked with bass fingerlings at a density that can vary from a low of 2.5 fish/acre to a high of 15 fish/acre. The chosen density depends on how far the predicted spring age-1 catch rate is below the average for that lake. Before being stocked, each largemouth bass fingerling is marked with a specific fin clip, to distinguish stocked fish from natural fish in the population if they are ever recaptured.

Processing largemouth bass fingerlings / Chris Hickey

Since 2005, the BSI has been used to determine where largemouth bass are stocked, and in earlier years of the project, larger lakes with perennial spawning problems received the bulk of the fish. Beginning in fall of 2009, more emphasis was placed on smaller lakes and the stocking density was increased to a high of 15 fish/acre. This higher density proved effective as there were more recaptures of stocked fish during the spring 2010 sampling than in any other year of the project. In the fall of 2010, the 15 fish/acre density was used in 4 of the 8 lakes that were stocked with largemouth bass fingerlings. Unfortunately, heavy rainfall and flood conditions in the spring of 2011 made it very difficult to effectively sample all 8 lakes that were stocked. However, 6 lakes were eventually sampled and all of them had recaptures of stocked largemouth bass.

Fall sampling efforts were conducted in 2011 and indicated that once again 8 lakes had below average largemouth bass spawns and could benefit from supplemental stocking. There were nearly 118,000 largemouth bass fingerlings, marked with fin clips, stocked in 2011 as part of this project. The catch rates of age-0 largemouth bass were low enough at 5 of these lakes that they qualified for the highest stocking density. Hopefully, normal conditions will continue during the spring of 2012 and biologists will be able to conduct sampling efforts at all of the project lakes. If the higher 15 fish/acre density results in more recaptures of stocked fish in 2012, then this rate will continue to be considered the standard for Kentucky's largemouth bass stocking program.

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

It was not long ago when the KDFWR first stocked blue catfish (*Ictalurus furcatus*) into some Kentucky lakes, and many of these original stockings have developed into popular sport fisheries. A handful of these populations have exhibited the potential to produce trophy-sized blue catfish. Since the population dynamics of these relatively new populations are not well known, additional research is needed to determine what management actions could further improve the blue catfish fisheries in Kentucky.

A blue catfish stocking program has been in place at Taylorsville Lake since 2002 and has developed into a high-quality fishery. Because of vast numbers of forage fish and the stocking of nearly 24,000 age-1 blue catfish a year, the population does very well in Taylorsville Lake and has become extremely popular with anglers. Ironically, this success would become a liability as resource managers, and even anglers themselves, soon recognized that the heavy fishing pressure could lead to problems with overharvest. The primary goal of this project when it started in 2007 was to assess the status of the blue catfish population at Taylorsville Lake. However, the project soon shifted to an evaluation of new regulations that were implemented with 2 goals in mind: 1) reduce the potential for overharvest and 2) further develop a trophy component to the fishery.


Taylorsville blue catfish / Chris Hickey

Prior to the start of this project, data indicated that blue catfish were doing well with average growth rates of 3–5 inches per year. Low-pulse DC electrofishing has been conducted annually (2007 – 2011) during the summer months to obtain data on catfish throughout the lake. All sampled fish were counted, measured and weighed before being released. Data analysis was designed to identify changes to the fishery over time. In 2008, an angler exploitation study was conducted by tagging just over 1,000 blue catfish and then collecting data from anglers who caught tagged fish. In 2009, a creel survey was carried out to determine angler success and opinions on the fishery. A subsample of blue catfish was also collected in 2009 for age and growth analysis.

Sampling results from 2007 indicated that the blue catfish population at Taylorsville Lake was doing very well. From both ends of the lake, 590 blue catfish were sampled for an impressive catch rate of 236.0 fish/hour. However, by 2009 and 2010, catch rates had decreased to only 119.1 and 116.1 fish/hour, respectively. This was found again in 2011 when annual sampling exhibited a low catch rate of 27.1 fish/hour. To reinforce these results, biologists sampled again later in the summer and reached a catch rate of 50 fish/hour during the second attempt. Anglers reported 120 tags during the 2008 exploitation study and of those 120 blue catfish, 81% were harvested. The 2009 creel survey estimated that nearly 12,000 blue catfish were harvested that year, which is a substantial increase from 2,400 blue catfish harvested during the 2006 creel survey. The 2009 age and growth analysis showed that average growth rates had declined only slightly from the initial estimates. The biggest issues were the decline in numbers of blue catfish sampled each year and growing concerns over potential overharvest.

In 2010, it was determined that the decreasing catch rates of blue catfish, higher estimates of harvest, and initial unanimous support from catfish anglers were enough cause for new regulations. In March 2011, a creel limit of 15 catfish per angler with a “1-over” length limit of 25 inches went into effect at Taylorsville Lake. This project has now moved to monitoring any impacts of this new regulation on the fishery. As blue catfish continue to be stocked and sampled in 2012, biologist hope to find that the regulations help slow, or even reverse, the declining catch rates, while increasing the number of larger fish in the population. If the new regulations are able to improve the overall numbers of blue catfish at Taylorsville Lake, fisheries biologists anticipate a potential increase in the “1-over” length limit that would give anglers the opportunity to harvest more of the bigger fish.

