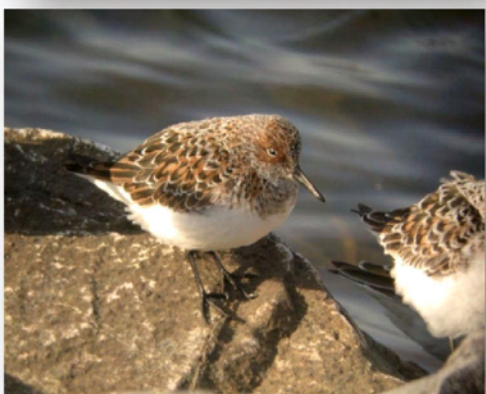
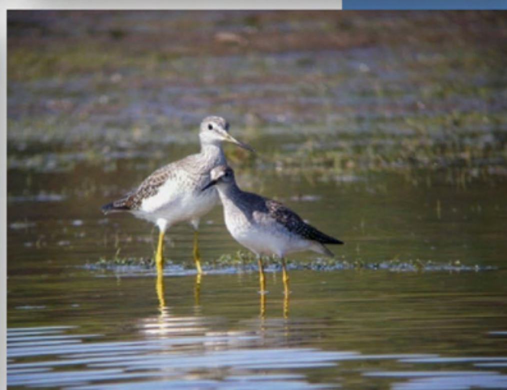
Results of the Tennessee River Valley Shorebird Initiative





Travis H. Henry

Final Report July 2012

Photo Credits

Cover photos clockwise from upper right (Photo Credit):

Mudflat vegetation, Lick Creek Embayment, Kentucky Reservoir, 5 October 2004 (Jenny Davenport)

Greater and lesser yellowlegs, Boyd's Branch Embayment, Kentucky Reservoir, 18 October 2006 (Hill Henry)

Aerial view of Big Sandy Embayment, Kentucky Reservoir (Barry Hart)

Pectoral sandpiper, Earth Complex, Memphis, Tennessee, 7 August 2007 (Mike Todd)

Lesser yellowlegs, Saffell Island, French Broad River, Douglas Dam Tailwater, 19 March 2009 (Hill Henry)

Dr. Brian Harrington (left) and Jeff Wilson, Shorebird Training Workshop, Memphis, Tennessee, 10 May 2005 (Mike Roedel)

Sanderlings in breeding plumage resting on riprap, Kentucky Dam, 16 May 2007 (Brainard Palmer-ball)

Willets in breeding plumage, island on Jonathan Creek, Kentucky Reservoir, May 2005 (Hill Henry)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

ADCNR	Alabama Department of Conservation and Natural Resources
Agencies	Federal and State Agency cooperators
Dewatering Unit	A sub-impoundment managed seasonally to remove water from low-lying sites
Flats	Mudflats
Group	Waterfowl and Shorebird Working Group
ISS	International Shorebird Survey
KDFWR	Kentucky Department of Fish and Wildlife Resources
ROS	River Operation Study
LIDAR	Light Detection and Ranging
ROS	River Operation Study
TRV	Tennessee River Valley
Sub-impoundment	Small impoundment maintained by dikes and a water control structure
TRVSMP	Tennessee River Valley Shorebird Monitoring Plan
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USFWS	U.S. Fish and Wildlife Service
UT	University of Tennessee

ACKNOWLEDGEMENTS

We acknowledge the efforts of Erin Hobson, Jenny Fiedler, Elizabeth Burton, Alana Terrell, and Alan Trently. These individuals worked tirelessly to gather data, develop graphics, and contribute to presentations and annual summary reports.

Jason Mitchell facilitated all of the meetings with the Shorebird Committee, performed numerous surveys, examined sites, and was instrumental in developing the overall project.

Barry Hart and Damien Simbeck coordinated regional shorebird surveys, spending many hours with shorebird survey teams. Their exceptional shorebird identification skills and observations of biological resources in the Valley are especially noteworthy.

Barry Hart and Alan Mays sampled vegetation on flats on Kentucky Reservoir over the course of the project.

Dr. Matt Gray and Dr. Roger Tankersley were instrumental in developing several aspects of the study and addressing research topics identified by the Shorebird Committee. Dr. Tankersley also acquired and managed funding through the Tennessee Valley Authority's (TVA) former Research and Development Program.

John Laux, Matt Smith, and Drew Wirwa completed several studies in pursuit of Masters of Science degrees supporting this project. Their studies, supervised by Drs. Gray and Tankersley, are a cornerstone for future shorebird, waterfowl and habitat studies in the region. University of Tennessee (UT) and Tennessee Wildlife Resource Agency (TWRA) provided boats and materials supporting these projects. Wirwa (2009) was funded through a cooperative agreement between TVA, U.S. Fish and Wildlife Service (USFWS) and UT.

