Kentucky Department of Fish and Wildlife Resources

Annual Research Highlights 2008

Volume II, Sept. 2009

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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

Wood duck banding / Brian Clark

Long Term Conservation Planning in Kentucky

The Kentucky Department of Fish and Wildlife Resources (KDFWR) understands the importance of long-term planning to protect and manage the natural resources of the Commonwealth and to effectively serve hunters and fishermen in Kentucky. 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 Comprehensive Wildlife Conservation Strategy (completed in 2007; (*http://fw.ky.gov/kfwis/stwg/*) and the 2008-2012 Kentucky Department of Fish and Wildlife Resources Strategic Plan (*http://fw.ky.gov/pdf/strategicplan2008-2012.pdf*). Both of these documents are designed to guide agency decisions; however, they serve two unique purposes. The Comprehensive Wildlife Conservation Strategy (CWCS) is Kentucky's roadmap for sustaining fish and wildlife diversity. The two primary goals of the CWCS 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. In contrast, the 2007-2012 Strategic Plan addresses both fish and wildlife management issues and 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.

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 2008 Kentucky Department of Fish and Wildlife Resources Research Summary represents our targeted efforts to fulfill the goals of our Comprehensive Wildlife Conservation Strategy as well as goals of the 2008-2012 Strategic Plan.

Figure 1. Federal programs that fund many KDFWR projects.

Federal Funding Source	Program Goal
State Wildlife Grant Program (SWG)	To develop and implement programs that benefit wildlife and their habitats, specifically species and habitats of conservation concern
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
Landowner Incentive Program (LIP)	To protect and restore habitats on private lands to benefit species of conservation concern
Cooperative Endangered Species Conservation Fund (Section 6)	To fund conservation projects for candidate, proposed, or listed species.

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. Projects that are entirely funded by the state are labeled "Kentucky Department of Fish and Wildlife Resources;" 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), the Landowner Incentive Program (LIP), 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 shown in Figure 1.

These federal programs provided approximately 16.6 million dollars to KDFWR in 2008 (Figure 2). 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 CWCS fulfilled, as well as the KDFWR contact responsible for each project.

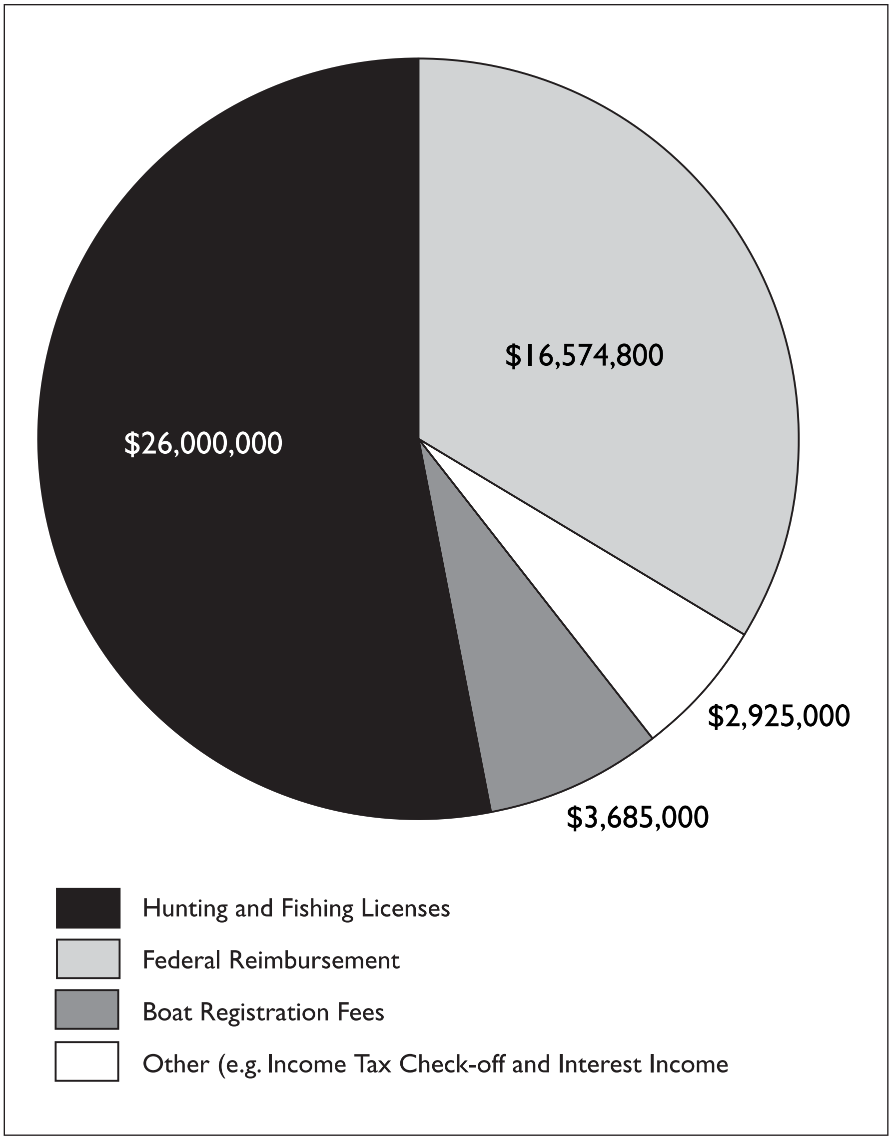


Figure 2. Kentucky Department of Fish and Wildlife Resources Funding Sources 2008

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 of the document. For projects that have just begun, 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 of this document. In the table of contents, an expected date of completion is listed for each project with a finite end-date. This will facilitate looking up detailed summaries of completed projects in later years.

Please use the following citation when referencing this document:

Kentucky Department of Fish and Wildlife Resources Annual Research Highlights, 2008. Volume II. Publication of the Wildlife and Fisheries Divisions. September, 2009, 79 pp.

Table of Contents

Published Research

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

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

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

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

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

Completed Projects

Big Game and Small Game Programs

Wildlife Diversity and Fisheries

Project Highlights

These projects began in 2008

Fishes

Mollusks

Reptiles and Amphibians

Birds

Mammals

Habitat Restoration

Project Updates

This section includes brief updates for selected projects that began prior to 2008.

Migratory Shorebird Updates

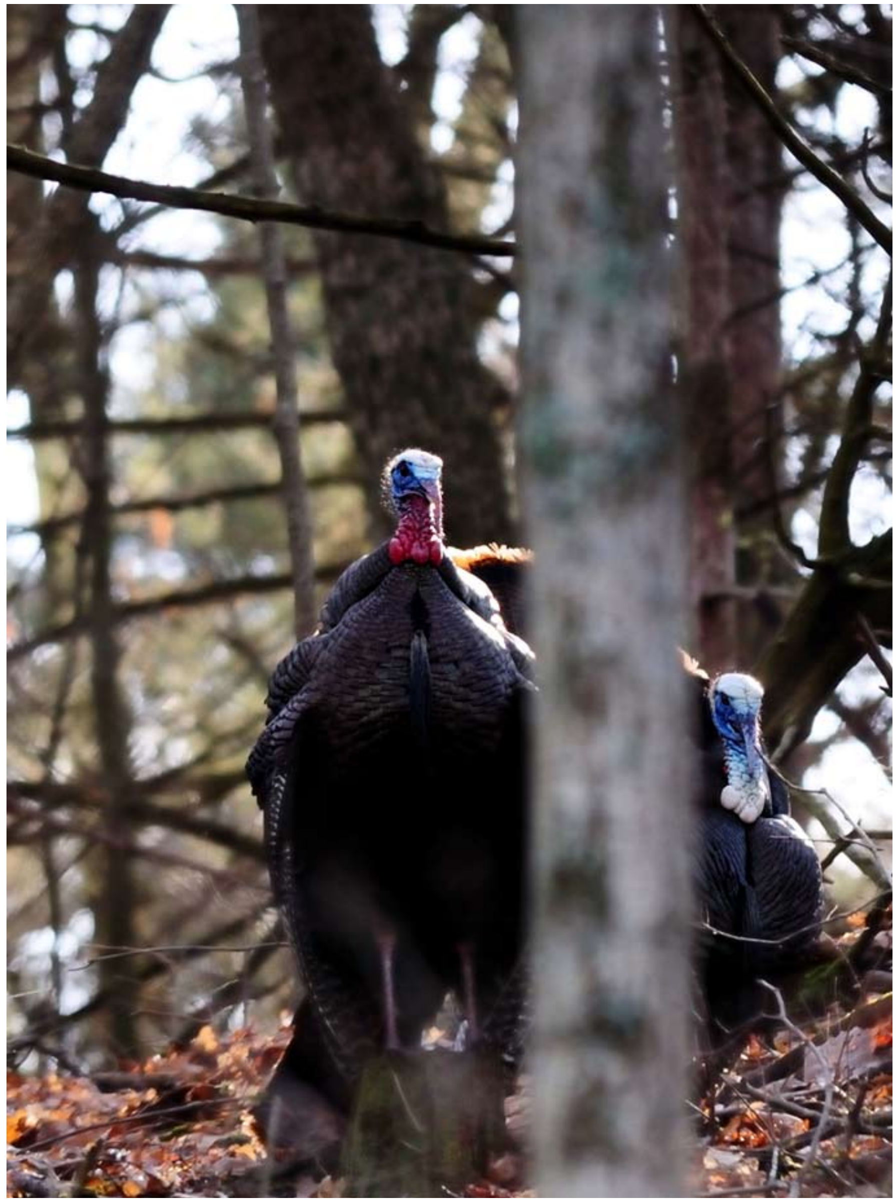
Habitat Restoration Updates

White-tailed deer / James Inman

Completed Projects

Hunters' Use of the Kentucky Department of Fish and Wildlife Resources' Telecheck System

Mark Damian Duda, Responsive Management; Tina Brunjes, Kentucky Department of Fish and Wildlife Resources



Wild turkeys / Joe Lacefield

Introduction

The Kentucky Department of Fish and Wildlife Resources first implemented a toll-free, automated phone-in Telecheck system in 1998 for collecting hunter harvest information. All deer, elk and turkey harvested must be reported through the Telecheck System by midnight on the day of harvest, and entering false information is unlawful. Reporting through the Telecheck system takes about five minutes and has increased the speed of collecting hunter harvest information. Hunters who report harvests through the Kentucky Department of Fish and Wildlife Resources' Telecheck Service can also review their reports online for accuracy including the hunter's name, species and gender harvested, type of weapon used, county code indicating harvest location, and whether there were visible antlers or a beard. "Telecheck Review" was implemented on the Department's website, *fw.ky.gov*, Monday, November 5, 2007, just before the 2007 statewide modern firearms deer season opener on November 10.

The purpose of this study is to better understand hunter compliance with the Kentucky Department of Fish and Wildlife Resources' Telecheck Reporting System. To assess total harvest numbers as well as Kentucky licensed hunters' and license-exempt landowners' compliance levels with the Telecheck Reporting System, Responsive Management conducted a statewide telephone survey of licensed hunters and license-exempt landowners. Responsive Management's goal was to interview 1,500 licensed hunters and 360 license-exempt landowners across the state, for a total of 1,860 completed interviews.

Methodology

To ensure the integrity of the telephone survey data, Responsive Management has interviewers who have been trained according to the standards established by the Council of American Survey Research Organizations. Methods of instruction included lecture and role-playing. The Survey Center Managers and other professional staff conducted project briefings with the interviewers prior to the administration of this survey. Interviewers were instructed on type of study, study goals and objectives, handling of survey questions, interview length, termination points and qualifiers for participation, interviewer instructions within the survey instrument, reading of the survey instrument, skip patterns, and probing and clarifying techniques necessary for specific questions on the survey instrument. The Survey Center Managers and statisticians monitored the data collection, including monitoring of the actual telephone interviews without the interviewers' knowledge, to evaluate the performance of each interviewer and ensure the integrity of the data. After the surveys were obtained by the interviewers, the Survey Center Managers and/or statisticians checked each completed survey to ensure clarity and completeness.

Interviews were conducted Monday through Friday from 9:00 a.m. to 9:00 p.m., Saturday noon to 5:00 p.m., and Sunday from 5:00 p.m. to 9:00 p.m., local time. A five-callback design was used to maintain the representativeness of the sample, to avoid bias toward people easy to reach by telephone, and to provide an equal opportunity for all to participate. When a respondent could not be reached on the first call, subsequent calls were placed on different days of the week and at different times of the day. The licensed hunter data were weighted so that the percentages of sample among the license types exactly matched the distribution of the license types statewide as shown in the table below.

Wild turkeys / Joe Lacefield

Results

Responsive Management interviewed 1,503 Kentucky licensed hunters and 374 landowners owning 10 or more acres for a total of 1,877 interviews. The reported Telecheck deer harvest numbers and Responsive Management's telephone survey numbers are in close agreement. The 2007 Telecheck system indicates that 113,436 deer were harvested, and this is within the confidence interval of Responsive Management's estimate of 106,701 to 128,710 deer. The reported Telecheck turkey harvest numbers are not in agreement with Responsive Management's telephone survey numbers. Responsive Management's turkey harvest estimates are higher than the numbers reported under the Telecheck system. Because the sample size of hunters who hunted otter was small, confidence intervals were not created, and it was not possible to make an accurate harvest estimate. The Telecheck figure of 2,385 bobcats harvested by hunting or trapping falls with the 95% confidence interval of the telephone survey estimate, between 951 and 2,886 bobcats harvested.

License Type	Number of Licenses in Dept. Provided Database	Percent of Sample
2007 Combo Residential	64,511	26%
2007 Hunting	79,552	32%
2007 Sportsman	31,985	13%
2007 Senior/Disabled	69,306	28%
TOTAL	**245,354**	**100%**

Discussion/Management Implications

Responsive Management's numbers indicate that hunters who harvest deer and bobcat adequately use the Telecheck system to report harvested animals; however, hunters who harvest turkey do not appear to be reporting all of their turkey harvest, particularly those hunting on public land. The Telecheck turkey harvest total of 28,898 is lower than and does not fall within Responsive Management's 95% confidence interval of 38,419 to 51,470 turkeys, as estimated from telephone interviews with hunters. The results of this research indicate that the Telecheck system is an effective means to track deer and bobcat harvest and is properly used by most hunters. Discrepancies between the Telecheck numbers and numbers estimated from interviews with turkey hunters are problematic. This finding will result in increased diligence and monitoring of turkey harvest in the upcoming years by the Kentucky Department of Fish and Wildlife Resources.

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

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Using FLIR (forward-looking infrared radiography) to Estimate Elk Density and Distribution in Eastern Kentucky

Lauren Dahl , John J. Cox, David S. Maehr, and Will Bowling, University of Kentucky; Karen Alexy and Tina Brunjes, Kentucky Department of Fish and Wildlife Resources; Joe Duchamp and Jeffery Larkin, Indiana University of Pennsylvania; David Unger Alderson Broaddus College

Kentucky elk / Lauren Dahl

Introduction

Wildlife management decisions are often driven by a species' population size (Lancia et al. 1996, Meffee and Carroll 1997). Kentucky's free ranging elk population was reintroduced from 1997 – 2001 with a total of 1,547 elk (*Cervus elaphus nelsoni*) released at 8 sites within eastern Kentucky. Initial studies demonstrated that Kentucky elk had a low mortality rate (0.07) and a high natality rate (0.86) during the initial 3 years post-reintroduction (Larkin et al. 2003) suggesting a high potential for a rapidly growing population. The successful reintroduction and subsequent population growth of elk (*Cervus elephus*) in Kentucky during the past decade has created unique population monitoring challenges for wildlife managers. The Kentucky elk model (KEM) predicted a population size of 5,700 elk in 2006, but these were solely based on mortality, natality and harvest rates and did not consider the available habitat or landscape patterns that facilitate the distribution and local abundance of elk. Regardless, the predicted population size suggested that the population had nearly quadrupled in less than 10 years. As the population began to reach the set goal of 10,000 elk, a comprehensive and accurate population assessment was needed to verify the KEM and set harvest levels to maintain the population within the desired goal.

Techniques typically used to visually survey large mammal populations to gain abundance and distribution data include: drive counts, aerial photography, double sampling, mark-resight, line-transects, and aerial visual surveys (Cochran 1977, Lancia et al. 1996). Detection problems arising from the rugged forested landscape of eastern Kentucky limit the efficacy of these sampling techniques. Restricted ground accessibility, elk avoidance of humans, and a predominately forested landscape make traditional ungulate population estimation techniques impractical in Kentucky's elk restoration zone. An alternative technique that addresses many of the weaknesses of conventional survey methods is aerial-based forward-looking infrared radiography (FLIR), a method that utilizes an infrared scope attached to the underside of an aircraft to detect thermal radiation of target species. FLIR has been used successfully to survey elk (Dunn et al. 2002), moose (*Alces alces*, Adams et al. 1997) and several other species in other areas of North America. Our research tested the feasibility of FLIR (forward-looking infrared radiography) to survey elk in rugged southeastern Kentucky.

Study Area

We determined FLIR detection rate of elk on a cluster of surface mines near Hazard, KY. This area was inhabited by 70 vhf radio-collared elk and thus allowed us to take advantage of marked animals to compare with FLIR identified elk. FLIR transect surveys were subsequently conducted along transects near or radiating from the 8 original elk release sites within the original 14-county elk restoration zone. Total area surveyed using transects was 41,000 ha, or approximately 4% of the original 14-county elk restoration zone.

Methods

We conducted the FLIR survey in December 2006 during leaf off and at nocturnal hours when infrared visibility and temperature contrast between animals and background objects were highest. The FLIR unit consisted of a PolyTech, Kelvin 350 II infrared radiometer that housed a Thermovision 1000 sensor (PolyTech Airborne Remote Sensing, Stockholm, Germany). The FLIR unit was attached to the underside of the wing of a Cessna 206 fixed wing aircraft (Cessna Aircraft Company, Wichita, Kansas) by a 4-axis gyro-stabilized system. A monitor within the cabin of the plane displayed the images received from the sensor in real time allowing the sensor operator to manipulate the sensor and zoom in on suspected elk locations. FLIR images were digitally recorded, georeferenced, and analyzed following the completion of the entire survey. The sensor operator used species-specific morphological features (e.g. body size and shape) to distinguish elk from other large mammals (white-tailed deer, cows, horses) in the study area. For each FLIR-identified individual or group of elk, we recorded group size and the majority activity (bedded, standing, or walking), and landcover type.

We conducted the elk detectability portion of the study in December 2006 and 2007. FLIR detection rate of elk was calculated by comparing elk locations identified by FLIR and those observed by ground crews visually or using telemetry ≤ 30 minutes of FLIR locations. We also located white-tailed deer in the same area using spotlights and recorded their locations to calculate a FLIR misclassification rate between elk and deer within the same temporal window.

In December 2006, we surveyed elk within a 2 x 16 km transect block that either radiated in the four cardinal directions surrounding each of the 8 elk release sites, or were in specific areas where information about elk was desired. We used this systematic sampling design to obtain minimum counts of elk at each release site while also modeling and extrapolating a population estimate for the majority of the Kentucky elk restoration zone (Caughley 1974). Landscape characteristics at FLIR-identified elk locations were gathered from Kentucky land cover type data. Because the distribution of animals is a function of several biological interactions that cannot be described in any one specific spatial scale we used two scales to assess the relationship between the density of elk and the landscape characteristics (Levin 1992, Buckland and Elston 1993, Stubblefield et al. 2006). By using a grid system we created 2 x 2 km (4 km^2) blocks within the FLIR survey transects which enabled us to identify landscape characteristics within an area that an elk may use within a day (average Kentucky elk daily movement in December is 1,200 m; W. Bowling unpublished data). We also created a 6 x 6 km (36 km^2) block surrounding each 4 km^2 block to identify landscape characteristics within an area representative of an average Kentucky elk home range (31 km^2; W. Bowling unpublished data).

We calculated several landscape metrics at both of the spatial scales based on previous literature and biological importance to Kentucky's elk (Cook 2002, Geist 2002, Skovlin et al. 2002, Schneider 2006, Sawyer 2007, Olsson et al. 2007, Telesco et al. 2007). Landscape metrics included the area of forest land cover (ForCA), the area of herbaceous land cover (HerbCA), herbaceous edge density (HerbED), herbaceous mean patch size (HerbMPS), forest mean patch size (ForMPS), herbaceous mean nearest neighbor (HerbMNN), herbaceous area weighted mean patch fractal dimensions (Herb AWMPFD), and urban core area index (UrbCAI). Additionally, we calculated road density at both spatial scales (4kmRdDen and 36kmRdDen), and site influence (SiteInflu) a variable that combined the distance from each site and the number of elk released at each of those sites. We conducted a principle component analysis (PCA) to transform correlated variables which were determined using a Pearson's product moment correlation coefficient (Dahl 2008).

To estimate the uncertainty that the undetected elk groups contribute to the population modeling process, we adjusted the observed elk groups by the detection rate and repeated this process 100 times to equalize the effects of the distribution of these additional missed groups (Efron 1979, Buckland and Elston 1993). We used multiple linear regression models to identify the relationship between the density of elk in each 4km² block and the landscape variables. By using Akaike's Information Criterion corrected for small sample size (AICc: Burnham and Anderson 2002) we selected the top models from each of the 100 iterations. We then used the relative model weights to select the strongest models for the final model averaging process (Burnham and Anderson 2002). The final derived elk population model was validated on a subset of FLIR survey data withheld prior to the model building process. The final derived model was then extrapolated to each 4 km² block within the core area of the restoration zone (7,076 km²).

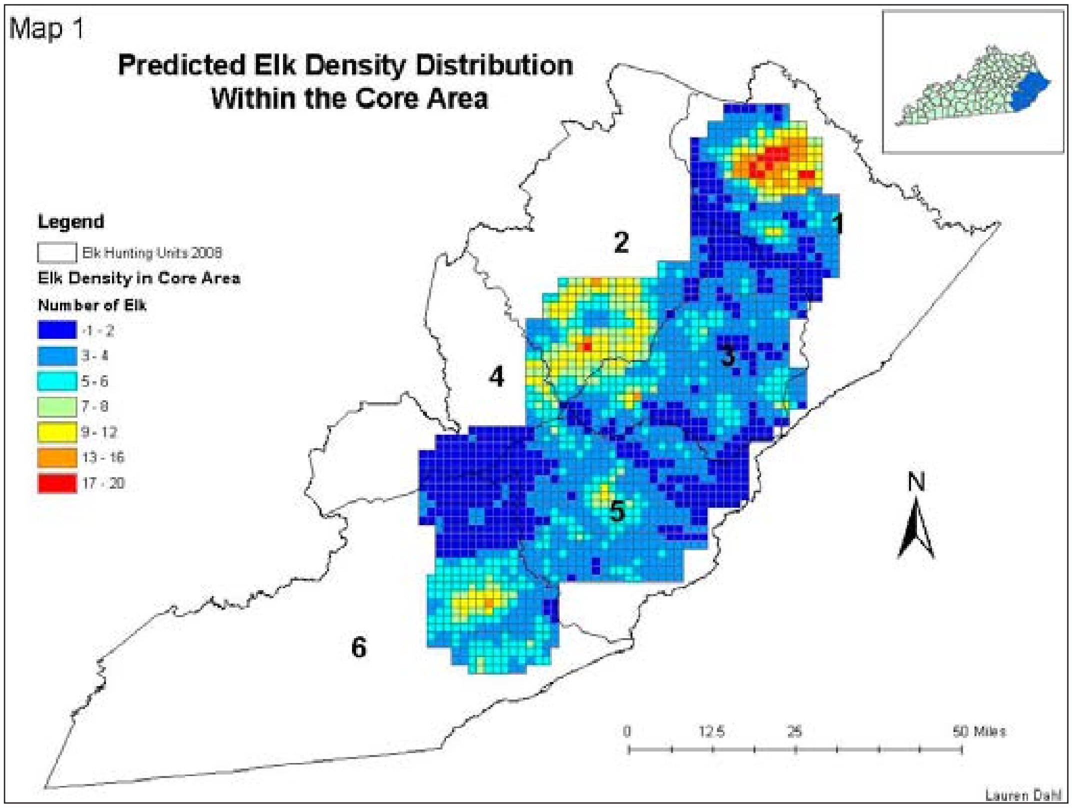


Figure 1: Elk density distribution estimated within 4 km² cells in the core area of the restoration zone in southeastern Kentucky, USA, December 2006.

Results

The detection rate of FLIR for elk in Kentucky was derived from 44 comparisons between ground located collared elk and FLIR observed elk locations. The derived detection rate was 76% for groups of < 10 individuals and 100% for groups of ≥ 10 individuals. FLIR misidentified 2 of 31 (6.5%) deer observed by the ground crew as elk during the detection rate portion of the study.

A total of 1,981 elk were detected using FLIR within the survey transects. The final population model was ultimately derived from the averaging of the overall top 4 competing models. The averaged model suggested that 5 variables were strong predictors of elk density in Kentucky demonstrated in the following equation:

Elk Density =
$1.61+0.07_{x1}-0.63_{x2}-0.18_{x3}+0.06_{x4}+0.33_{x5}$

Where:

x1= Site Influence (the number of elk released at each site and the distance to that site)
x2= 4 km² Road Density
x3= 36 km² Road Density
x4= 36 km² Urban Core Area Index (the amount of central urban area)
x5= PCA1 (The ratio of herbaceous area to forest area at both the 4 km² and 36 km² spatial scale)

We extrapolated the population model to the core area of the Kentucky elk restoration zone and calculated a population estimate of 7,001 (SE=772, CI=5,488-8,514) individuals for 2006 (Figure 1).