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

KDFWR Strategic Plan. Goal 1,Strategic Objective 5.

Evaluation of the Growth of Two Different 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

Processing blue catfish at hatchery / Chris Hickey

Blue catfish (*Ictalurus furcatus*) were initially stocked into some of Kentucky's small impoundments as a potential management tool to improve bluegill fisheries. Although they were not the ideal predator to control bluegill numbers, blue catfish eventually became a popular fishery at some of these small lakes. Monitoring efforts revealed that growth rates of the catfish in these populations were erratic. Some of the blue catfish were the same age, but differed in length by as much as 15 inches (in). An extensive review of past research made some mention of this large disparity in growth rates, but there was very little about the relationship between this growth and the size of the blue catfish when they were stocked. Since it is recognized that the growth of piscivorous fish do not increase substantially until they switch to a fish diet, it was hypothesized that blue catfish stocked at a larger size may have higher growth potential because they are able to consume small fish almost immediately. Hence, the purpose of this project is to determine if the size at which blue catfish are stocked has an influence on their long-term growth potential.

In order to address the issue, two distinct size classes (< 10 in and > 12 in) of blue catfish were stocked at the same rate into three small impoundments. The project's lakes (Boltz, Bullock Pen and Reformatory lakes) were chosen because data showed that their fisheries historically contained blue catfish of the same age, but with much different growth rates. From 2007 to 2009, annual stocking of age-1 blue catfish occurred at each project lake during the late summer. All stocked blue catfish received two different marks: a coded micro-wire tag that identified what size-class they were stocked at and a specific fin clip that marked the year they were stocked. Blue catfish were sampled each year of the project using low-pulse DC electrofishing. All blue catfish were measured, checked for the presence of the micro-wire tag, and examined for any fin clips. The abundance and average lengths of each study group will be monitored to determine if there are any differences in growth that can be attributed to stocking size.

After some initial difficulty during the earlier years of the project, researchers were able to successfully locate and collect blue catfish from both size groups in 2010. Their sampling efforts in 2011 increased, with the goal of finding a representative sample from both size classes at each project lake. Analysis of the data collected in 2011 shows that all blue catfish are growing, but neither size group appears to be doing substantially better than the other. In fact, early results indicate that as these blue catfish get older, the mean length of the 2 size groups could be getting closer together. For example, in 2011, age-3 blue catfish stocked into a project lake as part of the larger size class (> 12 in) had a mean length of 14.6 in, while the same age fish stocked as part of the smaller size class (< 10 in) had a mean length of 11.6 in, resulting in a difference of 3.0 in. Age-4 blue catfish stocked in the same lake from the larger size class had a mean length of 15.1 in, and those age-4 fish from the smaller size class had a mean length of 13.2 in, or a difference of only 1.9 in. However, the oldest fish in the project were only age-5 in 2011 and, as a long-lived fish that can reach ages of 20 years, it may still be too early to draw any conclusions regarding the overall growth of the blue catfish. The abundance and average lengths of the stocked catfish will continue to be monitored over the next several years. Eventually, this project should determine how important the size at stocking is to the long term growth potential of blue catfish.

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

Nearly 150,000 channel catfish (*Ictalurus punctatus*) are reared every year in Kentucky's hatcheries and stocked into small impoundments. These lakes are typically stocked at a rate of 10 – 25 fish/acre when the channel catfish reach 8 – 10 inches (in) in length. High harvest rates and low to no levels of natural reproduction make stocking the only way to maintain these catfish fisheries. Although data on anglers using these impoundments is limited, available survey results estimate that 30% to 63% of the channel catfish are harvested each year. Despite indications that too many catfish were being harvested, these small lakes often had no regulations on the fishery. The first efforts to improve catfish populations on a large scale came in 2004 when a 12.0-in minimum size limit on channel catfish was implemented at eleven state-owned lakes. The purpose of this project is to evaluate the impacts of this size limit, and determine if it can be used to enhance channel catfish fisheries in other lakes.

Four small impoundments with the 12-in minimum size limit were chosen as the experimental lakes (Beaver, Elmer Davis, Guist Creek and Shanty Hollow lakes). Unfortunately, since sampling channel catfish was not always feasible, reliable data from any time prior to this project was extremely limited. Hence, two lakes without catfish regulations had to be sampled concurrently to serve as the controls for this project. It was determined that tandem hoop nets (3 hoop nets fastened together) were the most effective method for sampling the channel catfish populations, and 5 sets of baited tandem hoop nets were used to sample each project lake. Channel catfish sampled with the hoop nets were counted and measured, and, starting in 2010, weights were also collected so biologists could track the condition of the catfish in each lake.

As soon as biologists were able to gather reliable data, they wanted to make certain that the 12-in minimum length limit was adequately protecting the channel catfish, but not so much that too many fish were piling up just below the 12-in size limit. This scenario almost occurred at Guist Creek and Shanty Hollow lakes, but as a precaution, the stocking rates were cut by 50% to reduce competition and allow the fish to make it over the 12-in mark. The 2011 data indicates that reducing stocking rates might have done the job as the numbers of channel catfish just below the 12-in mark have dropped, but the overall catch rates were still as good as or better than other lakes with the size limit. Additionally, changing the stocking rates freed up some of Kentucky's limited hatchery resources so that more effort could be used to produce fish for other waterbodies.