Dr. Brad Andres, Steve Cottrell, Dr. Brian Harrington, Wes James, Dr. Charles Nicholson, and Brainard Palmer-Ball provided numerous suggestions regarding the design of this study. Cottrell and James provided extensive knowledge about potential shorebird sites throughout the Valley.

Hap Chambers, Mike Sledjeski and Ken Dubke contributed extensive shorebird datasets from sites in Tennessee and Kentucky. Data collected by these individuals contributes substantially to the knowledge of shorebirds throughout the Tennessee River Valley.

Vanessa Pompei, Dwight Cooley, Greg Jackson and Dr. Chuck Hunter provided historic data for piping plovers in the Valley.

Dr. Brian Harrington and Jeff Wilson led several shorebird training sessions. Ducks Unlimited, USFWS and TWRA provided facilities for meetings and training workshops. We appreciate Dr. Harrington's advice and access to historical International Shorebird Survey (ISS) data for the region.

Lastly, we thank the members of the shorebird committee for their cooperation, guidance, and involvement during the development and implementation of this study. We look forward to further cooperation with this group to address shorebirds and other natural resource issues in the future.

EXECUTIVE SUMMARY

The Tennessee Valley Authority's (TVA) reservoir system provides a diverse array of benefits for the Tennessee River Valley (TRV). Benefits include recreation, water supply and water quality, the facilitation of navigation, production of hydroelectric power, cooling of generation facilities, and the prevention of floods (TVA 2004).

The reservoir system also provides benefits to wildlife resources. During annual reservoir drawdowns, thousands of acres of mudflats are exposed, providing habitat for migrating shorebirds and waterfowl (TVA 2004; Smith 2006; Laux 2008; Wirwa 2009). As mudflats are exposed, a complex community of invertebrates develops in moist soils along the receding reservoir edge, creating an important source of food for shorebirds and waterfowl (Skagen and Knopf 1994; Laux 2008; Wirwa 2009). As the drawdown continues, plant communities develop on upper portions of mudflats, providing an important source of food and cover for waterfowl during fall and winter months.

In 2004, TVA initiated the River Operation Study (ROS) to examine potential changes in reservoir operations to enhance recreational opportunities in the TRV (TVA 2004). Operational changes initiated after the ROS resulted in extensions of summer pool levels on many TVA reservoirs. This resulted in the delayed exposure of mudflat habitats, important feeding and resting sites for migratory shorebirds and waterfowl. This outcome was a source of concern for state and federal agencies, private organizations, and the public during TVA's environmental review. Precisely quantifying the scope and intensity of impacts was challenging because shorebird and waterfowl resources in the TRV are largely undocumented at a landscape level in scientific literature.

To address these concerns, TVA worked with state and federal agencies to determine habitat requirements of shorebirds and waterfowl in the TRV, and identify opportunities for enhancing these habitats. TVA goals were to complete the following:

- Coordinate regional shorebird/waterfowl monitoring to determine the distribution of these resources in the Valley
- Coordinate regional shorebird/waterfowl research to identify and address research needs.
- Monitor reservoir drawdown effects on shorebirds and waterfowl and their habitats.
- Characterize mudflat habitats used by shorebirds and waterfowl.

TVA collaborated with multiple state and federal agencies to establish a working group. The goals of the group were to identify and achieve common conservation goals regarding shorebirds and waterfowl in the region. Furthermore, TVA, Tennessee Wildlife Resources Agency (TWRA), and the U.S. Fish and Wildlife Service (USFWS) collaborated with the University of Tennessee (UT) to address specific research needs regarding shorebird and waterfowl resources identified by the working group.

Results

Regional Monitoring Coordination

The working group achieved the following goals:

- Identified sites historically and presently used by shorebirds throughout the TRV.
- Developed a regional plan to accomplish shorebird monitoring goals of cooperators.
- Determined the temporal and spatial distribution of shorebirds at stopover and wintering sites in the TRV.
- Explored ways to enhance and develop shorebird habitats within the TRV.

The working group collectively adopted a sampling methodology to perform comprehensive shorebird surveys throughout the TRV. TVA also developed and held workshops with national and regional shorebird experts to train survey participants. Ultimately, these surveys allowed the working group to identify critical shorebird habitats throughout the TRV and document seasonal use of habitats by shorebirds and waterfowl. TVA will use the acquired data to address any future operational changes in TVA's reservoir system.