Discussion

The ability of FLIR to detect the heat signature of animals allowed us to overcome many of the weaknesses of other commonly used visual survey techniques for elk. For example, FLIR allowed us to observe elk in habitats where their cryptic coloration and behavior would normally cause them to be undetected by visual methods. Footage from FLIR surveys was recorded and could be reviewed several times to verify counts, whereas resolution with many video recording devices is often poor or sensitive to vibration from moving aircraft. We found similar detection rates as other FLIR surveys of ungulates and had success distinguishing elk from deer within the survey area.

Areas of high elk density were associated with areas of extensive herbaceous cover, near release sites where large numbers of elk were initially translocated, and in areas with low road density. The population estimate for the core area of the Kentucky elk restoration zone was slightly above the 5,700 elk estimated by the current KEM.

The total cost of our study was $105,632 and included both the detectability testing and actual elk survey. While this cost is higher than several other visual survey techniques, FLIR was able to provide a relatively fast survey of a large geographic area. The potential downfalls of this survey technique include the time delay for analysis of the footage, the relatively higher expenses as compared to other survey techniques, and the coordination of the logistically complicated detection rate portion of the study.

Management Implications

The elk population estimate derived from this study has allowed state wildlife managers to identify elk abundance and distribution patterns in eastern Kentucky. These data have provided managers with an alternate method to evaluate the existing elk population model, and will be important in determining harvest allocation and intensity within the elk zone. The information derived from this elk population model may also be used as a reference in the creation of more fine scale habitat suitability models, which could lead to the identification of land important for elk related-habitat protection and herd connectivity. This research also assessed the general use of FLIR as a survey technique for wildlife in Kentucky. The detection rate of FLIR for elk, the ability of FLIR to identify species, and the experiences gained throughout this project help managers understand the limitations and benefits of FLIR.

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Funding Sources: *Pittman Robertson (PR)*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Maternal Antibody Transfer and Meningeal Worm Infection in Kentucky Elk

Willie Bowling, Lauren Dahl, John J. Cox, and David S. Maehr, University of Kentucky; Karen Alexy, Tina Brunjes, Dan Crank, and Charlie Logsdon, Kentucky Department of Fish and Wildlife Resources

Introduction

Elk (*Cervus elaphus*) were widespread throughout the area now comprising the continental United States prior to European settlement, with anecdotal and archeological evidence suggesting that this species was the most widely distributed North American cervid (O'Gara and Dundas 2002). Elk were historically abundant in Kentucky, but unregulated hunting and habitat loss led to its statewide extirpation by 1850 (Funkhouser 1925). The species was absent from the state until 1997, at which time the Kentucky Department of Fish and Wildlife Resources (KDFWR) initiated elk reintroduction efforts using animals from source populations in the western United States (Maehr et al. 1999).

Twentieth century elk restoration efforts in eastern states were often unsuccessful. Although these failed attempts often lacked definitive scientific data regarding reasons for decline, managers often implicated meningeal worm infection (Carpenter et al. 1973). *Parelaphostrongylus tenuis*, the meningeal worm, is a parasitic nematode that can infect a wide variety of cervid species, including elk (Anderson et al. 1966). *P. tenuis*, like all members of the Protostrongylidae family, requires both intermediate and definitive hosts (Adamson 1986). The normal definitive host for *P. tenuis* is white-tailed deer (*Odocoileus virginanus*), and a variety of terrestrial gastropods species serve as the meningeal worm's intermediate host (Anderson 1963). White-tailed deer are generally not pathologically affected by meningeal worm infections (Forrester and Lankester 1998), but *P. tenuis* infection in abnormal definitive hosts often causes severe neurological trauma that can compromise an individual's fitness (Anderson 1964).

Habitat influences the relative density of intermediate hosts (Raskevitz et al. 1991) due to differing levels of cover, moisture and vegetation regimes (Suominen 1999). Because the severity of meningeal worm infection in abnormal hosts is positively correlated with the number of *P. tenuis* larvae ingested (Samuel et al. 1992), cervids that use habitat supporting higher densities of infected gastropods

Kentucky elk / Joe Lacefield

may be at increased risk for meningeal worm infection (Raskevitz et al. 1991). Although Kentucky elk have a high probability of escaping fatal meningeal worm infections if they reach adulthood (Larkin et al. 2003, Alexy 2004), the effect of this parasite on population growth is unknown. Juvenile survival can enhance cervid population growth and colonization potential (Taber et al. 1982). Potential detrimental effects of *P. tenuis* infection on juvenile elk may be reduced if immunologically naïve age classes obtain a degree of parasite resistance that aids survival until a complete immune response can be achieved.

One scenario of acquired resistance could come from acquisition of *P. tenuis* antibodies through passive maternal transfer. This mechanism of antibody transmission could protect juvenile elk from fatal parasite infection until they reach immunological maturity (Hattel et al. 2007), but maternal *P. tenuis* antibody transfer has not been documented. Despite this conceptual link between habitat use and *P. tenuis* infection in cervids, previous studies were not able to evaluate this relationship due to the absence of a reliable antemortem test for *P. tenuis* infection (sensu Welch et al. 1991). This complication has been ameliorated following the development of an enzyme-linked immunoassay (ELISA) that identifies *P. tenuis* antibodies within blood samples (Ogunremi et al. 1999, Ogunremi et al. 2002). Our research objective was to determine if maternal transfer of *P. tenuis* antibodies occurred in elk.

Study Area

The Kentucky elk restoration zone lies along the Cumberland Plateau, an area historically characterized by rugged topography covered with continuous second and third growth deciduous forest. Land use has considerably altered the eastern Kentucky landscape resulting in a mosaic that was approximately 80% second and third growth forest, 10% active and reclaimed surface mines, 9% agricultural or cleared lands, and 1% urban (Cox 2003). Coal extraction through surface mining created herbaceous patches that varied in size, ranging from relatively small openings to 1,200-ha fields (Cox 2003).

The study area was a contiguous block of land, but differences in land management resulted in demarcations between property boundaries. The Laurel Fork area encompassed approximately 1,200-ha, and primarily consisted of recently reclaimed surface mines (< 15 years) and remnant forest patches, though active surface mining occurred on small portions of the peripheral landscape throughout the study. The Starfire area was an approximately 7,400-ha site that consisted primarily of reclaimed surface mines and remnant forest patches; active surface mining affected a substantial portion of the area during the course of the study. The Beech Fork area comprised approximately 700-ha, and consisted primarily of recently reclaimed surface mines (< 5 years), though some remnant forest patches remained.

Methods

We captured elk neonates using three different search methods: monitoring cows for parturition behavior, ground-based field searches in traditional calving locations, and aerial searches using a helicopter equipped with an observer using an infrared scope. Calf capture occurred during the months of May and June from 2004-06. Capture techniques followed practices described by Seward (2003). Captured elk calves were fitted with expandable vhf radio collars and plastic ear-tags to facilitate recognition of individuals, and we collected approximately 20 mL of blood from the jugular vein of each animal. We recorded sex, approximate age based on umbilicus healing and hoof epithelium wear, geographic coordinates of the capture site, and body weight. We attempted to recapture each study animal from the 2004 and 2005 cohorts at approximately 6 months of age. Upon recapture, we obtained a blood sample and equipped the elk with a permanent radio collar. Whole blood was separated into serum and red blood cells using a centrifuge, then serum was stored in cryogenic vials at -23º C for subsequent analysis. Prairie Diagnostic Services (Regina, Saskatchewan, Canada) conducted all *P. tenuis* serodiagnostic tests using indirect ELISAs after Ogunremi et al. (2002). We used a Fisher's exact test to determine if calf sex affected acquisition of *P. tenuis* antibodies from maternal transfer ($P \leq 0.05$), and performed logistic regression using forward selection to determine if predicted calf birth weight was associated with *P. tenuis* antibody presence ($P \leq 0.15$). We calculated predicted birth weight of neonates by multiplying estimated age (days) by 0.635 kg/100 kcal assumed daily growth rate (Seward 2003).

Results

Maternal transfer of *P. tenuis* antibodies occurred in over half of elk neonates. *P. tenuis* antibodies were detected in 10 of 19 (53%) neonates in the 2004 cohort, 22 of 40 (55%) neonates in the 2005 cohort, and 21 of 38 (55%) neonates in the 2006 cohort. Sex did not influence antibody transfer in 2004-06, so data were pooled across all years ($P = 0.148$). Likewise, predicted birth weight was not significant to *P. tenuis* antibody presence in 2004-06, and data were pooled across all years ($P = 0.951$).

Discussion

Passive immunity was previously described in cervid species (Grimstad et al. 1987, Gaydos et al. 2002), but this study is the first to demonstrate maternal transfer of *P. tenuis* antibodies in elk. We observed *P. tenuis* antibody presence in over half of elk neonates in all three years of this study, which suggests that passive maternal transfer of anti-meningeal worm immunoglobins commonly occurs in this population. Sex did not influence the presence of meningeal worm antibodies in elk calves, which is not surprising given that ruminants acquire maternal antibodies through ingestion of colostrum within hours of birth (Carpenter 1956). This suggests that any adaptive value inherent to antibody transfer operates independent of sex.

Roulin and Heeb (1999) proposed that antibody production is positively correlated with nutritional intake, while ungulate birth weight is directly affected by maternal dietary success during gestation (Keech et al. 2000). Accordingly, we expected higher predicted birth weights to be positively associated with prevalence of *P. tenuis* antibodies in elk calves, but failed to detect any association. Potential explanations include potential error in predicted birth weights due to inaccurate calf aging, adequate maternal nutrition intake during gestation to permit the production of large calves while maintaining optimal immune performance, and differing genetic propensities for addressing *P. tenuis* infection within the population.

Exposure of elk calves to maternal *P. tenuis* antibodies could favorably influence individuals in several ways. Passive immunity to the parasite could prevent infection while the juvenile elk is allocating resources to growth and development, potentially increasing fitness later in life (Buechler et al. 2002). Early exposure to meningeal worm antibodies could challenge the neonate's immune system, thus increasing the potential for a stronger, secondary immune response should the individual come into contact with infective *P. tenuis* larvae later in life (Boulinier and Staszewski 2007). Alexy (2004) noted that calves and yearlings accounted for 80% of the *P. tenuis*-related deaths in the Kentucky elk herd. However, in this study only 1 of 61 (1.6%) elk calves died from probable meningeal worm infection. The low observed mortality rate in this highly vulnerable age class suggests *P. tenuis* infection poses little threat to growth and viability of elk in this region. We did not have sufficient data to statistically determine if acquisition of maternal antibodies was associated with decreased likelihood of *P. tenuis*-related mortality, but neonate acquisition of meningeal worm antibodies may have conferred fitness advantages unapparent in our data.

Management Implications

In this study, we found that more than half of elk neonates acquired *P. tenuis* antibodies through maternal transfer. Antibody transmission from females to their progeny will not occur unless the dam has been exposed to the pathogen and mounted an immune response (Lemke et al. 2003). Grindstaff et al. (2006) suggested that maintenance of an elevated immune response required for transfer of maternal antibodies may decrease overall reproductive ability, but our findings illustrate that a substantial percentage of cow elk in Kentucky successfully birthed calves while maintaining *P. tenuis* antibody production. Given this information, it seems unlikely that meningeal worm infection diminished the reproductive potential of Kentucky elk over the course of this study. The Kentucky elk population has increased from 1,541 translocated animals to an estimated 8,500 individuals in 2008 despite *P. tenuis* infection. Consequently, habitat management for the sole purpose of decreasing *P. tenuis* infection is likely unnecessary in the Kentucky elk population. However, we recommend that monitoring efforts continue to identify potential changes in herd demographics over time.

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KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Estimating Black Bear Populations in Kentucky

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Abstract

Natural colonization of a new or historic range by carnivores is rare. In order to further understand dynamics of these unique populations, and to develop appropriate management guidelines to encourage further expansion, establishment of baseline demographic data is critical. We estimated the distribution and abundance of a naturally-recolonized black bear (*Ursus americanus*) population in eastern Kentucky during 2007 using mark-recapture statistical analyses. We used genotyping of remotely collected hair samples at 6 microsatellite loci to identify individual black bears in Kentucky. Our results suggest that the current distribution of the black bear throughout a 7,575-km^2 study area is not uniform, but localized to portions of extreme southeastern Kentucky. A pattern of population concentration and constrained expansion near protected public lands at high elevations may be influenced by human activity, or may be related to the population existing below saturation density. Despite a limited distribution and low estimated abundance (33 males, 56 females) genetic diversity at genotyped loci was high (mean H_E = 0.80) and did not indicate non-random mating. To encourage further black bear colonization of Kentucky, we recommend the expansion of the public lands network, and the regulation of anthropogenic activities that may cause further habitat loss and fragmentation. Until the population grows further, maintenance of high genetic diversity will be dependent on continued demographic ties with bear populations in the neighboring states of West Virginia, Virginia, and Tennessee.

Introduction

Prior to European settlement, the central Appalachians were composed of relatively unbroken mesophytic forest that provided habitat for many species, including the black bear (*Ursus americanus*) (Barbour and Davis 1973, Whitaker and Hamilton 1998). Unregulated timber harvests led to major losses of forested habitat in the region (Yarnell 1998), which, combined with overhunting, led to the extirpation of the black bear and other forest carnivores in the late 19th and early 20th centuries (Barbour and Davis 1974).

The return of the black bear to vacant range in Kentucky is at odds with the pattern of distributional collapse among the world's eight bear species (Servheen 1990). Although the black bear is among the world's most secure bear species, the loss and fragmentation of its forested habitat in the eastern U.S. is pronounced (Maehr 1984) and several populations are in jeopardy. In Kentucky, reproduction in the species was documented in 2003 after an absence of more than a century (Unger 2007). Individual black bears have been confirmed in 26 eastern Kentucky counties with most (90%) records from those bordering West Virginia, Tennessee, and Virginia (Unger 2007). The return of the black bear to Kentucky coincides well with increasing bear populations in neighboring regions of Virginia and West Virginia (Virginia Department of Game and Inland Fisheries 2003, West Virginia Department of Natural Resources 2006), suggesting known black bear populations in these states as the most likely sources driving recolonization. Interstate movements of male black bears radio-collared in Kentucky have been documented across the borders of Tennessee, Virginia, and West Virginia, indicating potential de-

Bear snare site / Vince Frary

mographic ties with populations in all three states (Unger 2007).

Our study was initiated because no empirical information has been attained regarding distribution and abundance of the black outside of several public lands in eastern Kentucky (Unger 2007). We used molecular genetic techniques to identify individual black bears in Kentucky throughout a much larger area than typically addressed through telemetry studies (Woods et al. 1999, Mowat and Strobeck 2000). Because of the abundance of forests in the region and because the overall quality of the forests in this landscape appeared similar, we hypothesized that the black bear would be evenly distributed throughout eastern Kentucky. We also hypothesized that observed genetic heterozygosity would be high due to links with larger populations in neighboring states. The results of this research are important for understanding the process of natural colonization in a wide-ranging forest carnivore, and in determining the most appropriate management scenarios to facilitate a self-sustaining population in Kentucky.

Study Area

The study area covered approximately 7,575 km² in eastern Kentucky and included portions of Floyd, Pike, Letcher, Knott, Perry, Leslie, Harlan, Clay, Bell, Knox, and Whitley counties. The highest elevations were found in the southeastern extent of our study area, which included the highest points in Kentucky (Black Mountain and Cumberland Mountain). Here, elevations averaged 450 m above sea level, reaching to 1,262 m above sea level (Homer et al. 2004). The southeastern extent of the study area also included Pine Mountain, a narrow, mostly forested ridge that extends from Elkhorn City, Kentucky to Jellico, Tennessee, reaching 975 m above mean sea level at its highest point (Homer et al. 2004). Our study also included a portion of the northern Cumberland Plateau of the Appalachian Plateau physiographic province, which is characterized by forested hills and deep, narrow valleys (Thornbury 1965). Elevations in this area generally ranged from 300 m to 500 m above sea level (Homer et al. 2004).

The study area was predominantly (89%) composed of mesophytic forests, which is characterized by nearly 30 dominant tree species (Ricketts et al. 1999). These include maples (*Acer* spp.), oaks (*Quercus* spp.), hickories (*Carya* spp.), magnolias (*Magnolia* app.), birches (*Betula* spp.), and others (Barbour and Davis 1973). Common understory shrubs throughout the study area included mountain laurel (*Kalmia latifolia*) and rhododendron (*Rhododendron* spp.) (Barbour and Davis 1973). Active and reclaimed surface mines accounted for approximately 6% of the land cover in the study area (Sayler 2006). The remaining portions of the landscape (5%) are classified mainly as agricultural and developed land (Sayler 2006).

Methods

Sampling Design

We overlaid a grid composed of 313 contiguous cells across the study area. Each grid cell was 25 km² in size, which at the time field work was conducted approximated the smallest known black bear home range in Kentucky (Unger 2007, Woods et al. 1999). We excluded 10 cells within this grid because they contained >80% non-forested habitat (*n*=4), or because landowner permission for access could not be obtained (*n*=6).

We installed a barbed-wire hair snare in each of the remaining 303 cells using methods similar to those described by Woods et al. (1999). Each snare consisted of 2 strands of barbed wire, wrapped parallel to the ground around 3-4 trees, at 25 and 50 cm above ground level. We selected snare locations within each cell based on 3 criteria, ranked in order of importance: 1) presence of contiguously forested habitat and bear forage 2) landowner permission, and 3) logistical feasibility (i.e. rugged topography occasionally made accessing certain areas time-prohibitive or dangerous). Snares were baited with two 4.25 oz cans of sardines, and monitored for the presence of black bear hair during five 8-day sampling sessions between 15 May and 29 June 2007.

Samples collected at hair snares were analyzed by Wildlife Genetics International (WGI, Nelson, British Columbia, Canada). WGI genotyped all hair samples at 6 nuclear loci (G10H, G10M, G10L, G10C, G1A, G1D) using methods described in Woods et al. (1999) to identify individual black bears. WGI employed genotyping quality assurance and error-checking recommendations described in Paetkau (2003) to ensure confident identification of individuals. Genotyping results allowed us to develop mark-recapture encounter histories for each individual bear identified. WGI used a single sample from each individual to assign gender based on size polymorphism at the amelogenin gene (Ennis and Gallagher 1994). WGI used a mitochondrial test to confirm species (D. Paetkau, WGI, personal communication) in samples where microsatellite DNA was insufficient to identify individuality, which allowed the sample to be used to document black bear occupancy.

WGI provided measures of genetic diversity including mean expected and observed heterozygosity, as well as the mean number of unique alleles at each locus. We used genotyping results to complete tests for a Hardy-Weinberg Equilibrium between genotypes and linkage equilibrium between gene loci to identify evidence of non-random mating in Kentucky's bear population (Frankham et al. 2002). We performed these tests using program Genepop 3.4 over 20 batches of 5000 iterations (Raymond and Rousset 1995). Alpha levels were adjusted for successive tests using a progressive Bonferroni correction (Legendre and Legendre 1998), with initial significance defined as $p < .05$.

Table 1. GIS habitat variables used to predict site-specific occupancy of the black bear in eastern Kentucky in 2007.

Variable	Resolution	Data source	$\bar{X}$	SD
Percent Forest (PERFOR)	30m	National Landcover Dataset (Homer et al., 2004)	0.82 %	.087
Elevation (ELEV)	30m	National Landcover Dataset (Homer et al., 2004)	481.93 m	114.30
Percent Slope (SLOPE)	30m	National Landcover Dataset (Homer et al., 2004)	21.67 %	2.61
Human Population Density (POP)	100m	GeoLytics (2003)	25.46 people/ km^2	16.44
Percent Canopy Cover (CANCOV)	30m	National Landcover Dataset (Homer et al., 2004)	74.05 %	9.55
Distance from Nearest Road (ROAD)	30m	United States Census Bureau (2000)	497.61 m	240.92
Distance from Nearest Forest Edge (EDGE)	30m	National Landcover Dataset (Homer et al., 2004)	172.52 m	87.64
Distance from Nearest Active Surface Mine (MINE)	30m	Kentucky Department of Mine Permits (2007)	2397.13 m	1609.69
Distance From Nearest Conservation Land (CLAND)	30m	Kentucky Department of Fish and Wildlife Resources Information System (2001)	7287.13 m	6040.72
Distance from Colonization Source (COLO)	30m	Kentucky Department of Geographic Information (2005)	18,799.75 m	11,497.60

Occupancy

We identified 9 habitat variables, represented in ArcGIS 9.x (Environmental Systems Research Institute, Redlands, California) Geographic Information System (GIS) that we considered important in predicting the probability of occupancy of each sample location (Table 1). We calculated neighborhood statistics in ArcGIS 9.x for each habitat variable at each sampling site using a moving window routine (Carroll et al. 1999, Apps et al. 2004), with each sampling location assigned the mean value of a surrounding landscape for each habitat variable. A window with a radius of 2,447 m corresponded to an area of 18.80 km², the average home range of female black bears in Kentucky (Unger 2007). All habitat variables were tested for correlation (r>0.80) using a Pearson pairwise correlation matrix in program R software version 2.8.0 (R Development Core Team, Vienna, Austria).

We calculated black bear detection and occupancy probabilities using encounter histories entered into MacKenzie et al.'s (2002) occupancy models in program MARK (White and Burnham 1999). We tested temporal and behavioral variation in detection probability by ranking these models in program MARK according to their match to the data using Akaike's Information Criterion (AIC; Akaike 1977) corrected for small sample size (AICc; Burnham and Anderson 2002). Model goodness-of-fit was measured using median c-hat tests in program MARK. Subsequently, occupancy predictor variables were selected using a stepwise backward selection where all non-correlated habitat variables were first included as covariates in occupancy models. We removed variables according to the lowest ratio between the beta-coefficient and the coefficient's standard error. Weak covariates were removed from models in a stepwise fashion until removal of variables failed to improve AICc values. We considered models that were ranked within 4 AICc values of the best model to be competing (Burnham and Anderson 2002), and we averaged detection probabilities from these models using program MARK. We averaged beta-coefficients of the occupancy covariates and their associated standard errors (Burnham and Anderson 2002, Moore and Swihart 2005) to fit a generalized linear model (GLM) using a logit-link transformation.

We calculated Moran's I statistic values (Moran 1950) for model residuals in Program R to check for spatial autocorrelation in our occupancy estimates (Moore and Swihart 2005). Moran's I values were calculated at nine 5 km distance classes (i.e., 0-5km, 5-10km, 10-15 km…40-45km), where 45 km corresponded to the average width of the study area, or the maximum distance at which we would expect autocorrelation to be significant (Moore and Swihart 2005). We adjusted alpha levels for successive calculations using a progressive Bonferroni correction (Legendre and Legendre 1998), with initial significance defined as p<.05. The greatest distance at which spatial autocorrelation was significant defined the neighborhood in the calculation of a spatial autocovariate term for occupancy models (Augustin et al. 1996). We included the autocovariate term described above as an additional covariate in occupancy models in program MARK. Following inclusion of the autocovariate, model selection was repeated as described originally, through the stepwise removal of the weakest predictors of occupancy. We used averaged regression coefficients from competing models to fit a GLM that accounted for spatial autocorrelation and allowed calculation of black bear occupancy probabilities for each cell.

Table 2. Competing 2007 Kentucky black bear occupancy models after inclusion of a spatial autocovariate.

MODEL	AICc	ΔAICc	AICc Weight	Parameters	Deviance
p(t), Ψ (ELEV - PUB + auto)	350.56	0	0.26	9	331.95
p(t), Ψ (ELEV – PUB + auto + EDGE – PERFOR)	350.96	0.40	0.21	11	328.05
p(t), Ψ (ELEV – PUB + auto + EDGE – PERFOR - ROAD)	351.08	0.51	0.20	12	326.00
p(t), Ψ (ELEV – PUB + auto + EDGE)	351.15	0.59	0.19	10	330.40
p(t), Ψ (ELEV – PUB + auto + EDGE – PERFOR – ROAD - POP)	351.66	1.10	0.15	13	324.40

Abundance

We used encounter histories developed for each black bear identified in laboratory analyses to estimate abundance of each gender using closed-capture statistical models (Otis et al. 1978) in program MARK. We ranked models that incorporated heterogeneous, temporal, and behavioral variation in detection probability in program MARK according to AICc values. Models that were ranked within 4 AICc values of the "best" model were averaged (Burnham and Anderson 2002). We used a Chi-square test to determine whether sex ratios estimated by program MARK differed significantly from 1:1 ($\alpha = 0.05$).

Results

Field Sampling and Genetic Analyses

A total of 1,402 hair samples were collected from 254 hair snares. Of these, 328 samples collected at 66 snares exhibited microscopic characteristics of black bear hair, and were submitted to WGI for genotyping. Of the 328 samples, 134 were discarded because of lack of sufficient DNA for extraction (*n*=131) or because they were from non-target species (*n*=3). A total of 194 samples were positively identified as black bear, and of these, 192 were matched to 54 individuals, including 20 males and 34 females. From these individuals, 38 were snared during only one sampling session, 10 were snared twice, five were snared three times, and one was snared four times.