? / Chris Hickey

At the other experimental lakes (Beaver and Elmer Davis), sampling results through 2011 showed that the channel catfish populations have either been stable or improved since the study began. Catch rates from Beaver Lake for the first 3 years of the project (2006 – 2008) averaged just over 36 catfish per set of hoop nets, but the average catch rates have increased to nearly 70 catfish per set in the last 3 years (2009 – 2011). In general, the abundance, length frequencies and condition of catfish in these 2 lakes are indicative of thriving channel catfish fisheries. In contrast, channel catfish populations in control lakes of this project, McNeely and Reformatory lakes, exhibit characteristics of high angling pressure. With no regulations, the overall catch rates of channel catfish at the control lakes are substantially lower than any of the experimental lakes.

The focus of this project will soon shift to the next logical step, which is to establish regulations on the channel catfish populations in the control lakes. These lakes will continue to be sampled in 2012 and, in March 2013, new 12-in minimum length limits will go into effect. The fisheries are expected to improve over time, but biologists will continue to closely monitor the channel catfish.

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

KDFWR Strategic Plan. Goal 1,Strategic Objective 5.

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

Stocking a FINs lake / Dane Balsman

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

In an effort to boost license sales and increase fishing opportunities, the Kentucky Department of Fish and Wildlife Resources (KDFWR) initiated the Fishing in Neighborhoods (FINs) program in 2006. The FINs program currently includes 35 lakes in 22 counties. Quality fishing opportunities now exist in cities of all sizes across the Commonwealth thanks to partnerships between KDFWR and local municipalities. As part of a cooperative agreement between KDFWR and local governments, the lake owners provide a 25% in-kind match for services at the lake to cover the cost of fish stockings. The program is operated with federal funds and in 2011 local governments provided over $85,000 in qualifying match. With the cooperative agreement, KDFWR works with the local parks departments to arrange fish stockings, provide technical guidance and promote fishing in the park lakes. A rod loaner program has been implemented at numerous lakes to provide equipment to anglers at no cost.

These lakes are conveniently located near large populations of people. Anglers do not have to travel far from home to find good fishing. In 2011, 124,000 trout and 95,150 catfish were stocked in the FINs lakes. The fish stockings provide fishing opportunities in 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 (12-16") and three times annually in the cool months (Oct.-Mar.) with rainbow trout (8-12"). Bass and sunfish populations are routinely sampled to ensure natural reproduction is meeting the needs of the anglers. A standard set of creel limits is established at all FINs lakes to help spread out fish harvest 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 fish stockings, license requirements, fish identification, poacher hotline, basic knot tying instructions and the mission statement of the FINs program. Additionally, the program has been intensively marketed through press releases, social media, radio, television, license vendors, boat shows and the KDFWR website.

Angler attitude surveys indicate that the FINs program is attracting families with 32% of anglers ≤ 15 years old. The program is also recruiting new license buyers with 10% of anglers reporting they had never bought a license and 24% reporting they had not bought a license the previous year. Angler satisfaction was extremely high at the FINs lakes with 85% of anglers reporting their overall trip as "good" or "excellent". Attitude and creel surveys continue at FINs lakes statewide. Fishing pressure continues to increase at these lakes and the feedback from local parks and anglers has been very positive.

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

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

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

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 blue catfish to consume overabundant sunfish. Unfortunately, these management actions have proven unsuccessful.

In June 2007, the KDFWR stocked 417 flathead catfish that ranged in length from 8.4 to 36.0 inches. In September 2009, an additional 308 flathead catfish were stocked. Fish ranged in size from 3.0 to 32.3 inches. In June 2011, 403 flathead catfish were stocked into A.J. Jolly Lake ranging in size from 3.8 to 38.2 inches. 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. In addition to the Georgia flathead catfish, Pfeiffer Fish Hatchery raised 2,862 flathead catfish averaging 5.1 inches that were stocked on 2 September 2011. 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.

A regulation was passed in 2009 that prohibited the harvest of flathead catfish from A.J. Jolly Lake. This regulation was critical to ensure that the stocked flathead catfish would remain in the lake to have the hypothetical desired effect. Sunfish and bass electrofishing are conducted each spring and fall to determine abundance, size structure, age, growth and condition. Bass catch rates and size structure has improved over the last several years. There have been two strong spawning years in 2010 and 2011 with abundant fish > 15 inches. However, sunfish size structure has continued to decline. The catch rate for bluegill continues to increase, with fish in the 2 – 4 inch range dominating the population. Very few bluegill reach 6 inches. Bluegill that were sacrificed for aging revealed slow growth. 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 49 flathead catfish were sampled in 2011. Of those, 18 fish were from the Georgia stockings and 31 were native flathead catfish. Interestingly, the nine largest fish captured $\geq$ 24 inches were all native fish. There were more flathead catfish sampled in 2011 (49), than in 2010 (31), or 2009 (17). However, sampling numbers remained low for the year and the true population size of flathead catfish is still unknown. KDFWR will continue to sample flathead catfish, largemouth bass, sunfish, and channel catfish, to determine if flathead catfish can improve sportfish populations at A.J. Jolly Lake.