Regional Research Coordination

The working group identified research topics related to shorebirds, waterfowl and their use of mudflat habitat in the TRV. The working group collectively addressed all priority research topics. TVA, the U.S. Fish and Wildlife Service (USFWS) and University of Tennessee (UT) funded three graduate studies examining the relationship between reservoir operations and shorebird resources. These studies contribute significant information regarding the distribution of shorebirds, waterfowl, and their habitats throughout the TRV. These resources were largely undocumented in scientific literature prior to these studies.

Monitor Reservoir Drawdown Effects

Monitoring activities documented the following:

1. Distribution of habitats in the TRV.
2. Spatial and temporal distribution of shorebirds and waterfowl in the TRV
3. Development of vegetation on mudflat habitats.

Habitats and vegetation

The TRV has a diversity of habitat and shorebird resources. We identified approximately 270 mudflats (>24,000 acres) in the TRV. Of these habitats, only 26 percent were determined to proved optimal shorebird and waterfowl foraging and loafing areas. Although these sites are distributed throughout the TRV, most occur on Kentucky, Wheeler, Douglas, and Chickamauga reservoirs. Eighty-nine percent of the mudflats in the TRV are located along TVA reservoir shorelines, the remainder occur on adjacent landscapes. These reservoir and off-reservoir localities were sample sites for comprehensive shorebird surveys. The relationship between reservoir and off-reservoir sites is critical as one type of habitat often offsets the temporary unsuitability of the other during drought or floods.

Habitats were affected by rate and timing of TVA reservoir drawdown. Rate of drawdown varied among reservoirs. Fast drawdowns promoted development of non-native invasive vegetation. Slower drawdowns maintained optimal shorebird and waterfowl habitat longer and promoted native vegetation favored by waterfowl.

Timing of drawdown strongly influences the availability of habitat during shorebird migration and the subsequent establishment of vegetation for waterfowl. Early drawdown (August) creates habitat for shorebirds throughout migration and allows vegetation ample time to mature and reproduce. Drawdowns initiated further into the fall provide habitat for late migrants. However, late drawdowns reduce time for vegetation growth and drastically reduces seed production or in some cases, eliminates vegetation altogether.

Shorebirds and Waterfowl

More than 129,000 shorebirds, representing 37 species, were observed during the 5-year study. This level of diversity exceeds those reported from other interior regions in the United States. The majority of shorebirds were observed on Kentucky, Wheeler, Douglas and Chickamauga reservoirs. Kentucky and Douglas reservoirs provide the highest quality habitats. Chickamauga and Wheeler reservoirs provide benefits for birds overwintering in the region; however, several historical shorebird aggregation sites on these reservoirs are no longer available due to prior changes in reservoir operations.

Shorebirds begin migrating through the TRV in late July. Exposure of mudflats during August is important for several shorebird species of concern. As feeding during migration is critical to shorebird survival (Skagen and Knopf 1993), conservation of habitats is a priority management objective (Brown et al. 2001).

Waterfowl resources are diverse in the TRV. Peak waterfowl abundance occurs during November; several daily surveys exceeded 5,000 birds on nine mudflats (Wirwa 2009). Whereas most reservoirs provide habitat for either early or late migrants, only Kentucky and Douglas Reservoirs provide important habitats throughout fall migration.

Timing and rate of drawdown of TVA reservoirs significantly influences suitability of habitat for waterbirds by affecting mudflat exposure, vegetation establishment, seed production, and invertebrate availability (Wirwa 2009).

Effectiveness of Multi-agency Collaboration

The working group was an effective collaborative effort. Aside from the biological information acquired during the 5-year study, participants noted that the collaboration led to improved communication between agencies, established an effective mechanism for addressing common conservation goals, including goals outside of the scope of this study, and fostered better understanding of the unique missions of each agency.

The working group collectively addressed all priority research topics. The partnership with the University of Tennessee (UT) provided third party evaluation of waterbird resources in the TRV. Studies at UT addressed several unmet research needs identified by the working group. The project not only acquired substantial data addressing shorebirds, waterfowl and their habitats, it also verified many of TVA's predicted outcomes outlined in the ROS EIS.

The success of the working group emphases the importance of collaborative partnerships, especially when developing landscape-level projects involving multiple species of wildlife. For a detailed description of working group meetings and an evaluation of the effectiveness of the Regional Monitoring Coordination, see *Section 10.1 Establishing a shorebird conservation working group in the Tennessee River Valley: A project evaluation*.

Conclusion

Given the annual variation in drawdown rates, operational changes implemented under ROS resulted in varying impacts to shorebirds, waterfowl, and their habitats. Timing of exposure of mudflat changed in varying degrees on several reservoirs, especially on Wheeler and Pickwick Reservoir. Other reservoirs (i.e., Douglas Reservoir) only saw slight changes on timing of mudflat exposure.

TVA's reservoir system continues to provide a diversity of habitat for shorebirds and waterfowl. On a landscape level, the mixture of early and late exposed habitats greatly benefits these resources.