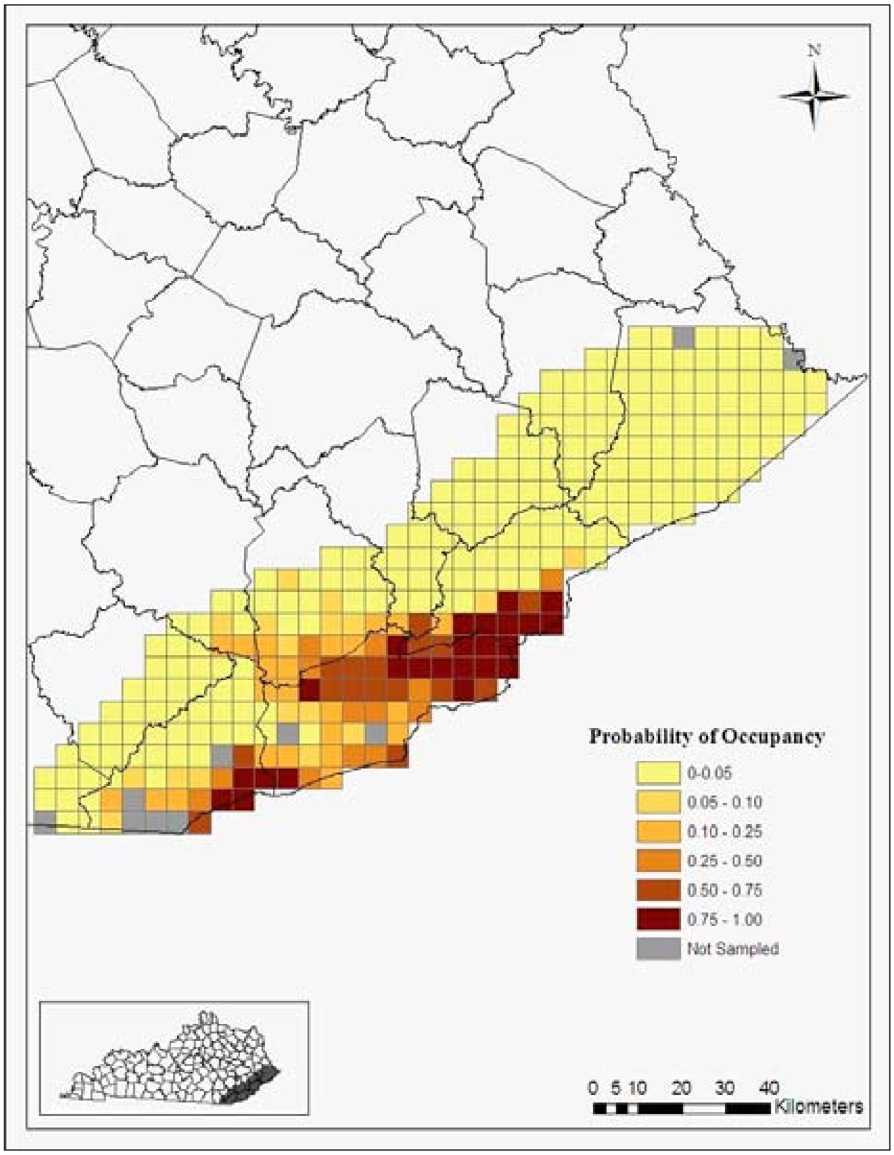
Genetic variability within hair samples was high, with mean observed (H_O) and expected (H_E) heterozygosities calculated as 0.81 (S.D. = 0.05) and 0.80 (S.D. = 0.06), respectively. Mean number of observed alleles at each locus was 7.5 (S.D. = 1.76). Deviations from Hardy-Weinberg equilibrium were not detected at any loci ($p > .08$). Linkage disequilibrium was detected between one pair of loci (G1A, G10M, $p < .003$).

Occupancy

Eight of 9 habitat variables were considered for inclusion in the occupancy models. CANCOV was correlated with PERFOR and EDGE ($r > 0.80$). Because we considered PERFOR and EDGE to adequately indicate the abundance and quality of forested habitat, CANCOV was eliminated from consideration.

Prior to accounting for spatial autocorrelation, model selection in program MARK resulted in 4 competing models. Median c-hat tests suggested adequate model fit for these data (c-hat < 0.9). All competing models allowed detection probability (p) to vary with time throughout all sessions (t). According to these initial models, black bears were more likely to occupy areas of high elevation (ELEV $\beta = 2.51 \pm 0.71$ SE), that were closer to conservation lands (CLAND $\beta = -1.87 \pm 0.89$). Black bears were also more likely to occupy areas further from the interior of a forest (EDGE $\beta = 0.84 \pm 0.64$), closer to roads (ROAD $\beta = -0.74 \pm 0.61$), and with lower amounts of forest (PERFOR $\beta = -0.62 \pm 0.53$), although these relationships were only weakly

Figure 1: Probability of black bear occupancy at each mark-recapture sampling cell in eastern Kentucky in 2007. Calculations were performed using models that accounted for spatial autocorrelation.



related to black bear occupancy.

Spatial autocorrelation in these original occupancy models was significant up to 10 km (p = .01). Therefore we repeated occupancy model selection with the inclusion of a spatial autocovariate (AUTO). AUTO was found to be a positive predictor of occupancy ($\beta = 0.96 \pm 0.65$) in five competing models (Table 2). After accounting for spatial autocorrelation, bears were still more likely to occupy high elevations (ELEV $\beta = 1.54 \pm 0.75$) and areas in closer proximity to conservation lands (CLAND $\beta = -1.54 \pm 0.90$). The effects of other variables were negligible. Application of this model across our study area suggests that high probabilities of black bear occupancy are localized to extreme southeastern Kentucky (Fig. 1).

Abundance

Abundance estimation in program MARK resulted in two competing models; the first of which allowed detection probabilities to be equivalent during sampling sessions one and three, and during sampling sessions two, four, and five (Model: Mt13; Table 3). A competing model allowed for the same temporal variation, but also accounted for heterogeneity in detection probabilities between two unspecified groups (Model: Mht13; Table 3). Abundance was estimated as 33 males (95% C.I. 20-56, S.E. =12.18) and 56 females (95% C.I. 34-95, S.E. = 20.02) after model averaging, resulting in a total population estimate of 89 (95% C.I. 54-151). Average detection probability throughout all sessions was 0.20 (S.E. = .09). Sex ratios favored females (56F:33M, χ^2 = 5.94, p= 0.015).

Discussion

This study developed the first empirical estimate of the naturally recolonized black bear population in Kentucky. Forested areas in a three-county area appear to be the centers of black bear abundance in the study area, and occupancy probabilities suggest that black bears are less likely to be encountered as one travels away from extreme southeastern Kentucky (Fig. 1). It is important to note that our results exclude McCreary County and a disjunct population that was introduced into the Big South Fork National Recreation Area in 1996-1997 (Eastridge 2000). Nonetheless, the results presented here revealed the primary areas of unassisted occupation in the state.

The black bear sex ratio in this study favored females, and is similar to the pattern of captures in an ongoing telemetry study (Unger 2007). This female bias bodes well for population increase in the region and suggests that parts of eastern Kentucky may become a source population for further expansion (Rogers 1987, Onorato and Hellgren 2001, Unger 2007). Past studies of bear colonization have demonstrated that density (and, thus, the probability of occupancy) decreases with distance

Table 3. Competing 2007 Kentucky black bear abundance models.

MODEL	AICc	Δ AICc	AICc Weight	Parameters	Deviance
{Mt13}	37.0626	0	0.85706	4	55.67912
{Mht13}	40.6447	3.5821	0.14294	7	52.9847

from core reproductive areas and males are often encountered at the periphery of occupied range (Swenson et al. 1998, Onorato and Hellgren 2001, Bales et al., 2005). Interestingly, with the exception of a single male, we detected no bears of either sex beyond 29 km from core areas. The reasons for this are unclear, but it may reflect anthropomorphic and geographic barriers to the west, and a population that is still well below saturation density (Sinclair 1992, Lidicker and Koenig 1996, Onorato et al. 2004).

The pattern of distribution revealed in this and other work (i.e. Unger 2007) suggests the geographic expansion of the population may be static. Records of wandering individuals suggest that dispersing subadult males do attempt to colonize areas outside of our three-county core area (Unger 2007), but due to their philopatric nature (Rogers 1987) females do not. A similar situation prevails in south Florida where male Florida panthers disperse from core breeding habitat across a variety of landscape filters and barriers (Maehr et al. 2002). Despite more than a decade of such dispersal attempts the regional pattern of panther distribution has not changed.

Locations in our study area with a high probability of occupancy generally correspond to the largest tracts of potential black bear habitat identified by Unger (2007). However, Unger (2007) identified bear habitat in our study area where our occupancy model predicted the species to be absent. Eventually, as currently occupied habitat reaches saturation density, these areas may be colonized by black bears. Alternatively, habitat suitable for reproducing and dispersing bears may be less abundant than predicted by Unger (2007), and, thus, be a hindrance to colonization (Sinclair 1992; Onorato et al. 2004).

Black bear occupancy in Kentucky was positively correlated with elevation and negatively correlated with distance from conservation lands. Although high elevations are not a requirement of black bear occupancy, these areas in Kentucky are associated with large tracts of forest that are relatively unfragmented. They also receive lower levels of human use than do lower elevations in the study area where many roads have been built and where most people live. Conservation lands throughout our study area included State and National Forests, National Parks, State Nature Preserves, and State Wildlife Management Areas. The management of such areas mandates wildlife and forest stewardship that may be absent on privately-owned lands. Such stewardship may have inadvertently created a network of bear refuges that has resulted in the uneven distribution of the species in the most mountainous region of Kentucky. Based on the relative importance of elevation and conservation land in our models, publicly owned portions of Black Mountain, Pine Mountain, and Cumberland Mountain in the extreme southeastern portions of the state appear to provide the best black bear habitat in Kentucky.

Despite relatively small estimates of abundance and geographic clustering of the black bear in Kentucky, genetic diversity in the population is high. Expected (H_E) and observed (H_O) heterozygosity, as well as mean number of alleles at genotyped loci compare favorably to the highest levels of genetic diversity reported in other bear populations where many of the same loci were examined (Paetkau et al. 1998, Belant et al. 2005, Dixon et al. 2007). Linkage disequilibrium was detected at one pair of loci. Considered with other evidence it is likely not the result of non-random mating, but a result of recent admixture of alleles within the population (Frankham et al. 2002).

Small populations of bears typically demonstrate lower genetic diversity than we found in Kentucky (Paetkau et al. 1998, Triant et al. 2004, Dixon et al. 2007). High genetic diversity in our results is likely due to demographic ties between Kentucky black bears and bears in neighboring states. In this case, although the black bear population in Kentucky is small compared to others nearby in the Appalachian Mountains, it possesses genetic characteristics of much larger, secure populations. High genetic diversity in Kentucky's population may eventually permit a wider array of management strategies (i.e. hunting) than are feasible for small, isolated populations.

Management Implications

The continued expansion of this population in Kentucky may be affected by the overall abundance of and connectivity to forested conservation lands available to colonizing individuals. To encourage further black bear colonization of Kentucky, the conservation land network in eastern Kentucky should be expanded. Areas of particular concern for conservation are potential black bear habitat and colonization corridors identified previously by Unger (2007). Throughout eastern Kentucky, practices that result in large-scale fragmentation and loss of forested habitat should be regulated. Future efforts aimed at black bear population growth and the preservation of genetic diversity should concentrate on the identification and preservation of corridors connecting the Kentucky black bear population with those in neighboring states. Periodic hair snare surveys will likely be an important tool in understanding black bear dispersal and colonization behavior as well as the factors that have, thus far, limited a more uniform distribution across the state's mountainous region.

Acknowledgments

We dedicate this manuscript to our friend and co-author, Dr. David Maehr, who was killed on 20 June 2008 while conducting a black bear telemetry flight in Florida. Dr. Maehr's insight and dedication to the conservation and restoration of wildlife and their habitats will be missed. We thank Dr. Kerry Murphy and Steve Rosenstock for reviews and comments. We thank Indiana University of Pennsylvania, University of Kentucky, Kentucky Department of Fish and Wildlife Resources, and Shikar Safari Foundation International for financial and logistical support. We also thank all those who granted access to property including Cumberland Gap National Historic Park, Big South Fork National Recreation Area, Kentucky State Nature Preserves Commission, Kentucky Division of Forestry, Kentucky Division of Parks, USDA Forest Service Daniel Boone District, Kentucky Department of Fish and Wildlife Resources, Eastern Kentucky University, The David School, Alice Lloyd College, and hundreds of private landowners. Field assistance was provided by Dr. David Unger, Matt Nickols, Andrew Whittle, Kevin Kingsland, Nathan Dryer, Tom Gieder, Geoff Grisdale, and Carson Lindbeck.

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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.

Assessment of Habitat Value for Recovering Disturbed Warm-Season Grass using a Multi-Cover Habitat Assessment Model for the Northern Bobwhite

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Introduction

Disturbance regimes such as disking, burning, and chemical treatment are often used to improve habitat quality for wildlife. There are several ways to determine if these disturbance regimes are effective in improving habitat quality. The U.S. Fish and Wildlife Service has recently-developed Habitat Evaluation Protocol (HEP) models for target species designed to assess habitat quality for target species. These models use cover type and habitat quality indicators to assess habitat value for target species with known habitat requirements. For Northern Bobwhite, HEP models characterize optimal habitat as containing 50% up-right growth cover (forbs and woody) and 50% bare ground. Beginning during the summer of 2006, a 7-acre experimental area was established on the Green River Wildlife Management Area (GRWMA) to determine what type and rate of disturbance is most effective for improving Northern Bobwhite habitat. Specifically, the goals of this study were to: 1) Evaluate effectiveness of several disturbance practices (physical and chemical) on Green River Wildlife Management Area using the HEP model for Northern Bobwhite Quail; 2) Thin warm season grasses to optimal densities for Northern Bobwhite and promote appropriate stem densities and diversity of forbs and woody species; and 3) Increase amount of bare ground to improve wildlife use of habitat area.

Methods and Materials

The 7- acre experimental tract on Green River Wildlife Management Area was divided into five one-acre plots. Of these plots, four were mechanically disturbed (disked 2x, 4x, 6x, 10x), one plot was treated with 1 quart (41%) Glyphosate, one plot was treated with

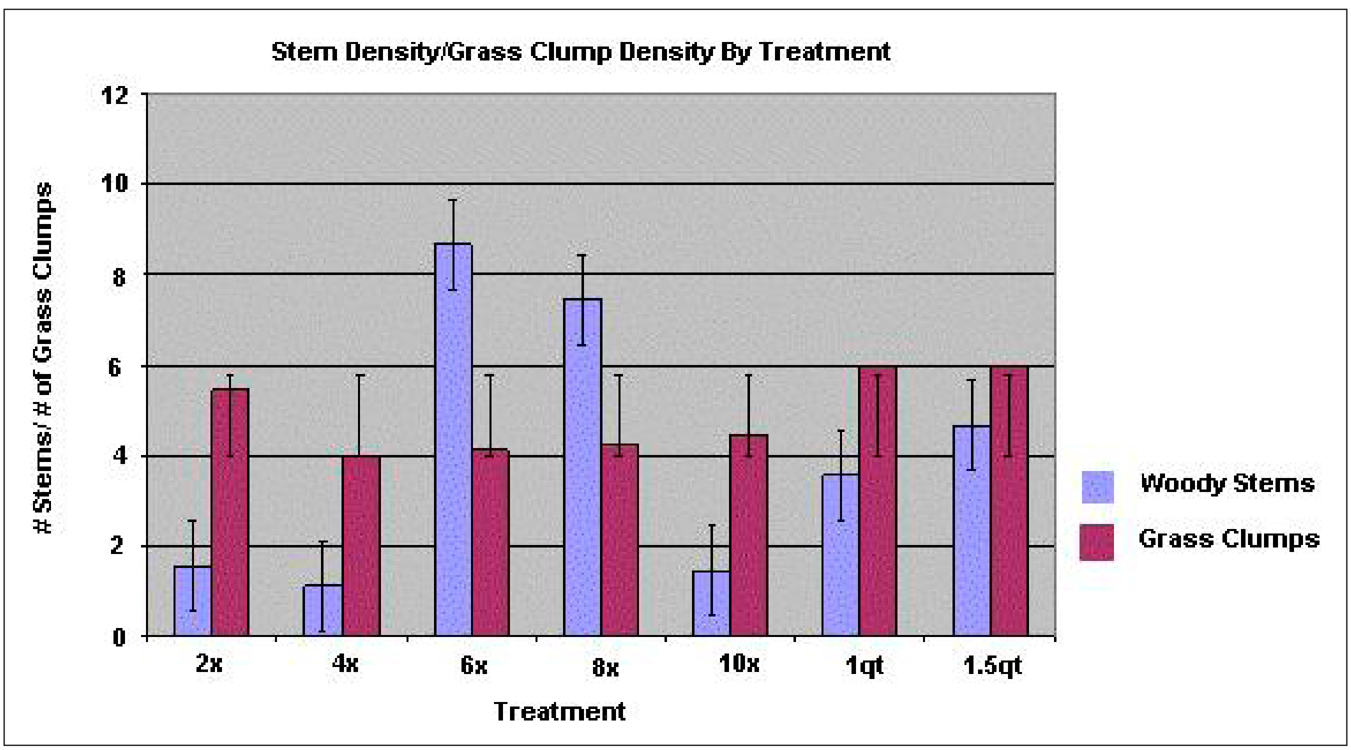


Figure 1.

1.5 quarts (41%) Glyphosate, and the last plot was a control plot receiving no treatment.

After implementation of treatments, habitat parameters were measured for each study plot (9 randomly sampled points per study plot). For each sample point, the following habitat parameters were collected: percent bare ground, percent grass cover, percent woody cover, pent forb cover, number of grass clumps, and number of woody stems. These specific habitat parameters were chosen because quality of cover for Northern Bobwhite is considered the most important habitat characteristic for the Habitat Evaluation Protocol Model designed by U.S. Fish and Wildlife Service.

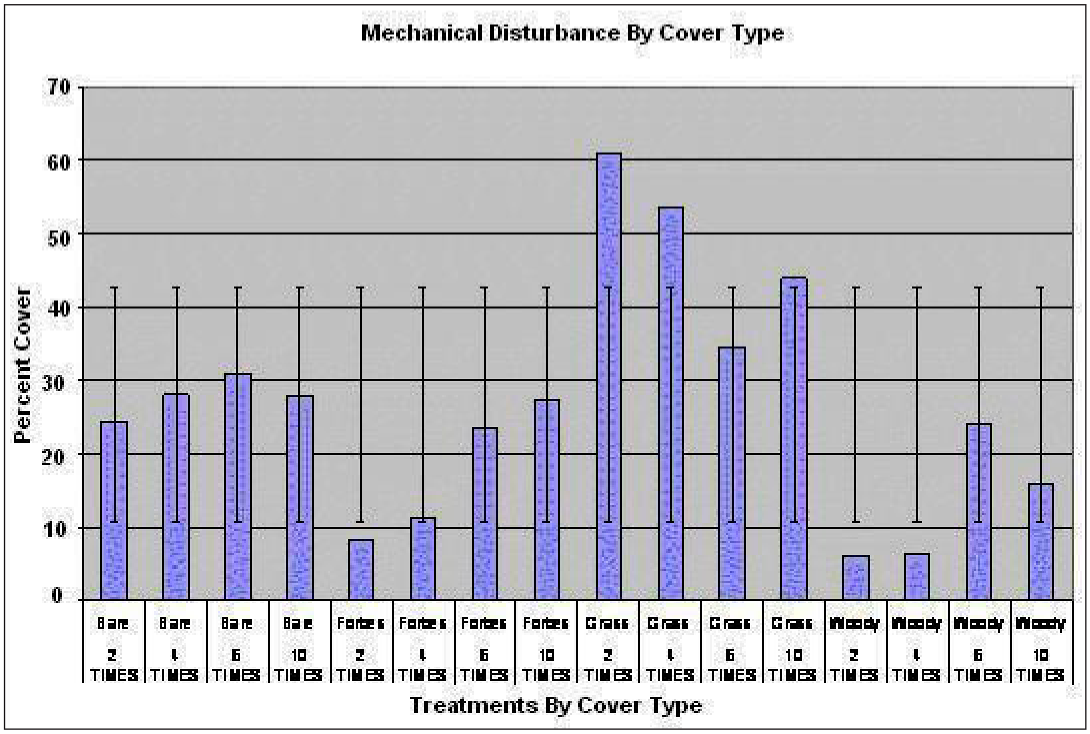


Figure 2.

For each experimental plot, sample data were averaged and standard deviations were calculated. Percent coverage data were normalized using arcsine transformation. We compiled percent cover and stem density bar graphs to assess patterns and trends in the collected data.

Results

The number of grass clumps within treatment plots did not show a large range between treatment types, while the number of woody stems varied from 8.4 in the plot disked six times to less than 2 stems per sample in the plots disked two and four times (see Figure 1). Plots treated with either 1.0 quart or 1.5 quarts of Glyphosate exhibited woody growth intermediate to the 2x/4x and 6x/8x treatment plots. Glyphosate plots were also characterized by greater numbers of grass clumps.

Bare ground cover ranged from 25% to 31% with the 6x plot having the highest proportion of bare ground (31%). Percent cover of forbs ranged from 8% to 28% with the 10x plot having the highest forb component of all treatments. Grass coverage ranged from 35% to 61%; the 2x and 4x plots had the highest percent cover of grasses. Woody percent cover ranged from 6% to 24% and the 6x plot had the highest percentage of woody cover (see Figure 2)

Discussion

In considering the HEP model of the Northern Bobwhite and its preferred habitat, the 6x and 10x disking improved habitat quality by providing adequate amounts of bare ground and cover. In these treatment areas, quail would have enough room to move through the grass without being detected by predators. The 2x and 4x treatments did not appear successful in creating a suitable habitat for the Northern Bobwhite since less bare ground and less woody cover was present in these plots. In terms of chemical versus mechanical disturbance, data trends show that the mechanical disturbance of disking 6 times is similar to a 1.5 quart/acre Glyphosate treatment.

Management Recommendations

Since the 6x and 10x treatments appear successful, but did not differ enough from one another to warrant 10x disking, we recommend using either a 6x disking protocol or a 1.5 quart/acre (41%) Glyphosate application to optimize Northern Bobwhite habitat and minimize labor and management costs.

Funding Source: *Lindsey Wilson College, Kentucky Department of Fish and Wildlife Resources, Pittman Robertson (PR)*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.2; Class Aves: Taxa specific research project #2.

Life History and Population Characteristics of *Moxostoma poecilurum*, the Blacktail Redhorse, in Terrapin Creek, Graves County, Kentucky

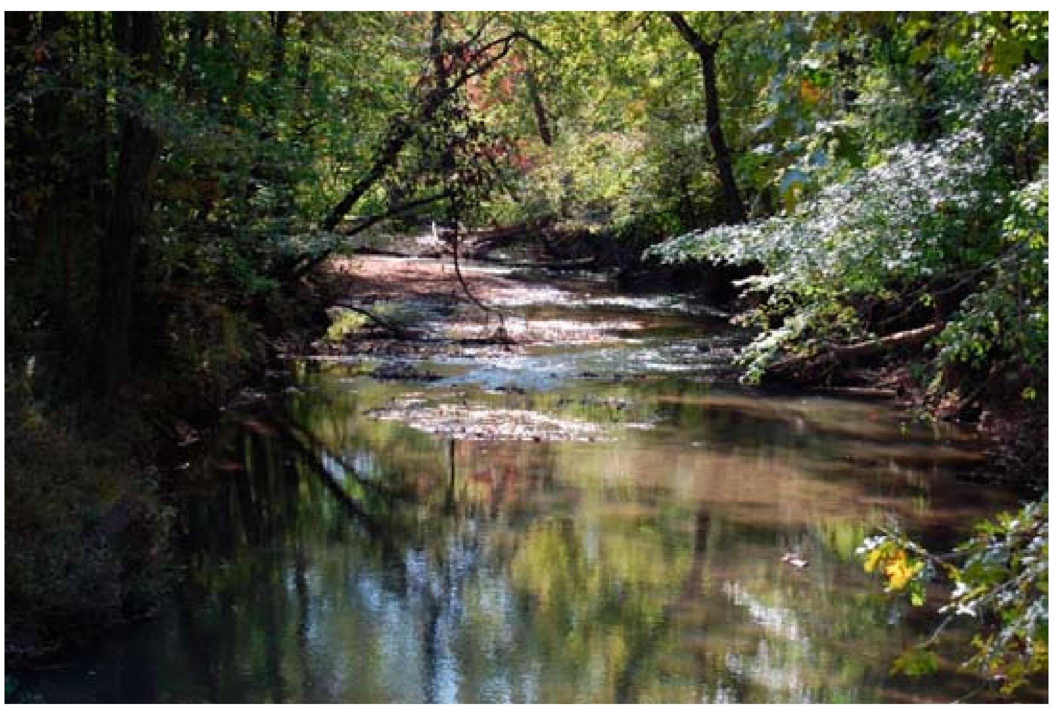
Brooks Burr and Robert Gerwig, Southern Illinois University
KDFWR Contact: *Ryan Oster*

Introduction

The Blacktail Redhorse is a small species of the genus *Moxostoma* that grows to a maximum total length of 508 mm (Carlander 1969). Habitats for this species range from sluggish Coastal Plain Streams with soft sand and silt substrates to more typically upland streams and rivers with high gradients and firm coarse substrates (Etnier and Starnes 1993). It can also be found in the numerous impoundments of the south-central United States. The Blacktail Redhorse tolerates (at least temporarily) brackish conditions based on a specimen collected from the Escambia River where salinities were above 5 ppt at the surface (Boschung and Mayden 2004). The species is a benthic feeder consistent with other members of the genus *Moxostoma* (Boschung and Mayden 2004). Spawning is known to occur in spring when water temperatures near 20 C in shoal areas that are 1-10 m wide (Kilken 1974). This too is consistent with other members of the genus *Moxostoma* which also utilize smaller streams for spawning (Meyer 1962; Bowman 1970; Curry and Spacie 1984). Overall however, the biology of the species has received little attention.