Catfish sampling at A.J. Jolly Lake / Dane Balsman

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

KDFWR Strategic Plan. Goal 1, Objective 5.

Preliminary Assessment of Bluegill and Redear Sunfish Populations in Small Impoundments

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

Redear sunfish / Dave Dreves

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.

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 in a previous rainbow trout strain analysis, the comparison is between a more "domesticated" hatchery strain (PR) and another considered to be a relatively "wild" strain (SC). 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 has 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 rehabilitation of Wolf Creek Dam has been completed.

Information gained from this study will help to enhance the management of the trophy brown trout fishery in the Lake Cumberland tailwater.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Cumberland River brown trout / John Williams

A healthy rainbow from the Cumberland River / Dave Dreves

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

Over the last decade, the Kentucky Department of Fish and Wildlife Resources (KDFWR) have 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 are being 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. 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 and the research study will be ending in 2012.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

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

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

All individuals of each cohort of stocked muskellunge were permanently marked with a fin clip prior to stocking in the fall. Population sampling was conducted with boat-mounted pulsed DC electrofishing gear from mid-February through the end of March at all three reservoirs. Electrofishing catch per unit effort data (CPUE) collected in the spring of each year is being used to index age-1 year-class strength, the relative frequency of various length groups of interest and mortality calculations. In the future, 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 will also be tagged to estimate angler exploitation. 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. 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.

Muskellunge / Chad Nickell

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

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

Walleye is a freshwater fish native to most of the major watersheds in Kentucky, including the Barren River 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 were collected from Wood Creek Lake and the Rockcastle River in the spring and transported to Minor Clark Hatchery to be used as broodfish. Walleye 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 at least 2012. 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. Beginning in 2013, small walleye may be sacrificed and otoliths removed for examination for OTC marks. We also have PIT tagged captured walleye to determine movement and growth rates. Walleye sampling in the Barren River is slated to continue through 2016 to allow for the reproductive potential of the stocked walleye population to reach a point where natural recruitment is possible and detectable.

Native walleye from the Upper Barren River / Dave Dreves

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

Walleye / John Williams

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) over-harvest 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 were sacrificed and otoliths removed for later examination for OTC marks.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

White bass / Dave Dreves

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 has continued for an additional 3 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. Stocked white bass contributed to the white bass population at Barren River Lake at lower levels than at Dewey Lake. In the absence of stocking, Barren River Lake produced good natural year classes in 2008-2010 and Dewey Lake produced good natural year classes in 2009 and 2010.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

River Sport Fishery Survey – Kentucky River

Sauger from the Kentucky River / Sara Tripp

Sara Tripp and Nick Keeton, Kentucky Department of Fish and Wildlife Resources

The Kentucky Department of Fish and Wildlife Resources (KDFWR) has stocked sauger and walleye in the Kentucky River since 1981. Between 1981 and 1985, the Department stocked over 2,000,000 sauger in the upper pools of the river. Walleye stocking began in 1989 with walleye fry and fingerlings being stocked in the upper reaches of the Kentucky River. However, neither stocking (sauger or walleye) was evaluated. As a result, the Department implemented a sauger and walleye study along the entire reach of the Kentucky River in the winter/spring of 2002-2003. From this evaluation, it became evident that the walleye stockings were not successful, with little reproduction having been documented. Because sauger are better adapted to the conditions present in the Kentucky River, it was decided that walleye stockings would cease and sauger fingerling stockings would begin again in Pools 4 through 14.

In 2006, the KDFWR began stocking sauger fingerlings into the Kentucky River along with a full evaluation of the sauger and walleye populations in the mid and upper river sections. The goal of this study was to evaluate the potential of establishing a self-sustaining sauger recreational fishery through supplemental stocking in select pools of the upper Kentucky River. Since 2006, a total of 505,912 sauger have been stocked in the Kentucky River. In the summer of 2011, the Department suspended stocking sauger so that we could evaluate whether the sauger population can be self-sustaining through recruitment of naturally reproduced fish.

For the sixth year, spring nocturnal electrofishing surveys were conducted in 2011 in the tailwaters of Lock and Dams 5, 10, 11, and 12. A total of 140 white bass, 11 hybrid striped bass, and 96 sauger were collected in 4.0 hours of electrofishing. Sauger catch rates in the spring of 2011 were lower than those observed the previous spring; however catch rates of sauger greater than 15 inches are the highest since this evaluation began in 2003. Spring sauger catch rates varied from 3.0 fish/hour at Lock and Dam 12 to 47.0 fish/hour at Lock and Dam 10 (mean=24.0 fish/hr). Additional sites were added to fall sampling to increase our chances of finding wild age-0 sauger. The surveys consisted of 6 nocturnal electrofishing transects in both the upper and lower pool areas below each dam, and the forks were sampled based on accessibility. Sauger dominated the catch with 209 fish sampled and a mean CPUE of 11.0 fish/hr, with over a twofold increase in CPUE from last fall. Over 90% of the sauger sampled and checked for OTC were marked and came from hatchery stockings, indicating that there may be very little natural reproduction of sauger occurring in the Kentucky River.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

River Sport Fishery Survey – Ohio River

Sara Tripp and Nick Keeton, Kentucky Department of Fish and Wildlife Resources

The Ohio River provides a thriving fishery for both recreational and commercial anglers. Since the Ohio River borders multiple states, it is beneficial both for the fisheries and its users to work cooperatively to manage these inter-jurisdictional fisheries. Because of this, the Ohio River Fish Management Team (ORFMT) was formed as 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 and biologist from these states have been working in collaboration to manage fisheries issues on the Ohio River common to each state. Population data is monitored on many species including black bass, sauger, paddlefish, and catfish.