As reservoir management regimes have changed over time, exposure of habitats on Pickwick, Wheeler and Chickamauga has been progressively delayed, only providing habitat for late migrants and overwintering birds, or during drought. It is important to note that this late-season, overwintering habitat provides an important resource for shorebirds and waterfowl; offsetting the reduction in habitat quality observed on mudflats exposed earlier in the migratory season.

Part of TVA's mission is to balance competing demands on the reservoir system, with its primary focus on navigation, flood control, renewable hydropower, and on providing sources of cooling water for power generation systems. TVA's ability to balance these demands is complex, especially in light of often-dramatic daily, seasonal, and annual variation in weather conditions observed throughout the Valley. Natural resource management is also an important component of TVA's mission of providing affordable and reliable power, promoting sustainable economic development, and acting as a steward of the Valley's resources. Given the regional importance of shorebird and waterfowl stopover and overwintering habitats on TVA reservoirs, considerations for these resources are important. Future changes in reservoir operations should consider effects to shorebird and waterfowl resources and their habitats, especially modifications resulting in changes in drawdown rate and timing.

Recommendations

The study resulted in eight specific recommendations that would benefit shorebirds, waterfowl and their habitats:

1. Continue current reservoir management as weather allows, providing slow drawdown, which benefits mudflat plant communities and wildlife.

2. Continue current reservoir management as weather allows providing a mixture of early (August) and late season (October) shorebird habitat.

3. Investigate the feasibility of installing small levees and water control structures, or excavate shallow depressions to hold water temporarily during drawdown in dewatering units or on large reservoir mudflats.

4. Examine modifying the management of dewatering units to further benefit shorebirds and waterfowl.

5. Future system changes should consider feasibility of initiating earlier, slower drawdown in fall and later spring fill of select reservoirs (Wheeler and Chickamauga).

6. Maintain the current operational guide curve at Kentucky Reservoir, initiating drawdown by July 5 (as rainfall permits).

7. Future system changes should consider feasibility of annually alternating pre- and post-ROS reservoir drawdown schedules on Wheeler Reservoir.

8. Collaborate with other agencies to protect important off-reservoir stopover habitats through purchase or placement of conservation easements.

1.0 INTRODUCTION

1.1. River Operation Study

TVA is a federal corporation responsible for managing water resources in the Tennessee River Valley (Figure 1-1). Throughout the river system, TVA operates a complex series of reservoirs and dams to manage flows through the TRV.