The distribution of the Blacktail Redhorse is restricted to the Gulf Coastal Plain from eastern Texas to the Choctawhatchee system, Florida and Alabama, except in the Mobile River Basin where it occurs above the Fall Line to the headwaters. The Blacktail Redhorse reaches the northernmost limit of its North American range in Terrapin Creek, Graves County, Kentucky, where it was formerly considered sporadic and rare (Burr and Warren 1986). The Blacktail Redhorse has a Kentucky Heritage status as endangered and is considered critically imperiled (S1) in Kentucky (NatureServe 2004). The species is one of 59 fish species identified as a "species of greatest conservation need" under the State's comprehensive Wildlife Action Plan. In Terrapin Creek, both adults and juveniles have been collected from sandy-bottomed pools: however the closest known reproducing population prior to this study occurs in downstream North Fork Obion River, Tennessee (Burr and Carney 1984). Terrapin Creek is a direct tributary to the North Fork Obion River. Therefore, an examination into the life history and population status, especially the possibility of Terrapin Creek supporting a reproducing population of Blacktail Redhorse was essential for future conservation efforts to maintain the species presence in the state of Kentucky.

This study is the first to examine the life history of the Blacktail Redhorse in any detail, and is intended to reveal whether Terrapin Creek supports a reproducing population of the species. Additional objectives were to determine life history aspects (e.g., spawning period and habitat, age at first reproduction, diet analysis, recruitment trends,



Terrapin Creek / Brooks Burr

critical habitat) crucial to an informed management plan for future conservation efforts that will benefit this species and others found in the Terrapin Creek watershed.

Methods and Materials

Sampling efforts for Blacktail Redhorse began on 14 January 2007 and terminated on 05 October 2008. Sampling was usually conducted every 2-3 weeks.The following data were compiled for a detailed examination into the biology of the species: 1) age and growth; 2) reproductive timing and output; 3) food habits and diet analysis; and 4) seasonal migrations. Age determination was made by counting annual rings on opercle bones. Lengths of fish were recorded in millimeters. Three measurements were taken for each fish: standard length (SL), fork length (FL), and total length (TL). Reproductive timing and potential output were estimated using the gonadosomatic index (GSI). GSI = 100(GWW/WW), where GW is the gonad wet weight and WW is total adjusted wet weight (de Vlaming et al. 1982; Crim and Glebe 1990). To estimate potential annual fecundity, ovaries were removed and eggs counted, measured (mm), and placed in categories of developmental stage as outlined by Heins and Rabito (1986): latent (LA), early maturing (EM), late maturing (LM), mature (MA) and ripe (RE). Spawning behavior and habitat were observed through observation of spawning fish from an elevated position on the stream bank. Spawning habitat parameters were recorded in a field notebook including velocity, depth, substrate characteristics, macrohabitat type (riffle, run, or pool), and temperature.

Food habits were determined for all retained adult specimens, and 10 age-0 individuals from each season. The Blacktail Redhorse, similar to other members of the Catostomidae, does not possess a true stomach but instead a large coiled gut that probably increases digestion time, a critical aspect in obtaining nutrition from detritus and living plant material (Weisel 1962; Jenkins 1970; Jenkins and Burkhead 1994). Contents of the "stomach" (the straight gut from pharynx caudad to first descending loop--Bowman 1970; Rupperecht and Jahn 1980; Moss et al. 1983; Peterson et al. 1999) and the remaining anterior 2/3 of the intestinal tract was suspended in water and agitated gently to remove all food items only when the anterior 1/3 was empty. The contents were identified as follows: invertebrates, algae, detritus, and sediment. Invertebrates were identified to the lowest taxonomic level possible (order or family). Food items were expressed as frequencies of occurrence and percent volume. In order to obtain percent volume of a food type all material from each stomach was grouped according to taxon or category (detritus and sediment) and placed over a grid system (Windell 1971). The total number of squares that each group of food items occupied was counted and expressed as a proportion of the total amount of squares that were occupied by all food material (White and Haag 1977). The data were pooled according to age class of fish (Timmons et al. 1983; Peterson et al. 1999). To determine any daily patterns of feeding activity the fullness of the "stomach" and time of capture were noted.

In order to ascertain any seasonal migrations within Terrapin Creek, 40 individuals were fitted with yellow T-bar Anchor Floy tags (Floy Tag Inc.) beginning on 08 June 2007 and ending on 18 July 2007. The tag was inserted between the first and second dorsal fin ray as to lock the T-bar in place. A total of 14 males and 26 females were fitted with tags. All tagged individuals were immediately released at their initial point of capture. All specimens for mark-recapture data were sexed, weighed to the nearest 0.1 g, and lengths in mm recorded (TL, SL, FL). Sexing of fish was accomplished through examination of the anal fin; males are fan shaped and females are rectilinear in shape (Pearson and Healy 2003). All fish were examined to determine overall condition such as, reproductive condition (free flowing milt or eggs, presence of tubercles, coloration), external parasites, the presence of any lesions or other abnormalities.

Macrohabitat characteristics of each of 3 replicated sites were determined using a Rapid Bioassessment Protocol designed by the U.S. Environmental Protection Agency (Barbour et al. 1999). Environmental parameters such as bank stability, velocity/depth regime, and riparian characteristics were scored using a range of values from 0-200 for 10 parameters. Substrate type was assessed using a modified Wentworth scale (Cummins 1962) as follows: sand (<4 mm), pebble (5-64 mm), cobble (64-256 mm), boulder (>256 mm), silt, clay, and organic detritus following a Wolman pebble count. Instream habitat features were noted and the total amounts of these features within each reach were visually estimated. Water quality parameters were measured including pH, dissolved oxygen, and temperature. Land use activities in the watershed were noted (and photographed) to determine potential threats to the watershed and ultimately the Blacktail Redhorse population.

Microhabitat parameters were recorded for adult and juvenile redhorse at their respective points of capture. At each capture site the following procedures were used to determine microhabitat use: 1) a series of 10 depths were taken with a 1.5 m graduated staff in 0.05 m increments and averaged, 2) a series of 10 velocity measurements (m/sec) with a Marsh-McBirney flow meter were recorded and averaged, and 3) instream location of capture was determined by either stream margin or mid-channel, macrohabitat type (riffle, run, or pool), or microhabitat type (undercut bank, large organic debris, root wad, or open channel). Large organic debris was in the form of wood and was classified into three separate categories: clumps, jams, and scattered (Brooks et al. 2003). Microhabitat types were measured with a roll tape and percent total area was estimated for each habitat type.

Results

Age Determination was made for a total of 101 sexed specimens by counting annual rings on the opercle bone (McConnell 1951; Scoppettone et al. 1986; Scoppettone 1988; Summerfelt and Hall 1987; Peterson et al. 1999). Males ranged in age from 1 to 7 years old with most (32 of 41,78.05%) between 1 and 3 years old. Those identified as females ranged in age from 1 to 7 years old and were more evenly distributed among age classes with the exception of only 1 female recorded as 1-year-old. The majority of individuals captured in this study were young-of-the-year fish (63.96%), and were grouped in the age 0 category. These were determined to be age 0 by following the development of young-of-the-year individuals following the spawning period in late May and early June.

Age and Growth

Blacktail Redhorse were observed actively spawning only once during the course of this study on 4 June 2007 at approximately 1825 hrs. Behavior did not differ markedly from behaviors described for other species of *Moxostoma* (Meyer 1962; Bowman 1970; Curry and Spacie 1984; Jenkins and Burkhead 1993). A single female was observed being followed by two males. The two males lagged just behind the female on either side of her. In a sudden rush the female made quick, spastic vibrating motions while facing upstream. At this same time the males quickly joined her on both sides and commenced with a rapid vibrating action. It appeared that the caudal peduncles of these fish were scouring the substrate while swimming upstream in the vibrating manner described. The large fan-shaped anal fins of the males probably aided in directing reproductive material towards the eggs that were being deposited assuring greater fertilization success (Burr and Morris 1977). The trio performed this behavior 3 times within 25 minutes of observation. Each individual spawning act lasted approximately 5 seconds, though precise times were not recorded. The female drifted downstream into the adjacent pool and disappeared from sight. The males moved upstream and were not seen again. Examination of the substrate in the area that the spawning behavior occurred did not reveal any products (i.e., water-hardened eggs) of the spawning act. This spawning behavior occurred in a sandy run with flows ranging between 0.08 to 0.17 m/sec (mean 0.11 m/sec). Depth ranged from 14 to 29 cm (mean 23.6 cm), the dominant substrate was sand (65%) and fine gravel (35%), and water temperature was 21.5º C. It appeared that the spawning fish came from a pool that was immediately downstream (8.2 m) from the spawning site. During the course of the anticipated spawning period of 2008 several high water events made observation impossible due to increases in turbidity and depth.

Male Blacktail Redhorse in breeding condition / Brooks Burr

All samples of stomachs examined contained detritus and periphyton. No attempt was made to discern between very fine detritus and periphyton due to the difficult nature of separating such food stuffs after mastication by the pharyngeal apparatus. It should be noted that young-of-the-year redhorse less than six months in age did not contain any discernible bits of vegetative or other detrital stuffs; it is assumed that the fine brown material found in young stomachs was periphyton growing attached to large pieces of detritus (leaf pack) that accumulated in preferred habitat. Ontogenetic shifts in both categories of food stuffs and mean volumes (Table 3 and Figures 16 and 17) were evident as the fish approached maturity. These shifts are most likely due to increases in mouth gape size as has been described for Spotted Suckers (White and Haag 1977) and Blackfin Suckers (Timmons et al. 1983) resulting in increasing exploitative benefits for gathering food stuffs in increasing quantities and compositions. In age 0 specimens detritus/periphyton made up 35.8% of the total volume of the diet with lesser amounts of Cladocera (24.4%), Ostracoda (19.6%), and Hydracarinae (12.3%). Chironomidae made up only 6.0% of the mean volume of the diet. The diet of juvenile fish became more diverse in both respect to volume and composition as they approached age III. Detritus inputs became greater and ranged from 19.3% volume in age I fish to 20.7% in age II fish. These trends in increased ingestion of detrital inputs are consistent with observations on other species of catostomids (Bowman 1970; Moyle and Mariochi 1975; White and Haag 1977;Timmons et al. 1983; Pearson and Healey 2003). Insect items became more important during this time and were dominated by the Chironomidae occurring in 88.9% of age I fish and found in 100% of age II fish. The Chironomidae were the only insect group encountered in juvenile fishes less than two years old.

Habitat characteristics were documented at each of the three replicate sites that were sampled for relative abundance data. Each site represented a typical reach of stream relative to the site conditions. Sites varied between 113 m to 144 m in length and contained riffle, run, and pool habitat units. Average depths ranged from 0.28 to 0.47 m between sites and had maximum depths of 1.3 m at the farthest downstream site to 0.56 m at the most upstream site. Following protocols suggested by the Environmental Protection Agency (Barbour et al. 1999) scores were based on visual inspection and specific measurements (depth, velocity, substrate, and instream cover). The results of these scores and observations were that Terrapin Creek supports only marginal to suboptimal habitat for Blacktail Redhorse. Habitat scores for pool variability, epifaunal substrate availability, sediment deposition, channel flow status, bank stability, and channel alteration all had scores that were between suboptimal and marginal as outlined in definitions and descriptions in the protocol (Barbour et al. 1999). Riparian vegetation scores were within the optimal range. Discharge estimates were conducted on 2 October 2007 and were calculated to be 49 m^3/ sec. Water temperatures ranged from 5 to 23 º C during this study. We never witnessed any sudden fluctuations in water temperature or cessation of flow, even during the drought conditions in the summer of 2007. We agree with Burr and Warren (1986) that considerable groundwater inputs must exist along most of Terrapin Creek. Flood events, however, were somewhat frequent and were characterized by very rapid rises and falls in water levels (Figures 4 and 5). This is almost certainly a result of past channelization efforts and the likely cause of overall low habitat assessment scores.

Microhabitat

Microhabitat variables were recorded for Blacktail Redhorse that were captured in this study. Following early development (the first two months of life) Blacktail Redhorse could be found consistently along stream margins as opposed to mid-channel locations. Because of this difference in habitat use the principal components analysis revealed no specific habitat requirements for juvenile redhorse. Partial least squares regression and principal components analysis revealed strong habitat preferences of adults for pool environments with large woody debris (e.g., log jams or clumps of large woody debris as defined by Brooks et al. 2003) and adequate depth (Figures 19 and 20). Blacktail Redhorse, especially adults, were particular in preference of habitat. With the exception of adult male Blacktail Redhorse, which occupy riffle and run areas in spring prior to the spawning period, all adult redhorse in this study were captured in calm pool habitats with ample woody cover (Figure 21). Results of partial least squares analysis ($F = 14.99$, $p = 0.007$) revealed positively correlated habitat variables affecting abundance of Blacktail Redhorse. The most highly ranked habitat variables included amount of detritus, depth, log jams, canopy cover, undercut bank, and location of habitat along stream margins. Increases in velocity were negatively correlated with overall numbers of redhorse captured. Velocity explained 41.2% of the variance among predictors. These patterns were also evident using principal components analysis (Figure 20). Juvenile and young-of-the-year redhorse were encountered in a variety of habitats but most often near some kind of small aggregation of woody debris (i.e., clumps *sensu* Brooks et al. 2003). They were generally located in fairly shallow (0.20 – 0.60 m) runs with sandy bottoms and moderate flows relative to Terrapin Creek (0.08 – 0.12 m/sec). These clumps were either mid-channel or along the stream margin, most often along stream margins adjacent to current.

Discussion/Management Reccomendations

The biology of the Blacktail Redhorse is similar to that described for other species of *Moxostoma*. As considered here, the species is a benthic trophic generalist, consistent with other species of Redhorse that feed on detritus and the chironomid inhabitants typical of pool environments where organic matter accumulates. The importance of such fish in stream ecosystem function has been poorly studied, but that should not undermine the significance of these organisms. Redhorses, including the Blacktail Redhorse, utilize organic allochthonous stream inputs readily and such material made up the majority of the diet of redhorse in this study; they also, however, ingest significant quantities of aquatic invertebrates and therefore represent a unique trophic position. Their trophic behavior not only helps recycle coarse and fine particulate organic material as a primary consumer, but also as a secondary consumer ingesting significant quantities and diversity of aquatic macroinvertebrates (though chironomid larvae made up the largest quantity of insects ingested). This is especially important if one considers that suckers usually make up the majority of fish biomass in aquatic systems (Jenkins and Burkhead 1993). River Redhorse, *Moxostoma carinatum*, may be an exception to this, and are specialized feeders on mollusks (Tatum and Hackney 1969) and the species of western suckers (genus *Catostomus*) found in the large rivers of the southwest are primarily invertebrate feeders

(Dauble 1986). Power et al. (1996) defined a keystone species as "a species whose impact on its community or ecosystem is large, and disproportionately large relative to its abundance." Whether or not the Blacktail Redhorse is a keystone species is not understood, but considering its overall large size, low abundance in comparison to other species of fish commonly encountered in Terrapin Creek, and the unique trophic guild it occupies, it could be speculated that it is an important component to nutrient cycling in this watershed.

Blacktail Redhorse are not a long-lived species in comparison to others in the family. Specimens examined during this study indicate a maximum age of 7 years. Scoppettone (1988) found western species of suckers lived as long as 43 years (*e,g,, Deltistes luxatus*) and most lived between 15 to 30 years. Blacktail Redhorse longevity is similar to other small suckers such as Golden Redhorse, *Moxostoma erythrurum*, which lived a maximum of 8 years (Meyer 1962) and the Blackfin Sucker, *Thoburnia atripinnis* (Timmons et al. 1983), which did not exceed 5 years of age. Growth rates of Blacktail Redhorse in Terrapin Creek were somewhat slower than that calculated for other species of redhorse and was much slower than what Kilken (1974) reported in pond-reared individuals; he found that young-of-the-year Blacktail Redhorse reached 186 mm TL in 6 months. Blacktail Redhorse only reached 88 mm TL in their first year of life in Terrapin Creek. A tagged female individual (tag 30) grew only 11 mm (from 283 mm SL to 294 mm SL) after being recaptured nearly a year later.

Before the onset of this study it was not known if Terrapin Creek sustained a reproducing population of Blacktail Redhorse, and the downstream North Fork Obion River, Tennessee, was regarded as the closest reproducing population (Burr and Carney 1984; Burr and Warren 1986). It is now clear that Terrapin Creek does have a reproducing population of Blacktail Redhorse, but we note that no adult individuals were found after October and none before March. It is therefore likely that adults use this system only seasonally as a breeding area. Page and Johnston (1990) and Curry and Spacie (1984) both summarized reproductive behaviors of catostomids and described migrations into smaller stream systems where reproduction takes place. Burr and Morris (1977) described similar spawning migrations of Shorthead Redhorse, *Moxostoma macrolepidotum*, into a tributary of the Fox River in northeastern Illinois. Werner (1979) hypothesized that White Suckers, *Catostomus commersonii*, home to their natal spawning streams primarily on the basis of olfactory cues. However, Bowman (1970) reported no site fidelity to any specific spawning shoal. We recaptured a tagged female a year later from the exact location where she was caught the previous year. This female had recently completed spawning when first caught and was found to have just completed spawning at the time of recapture (through examination of the gonads). Perhaps there is some fidelity to spawning shoals in the Terrapin Creek population of Blacktail Redhorse.

There were differences in seasonal abundance of Blacktail Redhorse in Terrapin Creek. Young-of-the-year fish were nearly always present but adults appeared to be seasonal. Adult Blacktail Redhorse first appeared in March with an onset of males that occupied large woody debris adjacent to flowing waters of runs and riffles. Female redhorse began to appear by the end of March and occupied pool habitats with low flows and usually were found in the deepest water relative to available habitats. The mark – recapture efforts revealed site fidelity (Table 5) with the majority of recaptured specimens coming from the same habitats within the same pools from where they were initially encountered. Curry and Spacie (1984) suggested that Golden Redhorse found within the same stream could actually represent two distinct populations, one that is resident and one that is migratory. The Terrapin Creek population could be a similar case; we only recaptured a few individuals several times, but did not recapture any other individuals that were also captured with tagged individuals from the same location within a pool. The lack of Blacktail Redhorse in winter samples could be the result of sampling bias because the deepest pools were inaccessible because of depth (> 1.3 m), and the large and complex amounts of woody debris, most notably log jams, which prevented the use of effective use of seines and electrofishing gear. Considering the overall amount of effort given to capturing Blacktail Redhorse in Terrapin Creek through all seasons indicates that the adults are, in reality, a transient population that uses Terrapin Creek for spawning and a summer refuge for females following the spawn.

The preferred habitat of adult Blacktail Redhorse is similar to that described for other species of redhorse. They are inhabitants of pools with woody debris temporarily occupying shoals/riffles for spawning or moving upstream. The importance of large woody debris in streams cannot be understated. Debris dams are critically important in the retention of organic materials in stream systems (Jones and Smock 1991) and this organic material is essential for secondary production of invertebrates and therefore the fish that feed upon both detritus and macroinvertebrates. These debris dams, most notably log jams, not only are important in nutrient cycling through trophic levels but also increase habitat heterogeneity (Smock et al. 1989) in low gradient streams such as Terrapin Creek. Nearly every pool that contained redhorse was immediately downstream from a log jam or several large clumps of woody debris. These pools were formed from the scouring action of water flowing through and over these obstructions. All undercut banks where redhorse occurred were also immediately downstream from large woody debris. Woody debris also helps reduce the energy of flowing water, and this is especially important in Terrapin Creek where channelization is quite evident. We consider the effects of channelization as still having a negative impact on the overall health of this system with continued increases in sedimentation, stream bed instability, headcutting in the upstream reaches (especially above County Road 1485), downcutting, and bank sloughing. Erosional stages have been classified by Schumm et al. (1984) who developed a five stage classification for stream reaches that had undergone headward erosion. With stage I being the natural stream channel prior to headcutting and ending with stage V where the stream is again meandering on a new floodplain that may be significantly lower in elevation than the old one that is now a terrace (Ross 2001). We suggest that Terrapin Creek is in stage III due to some bank failures and loss of riparian vegetation into the stream as erosional processes continue. In order to insure the continued existence of Blacktail Redhorse in Terrapin Creek it is our judgement that large woody debris is essential in creating the heterogeneity of habitat needed for this species, especially the presence of shoal areas critical for spawning and pool habitats that allow the species to recover from the stressors of migration and spawning. Not only does woody debris favor the Blacktail Redhorse but also other species of fish found in Terrapin Creek.

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Effects of Orientation and Weatherproofing on the Detection of Echolocation Calls in the Eastern United States

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Deployed Anabat units / Brooke Slack

Introduction

Acoustic monitoring of bat echolocation calls has allowed us to greatly expand our knowledge of bat ecology. Ultrasonic detectors permit non-obtrusive sampling of the bat community and can be used to sample bats in habitats that can not be sampled using traditional capture techniques (e.g., open fields, large rivers). Additionally, bat detectors can detect more species at a site than capture techniques, although the use of both techniques maximizes detection of all species (Murray et al. 1999, O'Farrell and Gannon 1999). Further, some ultrasonic detectors can be deployed to passively record the echolocation calls of bats without an observer present, thereby allowing a small crew to sample multiple sites simultaneously and for long periods of time (e.g., Gorresen et al. 2008).

The Anabat II (Titley Electronics, Ballina, New South Wales, Australia) is an ultrasonic detection system that is widely used for the study of bats. While the system allows for long periods of automated recording, the equipment is susceptible to damage from rain or high humidity. To protect the equipment, researchers have developed 2 types of weatherproofing. The first protective measure was placement of a detector in a polyvinyl chloride (PVC) tube in a waterproof box where the echolocation calls of bats enter the PVC tube and are transferred to the microphone, while the water drains out through small holes in the bottom of the tube (O'Farrell 1998). The second system is comprised of the microphone enclosed in a PVC tube pointed down at an acrylic-glass plate used for call deflection (BatHat; Arnett et al. 2006). We are not aware of any published data that has tested the effectiveness of the 2 weatherproofing options, despite the importance of the potential impacts on the results and subsequent interpretation of the data.

The ability to detect echolocation calls of bats can also be affected by the orientation angle of the detector (Weller and Zabel 2002). Depending on the height of the detector, detector orientation can significantly affect the number of bat detections. Although the orientation is relatively fixed at 45° from horizontal for the 2 weatherproofing methods, without weatherproofing the researcher can use any orientation between 0° and 90°.

While the Anabat II system has the potential to collect vast amounts of data, it is unknown to what extent detector orientation or weatherproofing affects detectability of bat calls. Acoustic sampling is often used to survey areas for species presence, including endangered species. For example, in Kentucky, the U.S. Fish & Wildlife Service Kentucky Field Office and the Kentucky Department of Fish & Wildlife Resources require Anabat II systems in survey efforts for the federally endangered Indiana bat (*Myotis sodalis*). Thus, it is critical to know the effects of weatherproofing and detector orientation on the number and quality of bat echolocation calls. The objective of this study was to determine how detector orientation and weatherproofing affect the quantity and quality of bat calls recorded.

Methods

We used Anabat II detectors connected to a CF storage ZCAIM as well as the SD1 units (Titley Scientific; www.titley.com.au). Before sampling, systems were calibrated following methods used by Larson and Hayes (2000). At each sampling site, 5 Anabat II systems were deployed side by side on tripods at 1.5 m. Each detector was randomly assigned to an orientation or weatherproofing treatment. The order of the treatments at each site was randomly determined. The detector orientations were 0° (horizontal), 45°, and 90°(vertical) and the 2 weatherproofing types were the PVC tube and the BatHat (EME Systems Inc., www.emesystems.com).

Detectors were set up before dark and calls were recorded for the entire night. The following morning, units were picked up and data were uploaded to a laptop computer using the CFCread program (www.hoarybat.com). Data from each unit were scanned with a customized filter in Analook Version 4.9j to delete extraneous noise (Britzke 2003). We used the scanFiles option in Analook to determine the number of files and the Countscan option to calculate the total number of pulses for each sequence. We then used a customized filter (modified from Britzke and Murray 2000) to extract parameters for species identification. The parameters were identified using a mixed DFA model in the statistical program R (v. 2.2.1; http://www.r-project.org; Duchamp 2006). The total number of files, average number of pulses, and the percentage surviving the identification filter were compared among 5 weatherproofing and orientation treatments using a randomized block ANOVA. Treatments were then compared using a Tukey test. Average species richness was compared using a Median test.

Results

A total of 17 sites were surveyed in which sampling equipment functioned properly for all 5 treatments. The mean number of files recorded per night varied by treatment ($F = 4.02$; $P = 0.006$). The mean number of files recorded per night by the BatHat was significantly lower than all other treatments; the units with the PVC protection recorded the highest number of files per night (Fig. 2a). The average number of pulses per file varied among treatment ($F = 8.02$; $p < 0.001$) and the BatHat had fewer pulses per file than all other treatments (Fig. 2b). The percentage of files that passed through the ID filter were significantly different among treatments ($F = 15.37$; $P < 0.001$) with the BatHat recording calls of lower quality than the other treatments (Fig. 2c).

A total of 6 species were detected: big brown bats (*Eptesicus fuscus*), red bats (*Lasiurus borealis*), hoary bats (*L. cinereus*), Indiana bats, little brown bats (*M. lucifugus*), and tri-colored bats (*Perimyotis subflavus*). Red bats and big browns were found at the most sites. Species richness varied significantly among treatments ($P = 0.003$) and the number of species recorded with the BatHat was approximately ½ that of the other detectors (Fig. 3). Detectors oriented in the horizontal position also recorded fewer species than the PVC and 45°and 90° orientations (Fig. 3). In general, the pattern of higher detections by the PVC and 45°and 90° orientations held for each of the species although northern long-eared bats were only picked up by the vertical detectors and Indiana bats were not as readily detected by the detectors with PVC or BatHats (Fig. 4).

Discussion

Significant differences among the treatment groups suggest that weatherproofing and detector orientation may have important impacts on the detection of the echolocation calls of bats. In particular, our data suggest that studies employing the BatHat system may detect lower activity and species richness than are present at a site. If researchers are simply interested in relative activity levels among sites, any weatherproofing or orientation is acceptable as long as detectors are deployed in a similar way among all sites. However, problems may arise if researchers want to conduct species identification or compare their results to studies where another weatherproofing design or orientation was used. Future studies using passive sampling with the Anabat system should include discussion of the method of deployment and the potential impacts of those methods on the results.