Ohio River catfish / Doug Henley

All states are concerned with the status of both black bass and sauger because of their importance to recreational anglers. Other species such as blue, channel, and flathead catfish are important to multiple user groups, including commercial anglers. 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. Paddlefish is another important inter-jurisdictional species 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.

Due to the changing pressures on the Ohio River fisheries, the Kentucky Department of Fish and Wildlife Resources will continue cooperative research with the ORFMT to monitor population demographics of target species. In 2012, states within the ORFMT will continue to monitor black bass and sauger populations, as well as collect age, growth, and mortality data on both catfish and paddlefish to determine if changes are occurring in these populations. This collaborative effort will continue to allow each state to most efficiently manage the Ohio River resources and ultimately enhance sport and commercial angler opportunities.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Ohio River Supplemental Stocking Survey – Markland Pool

Sara Tripp and Nick Keeton, Kentucky Department of Fish and Wildlife Resources

Largemouth bass / Sara Tripp

Largemouth bass production in the Ohio River is believed to be negatively impacted by the lack of high quality spawning habitat. In turn, poor production results in reduced recruitment leading to a less than optimal largemouth bass fishery. Supplemental stocking has been shown to benefit largemouth bass population levels in some large riverine systems. This project seeks to determine if supplemental stocking of largemouth bass in the Ohio River is a viable technique to increase year-class strength and ultimately improve the bass fishery in the river. As a pilot project, the Kentucky Department of Fish and Wildlife Resources began stocking largemouth bass fingerlings produced at Kentucky's two fish hatcheries into embayments of the Markland Pool in June of 2007 and continued stocking through June of 2010.

For the duration of the initial stocking project, the goal stocking rate was 100 fish/acre in each of the selected embayments. Fingerlings were marked with OTC in transit to each embayment, so that we could determine the contribution of stocked fish from age-0 to adulthood. Preliminary results from this study have shown that stocked fish composed 47% to 79% of the age-0 fish and that this contribution to year-class strength appears to be progressively adding to the fishery. To further investigate the success of stocking the Ohio River embayments, in 2011 the stocking rates for study embayments were varied (0 fish/acre, 50 fish/acre, and 100 fish/acre). This should allow us to determine if a reduced stocking rate will result in similar contributions to year class strength. We will also look at the potential negative effects due to competition by comparing growth, condition, and survival of bass among the embayments throughout the course of the study.

A total of 159,873 largemouth fingerlings, ranging from 1.6 and 2.0 inches (mean=1.8 in), were stocked in June, 2011. Department personnel continued to sample the six stocked embayments on the Kentucky side of the river with an addition of Steeles Creek, which had never been stocked (to act as a control site). Catch rates for stocked largemouth bass fingerlings in 2011 ranged between 0 in the Licking River (stocking rate 100 fish/acre) and 22.7 fish/hour in Craigs Creek (stocking rate 50 fish/acre). Stocked fingerlings were even collected in the embayments that were not stocked during 2011. At Steeles Creek (control embayment) age-0 largemouth bass catch rates were the highest at 30.70 fish/hour, with 4.5% of those being stocked fingerlings. Stocked fish comprised 38.6% of the age-0 largemouth bass sampled in the fall of 2011 compared to 46.6% the previous fall. Despite the varied stocking rates in 2011, we still observed relatively high catch rates of young of the year largemouth bass compared to the previous four years, and the overall catch rates for all sizes was the highest we have seen since the stocking study was started.

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

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

Ohio River Supplemental Stocking Survey – Meldahl Pool

Sara Tripp and Nick Keeton, Kentucky Department of Fish and Wildlife Resources

Meetings with Ohio River black bass fishermen in 1997 informed the Department that problems existed with black bass population structure in the Meldahl Pool. Efforts were initiated to sample various embayments and main river sites in this pool and determine the factors influencing these populations. This preliminary sampling confirmed angler concerns and indicated that a relatively poor largemouth bass population existed in Meldahl Pool compared to other Ohio River Pools. Electrofishing surveys indicated that young-of-the-year production was low, potentially due to limited spawning habitat.

The Department implemented a spawning habitat manipulation study in 2003 through 2010 to determine if largemouth bass spawning could be enhanced through the introduction of supplemental spawning structures and cover. While black bass were observed utilizing both structures, the effort needed to substantially influence black bass reproduction on a pool wide basis through these means appeared immense and impractical. Based on the bass stocking study conducted in Markland Pool, biologists determined that stocking may be a more viable option to increase year-class strength and ultimately enhance the largemouth bass fishery in Meldahl Pool.