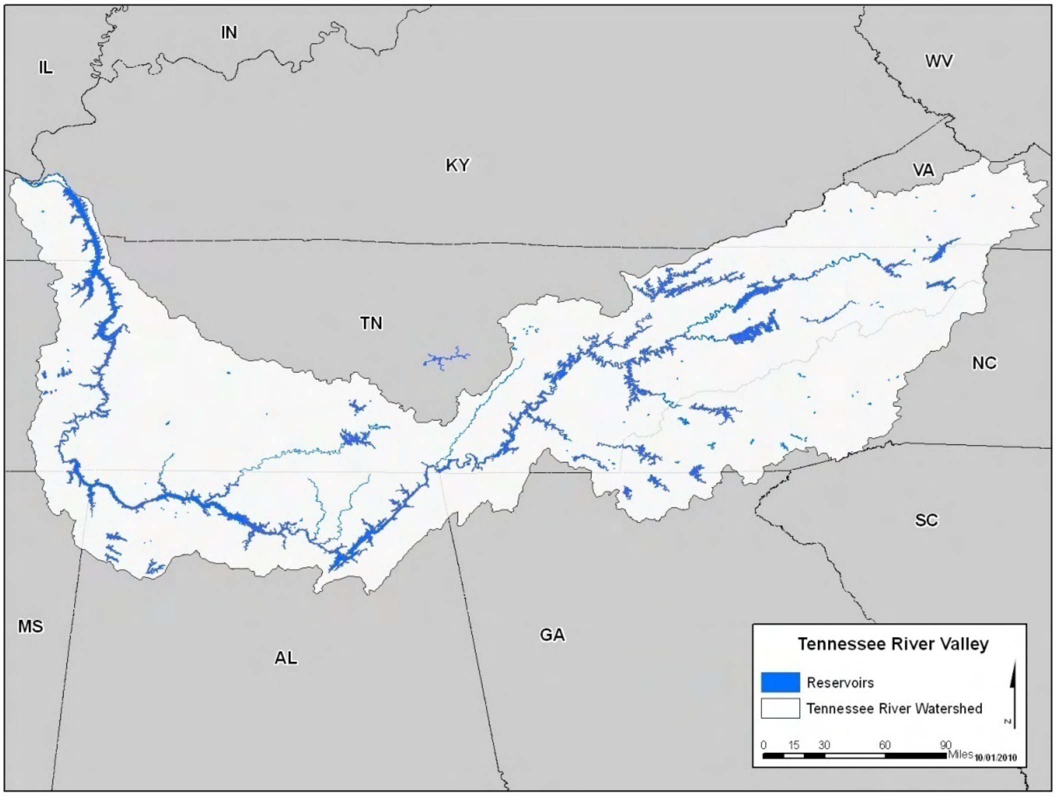


Figure 1-1. The Tennessee River Valley Watershed, USA

During annual reservoir drawdowns, thousands of acres of shoreline are exposed. This shoreline is composed of bedrock, clay-dominated ridges, and extensive mudflats. With the exception of mudflats, these areas provide little benefit to wildlife. As the mudflats become exposed, a complex community of invertebrates develops in the moist soil (mud zone) along the receding reservoir edge, creating an important source of food for shorebirds (Charadriiformes) and waterfowl (Anseriformes) (Skagen and Knopf 1994; Laux 2008; Wirwa 2009). As the drawdown continues, the mud zone and invertebrate community recedes down the elevational gradient, following the reservoir edge (Figure 1-2). Plant communities develop on upper portions of the mudflats, persisting through the first severe frost (Webb 1988; Gunn 2003; TVA 2004). This vegetation provides an important source of food and cover for waterfowl during fall and winter months, and nursery sites for fish as reservoirs fill during April.

In 2004, TVA completed the ROS to examine potential changes in reservoir operations to enhanced recreational opportunities in the TRV (TVA 2004).

TVA's implementation of changes, as outlined in the ROS, resulted in the delay of drawdown on several reservoirs from August until September, eliminating stopover habitat at some sites during the first half of shorebird fall migration (Smith 2006) and shortening the growing season for flats vegetation, potentially reducing this source of food for waterfowl. These outcomes were a source of concern for the public, state and federal agencies, and private organizations during the review of TVA's environmental impact statement.

Figure 1-2. A mud zone on a mudflat at Rankin Wildlife Management Area. Note the granular soil deposits created by invertebrates between the shoreline and the emerging vegetation zone.

TVA assessed the operational impacts to shorebird and waterfowl habitat proposed under the new operation schedule. Because of issues raised by the public and by regulators, in addition to TVA's need for more detailed information regarding these resources, TVA committed to work with state and federal agencies to determine habitat requirements and opportunities for enhancements to shorebirds and waterfowl in the TRV (TVA 2004).

To meet commitments related to shorebirds and waterfowl as outlined in the ROS, TVA worked with a multi-agency working group to identify and achieve common conservation goals. TVA's contribution to the working group focused on the following tasks:

- **Coordinate Regional Shorebird/Waterfowl Monitoring -** Coordinate a multi-agency working group to identify shorebird and waterfowl habitats. Determine habitat requirements and opportunities for enhancements to shorebirds and waterfowl. Coordinate a large-scale shorebird monitoring effort.

- **Coordinate Regional Shorebird/Waterfowl Research -** Identify critical research needs and collectively leverage resources to address them.

- **Monitor Reservoir Drawdown Effects -** Quantify the extent of mudflats exposed during reservoir drawdown and map the distribution of these sites throughout the TRV. Identify aggregations of migratory shorebirds and waterfowl throughout the TRV. Determine how reservoir drawdown influences establishment of vegetation or invertebrates on flats habitats.

- **Assess Mudflat Habitats Used by Shorebirds and Waterfowl-** Explore cost effective ways to map mudflats. Determine rates of exposure during drawdown at differing reservoir elevations.

This report describes the results of TVA's 5-year collaboration with the agencies, UT, private organizations, and members of the public to determine shorebird and waterfowl mudflat habitat requirements, and opportunities for enhancements to this habitat.

2.0 REGIONAL MONITORING COORDINATION

2.1. Introduction

TVA and several natural resource agencies (Table 2-1) developed a working group to examine shorebird and waterfowl resources in the TRV and to identify ways to enhance these resources. The working group was comprised of personnel from TVA, USFWS, the Kentucky Department of Fish and Wildlife Resources (KDFWR), and Tennessee Wildlife Resources Agency (TWRA). The Alabama Department of Conservation and Natural Resources (ADCNR) also provided initial input in the project. An advisory team comprised of leaders of national shorebird and waterfowl initiatives (e.g., International Shorebird Survey, U. S. Shorebird Plan, U. S. Waterfowl Plan-Joint Ventures) provided additional guidance to the group.