We measured a variety of parameters in this study to test the effects of orientation and weatherproofing. The total number of call sequences or files is often used as a measure of overall activity (e.g., Hayes 1997). The number of pulses per sequence provides a measure of the intensity of activity (Gorrensen et al. 2008). The percentage of calls surviving the identification filter is a measure of the quality of the recordings. Factors affecting the detection, quality, or length of sequences all have large impacts on the results of studies using Anabat detectors or other acoustic sampling equipment. The consistent pattern of differences across all parameters suggests that the differences among treatments are indeed real. However, the only significant differences occurred between the BatHat and the other methods. Thus, use of the BatHat should be avoided in future studies.

Weller and Zabel (2002) found no difference between detectors oriented at 30° or 45° if they were on 1.4 m high stands. However, we found that although not significant, the horizontal deployment tended to record lower activity levels (number of files) and species richness than the other orientations. However, the appropriate orientation may depend on the question of interest. If a researcher is interested in recording bats that forage near the water surface such as gray bats (*M. grisescens*), horizontal deployment is typically better than other orientations. Therefore, researchers should try to use the orientation that maximizes detections of the species of interest.

A total of 6 species were detected across the 5 treatments, but no treatment detected all 6 species. The PVC, 45°, and vertical (90°) treatments consistently recorded almost twice as many species as the BatHat. Further, the number of species recorded by detectors in the horizontal position tended to be lower than the detectors at 45°and 90° even though the number of calls recorded by detectors in the horizontal orientation was just slightly below the number of calls recorded by detectors in the vertical (90°) position, Thus, if the BatHat or horizontal orientations are used, researchers should deploy additional equipment to gain a more accurate representation of species present (Duchamp et al. 2006).

When conducting surveys for bats, such as the Indiana bat, multiple sampling sites may be required due to project size. Many detectors are often set throughout the project area to record simultaneously. Similarly, studies designed to test the effects of habitat type or management activities on bat habitat use and activity often set detectors simultaneously in each habitat type or treatment to control for the effects of temporal variation on activity (e.g., Loeb and Waldrop 2008). These situations require the use of weatherproofing equipment because detectors are widely scattered across the landscape and sudden storms are possible. Our results suggest that detections obtained from detectors at two common orientations without weatherproofing (45° and 90°) are similar to those from detectors with the PVC weatherproofing. Thus, data can be easily compared across studies that use any one of these methods. Our results also suggest that if weatherproofing is used, that the PVC method be used instead of the BatHat. The detection cone for the BatHat seems to be more directional than the PVC weatherproofing and detectors without weatherproofing (personal observation). Thus the performance of the BatHats may be improved if the detectors are deployed in the direction of the most bat activity (e.g., parallel to stream flow). Whatever weatherproofing method that is used (none, PVC, or BatHat), the implications of that choice on the results should be considered.

Management Implications

Ultrasonic detectors are commonly used to study bat ecology. Results from these studies are often used to infer habitat use of bats and management decisions are then based on these conclusions. Our results suggest that microphone orientation and the presence of weatherproofing may impact the results obtained from these studies. Knowledge of differences among orientations and weatherproofing designs can assist management efforts by maximizing the quality of data obtained through studies involving acoustic surveys, thereby improving the impacts of management activities on bats.

Acknowledgements

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Funding Source: *State and Tribal Wildlife Grant (SWG)*

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

Identifying and Protecting Hibernation Roosts for Endangered Bats in Kentucky

Jim Kennedy, Bat Conservation International
KDFWR Contact: *Brooke Slack*

Introduction

Bat Conservation International (BCI) has long been a proponent for habitat protection, especially of caves that are important to hibernating bats such as the critically Endangered Indiana myotis. However, many caves historically used by bats are no longer available due to poor management, including unrestricted visitation during critical periods, physical alterations from guano or saltpeter mining, commercialization for show caves, and restriction or closure of entrances due to erosion, trash dumping, and purposeful filling to prevent entry (Humphrey 1978). These caves are not currently considered "bat caves" and are not managed as such, but if even a small number are identified and properly managed (including microclimate restoration, if necessary), it will increase the number of available roosts dramatically, allowing populations to increase (Tuttle and Kennedy 2002). One of our strategies in this regard is to locate these "overlooked" bat caves, prioritize their historic importance, and work with landowners and management agencies to correct problems and improve management to better protect current colonies and allow bats to re-establish historic roosts. There are numerous examples of bat colonies increasing when management is improved, and of bats re-colonizing formerly abandoned roosts (Humphrey 1978, Tuttle and Kennedy 2002). Given the potential for undiscovered, overlooked, and currently altered caves to provide increased hibernacula and roosting sites for bats of 11 species in KY, BCI conducted this study in order to benefit natural resource managers in Kentucky and the bats and habitats that they manage. In order to explicitly address "Prioritized Research Projects #1 and #5 and Survey Project #1" as found in Appendix 3.2, Class Mammalia of the Kentucky Wildlife Action Plan (Kentucky's Comprehensive Wildlife Conservation Strategy 2005), BCI undertook the project detailed herein under the leadership of Cave Resources Specialist and Principle Investigator Jim Kennedy.

Funding for this research was generously provided through a State and Tribal Wildlife Grant administered by the Kentucky Department of Fish and Wildlife Resources (KDFWR).

Methods and Materials

Objective 1: Identify and assess previously overlooked hibernation roosts and develop management and restoration recommendations for the highest priority sites.

To accomplish our research goals, we started with a pool of all caves in the area, from which we derived a target list of caves most likely to be hibernacula, based on the cave maps and/or descriptions. Our selection criteria included length and size of the cave; configuration of passages and entrance(s); proximity to other known *M. sodalis* sites; bats, guano, roost stains, or saltpeter mining indicated on the map or description; and input from other knowledge-

Indiana Bat cluster / Traci Hemberger

able cavers in the area. Caves were then field-checked for suitability and to record important baseline data. Ownership was determined when possible, and permission secured. Contact information for thelandowner or their agent was obtained. At each site the field crew met with landowners to secure permission, and provide initial education about the purpose of the study and the importance of hibernation caves. Location information was recorded for each site visited, including time-averaged GPS data. Information about each entrance was documented, including size, shape, aspect, vegetative cover, recent alterations (enlargements or restrictions), amount of human disturbance, and any other important factors. Inside the cave the field crew documented locations, numbers, and species of any T&E or other bat species, as well as locations and size of bat sign, including roost stains, guano deposits, and accumulations of bat bones. Past bat populations were estimated based on measurements of wall and ceiling staining left by roosting bats, and/or guano deposits. Passage dimensions and environmental parameters as temperature, humidity, airflow, and presence of streams or pools were recorded. All roost sites were photo-documented, as were other important elements such as signs of vandalism and other (non-bat) biological observations. No bats were handled during these assessments. All work was accomplished by Jim Kennedy, Cave Resources Specialist at BCI, or by cavers and volunteers trained by him. A large portion of the work was performed by John Chenger and his team from Bat Conservation and Management (*www.batmanagement.com*). Chris Clark from the American Cave Conservation Association was instrumental in providing landowner contact information and assisting with data recording in the field. Other personnel participating in this study were Thor Bahrman, Kristi Lindberg, Kevin Rhome, Kyle Ryan, Anna Scesny, Rose Sisler, and Bill Walden. Maps and other cave data were provided courtesy of Louisville Grotto (Kentucky Speleofest guidebooks), Kentucky Speleological Survey, and American Cave Conservation Association.

Objective 2: Train cavers, biologists and land managers in hibernation cave recognition and documentation techniques, identifying threats to roosts and developing solutions.

BCI used a formal presentation to a large group of cavers and landowners and provided over 200 copies of the *Field Guide to Eastern Cave Bats* to current and future natural resources and land managers. More intensive cave assessment training was provided by BCI to more than 15 other individuals who were then dispatched to the field to practice these skills (see Objective 1).

Objective 3: Continue restoration work on Saltpeter Cave in Carter County, a high priority site.

BCI continued step-wise restoration efforts at Saltpeter Cave, Carter County, KY through initiating efforts to re-open a sinkhole above the northwest passage of the cave. Using results of a geo-probing study conducted last fall, BCI coordinated planning and assessment of the proposed project and sought and received permission from the USFWS Kentucky Field Office to perform the restoration acts of removing recent fill material, installing a culvert, replacing clean fill to hold the culvert in place, and installing an adjustable gate to modify airflow as may be necessary.

Results

Objective 1: Identify and assess previously overlooked hibernation roosts and develop management and restoration recommendations for the highest priority sites.

Forty caves were visited during the field investigations. Thirty-four of these were identified on our target list, approximately one third of all the caves on the list for central and eastern Kentucky. Five caves were added opportunistically during field crew searches for target caves. The names of most of these opportunistic caves are currently unknown, but none were significant bat sites. Investigations were attempted at three additional caves, but permission was denied for one, another was never located despite several attempts, and the third was not entered due to reports from the owner of past flooding. During the 2007–2008 field season, 5 new sites were documented with Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), a state Species of Concern. One, in Wayne County, is a significant winter roost for the species, with 195 bats reported. Three new gray bat (*Myotis grisescens*) roosts were discovered, most likely summer bachelor colonies. Even more exciting was the discovery of a significant (Priority 2) Indiana bat (*Myotis sodalis*) hibernacula in Wayne County.

Objective 2: Train cavers, biologists and land managers in hibernation cave recognition and documentation techniques, identifying threats to roosts and developing solutions.

During the grant period we were able to provide a one-hour formal presentation on bat cave assessment and protection to more than 200 cavers and landowners during the 2008 Kentucky Speleofest. A key component of that training was the distribution of more than 200 copies of the *Field Guide to Eastern Cave Bats.* We also provided informal training to multiple landowners,volunteer cavers, and members of our own field crews.

Objective 3: Continue restoration work on Saltpeter Cave in Carter County, a high priority site.

At Saltpeter Cave, in Carter Caves State Resort Park, BCI has been making stepwise efforts in restoring alterations to the cave's microclimate caused by historic saltpeter mining and more recent commercialization. This past year we have been working with the Environmental Services Division of

Hinkle Engineering in Lexington, KY to develop a plan for excavating a filled sinkhole over the northwestern branch of the cave. This sink was formerly open to the surface, providing moister air to that passage in the summer and colder temperatures in the winter. Extensive roost staining indicates past use by at least 10s of thousands of bats, but the passage is currently too dry and unusable in its current condition. Later this summer Hinkle Enginerring and Bat Conservation International will remove recent fill and construction debris from the surface, hand-excavate the remaining fill connection into the cave, install a culvert to prevent soil loss into the cave, backfill and grade around the culvert, and secure access to the newly-opened entrance with an adjustable gate to modify airflow.

Discussion and Management Recommendations

Objective 1: Identify and assess previously overlooked hibernation roosts and develop management and restoration recommendations for the highest priority sites.

Many of the best *M. sodalis* and *C. rafinesquii* hibernation caves visited during this study occurred in or near the Eastern Coalfields province, a part of the Cumberland Plateau and Mountains physiographic region. This is unsurprising, since relief is greater and caves can be deeper, potentially trapping more cold air. Counties with the greatest potential for discovering new *M. sodalis* sites appear to be Clinton, Wayne, Pulaski, Rockcastle, and possibly Jackson and Estill. The more westward caves visited appear to have greater use by *M. grisescens*. These caves are located at lower elevations in the Pennyroyal region of the Mississippian Plateaus physiographic province. These include caves in Breckenridge, Hardin, Grayson, Hart, Warren, Barren, Metcalf, and Adair counties. Several caves that were visited were incompletely assessed due to the initial passages (entrance area) being too warm, when the layout of the cave dictated that those areas should be the coldest in the winter. There are many dozens of caves still to be checked that may be potential bat caves, or have been bat caves historically. It is obvious that our investigative approach – that of selecting target caves based on maps, descriptions, and recommendations from knowledgeable cavers – and then field checking those caves, will bring to light more important cave habitats that require better management. For most caves identified as important bat hibernacula, the next logical steps are to secure future management through a Cave Management Plan, Conservation Easement, or outright purchase, and restore altered microclimates when necessary or control winter access through proper cave gates (Kennedy 2004, 2006). Data collected in this study were analyzed to identify sites needing restoration or increased protection efforts. In cases where caves still possess suitable temperatures but are not currently used by bats, we recommend halting visitation of these caves during winter months to encourage re-colonization. Bat-friendly, zero-air-flow-modification gates may be recommended at sites with a strong history of local visitation and where simple signage would be ineffective. Often, caves that have been known as historical bat caves have been modified by humans such that they become unsuitable for hibernation. In these cases restoration to conditions favorable for bat re-colonization often requires physical modification. Such actions may involve a variety of actions including entrance restoration (enlargement or restriction), air dams (in-cave or at the surface), reopening closed entrances, closing artificial entrances, removal of obstructions (buildings over entrances, walls, poorly-designed gates, trash, rock, etc.). During the time frame of this project, BCI has assessed the past bat use and restoration potential of less than 1% of the known caves in Kentucky. These data resulting from these efforts can now be used by state and federal agencies to help guide future efforts to increase the amount of available habitat for hibernating bats in Kentucky through site protection and restoration work, ultimately helping populations of endangered Indiana myotis to recover.

Cave gate / Traci Hemberger


Bobcat / Adam Jones

Project Highlights

Analysis of the Environmental Requirements for *Etheostoma cinereum* and *Percina squamata* in the Rockcastle River

Michael C. Compton and Christopher M. Taylor, Texas Tech University
***KDFWR Contact**: Ryan Oster*

Rockcastle River / Michael Compton

The integrity of rivers and the persistence of aquatic life are under constant pressure from agricultural practices, urban sprawl, road development, deforestation, and mining activities. The effects of these disturbances upon the landscape have a direct and indirect impact on the aquatic biota and their environment. The Rockcastle River is no exception to these threats and is of immense concern given that it has an exceptionally high aquatic biodiversity and contains numerous unique species to Kentucky. Two species, the ashy darter and the olive darter, are of particular interest given their presence within the Rockcastle River watershed and their overall rarity in the commonwealth.

Historically the ashy and olive darters inhabited numerous stream systems within the Cumberland and Tennessee River drainages among six southeastern states, but their distribution has become fragmented over time and their populations have declined. Although various aspects of life history are known for both species, many aspects are not fully understood, such as habitat preferences, tolerance to impacts, or a current conservation status. In Kentucky, the Rockcastle River contains the best populations of the two species; therefore, the watershed provides an excellent setting to model habitat preferences and environmental conditions for the target species. Multiple regression models will be developed based on presence-absence data of the two species within 30 stream reaches of the Rockcastle River. Data will be collected during the summer months of 2008-2010 to determine what stream reaches within the Rockcastle river watershed are inhabited by the species, and within those stream reaches, what microhabitats are used by the species. In addition, fish community data will be collected to determine the overall health of the watershed and to determine if any species association exist between the ashy and olive darters and any other species within the river.

Collecting efforts in 2008 yielded no ashy darter or olive darter individuals from eleven 3rd order reaches surveyed within the Rockcastle watershed. However, three stream reaches within the 4th and 5th order portions of the Rockcastle River yielded nearly 30 ashy darter individuals, in addition, 3 Olive darter individuals were collected from two of the five stream reaches sampled. Currently no associations between darter presence and habitat have been made. The importance of the data is to ultimately identify and model the environmental conditions and habitat preferences of the species, which will provide KDFWR the needed information to ensure the species existence within the Rockcastle River but also to enhance conservation efforts in other watersheds that contain or historically have contained ashy and olive darters.

Funding Source: *State and Tribal Wildlife Grants (SWG)*

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

Captive Propagation and Reintroduction of Cumberland Darter and Kentucky Arrow Darter in Southeastern Kentucky

Conservation Fisheries, Inc., Knoxville, TN
KDFWR Contact: *Ryan Oster*

Captive propagation and reintroduction are considered appropriate tools for the recovery and delisting of threatened and endangered fishes and to prevent declining species from being added to the federal List of Endangered or Threatened Wildlife. The Cumberland Darter (*Etheostoma susanae*) and Kentucky Arrow Darter (*Etheostoma sagitta spilotum*) are two small native fishes with naturally limited ranges in Kentucky. A proposed rule is currently in review to federally list the Cumberland Darter as endangered, because of recent range curtailment and fragmentation resulting from habitat degradation. The Cumberland Darter is currently limited to six streams in the Cumberland River drainage above Cumberland Falls. A recent status assessment of the Kentucky Arrow Darter in the upper Kentucky River basin has shown that populations have declined considerably during the past two decades, having become extirpated from many streams where they were known to occur historically. Conservation Fisheries, Inc. (CFI), in cooperation with KDFWR has begun developing spawning protocols for both species in a controlled setting to produce offspring that can be used to re-establish extirpated populations. Brood stock for each species were collected during winter 2008, and are currently being held at the CFI facility in Knoxville, where captive breeding will occur in spring 2009. Methods for egg and larval collections and rearing will be applied and developed specifically for each species, based on taxonomic relationships and prior experience with other species at CFI.

Kentucky Arrow Darter / J.R. Shute

Cumberland Darter / Matt Thomas

Offspring produced in captivity will be released into carefully chosen streams where suitable habitat exists and that lie within the historic range of each species. Reintroduction is anticipated either in late summer or fall 2009 or in 2010, depending on the number of offspring produced and rate of growth. Following reintroduction, survivability and movement patterns will be assessed through mark-recapture methods and through periodic monitoring using non-invasive methods, including visual census techniques such as snorkeling. Depending on age and time of release, stocked fish may be tagged with Visible Elastomer Implant (VIE) fluorescent marks. Use of different tag positions and colors permits future determination of age and potential dispersal information for recaptures.

Funding Source: *State and Tribal Wildlife Grants (SWG)*

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

A Survey of Fishes of Rock Creek, Kentucky, with Emphasis on the Impact of Stocking Rainbow Trout on Native Fishes

Stephanie Brandt and Sherry Harrel, Department of Biological Sciences, Eastern Kentucky University, Matt Thomas, Kentucky Department of Fish and Wildlife Resources

Rock Creek, located in McCreary County, Kentucky, is a tributary to the Big South Fork Cumberland River. The stream spans twenty-one miles, with its origin in Pickett County, Tennessee. The lower section from White Oak Creek to its confluence with the Big South Fork has been impacted by acid mine drainage, but reclamation efforts have been ongoing. Rock Creek supports a federally endangered fish species, blackside dace, as well as five species of greatest conservation need (SGCN) in Kentucky: sawfin shiner, emerald darter, ashy darter, bloodfin darter, and mountain brook lamprey. Since the early 1960's, the Kentucky Department of Fish and Wildlife Resources has stocked Rock Creek annually, at multiple sites, beginning at the junction of White Oak Creek upstream to the Kentucky/Tennessee state line with catchable-size (9-10 inch TL) rainbow trout (*Oncorhynchus mykiss*). Stockings occur once per month from March-June and from September-December. Habitat destruction as well as predation may be negatively impacting SGCN. Research has shown that predation by stocked rainbow trout can influence intrastream (habitat) and interstream (geographic) distributions of small native fishes. However, interactions between stocked rainbow trout and SGCN and whether they may be influencing the distribution of SGCN in Rock Creek are unknown.

The purpose of this study was to document present distributions, relative abundance and habitat use of fishes in Rock Creek, with emphasis on SGCN. In addition, we determined distribution and habitat use of stocked rainbow trout in relation to SGCN and examined their gut contents for the presence/absence of SGCN. Sites on Rock Creek were sampled on a seasonal basis from summer 2008 to spring 2009. All available habitats at each site were thoroughly sampled using a combination of seining and backpack electrofishing. Any trout collected were retained for gut contents analysis. Presence of SGCN in gut contents of trout would be interpreted as direct evidence of predation as a factor impacting these species.

Data analysis is ongoing, and thirty-five fish species have been collected throughout Rock Creek samples thus far. Two SGCN, sawfin shiner and emerald darter, were present, as well as blackside dace. The ashy darter and bloodfin darter were not collected. Although not collected in the present study, the mountain brook lamprey has been collected within the last three years in the upper section by other biologists. Sawfin shiners appear to be more common in the upper portion of Rock Creek and were not previously taken from below Hemlock Grove showing a downstream range extension of distribution. Emerald darters appear to be uncommon with only seven individuals found in the lower section of Rock Creek. Rainbow trout, sawfin shiners and emerald darters were collected together at two sites. Gut contents of two trout specimens included the remains of telescope shiners and barcheek darters, as well as aquatic insects. Preliminary observations suggest that fish species richness and abundance are comparable between the unimpacted and the reclaimed reaches of Rock Creek. Initial sampling has found no direct predation by trout on SGCN, but overlap in species distributions is cause for concern.

Etheostoma sanguifluum / Matt Thomas

Funding Source: *State and Tribal Wildlife Grants (SWG)*

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

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

Cavefish / Dante Fenolio

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

Nearly 1800 species of subterranean organisms are known in North America and many species remain undescribed. However, little is known about the distributions and limiting factors of many of these species. Over 95% of subterranean species in North America are considered vulnerable or imperiled, mainly because of habitat degradation and restricted geographic ranges. Unfortunately, data on the distribution and status of cave-obligate species are incomplete or lacking entirely, making conservation and management decisions difficult. Therefore, a need exists to document subterranean diversity and identify threats that impinge upon the continued survival of these species.

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

Surveys over the past year have focused in caves of Pulaski and Wayne Counties in the Upper Cumberland watershed where the Southern Cavefish is known from just a single cave in Pulaski County. With the assistance of several cavers and caving-affiliated groups, we have documented this species in four additional caves and collected numerous invertebrate samples that are being sent to taxonomic experts for identification. Moreover, preliminary genetic analyses indicate that these populations are distinct from others associated with the Cumberland Plateau in Tennessee and from populations in the Mammoth Cave region of central Kentucky. This research will provide KDFWR with important data regarding the status, distribution, life history, and genetics of these species. In addition, data acquired on other cave fauna can also be used when making conservation and management decisions.

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

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

Status Survey of the Northern Madtom, *Noturus stigmosus*, in the Lower Ohio River

Northern madtom / Matt Thomas

Donovan Henry and Lennie Pitcher, Three Rivers Environmental Assessments LLC
***KDFWR Contact**: Ryan Oster*

The Northern Madtom is a small, secretive inhabitant of large creeks and rivers where there are moderate to swift flows, and clean sand and gravel substrates. This species is listed as threatened, endangered, or of special concern in every state in which it occurs, and is disappearing from the margins of its range. In Kentucky, the Northern Madtom is listed as special concern by KDFWR's Comprehensive Wildlife Conservation Strategy, has a global rank of G3 (Vulnerable), and is considered a Species in Greatest Need of Conservation (SGNC). This species is sporadic and uncommon throughout its distribution, and occurs sporadically in the upper Kentucky, and Big Sandy, with isolated but apparently stable populations in the Licking and Salt Rivers of Kentucky. Furthermore, this species appears to be extirpated from the upper Green River in Kentucky. In the Ohio River there were only three records of this species before 1997. Since 1997, four collections of Northern Madtoms have been made on the lower Ohio River where it borders Kentucky. This population has likely been overlooked for many years due to difficulty sampling large, dynamic systems such as the Ohio River. More recent surveys have been conducted on eastern Kentucky populations, but the Ohio River population, which is on the western periphery of the species range, has not been investigated. This population may be at risk due to further habitat degradation by the construction of a new lock and dam near Olmsted, Illinois at river mile (RM) 964.4. To facilitate future management implications, a focused and thorough survey, geared specifically toward this benthic dwelling species, is needed to determine the conservation status of the Northern Madtom in the lower Ohio River along Kentucky shores.

To address this information need, we established a sampling protocol within five sections of the lower Ohio River between the upper end of Smithland Pool and the confluence of the Ohio and Mississippi Rivers. Beginnning in 2008, we began extensively sampling these sites to address the following objectives: 1) Determine the present distribution and abundance of the Northern Madtom in the lower Ohio River; 2) To determine why the recorded abundance of the Northern Madtom has been so diminutive in the Ohio River; 3) Identify habitats vital to the persistence of this species; 4) Identify potential threats to existing populations of the Northern Madtom; and 5) Recommend any additional effort required to ensure conservation of the species in Kentucky. In addition to field sampling, we also conduct habitat analysis, and collect field observations to address these goals. The information resulting form this project (on habitat use and resource requirements) will be useful for determining needs for conserving or enhancing this population, and will likely benefit other species of conservation need such as benthic dwelling invertebrates (e.g. unionid mussels, gastropods, macroinverterates, etc.).