A total of 33,445 largemouth fingerlings averaging 1.6 inches were stocked in June, 2011. Five embayments (Big Snag, Big Locust, Bracken, Lawrence, and Lee's Creek) were stocked at a rate of 100 fish per acre and Big Turtle Creek was stocked at a rate of 200 fish per acre. Largemouth bass CPUE ranged from 61.8 fish/hour in Bracken Creek to 83.3 fish/hour in Big Turtle Creek, while the mean CPUE across all embayments for largemouth bass was 70.6 fish/hour. The mean largemouth bass CPUE was over three times higher than the 2010 mean CPUE of 23.5 fish/hour. The largest increase in CPUE was observed in the <8 inch size group, where CPUE increased from 9.4 fish/hour to 37.3 fish/hour after stocking in 2011.

Otoliths were taken from a subsample of young-of-the-year largemouth bass, aged and checked for OTC marks. Age-0 largemouth bass lengths ranged from 3.7 to 9.2 inches in the 6 study embayments. Catch rates for stocked largemouth bass fingerlings ranged between 8.0 fish/hour in the Big Turtle Creek (stocking rate 200 fish/acre) and 55.3 fish/hour in Big Snag Creek (stocking rate 100 fish/acre) . All embayments except for Bracken and Big Turtle Creek had a higher percentage of age-0 largemouth bass being stocked fish, with stocked fish composing 63.3% of all age-0 fish collected in the Meldahl Pool.

Supplemental stocking / Doug Henley

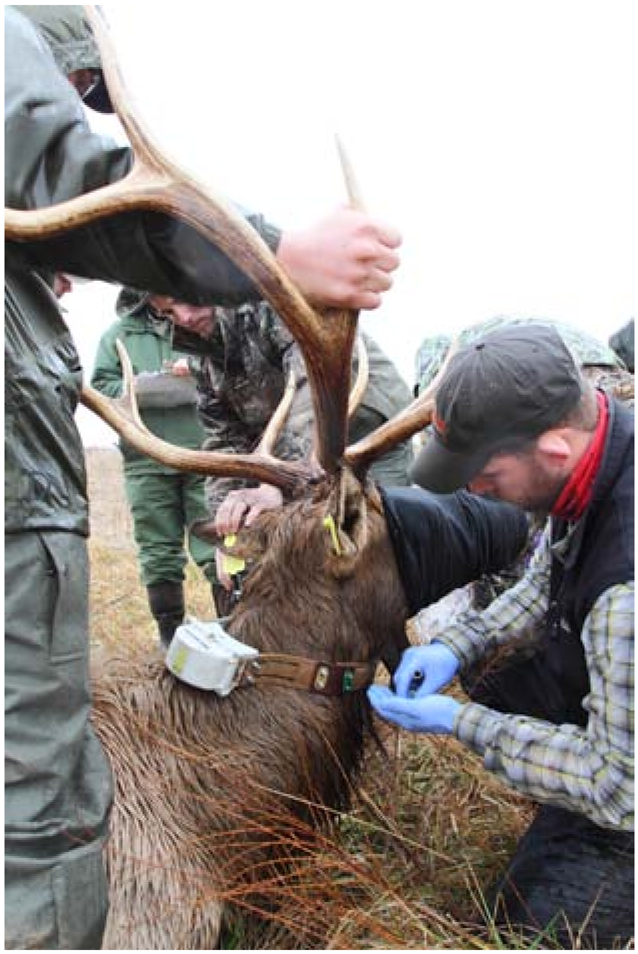
Funding Source: *Sport Fish Restoration Program (Dingell-Johnson)*

KDFWR Strategic Plan. Goal 1, Strategic Objective 5.

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

John T. Hast and John J. Cox, University of Kentucky Department of Forestry

KDFWR Collaborators: *Kristina Brunjes, R. Daniel Crank, Will Bowling, Gabriel Jenkins, and Aaron Hecht*


Researcher processes elk / John Cox

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 but are notoriously difficult to study in hunted populations. Although harvest numbers have been recorded since the implementation of a sustainable hunting season in Kentucky, 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. 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, (2) characterize seasonal movement patterns, (3) identify important population-level movement corridors, (4) determine survival and cause-specific mortality, (5) characterize dispersal movements, (6) characterize the relationship between home range and genetic relatedness, (7) determine the prevalence of common internal and external parasites, and (8) determine the influence of the Kentucky elk herd as an Epizootic Hemorrhagic Disease (EHD)/bluetongue reservoir.

In an attempt to fill the above-mentioned knowledge gaps, 64 mature bull elk were fitted with GPS (global positioning system) or VHF (very high frequency) tracking collars in the winter of 2011. Over the course of 2011, 21 mortality events were recorded (5 from meningeal worm, 1 from poaching, 11 from legal hunter harvest, and 4 unknown). Forty additional bull elk were captured in the winter of 2012 and fitted with tracking collars to expand the sample size of the survival portion of the study. Currently, there are 76 mature bull elk fitted with tracking collars (23 GPS, 53 VHF). We intend to expand this further by capturing approximately 24 more adult bull elk upon antler re-growth in the summer of 2012. With one year of data collected from bull elk wearing GPS tracking collars, it will be possible to begin the analyses necessary to complete objectives 1-3. Additionally, the genetic analysis critical to objective 6 will begin in the summer of 2012.

Funding Sources: *Pittman-Robertson (PR), Rocky Mountain Elk Foundation, University of Kentucky*

KDFWR Strategic Plan: Goal 1. Strategic Objective 5.