The working group held five meetings (see Appendix 10.1) to address common conservation goals, while examining opportunities to identify unmet resource needs in the region. This focus allowed the group to prioritize tasks and pool resources (e.g., staff, money and equipment) to address tasks in a coordinated manner. The group identified the following tasks:

- Identify current monitoring initiatives within each agency
- Adopt a common monitoring methodology
- Develop a comprehensive monitoring plan
- Provide quality training for participants
- Identify and prioritize potential sample sites
- Identify repositories for data

Table 2-1. Participants of the Tennessee River Valley Shorebird and Waterfowl Working Group.

Working Group	Position	Agency
Richard Kirk	Non-Game Director	TWRA
Mike Roedel	State Ornithologist (former)	TWRA
Pat Hahs	Wildlife Biologist	KDFWR
John Bronjes	Wildlife Biologist	KDFWR
Beth Ciuzio	Wildlife Biologist	KDFWR
Dwight Cooley	Refuge Supervisor	USFWS
Bill Gates	Refuge Wildlife Biologist	USFWS
Robert Wheat	Refuge Wildlife Biologist	USFWS
Hill Henry	Wildlife Biologist	TVA
Jason Mitchell	Natural Areas Coordinator	TVA
Roger Tankersley	Geographer	TVA
Damien Simbeck	Watershed Team, Wheeler/Pickwick	TVA
Barry Hart	Watershed Team, Kentucky	TVA
Jenny Fiedler	Biologist	TVA
Advisory Group		
Brad Andres	National Coordinator – US Shorebird Conservation Plan	USFWS
Brian Herrington	Lead Scientist	MANOMET Center for Conservation Sciences
Randy Wilson	Biologist, Lower MS Joint Venture	USFWS

2.2. Overview of Current Waterfowl and Shorebird Monitoring in the TRV

The working group identified current waterfowl and shorebird monitoring efforts performed by each agency (Table 2-2); survey efforts varied. Several state and federal agencies conduct monthly waterfowl surveys during the migratory season, including sites on TVA reservoirs. The USFWS regional office in Memphis, Tennessee collects and summarizes these data annually. The group determined that waterfowl surveys are sufficient throughout most regions of the TRV; however, we examined several research topics related to waterfowl (see *Section 4.0 Regional Research Coordination*).

The working group determined that little was known about shorebird use of stopover and wintering sites in the TVA reservoir system. Despite the existence of a national shorebird plan, few agencies performed systematic surveys for shorebirds throughout the TRV. Consequently, our primary focus in this study was to examine shorebird resources in the region. Due to the overall lack of shorebird information, the working group agreed to collectively design and conduct annual surveys of shorebird resources throughout the TRV.

Table 2-2. Waterfowl and shorebird monitoring efforts performed by various agencies throughout the Tennessee River Valley, 2005.

Agency	Site	Activity	Comments
USFWS	Wheeler National Wildlife Refuge	Performs bi-weekly waterfowl census during migration and a winter shorebird census.	Ground surveys are performed by 5-6 people; has historical data from 1947.
USFWS	Tennessee National Wildlife Refuge	Performs bi-weekly waterfowl census during migration and spring and fall shorebird census following ISS protocol.	Aerial waterfowl census in all units, shorebird census are restricted to Duck River Unit.
TVA	Valley-wide	Performs fall through spring shorebird census and habitat study.	Initiated in 2004, involving 3 biologists - Targeted for 5 years.
TWRA	State-wide	Performs fall and spring waterfowl census; began new shorebird census under State Wildlife Grants.	Surveys waterfowl at most WMA's; surveys shorebirds at two sites per region, involving 4 biologists.
KDFWR	State-wide	Performs waterfowl and shorebird surveys at various sites throughout Kentucky.	The state hired a shorebird biologist and funded graduate studies examining shorebird use of WMA's throughout the state.
ADCNR	State-wide	Performs fall and spring waterfowl census; shorebird surveys are limited to the Gulf Coast only.	The state maintains several shorebird-viewing sites along the Tennessee River.

2.3. TRV Shorebird Monitoring Plan

The working group developed a comprehensive approach to systematically survey shorebirds throughout the TRV and to examine existing monitoring plans throughout the country. The working group assessed existing monitoring efforts in the TRV, which included ongoing monitoring programs led by some of the working group members. It was important to identify protocols that resulted in few changes in existing programs, yet were easily adopted by the other agencies.

After reviewing existing national and international shorebird initiatives, the group adopted the International Shorebird Survey (ISS) methodology. The ISS methodology is an established, standardized process for collecting data in a scientifically rigorous manner that fits into current regional, national, and international shorebird initiatives. Adoption of the ISS methodology results in the following benefits:

- Use of existing ISS data and data recording processes
- The ability to retrieve data
- Adoption of an existing scientifically rigorous protocol
- Access to historical data from several sites throughout the TRV
- Ability to use data to make management decisions

The ISS methodology provides three monitoring options with varying levels of survey intensity. Additionally, volunteers can easily implement ISS surveys, increasing the number of participants in this valley-wide survey. Using this methodology, the working group developed the Tennessee River Valley Shorebird Monitoring Plan (TRVSMP).