Funding Sources: *State and Tribal Wildlife Grant (SWG), Three Rivers Environmental Assessments LLC, Illinois Endangered Species Protection Board*

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

Advances in the Propagation of Rare and Endangered Mussel Species

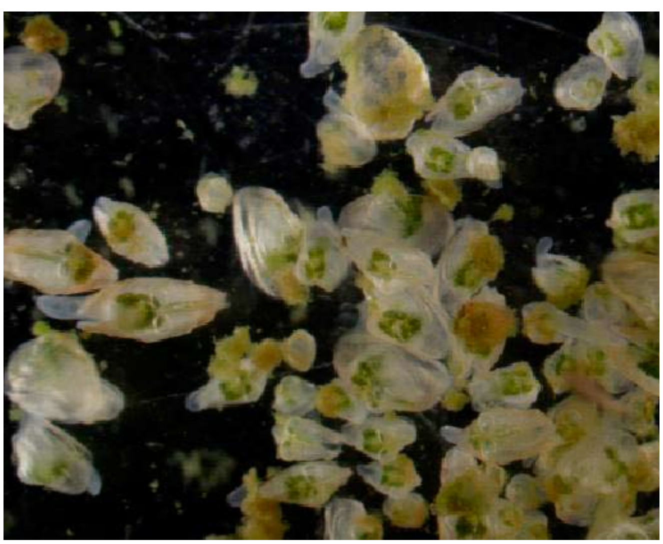
Center for Mollusk Conservation, Kentucky Department of Fish and Wildlife Resources Monte A. McGregor, Adam C. Shepard, Fritz Vorisek, J. Jacob Culp, Jim Hinkle, Andrew Wooldridge, Vaughn Kauffman

The Center for Mollusk Conservation made several advances on the propagation of mussels in 2008. Last year, we were able to propagate 5 new endangered or rare species. We developed several small aquaculture systems for use in research and propagation of juvenile mussels. Starter systems (nursery stage I) include air lift downwellers for early stage juveniles, mini-riffle systems (nursery stage II) for the next several months. The final nursery (stage III) consists of variable sized upwelling tanks that may be recirculating or open design. We have experimented with several species, including *Simponsias ambigua*, *Alasmidonta viridis*, *Lampsilis siliquoidea*, *L. cardium*, *L. abrupta* (endangered), *Epioblasma triquetra*, *E. capsaeformis* (endangered), and *Villosa trabilis* (endangered). Growth for most species has been up to 15-20mm in less than 9 months, regardless of time of year. The rare animals are surrogates for other federally endangered species such as the Littlewing Pearlymussel and the Northern Riffleshell. We have improved both survival and growth rates of mussels in captivity.

Juvenile mussels (2-10 months old) / Monte McGregor

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

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



Juvenile mussels (2-10 months old) / Monte McGregor

Upwelling growout tank / Monte McGregor

Successful Reintroduction of Two Endangered and Two Candidate Mussel Species to the Big South Fork Cumberland River, Kentucky

Center for Mollusk Conservation, Kentucky Department of Fish and Wildlife Resources Monte A. McGregor, Adam C. Shepard, Fritz Vorisek, J. Jacob Culp, Jim Hinkle, Andrew Wooldridge, Vaughn Kauffman

Big South Fork Cumberland River, Kentucky / Monte McGregor

In June 2008, The Kentucky Department of Fish and Wildlife collaborated with The National Park Service (Big South Fork), United States Fish and Wildlife Service, Tennessee Wildlife Resources Agency, and the United States Geological Survey to reintroduce two federally endangered mussels and two mussels that are candidates for federal listing into the Big South Fork Cumberland River. The four species released were the oystermussel (FE), the dromedary pearlymussel (FE), spectaclecase (candidate species), and the fluted kidneyshell (candidate species); all are likely to be extirpated from the Big South Fork. Individuals from all four species were collected from the Clinch River, TN. After mussels were collected, they were tagged and held at the Center for Mollusk Conservation in Frankfort, KY. On June 9 2008, we released approximately 300 individuals: 97 oystermussel, 19 dromedary pearlymussel, 43 spectaclecase, and 142 fluted kidneyshell. Before the release, quantitative sampling was done in the area where the mussels were to be released. We found 12 species present in low densities. None of the species being reintroduced were found. After the survey was completed, we selected a 6 m x 12 m grid to release the mussels. To facilitate the release in known areas of exact densities, 8 sections (each 3 m x 3 m) were selected and a known number of mussels were released in each section. The spectaclecase, which is generally found under large rocks, were released outside the grid in habitat that was more suitable for the species. Three days after the release, mussels could be seen at the surface siphoning and displaying fish host lures.

In September 2008, we went back to the site to monitor the reintroduced mussels. We completed another quantitative survey that included the entire 6 m x 12 m release grid, with an additional several meters surrounding the grid. This allowed us to encounter mussels that may have moved outside of the release grid. Because we released all mussels in a known area, and we recorded tag numbers in all 8 sections, we could track movement of the released mussels. All species released in the grid were located during quantitative sampling, and on average the mussels did not move from their original release area. We estimate that all except for 2 tagged mussels moved less than 3 meters. This site will continue to be monitored semi-annually to examine survival and reproduction of all released species, as well as changes in the entire mussel community at the release site.

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

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

Successful Augmentation of the Fatmucket, *Lampsilis siliquoidea*, in Elkhorn Creek, Kentucky

Center for Mollusk Conservation, Kentucky Department of Fish and Wildlife Resources Monte A. McGregor, Adam C. Shepard, Fritz Vorisek, J. Jacob Culp, Jim Hinkle, Andrew Wooldridge, Vaughn Kauffman

In August 2007 the Kentucky Department of Fish and Wildlife released 100 individuals of the Fatmucket in Elkhorn Creek, KY. Released individuals were propagated at the Center for Mollusk Conservation for approximately 1.5 years. The mean length at release was 20.83 mm. Before the augmentation a quantitative survey was completed and 9 species were found in low densities, including the Fatmucket. Only two individuals of the Fatmucket were found in initial survey. A 5 m x 5 m release area was chosen based on habitat stability and mussel density. All individuals were released in the area and allowed to bury into the substrate.

Approximately one year later, in September of 2008, another quantitative survey was done to monitor the released individuals and evaluate the augmentation. We surveyed a concentrated area surrounding the release site and again found 9 species, this time with higher densities. We also found 12 of the released Fatmuckets. Their mean length after one year in the wild was 47.62 mm (an increase of 129% from the initial release size). No released Fatmuckets were found gravid (too young), but we will continue to monitor this site semi-annually to examine growth, survival, and reproduction, as well as changes in the entire mussel community at the release site.

Post-release tagged fatmuckets collected from Elkhorn Creek, Kentucky / Monte McGregor

Pre-release tagged fatmuckets in 2007 / Monte McGregor

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

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

Freshwater Mollusk Monitoring in the South Fork Kentucky River System

Redbird River, quantitative sampling site / Ryan Evans

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

This project is focused on identifying the best remaining freshwater mussel hotspots in the South Fork Kentucky River watershed. In addition, basic inventory is being done for freshwater snails as recent information on the group is generally lacking within the basin.

In 2008, 28 sites were qualitatively sampled in the basin, with 1 site quantitatively sampled. The project to date has located 16 species of freshwater mussels, including records for the round hickorynut (*Obovaria subrotunda*), a species of conservation need in Kentucky as well as the little spectaclecase, *Villosa lienosa*. KSNPC is still compiling information and identifying freshwater snail specimens but field data indicates no KSNPC-listed species have been located to this point. We have generated a sampling grid for the South Fork Kentucky River and have been doing reconnaissance of potential field sites. We will be sampling approximately 29 stations on the mainstem South Fork Kentucky in the upcoming field season.

Preliminary observations indicate that the Redbird River is the best remaining tributary in the South Fork Kentucky River system for freshwater mollusks; however, this does not infer that this system is without threats. Strip mining has obviously taken a toll on the upper sites in the Redbird as no freshwater mussels were located despite intensive search effort. Further, our quantitative sampling data at one of the higher quality sites in the lower Redbird River identified during qualitative sampling indicates a low density mussel population with little recent recruitment. This information is troubling, as the Redbird Ranger District of the Daniel Boone National Forest (DBNF) is one of the most intensively utilized for gas and mineral extraction. Other tributaries showed moderate to serious sedimentation likely attributable to runoff from coal mining and poor agricultural practices.

KSNPC has been fortunate to have received intensive instream habitat mapping data collected by DBNF staff for the Redbird River. We hope to use this information to contrast against the mussel data in the system to help examine trends. Because the South Fork Kentucky River watershed is generally regarded as the best quality of the three forks of the Kentucky River, future projects to abate issues from sediment runoff and mining effluent should be considered.

Funding Source: *State and Tribal Wildlife Grants (SWG)*

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

Round hickorynut (Obovaria subrotunda) / Ryan Evans

Life History and Population Assessment of the Western Cottonmouth in Western Kentucky

Edward Zimmerer, Murray State University
KDFWR Contact: *John MacGregor*

The Western Cottonmouth (*Agkistrodon piscivorus leucostoma*) is a large venomous snake that occurs in the Western Kentucky Coal Field and the Mississippi Embayment regions of Kentucky (West of Ohio and Butler counties). Usually found in sloughs, sluggish streams, bayous, and other slow-moving water habitats, the Western Cottonmouth prefers areas that are at least partially wooded that contain emergent or aquatic vegetation. Although rangewide population trends for the cottonmouth are unknown, populations in Kentucky are thought to be declining, primarily due to the loss of high quality forested wetland habitat as a result of surface mining, conversion to cropland, and urban/suburban development. As a result of the perceived population decline of the Western Cottonmouth in Kentucky, this species is listed as a Species of Greatest Conservation Need in Kentucky's Wildlife Action Plan. Until recently, major hibernacula and locations of high-density populations of this taxon were unknown in Kentucky.

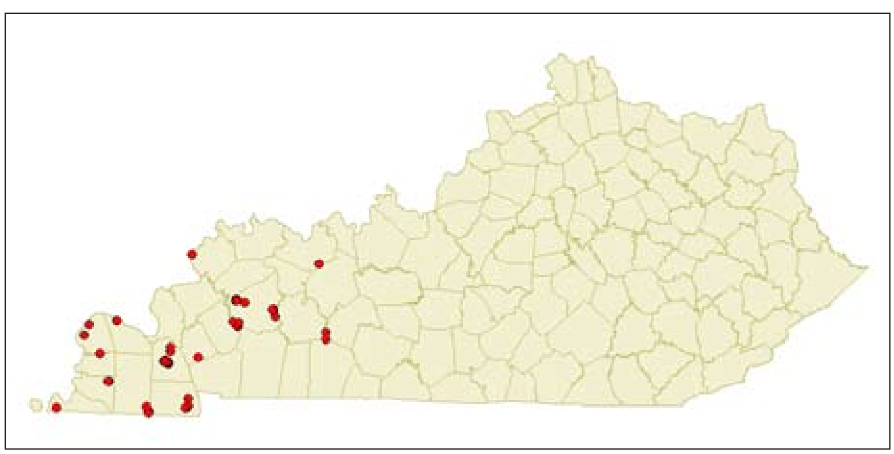
Beginning in 2008, Murray State University began monitoring the healthiest known cottonmouth population within Kentucky. At this site, drift fence arrays are used to capture and monitor cottonmouths moving from winter hibernacula to their spring and summer foraging areas. To date 1,619 cottonmouths have been captured at the site of interest, which is the only known area in Kentucky where these snakes are concentrated at such high densities. Of these 1,619 snakes, 439 have been marked with a Passive Integrated Transponder (or PIT tag) containing a unique electronic identification number, so that these individuals can be identified in subsequent years. By marking these snakes with PIT tags, growth rates, survivorship, age-specific mortality rates, and other important life history parameters will be assessed.

We plan to continue monitoring this important cottonmouth population in future years. Continued monitoring will enable us to collect valuable life history information which will be necessary for implementing a long-term conservation plan for this snake.

Western cottonmouth / Phil Peak

Funding Sources: *Murray State University, State and Tribal Wildlife Grant (SWG).*

Comprehensive Wildlife Conservation Strategy: Appendix 3.3, Class Reptilia. Priority Research Project #1.



Western cottonmouth records for Kentucky

Status Assessment and Conservation of the Eastern Hellbender

Gregory Lipps and Mike Sisson, Gregory Lipps, LLC
***KDFWR Contact:** John MacGregor*

Worldwide declines of amphibian populations have garnered international attention over the past two decades. The recent Global Amphibian Assessment found that 32% of the known amphibian species are threatened with extinction or already extinct, while 42% are declining. One of these declining species is the hellbender (*Cryptobranchus alleganiensis*), the largest North American amphibian. Hellbenders are completely aquatic salamanders, living their lives in large creeks and rivers, where they take refuge under large slab rocks and feed on crayfish. While Kentucky makes up a substantial part of the range of the Eastern Hellbender, the current status and distribution of hellbenders in the state is unknown.

In 2008, we began a survey to determine where hellbenders occur in Kentucky, collect information on populations, and identify threats to hellbender populations and habitats. Our goal is to search for hellbenders in every historic location of occurrence, using records from the Natural Heritage Database and other sources. Searches consist of skin diving using a snorkel and mask while lifting large rocks. Captured hellbenders are measured and massed, and all injuries and deformities are carefully documented. Prior to release, a microchip (identical to those used to identify pets) is placed under the skin to allow us to identify previously captured individuals. As larval hellbenders are thought to reside in the interstitial spaces of gravel and adults spend their lives in cavities under large rocks, we are quantifying the substrate quality at each location using a zig-zag pebble count procedure, providing one measurement of the health of the habitat.

To date, we have captured Eastern Hellbenders at only two of 24 historical locations in the Licking and Kentucky River watersheds. Furthermore, individuals of multiple size classes (indicating recent successful reproduction) have been found in only one waterway. These preliminary results are very similar to what is being reported elsewhere throughout the hellbender's range -- a 75-80% decline in overall abundance with declining populations comprised of old individuals. Excess siltation is degrading many hellbender habitats, caused by development and agriculture along streams, ATV use, and in-stream gravel mining. Going forward, we will be examining the remaining 38 locations of historical occurrence as well as other areas of potential hellbender habitat throughout the state. In addition, we are working with our partners to protect stream and riparian habitats where healthy hellbender populations still occur, so that this unique animal will continue to contribute to the rich biodiversity of Kentucky.

Funding Sources: *State and Tribal Wildlife Grant (SWG), Gregory Lipps, LLC, and Columbus Zoo and Aquarium*

Comprehensive Wildlife Conservation Strategy: Appendix 3.2, Class Amphibia. Priority Research Project #1 and Priority Survey Project #2.

Eastern hellbender / Ralph Pfingsten

Inventory, Monitoring and Management of Amphibians and Reptiles in Kentucky

Will Bird and Phil Peak,
Kentucky Herpetological Society
***KDFWR Contact**: John MacGregor*

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. The actual distributions for many reptile and amphibian species in Kentucky have not yet been entirely determined. Many of the records that we have in our current database are decades old, and the landscape has been altered to such a degree that the current distributions of many species remain unknown. Species for which baseline data is most needed from all groups of reptiles and amphibians have been identified, as have the regions within Kentucky where this information should be gathered.

Timber rattlesnake / Will Bird

Locating reptiles and amphibians can be difficult. We begin the process by identifying locations where we believe targeted species can be found. These locations are on state, federal, and even private lands. Once permission is granted to conduct surveys, we use different methods for locating reptiles and amphibians 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, along with drift fence arrays, to assist in their location.

Once animals are discovered, we record their exact location and any other natural history observations such as weather conditions, time of day, etc. If the species is not common or if it is a species that could be difficult to properly identify, we photograph it prior to release. All of our information is sent to KDFWR State Herpetologist John MacGregor for review prior to being entered into the main database. Should there be any question about the authenticity of entered data we are able to provide photographic evidence. This process eliminates the need to preserve or collect the animals that we find.

2008 proved to be a good year for gathering reptile and amphibian data. We were able to locate many of the species identified by the CWCS including some in areas where they had not been recorded at all or for many years. We were also able to secure new survey locations where we deployed AC that we hope will lead to 2009 records. The surveys we conduct will help in identifying key habitats for species of reptiles and amphibians in Kentucky. As more information is collected we believe that potential for the implementation of effective conservation plans will be possible.

Funding Sources: *State and Tribal Wildlife Grant (SWG), Kentucky Herpetological Society*

Comprehensive Wildlife Conservation Strategy: Appendix 3.4, Class Amphibia. Priority Conservation Action #2; Class Reptilia. Priority Conservation Action # 2.

Reproductive Success of Interior Least Terns in Western Kentucky

Caitlin Borck and Robert B. Frederick, Eastern Kentucky University, John Brunjes, Kentucky Department of Fish and Wildlife

Historically, interior least terns (*Sterna antillarum athalassos*) have nested along the Colorado, Red, Arkansas, Missouri, Ohio, and Mississippi Rivers. They were extremely abundant in the 1800s but nearly extirpated by the end of that century due to demands of the millinery trade, hunting, and egg collection. Their numbers declined again in the 1940s because of human development along river banks and changes to the river channels. The loss of nesting habitat due to channelization, dam and weir construction, irrigation, and reservoir construction is considered the greatest threat to least tern populations. Human disturbance of nesting sites is considered the second greatest threat to least tern populations while other causes of reproductive failure include depredation and flooding. Because of the loss of their nesting habitat and population decline they were listed as federally endangered in 1985.

Interior least terns are now only found in small, local populations in their former nesting range. Those nesting on islands on the Ohio and Mississippi rivers in Kentucky have lost natural islands or seen island quality degraded because of changes in the historic flooding regime. In the absence of natural islands, least terns have nested on islands created by US Army Corps of Engineers dredging operations or at other alternative nesting sites. Due to prolonged flooding and high water from May to August 2008 least terns in western Kentucky were unable to nest on islands along the Ohio and Mississippi rivers. With traditional sites unavailable, least terns nested on agricultural fields and industrial sites.

Nesting sites were discovered through reports by the public and Kentucky Wildlife Division employees. Each site was systematically searched for nests until the entire area was covered. Nests were uniquely marked and monitored every 2-4 days. Clutch size, nest fate, and clues to fate were recorded at each nest. The two agricultural sites, Swan Lake and Open Pond suffered heavily from predation. Several sites on Open Pond were accidentally plowed under. Open Pond had 89 nests, but only one egg hatched successfully. Swan Lake had 54 nests, but, likewise, only one egg hatched. Arkema, our industrial site had a much higher success. This site had only 14 nests, but nest success was 93% and hatch success was 91%. Average clutch size for all sites was 1.5. In 2009 we plan to continue to monitor these sites and others along the Ohio and Mississippi Rivers in Kentucky and record basic reproductive data. If water levels allow, we also will evaluate and compare habitat suitability of man-made versus natural islands. With the loss of so many suitable nesting sites, management and protection of existing natural and alternative sites is increasingly important. These data will help us manage these sites to improve tern reproductive success.

Funding Source: *State and Tribal Wildlife Grant (SWG)*

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

Caitlin Borck checking fate of tern nest at the Swan Lake agricultural site / Bob Frederick

The Common Raven in Cliff Habitat: Detectability and Occupancy

Josh Felch, John J. Cox, University of Kentucky; Matthew Dzialak, Hayden-Wing Associates, WY; and Shawchyi Vorisek, Kentucky Department of Fish and Wildlife Resources

The cliff-nesting common raven (*Corvus corax*) is of conservation interest in Kentucky and currently listed as state threatened. The common raven was nearly extirpated in the eastern U.S. by the mid 1900s as a result of human persecution, loss of forest habitat, and likely the absence of large mammal carrion. Today, portions of its range have been recolonized by remnant populations including southeastern Kentucky where a handful of sightings and nests have been observed during the past 3 decades. The Commonwealth appears to have extensive suitable breeding habitat but ravens have remained relatively rare and unstudied, thus little is known about the local ecology or population status or this oft reclusive corvid.

Our research will employ a detection-occupancy approach to assess distribution and abundance of ravens in cliff habitat of eastern Kentucky. Our objectives are threefold. First, we plan to quantify factors that affect our ability to detect ravens in cliff habitat by determining the intensity and duration of survey visits at occupied raven nests required to detect these species with a level of confidence. Second, we will quantify landscape attributes at known nesting locations to create a landscape-scale species predictive models in cliff habitat of this region. Finally, using data from the first field season, we will develop and initiate protocols for monitoring the occupancy of key potential breeding habitats in Kentucky in winter-spring 2010.

Raven hatchlings / Josh Felch

Detectability of ravens in cliff habitat will be estimated by conducting repeated visual/auditory surveys at 12-15 known raven breeding sites in the Southern Appalachians during the 2009 breeding season (February – early May). These sites have been identified through coordination with biologists, naturalists, birders, and others throughout the region, and paired with an equal amount of unoccupied sites, will provide the basis for a site-attribute habitat model that will quantify breeding habitat in the region. Key potential breeding habitats in Kentucky will be identified through communication with state ornithologists, by historical observations, and by recent sightings. During the 2010 breeding season, we will conduct repeated visual/auditory surveys at these potential sites as was done before at the known breeding sites. The detectability estimate obtained during the first field season will be used to determine the protocols for monitoring occupancy at these sites, such as the necessary allocation of survey effort needed to reliably infer presence/absence of ravens in an area. Should breeding locations of ravens be identified within the Commonwealth, additional benefits will include data on timing, productivity, and breeding season food habits. We will opportunistically gather similar data on ravens discovered to nest in non-cliff habitat in the state.

Ultimately, we expect to gain a better idea of the status of the common raven population in Kentucky and to generate new information for detecting ravens at Kentucky's cliffs and on habitat features that might be important in their occupancy of potential breeding sites. We hope to develop a monitoring protocol useful to wildlife managers and land stewards interested in long-term monitoring, management, and conservation of the species in cliff habitat.

Funding Source: *State and Tribal Wildlife Grant (SWG)*

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

Common raven / Josh Felch

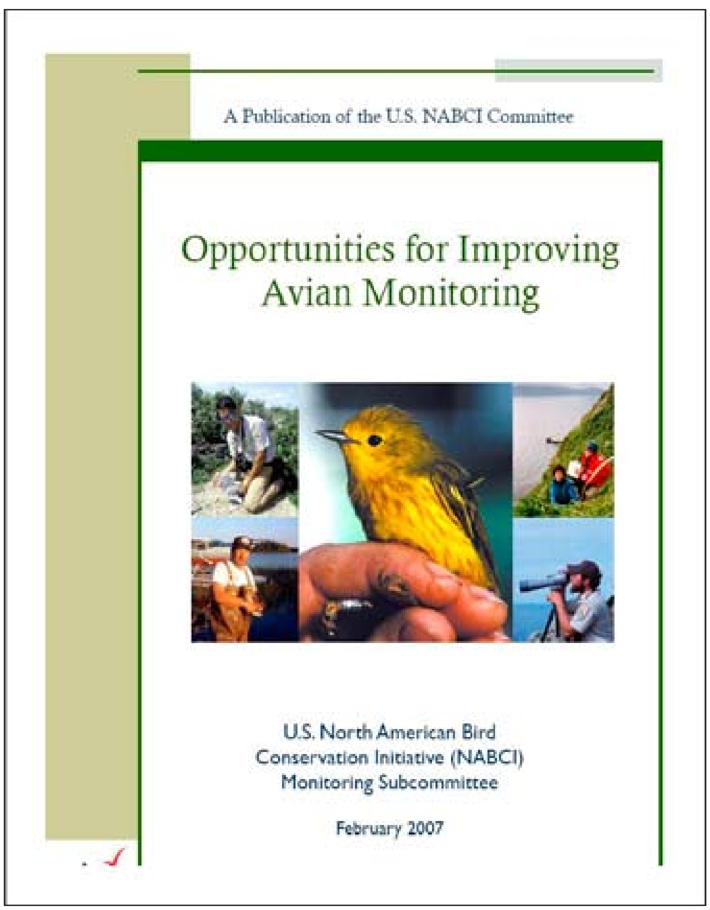
An Evaluation Tool for Avian Monitoring Programs

Rua S. Mordecai, Shawchyi Vorisek, Kentucky Department of Fish and Wildlife Resources; and The Central Hardwoods Joint Venture

The need to coordinate bird monitoring efforts has been identified by the U.S. North American Bird Conservation Initiative's (NABCI) as one of their highest priorities. As a result, the NABCI Monitoring Subcommittee identified a set of goals to improve avian monitoring. These are: 1) Fully integrate monitoring into bird management and conservation practices and ensure that monitoring is aligned with management and conservation priorities, 2) Coordinate monitoring programs among organizations and integrate them across spatial scales to solve conservation or management problems effectively, 3) Increase the value of monitoring by improving statistical design, and 4) Maintain bird population monitoring data in modern data management systems.

Although many large-scale organizations (e.g., Joint Ventures and regional bird monitoring partnerships) are now attempting to align their bird monitoring efforts with the four goals of the NABCI subcommittee, none of these groups have a standard way to measure and track progress toward these goals. Additionally, many states are struggling with evaluating their monitoring programs under the State Wildlife Action Plans (SWAP). For instance, many state agencies have supported and conducted various avian monitoring projects throughout the years without consideration of management priorities, regional or continental conservation goals, statistical rigor, and data management. Thus, a regular assessment of existing and proposed projects is needed by states so that current and future population monitoring projects can be altered to address current management and bird conservation objectives. As a starting point in assessing states' monitoring programs, we developed a set of multiple choice questions based on the elements identified by the Monitoring Subcommittee, which where then used to evaluate bird monitoring programs, recommend improvements, and track implemented improvements over time. A secure online database was used in which biologists could evaluate monitoring programs, based on the developed questions, and to track improvements in monitoring over time.

Kentucky served as the pilot state for this project as KDFWR staff worked with the principal investigator and the Central Hardwoods Joint Venture in developing the questions, testing the evaluations, and online applications. Additionally, three outside reviewers were asked to evaluate the questions for applicability. The monitoring evaluation tool was also presented at the Joint Southeast Quail Study Group and Southeast Partners In Flight (SEPIF) Meeting in Columbia, SC in March of 2009. The evaluation tool was well received by the SEPIF working group and the group plans to bring this tool forward and integrate it into future web-based systems and avian conservation planning organizations.



Funding Sources: *State and Tribal Wildlife Grants (SWG)*

Comprehensive Wildlife Conservation Strategy: Appendix 3.4; Class Aves: Taxa specific conservation action #1. Appendix 3.9; Critical Elements of Successful Monitoring in Kentucky.

Estimating Abundance of Species of Concern in the Central Hardwoods Region

Shawchyi Vorisek and Kate Heyden, KDFWR; Frank R. Thompson III, Jennifer Reidy, Kerri Cornell Duerr and Wes Bailey, University of Missouri, Jane Fitzgerald, American Bird Conservancy.