Genetic Characteristics of Restored Elk Populations in Kentucky

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

Eastern Kentucky has a thriving elk (*Cervus elaphus*) population, thanks to restoration efforts by the Kentucky Department of Fish and Wildlife Resources (KDFWR). Retention of genetic diversity was considered by KDFWR because it is important to population adaptability and longterm success. Future management decisions should be based on an understanding of the genetic structure of the restored population.

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 2008-2010, biologists and hunters collected a total of 213 tissue and hair DNA samples from harvested eastern Kentucky elk. During this same time, biologists from five western source states obtained a total of 95 DNA samples from harvested elk. These samples, plus those from 150 of the original western source elk, were genotyped using 15 microsatellite DNA. These data will be used to evaluate the genetic makeup of the elk across the restoration area and compare this to their source populations in western states.

Western biologists also obtained antler and/or body measurements from a total of 339 harvested bull and cow elk in Arizona, Kentucky, New Mexico, Oregon and Utah. Antler and body measurements were taken to allow us to evaluate the health of the population as it relates to genetic potential in restored and source populations.

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 to evaluate genetic diversity. 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. Mean heterozygosity values from each western source population were very similar to Kentucky, as well as each other, ranging between 0.64 and 0.67. There appears to be no significant genetic difference between the source populations and Kentucky, so restoration efforts were successful in maintaining genetic diversity.

An analysis of physical comparisons shows that female eastern Kentucky elk are larger than some of their female source state elk. Female elk in Kentucky were 5.6 % taller at the shoulder compared to females in Utah in the mature (5 years and older) age class and 10.4% taller than Arizona females and 6.5% taller than Utah females in the middle (2-4 year) age class. Female Kentucky elk also had 8.5% and 9.0% longer total body lengths than females in Utah in the mature and middle age classes. Physical comparisons of male elk show that Kentucky males have 21.57% shorter main beams lengths, 15.9% narrower inside spreads and 13.4% less number of points in the middle age class than male Arizona elk. Male elk in Kentucky also had 10.0 % narrower inside spreads than male elk in Utah in the mature age class.

The phenotypic quality of the female eastern Kentucky elk is comparable and in some cases surpasses that of comparable female western source elk. The smaller antler measurements found in the male eastern Kentucky elk may be due to a potential harvest selection bias (Martinez et al. 2005, Mysterud 2011). The eastern Kentucky elk population is a young and expanding population and the Kentucky hunters may not have the same reference point as western hunters who have been exposed to elk throughout their lives. By the end of 2012, the final analysis will be complete and this information will allow the KDFWR to make future management decisions that will promote elk population health and provide a current example of how to effectively reintroduce elk into the eastern United States.

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

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

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Researcher radio-tracks quail / David Peters

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

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

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 to increase and manage large tracts of potential habitat is through management of 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 1,000 birds, with a 3.45% trapping success rate, which is comparable with other studies performed throughout the Southeast. Overall crude mortality rate averaged 54%. 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 and increased once again to 4,566 in the fall of 2011. 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.

Demographics and Population Estimation of Black Bear in Southeastern Kentucky

Sean Murphy and John J. Cox, University of Kentucky, Department of Forestry

KDFWR Collaborators: *Jayson Plaxico and Steven Dobey*

The black bear (*Ursus americanus*) historically inhabited all of Kentucky, but was extirpated from the state by the early 1900s as a result of overexploitation, habitat loss, and habitat fragmentation. Beginning during the mid-1980s, the black bear naturally recolonized a portion of extreme southeastern Kentucky in counties bordering Virginia, West Virginia, and Tennessee. Over the previous 3 decades, confirmed nuisance complaints and roadkills have increased in southeastern Kentucky counties harboring resident bears. Additionally, evidence from live-trapping data and reproductive analyses (University of Kentucky, unpublished data) suggests the population has increased in number and expanded its range. Cumulatively, this data prompted the Kentucky Department of Fish and Wildlife Resources (KDFWR) to implement the first annual legal black bear hunt in Kentucky in over a century during winter 2009.

To date, targeted harvest numbers (n = 10/year) have not been achieved, suggesting the population may still be relatively small. Although the legal harvest has remained a short season with a small quota, recent changes to the bear harvest, including a longer duration season and implementation of a dog chase season, have been proposed. As such, population estimates and demographics of this small bear population are critically important data required to inform bear management in Kentucky and ensure long-term population persistence of this ecologically and economically important species. We therefore implemented the following research project objectives during summer 2011:

1. Estimate population abundance, density, and growth rate in the core counties harboring resident bear.
2. Estimate survival and identify cause-specific morality of black bear in southeastern Kentucky.
3. Investigate patterns of range expansion in peripheral counties.

To estimate population abundance, density, and growth rate, and to investigate genetic characteristics and patterns of range expansion, non-invasive hair sampling is being used in a systematic capture-mark-recapture study design. We plan to survey one core population (Black Mountain-Pine Mountain area), and several outlying "satellite" areas where bears have only recently appeared. During summer 2011, we established a total of 144 hair traps in the Black Mountain-Pine Mountain area, Cumberland Gap National Historical Park (CGNHP), and Redbird Wildlife Management Area (WMA). We checked and baited all 144 hair traps every week for 8 consecutive weeks from June – August, 2011. A total of 384 hair samples were collected from 85 of the 144 hair traps. Hair samples will be analyzed using ≥ 12 microsatellite loci to identify individuals and delineate gender of sampled individuals. Robust design population models, which allow closed-population models to be used for estimating yearly population size and density, will be used to estimate population growth rate from 2011 – 2014.