2.4. Goals and Objectives

The goals and objectives of the TRVSMP addressed the collective needs of the working group (Appendix 12.1) and achieved the following:

- Incorporated a large-scale monitoring plan that achieved the monitoring goals of cooperators
- Documented seasonal use of habitats by shorebirds
- Documented the distribution of shorebirds at stopover and wintering sites TRV
- Explored ways to enhance and develop shorebird habitats

2.5. Training for Participants

To insure the quality of data acquired, the group hosted several training sessions to improve shorebird identification skills of survey participants. Dr. Brian Harrington, a shorebird scientist at the international Manomet Center for Conservation, led a shorebird workshop at the Ducks Unlimited National Office in Memphis, Tenn. Dr. Harrington introduced techniques to identify and census shorebirds. Surveyors throughout North America and South America have adopted these data acquisition techniques for incorporation into national and international shorebird initiatives. Randy Wilson, a USFWS biologist with the Lower Mississippi River Joint Venture and Jeff Wilson, a regional shorebird expert, provided additional instruction.

2.6. Implementation of the TRVSMP

TVA examined various sites in 2004 to assess the exposure of habitats during drawdown and accessibility to these habitats. The group hosted workshops with professional biologists and regional resource specialists to identify known shorebird sites. Resources developed by various state ornithological societies provided additional information. TVA biologists also reviewed aerial photography of the TRV to locate all mudflats on each reservoir in the TVA reservoir system. The group identified and prioritized suitable reservoir mudflats throughout the Valley (see *Section 5.0 Distribution of Habitats in the TRV*). Annual evaluations of sites resulted in changes in priorities as needed to improve survey efficiency.

The working group formally initiated shorebird surveys with a network of biologists and volunteers in 2005. Surveyors recorded birds migrating through the region during the fall and spring seasons, as well as birds overwintering in the TRV. Overwintering shorebirds were largely undocumented in the TRV, and few shorebird studies in the interior U.S. examined overwintering populations. Regional coordinators provided sample dates and sites to all participants in the eastern, central and western regions of the TRV ensuring that survey data were comparable between regions. See *Section 6.0 Distribution of Shorebirds in the TRV* for protocols and results of the multi-year shorebird surveys.

2.7. Results of Regional Monitoring Coordination

The Regional Monitoring Coordination was successful from several standpoints. The working group selected a common methodology for surveying shorebirds and documented shorebird and waterfowl mudflat sites throughout the TRV. This effort led to the collection of substantial amounts of shorebird data for the region.

The working group had four goals and 26 objectives (Appendix 12.1). The status of the goals and objectives are:

Goal 1. <u>Identify historic and current shorebird sites throughout the TRV</u>. All objectives were completed.

Goal 2. <u>Develop a regional monitoring plan to accomplish shorebird monitoring goals of the working group</u>. All objectives were completed.

Goal 3. <u>Determine the temporal and spatial distribution of shorebirds at stopover and wintering sites</u>. All objectives were completed.

Goal 4. <u>Explore ways to enhance and develop shorebird habitats within the TRV.</u> Six of seven objectives were completed.

Limited funding sources were identified for Goal 4. Opportunities for habitat enhancement exist at reservoir and off-reservoir sites; these types of initiatives are an excellent opportunity for multi-agency demonstration projects. Habitat enhancement opportunities are discussed further in Section 5.4.

Aside from the biological information acquired during the 5-year study, working group participants noted that the coordination and the facilitation of group meetings led to improved communication between the agencies. Overall, this initiative improved working relationships between agency partners and fostered a better understanding of each partner's missions and objectives. For a detailed evaluation of the Regional Monitoring Coordination effort, see *Section 10.1 Establishing a shorebird conservation working group in the Tennessee River Valley: A project evaluation*.

3.0 REGIONAL RESEARCH COORDINATION

3.1. Introduction

In 2005, TVA held a regional coordination meeting with state and federal partners to address research needs related to shorebirds and waterfowl resources in the TRV. Although the agencies primarily have a conservation focus, their missions differ and their research interests varied accordingly.

TVA was interested in developing a baseline for shorebird data, as well as assessing impacts of the implementation of ROS to shorebird and waterfowl resources in the TRV. TVA was also interested in quantifying both the presence and the quality of mudflat habitats throughout the region.