In 2007 and 2008, KDFWR coordinated Cerulean Warbler surveys for the Central Hardwoods Joint Venture. Surveys were completed utilizing KDFWR staff, as well as personnel from many other state and federal agencies. There were 580 road points and 107 river points sampled. Road surveys sampled upland habitat; river surveys sampled bottomland habitat. There were 1437 individuals of target species detected, 44 of which were cerulean warblers (Table 1).

The goal of this survey effort was to develop a sampling design, survey methods, and analysis methods to produce population estimates and to identify suitable forest habitat for target priority species, including Cerulean Warblers, on public lands in the Central Hardwoods Bird Conservation Region. Analysis was completed by the University of Missouri in Columbia. Distance and removal models were compared for density estimation of forest birds, accounting for variability in the probability of detection of individuals during a point count (Table 2).

Table 1. Detections of each target species from sampled areas (public forested land) within Kentucky, 2007–2008.

Site	Acadian Flycatcher	Cerulean Warbler	Kentucky Warbler	Louisiana Waterthrush	Worm-eating Warbler	Wood Thrush	Total
Bernheim Research Forest	19		18	3	26	37	103
Clay WMA	41	1	19	1	4	28	94
Clark's River NWR	18	7	7	6	1	1	40
Dale Hollow WMA	4	2	2	2	2	8	20
Fort Knox	20	3	19	6	11	48	107
Green River WMA	36		16	4	5	39	100
Kleber WMA	3					1	
Lake Cumberland State Park	4				2	4	
Land Between the Lakes NRA	115	6	41	19	52	85	318
Mammoth Cave NP	102	18	101	19	77	141	458
Pennyrile SF	13	2	27		30	41	113
Taylorsville WMA	18		1			14	33
Tradewater WMA	3		2		3	2	10
Yellowbank WMA	14	5	7	5		10	41
Total	**410**	**44**	**260**	**65**	**213**	**459**	**1437**

Table 2. Population estimates (based on males) and 95% confidence intervals for each target species from top distance and top removal models from sampled areas (public forested land) within Kentucky, 2007–2008 (University of Missouri, unpubl. report).

Species	Area (ha)	Distance		Removal	
		Estimate	95% CL	Estimate	95% CL
Acadian Flycatcher	14787	6912	(5285–9216)	5382	(4177–7441)
Cerulean Warbler	14787	500	(235–1276)	1009	(423–3304)
Kentucky Warbler	14787	3540	(2191–6075)	1697	(1514–2422)
Louisiana Waterthrush	14787	1588	(521–8294)	390	(320–681)
Worm-eating Warbler	14787	2746	(1839–4498)	1701	(1409–2474)
Wood Thrush	14787	2037	(1476–2893)	5700	(3148–14020)

Funding Sources: *State and Tribal Wildlife Grants (SWG)*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.4; Class Aves: Taxa specific conservation action #1.

Female and male cerulean warbler / Adam Smith

Golden-winged Warbler Monitoring

Shawchyi Vorisek, Kentucky Department of Fish and Wildlife Resources and Sara Barker (Cornell Lab of Ornithology)

Golden-winged warbler / Patricia Hartman

The Golden-winged Warbler (*Vermivora chrysoptera*) is a Neotropical migrant that is of high conservation concern in eastern North America. In Kentucky, they breed in the higher elevations of the Appalachian Mountain in the Southeast. They currently utilize the early sucessional habitats created on reclaimed mined lands. However, their populations are quickly declining. Furthermore, the species is hybridizing with Blue winged Warblers (*Vermivora pinus*) which have been expanding into the Golden-winged Warbler's (GWWA) range in Southeast Kentucky, adding another threat to the species. Similar threats face the species rangewide.

Thus, the Golden-winged Warbler Working Group was established and consists of ornithologists, conservationists, and managers with the common goal of ensuring the conservation of GWWA populations through sound science, education, and management. The group acknowledged that because GWWAs are patchily distributed and poorly sampled by other surveys, such as the Breeding Bird Survey, long-term monitoring of the species is needed. As a result, the Cornell Lab of Ornithology (CLO) established a pilot monitoring protocol in 2008 that incorporated the use of playback, passive point counts, and a mobbing sequence throughout the species range in the Appalachians. Kentucky participated in the project by utilizing the protocol to survey points where GWWAs were observed during a 2003 atlas survey.

Seven sites were surveyed in KY from late May through early June in Bell, Harlan, McCreary, Pike, and Whitley Counties. Twenty-seven points were surveyed, with only 4 points having GWWA only observations. All other points had either only BWWA, both species, or neither species observed, suggesting that isolated GWWA populations have declined. We plan to continue monitoring the populations in 2009 following revised protocol from CLO that incorporates a spatially balanced sampling design. Such a design will enable us to determine population trends throughout the Appalachians and portions of New York.

Funding Source: *State and Tribal Wildlife Grant (SWG), National Fish and Wildlife Foundation (NFWF)*

Comprehensive Wildlife Conservation Strategy: Appendix 3.2; Class Aves: Taxa specific research project #6, taxa-specific survey project #3 and #5. Appendix 3.9. New projects.

Grassland Songbird Survey

Shawchyi Vorisek (KDFWR; David Buehler, University of Tennessee; Tiffany Beachy, University of Tennessee; Central Hardwoods Joint Venture

Many grassland and early successional songbirds, such as Henslow's Sparrows (*Ammodramus henslowii*) have been experiencing precipitous population declines in North America. Causes include habitat alterations, succession, mowing regimes, fire suppression, and development. Additonally, the game species Northern Bobwhite (*Colinus virginianus*) utilizes similar habitat and is also experiencing major population declines. Thus, management is clearly needed to benefit these grassland species. However, few surveys are available to assess the effects of management nor to track population trends for these species. For instance, the national Breeding Bird Survey is not sufficient in capturing Henslow Sparrows or grassland birds at smaller scales that would be useful to land managers.

As a result, this project was established in an effort to develop an adequate and readily repeatable methodology for surveying the available early successional habitat across a regional bird conservation region (BCR), the Central Hardwoods BCR and attempts to document priority grassland bird species' distributions and habitat associations. Roadside and atlas surveys were conducted in priority bobwhite focus areas within the states of IL, IN, KY, and TN during May-July 2008. Roadside surveys consisted of 5-minute point counts that targeted several grassland species of conservation concern. Habitat was also categorized into different land use types. Surveys were conducted at the county scale as agriculture census data from the USDA are maintained at the county level.

The 2008 surveys yielded more Henslow Sparrows (n = 45) in KY than any other state with pasture and hayfields being the most dominant land use type. For all states combined, Henslow's Sparrows occurred in areas with a greater percentage of cool season grass fields and Northern Bobwhites were found more often in a mixture of cool season grasses and forbs. These results suggest that proper grassland management in KY (e.g. higher percent cover of native warm season grass stands) can favor priority grassland species and that region-wide surveys such as these can offer useful information on population trends and land use. Plans for 2009 include expanding this protocol to cover counties in other states within the Central Hardwoods BCR and coordinating efforts so that states can conduct these surveys systematically to ultimately better manage our grassland species.

Grasshopper sparrow / Don Martin

Funding Sources: *U.S. Fish and Wildlife Service, State and Tribal Wildlife Grant (SWG), Kentucky Department of Fish and Wildlife Resources, Central Hardwoods Joint Venture, University of Tennessee*

Comprehensive Wildlife Conservation Strategy: Appendix 3.2; Class Aves: Taxa specific survey project #5.

Black Bear Resource Selection, Demographics, and Movement Patterns in Kentucky

Ben Augustine, Rebekah Jensen, John T. Hast, and John J. Cox, University of Kentucky; Steven Dobey and Jayson Plaxico, Kentucky Department of Fish and Wildlife Resources

After being extirpated from Kentucky in the late 19th century, the black bear (*Ursus americanus*) has expanded its range back into the state and the population may still be increasing in both size and range. As forest obligates with large space requirements and seasonal variation in the location of forage resources, black bears in eastern Kentucky must navigate through a matrix of natural and human-modified habitats to meet their life requisites. The interspersion of black bear habitat and areas of human activity often leads to human-bear conflict, sometimes resulting in property damage and bear mortality. In order to manage black bears in a way that allows for population persistence and minimizes human-bear conflict, an understanding of how bears respond to landscape structure and human activity is especially important. Further, the black bear has recently become a game species in Kentucky, necessitating an accurate estimation of demographic parameters for robust population models and harvest regulations.

Research conducted by the University of Kentucky has recently focused on the collection of high-intensity GPS data that allow for the assessment of fine-scale resource use and movement patterns, while also allowing for the continued collection of demographic data. Since 2002, 48 bears have worn GPS collars, with 24 being deployed in the past year and at least 17 to be deployed this summer. These data will be used to assess how black bears are responding to landscape structure and human activity, ultimately leading to a spatially-explicit probability of occurrence map for the black bear in eastern Kentucky, which can inform management decisions and land acquisition by conservation organizations. While statistical analyses have not yet been conducted, it appears that females generally avoid areas of human activity, while males are often attracted to human food sources, suggesting the distribution of female black bears will ultimately be more restricted than that of males.

Bear tracks / John Cox

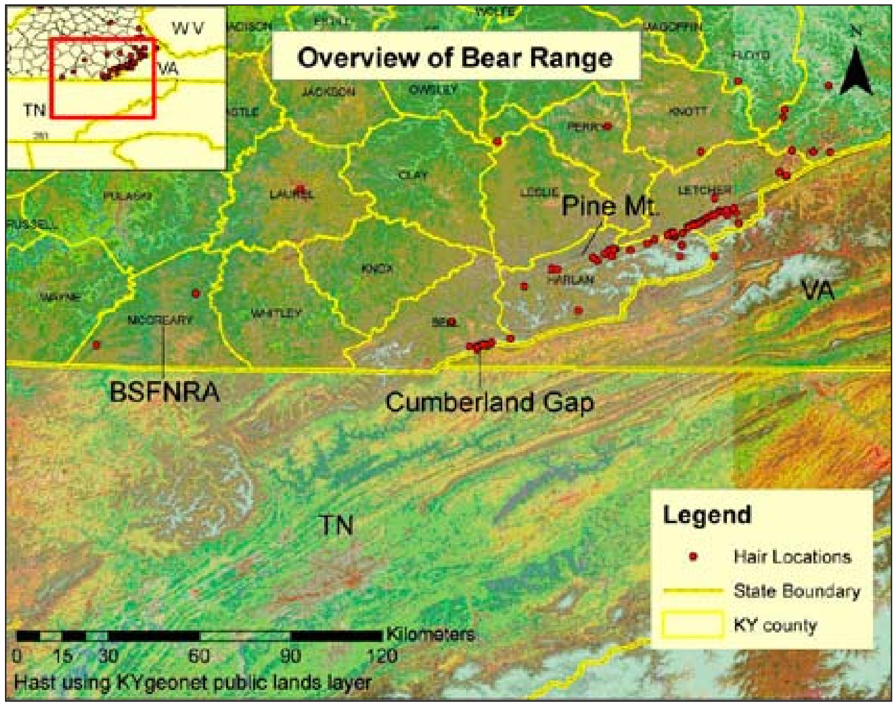
Since 2003, 31 litters have been documented with 69 cubs being handled and the 2009 den season resulted in the documentation of 7 litters and 13 cubs. As demographic data accumulates, it appears initial fecundity estimates were overly optimistic – 3.25 cubs/litter from 2002-2006. Black bear productivity in eastern Kentucky now appears to be more consistent with other black bear populations in the southern Appalachians. To date, eastern Kentucky black bears have averaged 2.7 cubs per litter. Another trend is the increase in the capture of females – 16 of the 33 females captured to date were captured in the past 2 years. While many demographic parameters remain uncertain, the black bear population in eastern Kentucky appears to be healthy and continued research will ensure that wildlife managers have the information needed to properly manage this species.

Funding Source: *Pittman Robertson (PR)*

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

Genetic Diversity, Structuring, and Recolonization Patterns of Black Bears in Eastern Kentucky

John Hast, John J. Cox, and Ben Augustine, University of Kentucky; Steven Dobey and Jayson Plaxico, Kentucky Department of Fish and Wildlife Resources



Red dots represent the 63 hair samples taken for Kentucky black bears.

Population genetics has become a popular and useful tool for addressing important management and conservation questions involving large mammals. The black bear (*Ursus americanus*) has successfully recolonized the extreme southeast portion of Kentucky following nearly a century of conjectured absence from the Commonwealth. Recolonization of bears into Kentucky has spawned a myriad of questions involving the source population, travel corridors, and the genetic makeup of the resident bear population. It has been hypothesized that the bears currently present in Kentucky represent the outer fringes of a larger regional metapopulation recently (if not currently) sourced by surrounding states. Although possible that bears residing within Kentucky are products of a small remnant population, many examples of interchange between Virginia and Tennessee have been documented using radio tracking devices.

Trapped male bear / John Hast

Our research will employ a population genetics approach using microsatellite analysis of hair samples from black bears to examine the following four project objectives: (1) evaluation of the genetic diversity of the Kentucky black bear population, (2) evaluation of the genetic structure of the Kentucky black bear population, (3) evaluation of possible source populations located in surrounding states, and (4) evaluation of recolonization patterns and corridors associated with the Kentucky black bear population. Hair samples will be collected from captured bears that are part of a complimentary ecological study, as well as opportunistically from state employees dealing with road kill and poaching incidents. To date we have obtained 63 Kentucky and 9 West Virginia black bear hair samples with intact follicles and geographical coordinate data. University of Tennessee has agreed to provide 30 hair samples from the Smokey Mountains. In May and June 2009, we will use hair snares and biopsy darting to collect additional hair samples in Virginia and Big South Fork, Kentucky. Given that bears appear to be regionally increasing in number, and are perhaps transitioning from an establishment to growth phase, our findings should prove useful to adaptive management of this socio-economically and ecologically important large game species.

Funding Source: *Pittman Robertson (PR)*

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

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; Tina Brunjes, Kentucky Department of Fish and Wildlife Resources

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

The KDFWR and Mississippi State University have teamed up to evaluate the genetic makeup of the eastern Kentucky elk herd. During fall and winter 2008-2009, biologists obtained tissue and hair samples from hunter harvested elk and will collect these samples again during the 2009-2010 hunting seasons. We will use DNA taken from these samples to evaluate the genetic makeup of the elk across the restoration area and compare this to their source populations in western states. Weight and antler size will also be evaluated. This information will allow the KDFWR to make future management decisions that will promote elk population health.

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

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

Collared elk calf / Will Bowling

Harvested elk / KDFWR

Geographic distribution and prevalence *Cytauxzoon felis* in wild felids

Barbara C. Shock, University of Georgia; Staci M. Murphy, Southeastern Cooperative Wildlife Disease Study; Laura L. Patton, Kentucky Department of Fish and Wildlife Resources; Philip M. Shock, West Virginia Division of Natural Resources; Colleen Olfenbuttel, North Carolina Wildlife Resources Commission; Jeff Beringer, Missouri Department of Conservation; Suzanne Prange, Ohio Department of Natural Resources; Dorothy Fecske, North Dakota Game and Fish Department; Matt Peek, Kansas Department of Fish and Wildlife; Victor F. Nettles, Southeastern Cooperative Wildlife Disease Study; Holly Brown, University of Georgia; David S. Peterson, University of Georgia; and Michael J. Yabsley, University of Georgia

Bobcat / Adam Jones

Cytauxzoon felis, a tick-borne protozoal parasite of wild and domestic felids, is the causative agent of cytauxzoonosis in domestic and exotic felids. *C. felis* can be transmitted by two tick species, *Dermacentor variabilis* and *Amblyomma americanum.* The distribution of these ticks overlap considerably throughout the Southern US, but *D. variabilis* ranges farther into northern states. The objective of the current project was to determine the distribution and prevalence of *C. felis* in bobcats (*Lynx rufus*) and other wild/exotic felids from ten eastern states (Georgia, Kansas, Kentucky, Louisiana, Missouri, North Carolina, North Dakota, Ohio, Oklahoma, and West Virginia). The bobcat is believed to be the primary reservoir for *C. felis*, but few studies have looked at the distribution and prevalence of the parasite within wild felids. Blood and/or spleen samples from hunter/trapper-killed felids (n=420) were tested for *C. felis* by PCR, targeting the ribosomal internal transcribed spacer region 1 (ITS-1). Prevalence was higher in southern states where both tick species are present. The prevalences in Kansas (41 bobcats), Kentucky (74 bobcats), Louisiana (1 bobcat, 1 cougar [*Felis concolor*], 1 serval [*Leptailurus serval*]), Missouri (39 bobcats), North Carolina (8 bobcats) and Oklahoma (20 bobcats), were 27%, 55%, 33%, 79%, 63% and 60% respectively. The prevalence was lower in West Virginia (0%, 37 bobcats), Ohio (5%, 19 bobcats), Georgia (3%, 69 bobcats) and North Dakota (3%, 114 bobcats). These data indicate that *C. felis* is widespread in bobcat populations, but the spatial differences in prevalence may relate to differences in the distributions of the two tick species. The ultimate goal of this project is to investigate intraspecific variability of *C. felis* throughout the Eastern U.S. by comparison of ITS sequences present in wild felids with those detected in domestic cats and ticks.

Funding Sources: *Southeastern Cooperative Wildlife Disease Study, Various State Agency Interests (including Kentucky Department of Fish and Wildlife Resources).*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Bottomland Hardwood and Riparian Restoration in Obion Creek/Bayou de Chien Watersheds

Jeff Sole and Shelley Morris, The Nature Conservancy

TNC biologist discussing habitat improvement practices in Obion Creek bottoms / Nathan Hicklin

The Obion Creek/Bayou de Chien watersheds have been identified by multiple agencies and organizations as high-priority conservation areas. The majority of the bottomland hardwood forests within these two watersheds have been negatively impacted by incompatible forestry or agricultural practices; consequently, most of the streams have very little riparian vegetation and are in need of restoration attention. Beginning in 2008, we sought to achieve the following conservation objectives on private lands within these two watersheds: restore four miles of riparian cover, promote implementation of streambank stabilization projects such as grade stabilization, cedar revetments, and rock veins, plant 150 acres of bottomland hardwoods, conduct prescribed burns to improve habitat in target areas, and create ephemeral pools for pond-breeding amphibians. Restoring riparian cover and improving wildlife habitat in these watersheds will reduce sedimentation and will help improve habitat for several species of greatest conservation need including the relict darter and the federally listed Indiana Bat.

In 2008, we partnered with Quail Unlimited to implement prescribed burns to improve habitat for grassland songbirds within this project area. Additionally, we planted bottomland hardwood trees on private property along Brush Creek, and will plant riparian buffers on this same property during fall 2009. Also planned for fall 2009 is a riparian restoration project along Cane Creek, a tributary to Bayou de Chien.

We plan to continue this project through 2010 and hope to partner with federal, state, and local partners to restore habitat, improve water quality, and abate threats to species of greatest conservation need within the Obion Creek/Bayou de Chien Watersheds.

Funding Sources: *State and Tribal Wildlife Grant (SWG), The Nature Conservancy*

Comprehensive Wildlife Conservation Strategy: Appendix 3.4, Prioritized taxa-specific conservation actions, Class Mammalia; Appendix 3.3, Conservation Action # 7, #14, #32, #80, #97 #120, and #129.

Restoration of Bur Oak on the Clay Wildlife Management Area by Means of Direct Seeding

Wes Mattox, Nathan Gregory, Brian Wagoner, Scott Freidhof, and Stephen Bonney, Kentucky Department of Fish and

Bur Oak seedlings in Blue-X direct seeding shelters / Wes Mattox

Bur oak (*Quercus macrocarpa*) is native to at least 103 Kentucky counties (Stein, Binion, and Acciavatti, 2003). It is an especially important tree in the Bluegrass Region of the state where it was historically a dominant component of the Bluegrass Ash-Oak Savannah community described by Braun (1950). Bur oak is commonly found growing on broad fertile ridges of the inner Bluegrass ecoregion and to a lesser extent in fertile bottom land within the rougher topography of the Hills of the Bluegrass. The Clay Wildlife Management Area (CWMA) lies within the Hills of the Bluegrass ecoregion and borders the Licking River. Unfortunately, the many long, fertile river bottoms located on the CWMA have all been cleared and farmed in the past, leaving very little of their original forest cover. Some of these bottoms have grown back to forest in recent

Table 1. Bur Oak Seed Collection Location Characteristics

Location	# of Trees	County	Ecoregion	Landscape Position	Soil*	Elev.
Oxbow Road	2	Nicholas	Hills of the Bluegrass	NE mid-slope	Eden flaggy silty clay	870’
Carpenter Road #1	1	Nicholas	Outer Bluegrass	NE slope	Cythiana-Faywood	880’
Carpenter Road #2	1	Nicholas	Outer Bluegrass	E road bank ridge	Lowell silt loam	865’
Cemetery	2	Nicholas	Outer Bluegrass	N lower slope	Lowell silt loam	835’
Carlisle	1	Nicholas	Hills of the Bluegrass	Narrow ridge	Faywood silty clay loam	920’
Bee Lick	1	Robertson	Hills of the Bluegrass	Creek Bottom	Nolin silt loam	700’
Johnson Creek Bridge	2	Robertson	Hills of the Bluegrass	Creek Bottom	Nolin silt loam	660’
HWY 324	1	Mason	Outer Bluegrass	Broad ridge	Lowell silt loam	940’
Lewisburg Baptist Church	3	Mason	Outer Bluegrass	W lower slope	Lowell-Faywood silt loam	780’

years but these areas are dominated by light seeded species such as sycamore (*Platanus occidentalis)* and box elder (*Acer negundo*). Black walnut (*Juglans nigra*) is typically the only hard mast producing species found in these bottomland forests. The purposes of this project are to; 1) restore an important native hard mast producing species to the bottomland forests of the CWMA and 2) to test the efficacy of direct seeding of acorns compared to planting bare root seedlings.

Acorns were collected on the 2nd, 9th, and 17th of October 2008 from 14 different bur oak trees in 9 locations in Nicholas, Mason, and Robertson Counties. The acorns were inspected and those that were desiccated, rotten, or excessively damaged by weevils were discarded. The acorns were stored in peat moss until planting on October 20th and 23rd. Acorns were planted 1-2 inches deep approximately 8 feet apart in three fields and one forested area. Blue-X direct seeding shelters were placed over 750 of the planted acorns. Approximately 300 acorns were planted without shelters but were marked with stakes.

An additional 200 bare root bur oak seedlings were planted March 4, 2009 for comparison. Additional treatments to the planting sites are planned for the spring and summer of 2009 and include treating fescue competition with clethodim herbicide and reducing the basal area within the forested plantation to provide optimum light levels for seedling growth.

These plantations will be monitored over the next several years to determine rates of predation and browsing on acorns and seedlings, germination rates of acorns, and to compare growth rates between seedlings with and without shelters and between direct seeded and bare root seedlings. Preliminarily, rodent predation of seedlings has been surprisingly low (<4%). However, this will be reassessed later this spring (2009) after germination is complete and seedlings have emerged.

Literature Cited

Braun, E. L. 1950. Deciduous Forest of Eastern North America. Hafner Press, New York.

Stein, J., Binion, D., and Acciavattii, R. 2003. Field Guide to Native Oak Species of Eastern North America. USDA, Forest Service, FHTET-2003-01, page 55.

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

KDFWR Strategic Plan Goal 1. Strategic Objectives 2 and 3.

Table 2. Plantation site descriptions

Location	Size (acres)	Cover	Soil*	Site Index*	Elevation	# of Acorns
Field 1	1.2	Mowed briars	Elk silt loam	NRO = 80 YP = 90	620’	309
Field 2	.7	Mowed fescue	Allegheny loam	NRO = 80 YP = 83	620’	269
Field 3	1.5	Mowed fescue	Allegheny loam	NRO = 80 YP = 83	620-630’	300+
Field 4	.4	Woods	Nolin silt loam	SG = 99 ECW = 72	610’	136
Field 5	.4	Fallow Field	Allegheny loam	NRO = 80 YP = 83	620-630’	200 seedlings

**Soil and Site Index data taken from Soil Survey of Nicholas and Bourbon Counties Kentucky. 1982. USDA, Soil Conservation Service. (NRO = Northern Red Oak, YP = Yellow Poplar, SG = Sweetgum, and ECW = Eastern Cottonwood)*

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

Brian Yahn, Ecologist, Kentucky State Nature Preserves Commission
***KDFWR Contact:** Danna Baxley*

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

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

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

The project continues in 2009 with focus areas in parts of Barren, Butler and Grayson and all of Edmonson and Hart counties. The same methodology is being applied.

Grassland / Brian Yahn

Funding Sources: *State and Tribal Wildlife Grant (SWG), Kentucky State Nature Preserves Commission and The Nature Conservancy*

Kentucky's Comprehensive Wildlife Conservation Strategy: Appendix 3.8, Terrestrial habitat guild (Grassland/agriculture), Objectives 1, 3, 4 and 5. (vol. III - pgs. 63-65).

Gadwall / USFWS

Project Updates

Conservation Status and Habitat of the Longhead Darter (*Percina macrocephala*) in Kinniconick Creek, Kentucky

David J. Eisenhour, Joshua M. Schiering, and A. M. Richter, Morehead State

Longhead darter (Percina macrocephala) / David J. Eisenhour

Management of a rare fish requires knowledge of its past and present distribution and population size, in addition to basic biological information, such as habitat use. These are lacking for many nongame fishes, including the longhead darter (*Percina macrocephala*), a Kentucky endangered species. This study examines the distribution and population size and habitat use of longhead darters in Kinniconick Creek, Lewis County, Kentucky. Data generated from this study will be used to develop management plans that protect this species and maintain biodiversity in Kinniconick Creek.