Researchers process a bear / Rachel Rowe

To estimate survival and identify cause-specific mortality of black bear, live-trapping via Aldrich spring-activated snares, culvert traps, and free-darting will be used to capture individual bears. Captured individuals will be outfitted with VHF radio-collars to enable tracking. Aerial telemetry via fixed-wing aircraft will be conducted every 10 days to locate individuals and determine status (*i.e.* live or dead). During summer 2011, 23 individual black bear were live-captured and outfitted with VHF radio-collars. Of these 23 collared individuals, 2 were hit and killed by vehicles, 1 was illegally poached, and 1 was legally harvested in Virginia, suggesting that anthropogenic mortality may play a larger role in slowing growth of the southeastern Kentucky black bear population than previously speculated.

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.

Statewide Osprey Nesting Survey

Kate Heyden, Kentucky Department of Fish and Wildlife Resources

An Osprey nest, containing three young on a navigation light platform at Lake Barkley, during the 2011 Osprey survey / Tonya Mammone

In Kentucky, Osprey historically nested along the floodplains of the lower Ohio and Mississippi rivers. However, Ospreys, like many other fish-eating birds and raptors, declined significantly in numbers during the 1960s and early 1970s, due to their productivity being hindered by the pesticide DDT. As a result of the release of young birds and the ban on DDT in 1972, Kentucky's nesting population started to reestablish in the mid-1980's.

A statewide survey was conducted in 2011 to determine the approximate current size of Kentucky's nesting Osprey population. Known nesting locations statewide were checked, where possible, by ground and boat, during the nesting season (late March-July). The Land Between the Lakes (LBL) area and lower Tennessee River between KY Dam and the Ohio River was surveyed by boat and ground by KDFWR personnel on June 29-July 1, 2011. In hopes to find new nests, the entire main channel at Lake Barkley and all but the northernmost portion of the main channel of Kentucky Lake were searched by boat. Nests east of LBL were monitored from the ground by KDFWR personnel, volunteers, and USFS personnel (at Cave Run and Laurel River Lake). Over 100 locations were checked for nesting activity statewide.

During 2011, 87 occupied Osprey nests were documented in Kentucky. The majority of nests were on manmade structures (78%) such as navigation lights and transmission towers. Western KY supports the bulk of the nesting population, but there are several nests in central and eastern KY near major rivers and larger reservoirs (Figure 1).

The statewide Osprey survey will be conducted at three-year intervals with the next survey in 2014.

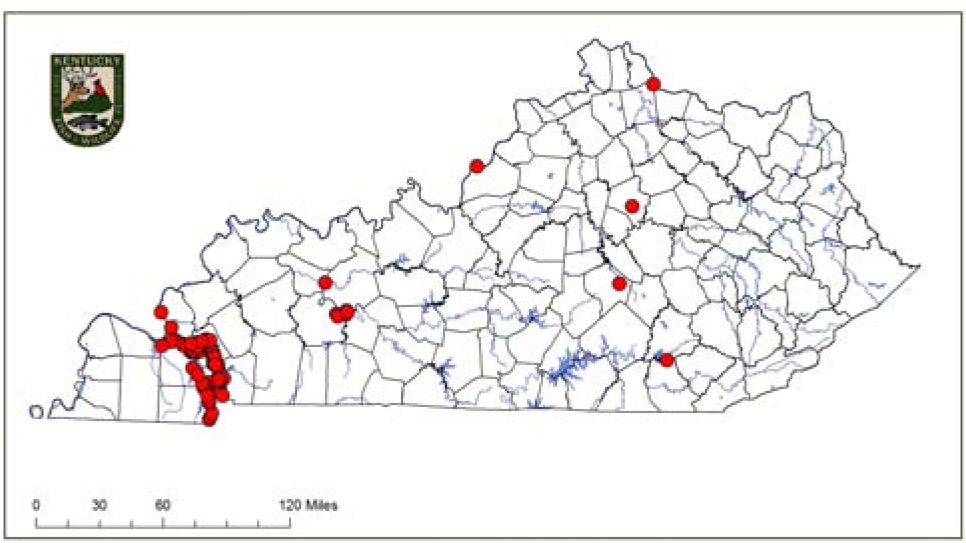

Figure 1: *Distribution of occupied Osprey nests in 2011.*

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.

Kentucky pine snake / Will Bird

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

Will Bird and Phil Peak,
Kentucky Herpetological Society

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. Reptile and amphibian species for which baseline data is most needed 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 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 creatures 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)*

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Big Game (Elk and Deer)

Small Game
(Quail, Squirrels, Rabbits)

Turkey

Furbearers

Bear

Birds
Songbirds and Raptors

Migratory Shorebirds and Colonial Nesting Waterbirds

Bats

Reptiles and Amphibians

Mollusks

Crayfish

Fishes

Habitat Restoration / Management

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Whitetail in velvet / Joe Lacefield

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