Prior to this survey, longhead darters were known from Kinniconick Creek from only eight specimens, all collected prior to 1982; the present status of this endangered species was unknown in the creek. In 2007 and 2008 we surveyed, via canoe, 69 stream km of Kinniconick Creek, dividing it into 198 sampling reaches, with each reach extending from the crest of one riffle to the crest of the next riffle. At 55 randomly selected reaches we sampled for presence and abundance of darters and collected habitat data. Darter sampling was done primarily by snorkeling, supplemented by seining and backpack electrofishing. Fourteen habitat variables were collected at the macro (reach) level to examine differences between reaches with and without darters. Five additional habitat variables were collected at the micro level (1 m^2) to examine differences in microhabitat usage. Data collection and analysis of population trends have been completed; analysis of habitat data is nearly complete.

We found longhead darters in 15 of 55 reaches sampled, extending the known range to 50 stream km in Kinniconick Creek. The highest densities occurred in the middle part of Kinniconick Creek, which has the lowest land disturbance. A total of 93 darters were encountered during the survey, including both young-of-the-year and adults, indicating successful reproduction and recruitment. We conservatively estimate the population in Kinniconick Creek to be 2000-5000 individuals. Although still an uncommon and localized fish within the system, it has an apparently stabile population. Longhead darters were typically found at the ends of long pools in areas of moderate depth (0.3-0.8 m), little or no current, and substrates of clean boulders and cobbles. Preliminary analysis of habitat data suggest that longhead darters are associated with reaches having long pools, and avoid areas with high silt or sand or strong currents. Because their habitat (low flow areas) is highly vulnerable to sedimentation, we recommend that management strategies focus on reducing sediment input. Currently, most sediment appears to be entering from major tributaries, which suffer from *extensive* (and presumably illegal) gravel mining and channelization. In addition, the upstream portion of the population appears to exhibit source-sink dynamics, which suggests migration to replace periodic, local extirpations is necessary. We suggest that road crossings be built or modified so that they permit darter movements.

Funding Source: *State and Tribal Wildlife Grants Program (STWG)*

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

Assessing Avian Use of Land Enrolled in Conservation Practice 33 (CP-33), Conservation Reserve Program

Kate Heyden and Shawchyi Vorisek, Kentucky Department of Fish and Wildlife Resources; Wes Burger, Mark Smith, and Kristine Evans, Mississippi State University

In 2004, the USDA's Conservation Reserve Program (CRP) introduced a new conservation practice called CP-33. This conservation practice provides habitat buffers for upland birds, and is designed to supply food and cover for bobwhite quail and other avian species in areas dominated by agricultural row crops. Specifically, CP-33 involves planting native warm-season grasses, forbs, legumes, and a limited amount of shrubs around cropland field edges. To assess the actual value of CP-33 areas to wildlife, KDFWR coordinated monitoring for winter use of CP-33 fields by avian species in 2007 and 2008.

In two field seasons, observers completed 128 transect surveys (63 in CP33 fields and 65 in control fields). Surveys occurred in 15 counties during January-March. Sixty-five species were detected overall and nine Species of Greatest Conservation Need (SGCN), as listed in our State Wildlife Action Plan (SWAP), were observed: American black duck (*Anas platyrhynchos*), American woodcock (*Scolopax minor*), loggerhead shrike (*Lanius ludovicianus*), northern bobwhite (*Colinus virginianus*), northern harrier (*Circus cyaneus*), red-breasted nuthatch (*Sitta canadensis*), rusty blackbird (*Euphagus carolinus*), savannah sparrow (*Passerculus sandwichensis*) and short-eared owl (*Asio flammeus*).

Data from 2007 and 2008 were pooled for analysis in 2008. The analysis tested for significant differences in densities between control and CP-33 fields for the following species: American robin, song sparrow, white-throated sparrow, field sparrow (*Spizella pusilla*), swamp sparrow (*Melospiza georgiana*), and other sparrows (American tree sparrow (*Spizella arborea*), savannah sparrow, white-crowned sparrow (*Zonotrichia leucophrys*), fox sparrow (*Passerella iliaca*) and unknown sparrow).

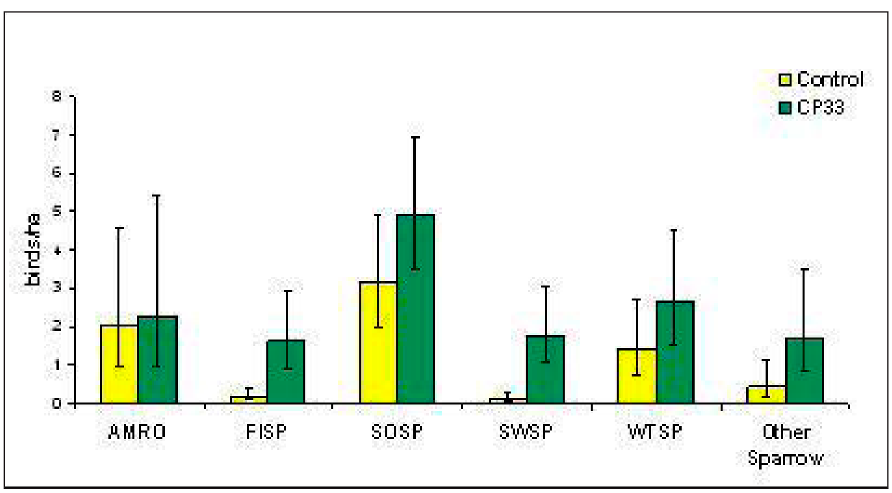
In 2007-2008, field sparrow and swamp sparrow had significantly greater densities at the CP-33 treatment transects than at the control transects. Song sparrow, white-throated sparrow, other sparrow and American robin exhibited notably greater densities at CP-33 treatment sites, but these values were not significantly different from control site densities (Figure 1). Average cluster size (group size) was larger at CP-33 treatment transects than at control transects for all species included in the analyses. Field sparrows showed the most drastic comparison in cluster size with groups at CP-33 sites being twice as large, on average, than at control sites.

Song Sparrow / Kate Heyden

Funding Sources: *State and Tribal Wildlife Grants (SWG)*

KDFWR Strategic Plan. Goal 1. Strategic Objective 5. Comprehensive Wildlife Conservation Strategy: Appendix 3.4; Class Aves: Taxa specific conservation action #1.

Figure 1. The density of wintering birds on CP-33 sites vs. control sites in Kentucky during 2007-2008.



Avian Influenza Monitoring Throughout Kentucky

Rocky Pritchert, John Brunjes and Erin Harper, Kentucky Department of Fish and Wildlife Resources

Avian influenza sampling / John Brunjes

Avian influenza (AI), also known as "bird flu," is caused by several different strains viruses commonly found in some species of water birds. AI viruses are labeled as either highly or lowly pathogenic depending on the response of poultry to the infection. Although many different subtypes of avian influenza exist, the highly pathogenic AI, H5N1 (HPAI H5N1) has been the cause of global concern as a potential pandemic threat. First detected in Southeast Asia in 1996, it has spread across the Asian continent and into Europe and Africa. Millions of poultry have been killed by this subtype throughout the regions of the world where the virus has been isolated. But to date, HPAI H5N1 has not been found in North America. While HPAI H5N1 is primarily an avian virus, there have been instances in which human infections have occurred. Most people have been infected through very close contact with infected birds, usually poultry. There is concern about the possibility of genetic exchange between human and avian viruses. If this genetic exchange were to occur, the potential result would be a novel, possibly lethal, virulent influenza strain that is easily transmissible from human to human. Thus far, approximately 400 human infections have been documented with most infections resulting in death from HPAI H5N1. Disease-control centers worldwide have prioritized the study of this pathogen. As a result of worldwide concern regarding the presence and transmission of the HPAI H5N1, the U.S. Department of Agriculture (USDA) has launched a national avian influenza surveillance program. The primary objective of this program is to partner with states to embark on sampling and surveillance efforts sufficient to detect this pathogen should it exist within the Unites States. By collecting cloacal and tracheal samples from waterfowl, shorebirds, and other migratory birds and submitting these samples to the National Animal Health Laboratory Network (NAHLN) for testing, early detection of the high-path H5N1 strain is possible. States are separated into one of three tiers (I, II or III), depending upon the suspected vulnerability to appearance of HPAI H5N1 strain. Kentucky is a tier III region, and thus labeled with a low probability of viral importation. In Kentucky, KDFWR collected approximately 465 samples during the 2008-09 period, from a broad geographic area within the state, all of which have tested negative for the high-path H5N1 strain of avian influenza. Represented in this sample are 415 hunter-killed birds, 50 live birds. Primary species surveyed include mallards, wood ducks, green-winged teal, Canada geese and 9 other waterfowl species. Under the current 2009 AI monitoring plan broad scale monitoring in If deemed necessary by the USDA, we plan to continue these surveillance efforts in the Commonwealth in 2008.

Funding Source: *United States Department of Agriculture (USDA)*

KDFWR Strategic Plan. Goal 1, Strategic Objective 1c. Comprehensive Wildlife Conservation Strategy: Appendix 3.3; Priority Conservation Action #132.

Migratory Shorebird, Colonial Water Bird and Woodcock Investigations

Erin Harper, John Brunjes and Rocky Pritchert, Kentucky Department of Fish and Wildlife Resources

In spring 2008, we began monitoring a colony of black-crowned night-herons (*Nycticorax nycticorax*), which have become a nuisance, nesting in suburban Louisville. They have recently expanded their numbers and range within Kentucky. Their droppings and waste pose health and aesthetic concerns for citizens living in this area. Over 80 breeding pairs were nesting within a 0.2 mi^2 area in Germantown. In May 2008, nests were removed by USDA Wildlife Service personnel, with the hope that the night-herons would renest elsewhere. About 75% of the pairs renested, with some moving further south and expanding the colony among a 0.3 mi^2 area. A large percentage of nests were successful. Young night-herons were seen later in the summer walking among tree branches waiting for parents to bring food. We captured and attached leg bands and transmitters to two adult night-herons in order to monitor behavior and movements. One transmitter was removed due to complications, while the other bird continued to roost and forage until it migrated south in October. With no nest or mate to tend to, it proved to be a non-breeding adult. In addition to continued monitoring efforts in 2009, we plan to attach more transmitters to breeding adults. These efforts will help us manage for future problems created by the night-herons.

During migration, greater sandhill cranes (Grus Canadensis tabida) travel in large flocks through central regions of Kentucky on there northward route to the Great Lakes and Canada. Sandhill cranes have been using migratory stopover sites in Kentucky for many years. One of these major sites is east of Cecilia in Hardin County where there are abundant grain fields with water-filled ditches or depressions that provide food for the thousands of cranes that stop and rest. We conducted 10 surveys between 5 December 2008 and 3 March 2009 at this site. We counted 15,262 sandhill cranes. The peak migration occurred between 17 February and 3 March when a total of 10,455 cranes were counted. Few to no cranes were observed after the first week of March. Surveys are important because they provide information to develop a chronology of migration through Kentucky and will be useful in assessing changes in abundance and distribution.

These monitoring and survey efforts will provide a platform by which long-term trends may be assessed, and management actions that are consistent with long-term welfare of specific populations may be implemented.

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

KDFWR Strategic Plan. Goal 1. Strategic Objective 5.

Black-crowned night heron / John Brunjes

Monitoring and Management of Kentucky's Waterfowl

Rocky Pritchert, John Brunjes, Thomas Young and Pat Hahs, Kentucky Department of Fish and Wildlife Resources

Periodic aerial surveys have been implemented by KDFWR to monitor winter waterfowl populations across the state. These wide-reaching surveys are conducted about once every two weeks from late November through February. All known major migration/wintering waterfowl concentration areas are surveyed. These areas include the Mississippi River, Ohio River, major wetlands in the Purchase and Green River regions, as well as the major reservoirs of central and northeastern Kentucky. Survey observers identify birds to species ducks, geese, and swans whenever possible and record the total number of each species observed along the routes. In addition, observers record the number of coots, sandhill cranes and eagles encountered along each route. Surveys are conducted along established flight routes and ducks (dabblers and divers), geese (Canada, snow, and blue), and coots are counted during each flight. Bald eagles are also counted, when present, on these survey routes. Over the 2008/2009 winter period, we conducted six waterfowl surveys between 29 November 2008 and 15 February 2009. KDFWR observers recorded 822,764 ducks, 135,722 Canada geese, 112,099 snow geese, and 177 eagles. The average number of birds recorded per survey during the 2008/09 wintering period was 137,127, 41,303 and 30, ducks, geese and eagles, respectively. Although waterfowl populations exist within each of these survey routes, waterfowl populations within the Western Kentucky Purchase Region are consistently greater than elsewhere in the Commonwealth. These periodic waterfowl surveys are extremely because they provide much-needed information pertaining to population sizes, species distribution and patterns of winter use on Kentucky wetland habitats. Without this information, waterfowl management in Kentucky would be a daunting task. We anticipate that these waterfowl surveys will continue for the 2009/10 winter period and beyond, to ultimately provide land managers and biologists with data addressing long-term waterfowl trends within Kentucky.

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

KDFWR Strategic Plan. Goal 1, Objective 5.

Waterfowl / John Inman

Monitoring Canada Goose Populations in Kentucky

Rocky Pritchert, John Brunjes, and Erin Harper, Kentucky Department of Fish and Wildlife

Canada goose roundup / Joe Lacefield

Waterfowl managers use banding data to assess survival and harvest rates, migration routes, speed and timing of migration, population distribution and numerous basic life history parameters. Kentucky Department of Fish and Wildlife Resources have banded Kentucky nesting Canada geese since the early 1980's. According to Ducks Unlimited, the Canada Goose (*Branta Canadensis*) is second only to mallard ducks (*Anas platyrhynchus*) in the number of birds banded in North America with nearly 3.0 million birds banded through 2008. Although Canada Goose populations are globally secure, Kentucky, Virginia, Alabama, and Louisiana list this some populations of this species as vulnerable (S3 designation; Natureserve Explorer). Fortunately, prudent management efforts in Kentucky as well as across the flyway have resulted in an increase in the number of temperate nesting Canada geese in the Commonwealth, especially in the central and northeastern portions of the state. The Kentucky Department of Fish and Wildlife Resources has been a long-time participant (since the mid 1980s) in Canada Goose banding efforts. In 2008, a total of 1,359 Canada geese were captured and banded in Kentucky and another 5,377 Canada geese that were captured, banded and translocated to Kentucky from Michigan were banded by KDFWR personnel. Canada geese were banded from 25 sites in Kentucky, representing 1,245 adults and 108 hatch year birds. The sex ratio for these birds approached 50:50 (we were able to sex all but 6 of the birds captured in Kentucky). Kentucky's growing population of Canada geese has afforded increased hunting opportunities across the state. Several decades ago, hunting opportunities were largely limited to the western portion of the state; today, giant Canada geese are present on water bodies statewide. Through the continued collection of data from capture and banding efforts, KDFWR will be able to make informed management decisions regarding season dates and bag limits and insure a sustainable and healthy population of these birds in Kentucky.

In addition to banding Canada goose banding efforts, aerial spring surveys are employed by KDFWR to evaluate population status of nesting Canada geese. Since 1994, Mississippi Flyway states have surveyed temperate nesting (resident) Canada goose populations annually and have used the data to assess the overall status of this important goose population on both statewide and flyway wide basis. In turn the information is used to make harvest management decisions with focus on temperate population with limited impacts on other migrant Canada goose populations. KDFWR has conducted spring temperate nesting Canada goose surveys since their initiation in 1994. During that period Kentucky has observed slow but steady growth in the number of temperate nesting Canada geese in the state. In 1994, Kentucky's spring population was estimated to be about 18,000 total Canada geese with the number of breeding pairs estimated to be about 3,000. The estimated population from the 2008 survey was about 32,500 in the surveyed area with about 10,000 breeding pairs. The slow growth of this population compared to that observed in northern states can possibly be attributed to two factors. The first, Kentucky's population of temperate nesting Canada geese has a relatively low reproductive rate as observed by the low number of goslings banded annually. The second factor may be related to harvest during the hunting season. KDFWR over the years has slowly expanded Canada goose hunting opportunities to be consistent with the long-term welfare of the resource. Since the 1990's the proportion of Kentucky nesting temperate Canada geese harvested by area hunters has increased from 8% in 1990 to 52% of the total harvest in 2007. Given the slow but steady growth of the population, this is consistent with KDFWR temperate nesting Canada goose management efforts. The information provided by this survey is critical for continued monitoring and management of this population and KDFWR will again conduct spring surveys in 2009.

Funding Source: *Non Federal Aid (NFA)*

KDFWR Strategic Plan. Goal 1, Objective 5.

Mourning Dove Banding in Kentucky

John Brunjes, Kentucky Department of Fish and Wildlife Resources

Although mourning doves are considered one of the most common bird species in eastern North America, long-term, nationwide monitoring (beginning in 1966) has revealed downward population trends. Given the economic and social importance of mourning doves, KDFWR, along with 32 other states nationwide, initiated a dove banding program in 2002 to better monitor and mange Kentucky's and the nations mourning dove population.

To date, more than 10 thousand bands have been applied to mourning doves in all five regions of Kentucky. In 2008, banding efforts occurred between July 1st and August 31st, and we successfully banded 1,837 birds from 61 sites statewide. Of these captured birds, 968 were adults and 869 were young birds, and we were able to determine the sex of 916 birds of which 66% were male and 33% were female. Interestingly, young birds were very difficult to catch until late in the trapping period with only 103 young birds banded by August 1. This may be explained by heavy early season rainfall which could have caused early season nest failures.

Hunters reported the harvest of 70 banded in 2008, and have recovered over 600 bands since the onset of this program. One hunter harvested a bird banded as an adult in 2004. Although most recoveries occurred in Kentucky, doves banded in Kentucky have also been recovered in Illinois, Indiana, Arkansas, Louisiana, Missouri, Ohio, West Virginia, North Carolina, South Carolina, Georgia, Florida, Tennessee, Mississippi, Oklahoma, Texas, and North Dakota.

In addition to banding, KDFWR also collects wings from harvested mourning doves. In 2008, 4,563 wings representing 19 sites were obtained from collection barrels, check stations manned by KDFWR personnel. Approximately 5000 additional wings were obtained from mail surveys to hunters. Valuable life history data were obtained from these wings including: age at harvest, sex ratios of harvested birds and information on the timing of nesting activities. We plan to continue banding and monitoring Kentucky's mourning dove population in 2009. By gathering regionally-specific life history data, we will be able to make optimally informed harvest management decisions.

Mourning dove banding / KDFWR

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

KDFWR Strategic Plan. Goal 1, Objective 5.

Proactive Wood Duck Monitoring and Management in Kentucky

Rocky Pritchert, John Brunjes, and Erin Harper, KDFWR

Female green-winged teal and male wood duck / Joe Lacefield

Wood ducks are the most common breeding duck in Kentucky, and 2008 marked yet another year of successful wood duck management by the Kentucky Department of Fish and Wildlife Resources. Historically, KDFWR has proactively managed wood duck populations through banding, nest box programs, spring stream surveys, and careful regulation of hunting. These management efforts have been important in restoring wood duck populations, which approached nearly unsustainable lows by the mid 1950's due to over-hunting and habitat destruction. Fortunately, through prudent management efforts wood ducks are now common, permanent residents of Kentucky. In addition to long-term banding programs, KDFWR has conducted annual stream surveys to assess reproductive effort across the state. Wood ducks are secretive ducks which prefer to use forested wetlands and mature wooded stream/river riparian zones which are not easily surveyed using conventional aerial survey methods. Wood duck stream surveys are one of the longest running surveys currently conducted by KDFWR, beginning in the mid 1960's it still continues today with some modification. In the early years observers only reported the number of broods and young per brood, regardless of the number of adults encountered. Today the survey still monitors broods and young but also collects data on adults such as sex, whether birds are paired or whether females are present with broods. The additional data provides KDFWR with better insight into wood duck reproductive efforts.

In 2008, the number of young per brood was 5.34 and near the long-term average of 5.4. The 0.36 broods per mile and was similar to 0.34 broods per mile observed in 2007, but well below the 0.47 reported in 2006 and also lower than the long-term average of 0.4. However the lower brood counts are probably reflective of the drought experienced over the last two nesting periods and these counts fall within the range of experience encountered during the history of the survey. While wood duck reproductive was somewhat depressed the last two years because of the drought, overall Kentucky's wood duck population is healthy and the trend remains stable.

In addition to wood duck stream surveys, KDFWR also has a summer banding program for wood ducks. The importance of nesting wood duck populations was elevated when Kentucky and two other states were permitted to establish an experimental September wood duck season. This early hunting opportunity quickly gained favor with Kentucky's waterfowl hunters. A major factor for maintaining the September season was that KDFWR would monitor local wood duck numbers to evaluate the potential harvest affects. The wood duck's secretive habits make this species somewhat difficult to survey using standard techniques. Therefore, KDFWR established a summer banding program to determine, harvest and survival rates, as well as harvest distribution for local nesting wood ducks. Since 1980, KDFWR has banded between 1,700 - 3,000 birds annually, after the primary nesting period and prior to the September hunting season. In 2008, KDFWR captured 2,378 wood ducks and placed leg bands on 2,035 of them. Wood ducks were captured from numerous locations across the state. Most wood ducks (688) were banded in the Green River region, but substantial numbers (13%) were banded in eastern regions of the state as well. Banding effort was stratified by regions of harvest and this effort has been successful in identifying the southern populations as that segment Kentucky's birds are most closely associated with. As a result of these banding efforts, KDFWR was granted operational status of the September wood duck season in 2003. KDFWR has committed to continued banding as one of the conditions for maintaining operational status this season.

KDFWR will continue to use stream counts and band data to monitor this important Kentucky resource.

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

KDFWR Strategic Plan. Goal 1, Objective 5.

Impacts of Herbicide Application Following a Late Summer Burn

Brian Clark, Ben Robinson, John Brunjes, Dave Frederick, Chris Grasch, and Jim Barnard, Kentucky Department of Fish and Wildlife Resources

At KDFWR headquarters we anecdotally gauged the impacts of Select herbicide (grass killer, (chemical name Clethodim) on plants following a late summer prescribed burn. In September 2007, a burn was conducted on a small field previously converted from fescue to native grasses and forbs. After re-growth of grasses half of the field was sprayed during early October with Select herbicide at a rate of 12 ounces per acre, while the eastern/downhill half was left untreated. Suppression of the grasses was visibly evident by winter and persisted through the following spring. In July 2008 following herbicide application, total grass cover was still noticeably reduced, especially among cool season grasses such as tall fescue and brome species, which were probably most affected by the herbicide due to timing of application. Native warm-season grasses were more clumpy and forbs were more diverse and predominant 1 year after treatment.

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

Comprehensive Wildlife Conservation Strategy: Appendix 3.3, Priority Conservation Action #76.

Clethodim-treated (east/left side) vs. untreated side of field at KDFWR headquarters, 9 months following burning and subsequent spraying / Brian Clark

Establishing Shrubs and/or Brambles on Reclaimed Minelands

Scott Harp and Eric Williams, Kentucky Department of Fish and Wildlife Resources

The successful establishment of shrubs and/or brambles on mine reclamation sites is an important task because these habitats provide structure, cover, and foraging areas for many types of wildlife. Additionally, these areas often act as movement corridors for wildlife and may serve as important erosion control components of the landscape. Unfortunately, it is often costly and difficult to establish and maintain shrub/bramble habitats on reclaimed mining sites. Competition and domination of reclamation sites by Sericea lespedeza*, Lespedeza cuneata,* an aggressive invader of open areas, poses a considerable challenge when attempting to re-establish shrubs and brambles. Previous efforts to plant seedlings have not been successful; high mortality rates are usually present, making these efforts somewhat cost prohibitive.

In 2007 we initiated a long-term study to assess success of direct seeding shrubs/brambles on reclaimed mine ground within Peabody Wildlife Management Area. Through this study, we hope to address the following questions: 1) Will direct seeding of shrubs/brambles result in better survivability than planting seedlings? 2) Will developing shrubs out-complete sericea with only one year of control? 3) Will shrubs develop in a mixed species situation or will one species out-compete the others? 4) Is direct seeding efficient when considering time and money involved when compared to planting seedlings? 5) Will cold storage be sufficient to break seed dormancy and initiate germination, or will planting during natural summer conditions improve germination?

In an attempt to answer these questions, we created two test plots in the summer of 2007: a 0.76 acre plot and a 0.66 acre plot. These sites were sprayed with Garlon 3A and disked to bare ground in August & September 2007. Seeds were ordered, soaked for 24-hours in water, and then placed in cold storage substrate (43 degrees farenheit) the first week of October. They remained in cold storage until planting on June 8, 2008. Seven species were planted: Silky Dogwood, Gray Dogwood, Smooth Sumac, Elderberry, Coralberry, Blackberry, and Wild Plum. A third 1.0 acre test plot was created in August 2008. This plot was prepared identically to the previous 2 test plots, and was seeded with dormant seed on August 15, 2008 to mimic the natural distribution of seeds from fruit over the summer months. Five species were planted: Silky Dogwood, Gray Dogwood, Smooth Sumac, Wild Plum, and Serviceberry.

No initial germination from the chill-treated seed was evident in the summer/fall of 2008. However, subsequent research indicates that a “warm stratification” period is typically required before cold stratification in order for dormancy to break. The addition of the third test plot should indicate if that was the cause of the first 2 plots not germinating. This is a long-term project which will continue until vegetation becomes established in each test plot such that we may evaluate the success of our direct seeding efforts. If direct seeding of shrubs/brambles proves to be effective, we hope to have this practice valuated/approved by NRCS for potential inclusion in Farm Bill programs.

Funding Source: *Pittman Robertson (PR)*

Comprehensive Wildlife Conservation Strategy: Appendix 3.3, Priority Conservation Action #76.

Reclaimed mineland / Scott Harp

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Sawfin shiner / Matt Thomas

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