National Wildlife Refuge biologists were interested in studying ways to vary management of their sub-impoundments to provide habitat for waterfowl and shorebirds. They were also interested in baseline information regarding habitats used by shorebirds and waterfowl throughout their management units.

State conservation agencies were developing State Wildlife Action Plans during the early portions of this study. These comprehensive plans place a greater emphasis on the management of nongame species. Therefore, state agencies were interested in studying the distribution of shorebirds and their habitats throughout respective states.

3.2. Research Topics

Despite difference in research interests, all agencies agreed to identify and prioritize research topics focusing on the regional use of habitats by shorebirds and waterfowl. The working group collectively addressed seven research topics:

1. How does extending summer pool levels on TVA reservoirs impact shorebird/waterfowl food?

2. Do shorebirds use off-reservoir sites when habitat is not available on TVA reservoirs? What are the conditions and availability of these sites?

3. Does habitat quality differ between off-reservoir and reservoir sites?

4. How does habitat quality differ between reservoir mudflats exposed in August (early drawdown) vs. October (late drawdown)?

5. Does management of shorebird sub-impoundments promote the expansion of invasive/exotic plant species? If so, how can agencies control invasive plant species?

6. What variables of a reservoir drawdown regime influence both the quality of habitats and the use of habitats by shorebirds and waterfowl?

7. Where do shorebird habitats exist in the TRV? When are mudflats available and do an adequate number of mudflats exist to support populations of shorebirds?

3.3. Results of Regional Monitoring Coordination

Regional research coordination between conservation agencies in the TRV proved beneficial. The working group addressed most research topics and collectively funded investigations of shorebirds, waterfowl and their habitats, in addition to addressing effects of reservoir drawdowns on these resources. Studies below address specific research topics identified in Section 4.2.

TVA compared remote mapping techniques to quantify flats habitat on Douglas Reservoir. Additional mudflats were mapped on Chickamauga, Wheeler, and Kentucky Reservoirs (see Section 10.2 - *A comparison of methods to measure mudflat exposure*). TVA also funded a graduate study (Smith 2006) that produced a visual model depicting the exposure of mudflats at Rankin Bottoms along an elevation gradient at 0.5-ft. intervals (see abstract in *Section 10.3 - Spatiotemporal modeling of shorebird habitat availability at Rankin Wildlife Management Area, Tennessee*; **Topic 7**)

TVA, TWRA and UT jointly funded a study (Laux 2008) of shorebird and waterfowl use of reservoir mudflats exposed in August versus October on two reservoirs in east Tennessee (see abstract in *Section 10.4 - Waterbird responses to drawdown of two east Tennessee River Valley Reservoirs*; **Topics 1, 4 and 6**).

In 2006, USFWS, TVA and UT submitted a USFWS Cost Share Agreement request to expand the Laux (2008) study to Kentucky Reservoir. The USFWS approved the request and awarded funding for a 3-year study (Wirwa 2009) to examine shorebird and waterfowl responses to fall reservoir drawdown rates on Kentucky Reservoir (see abstract in *Section 10.5 Waterbird use of Kentucky Reservoir Mudflats*). This partnership resulted in an additional $130,000 to study shorebird and waterfowl resources on Kentucky Reservoir. This funding complements TVA's $70,000 applied annually for 5 years to study shorebird and waterfowl distribution throughout the TRV.

The cost share agreement allowed TVA, UT and USFWS to:

- Quantify availability (timing and acreage) of select mudflats distributed throughout Kentucky Reservoir (**Topic 6 and 7**)
- Quantify the activity of shorebirds and waterfowl on these selected mudflats (**Topic 6**)
- Quantify food resources and approximate factors associated with habitat-use patterns (**Topic 1**)

Additional accomplishments of the working group included matching funds to develop aerial photography and light detection and ranging (LIDAR) projects at Tennessee National Wildlife Refuge sub-impoundments and mudflats on Pickwick and Wheeler reservoirs. These projects documented changes in elevation at sub-meter accuracy on some of the most significant shorebird and waterfowl habitats in the TRV (**Topics 2 and 7**).

At the final meeting in 2007, the group discussed new research at Auburn University (Allen 2006) describing measures to control alligator-weed (*Alternanthera philoxeroides*), an invasive species that often invades sub-impoundments managed for shorebirds. This topic highlights an issue that resource agencies are working to resolve in sub-impoundments and reservoirs throughout the TRV (**Topic 5**).

Results of shorebird surveys indicate that habitat quality differs between reservoir and off-reservoir habitats (**Topic 3**). See *Section 5.0 Distribution of habitats in the TRV* and *Section 6.0 Distribution of shorebirds in the TRV* for details.

The working group collectively addressed all priority research topics. Data acquired from these studies allows each agency to address their specific unmet research needs, while providing TVA with detailed information regarding mudflat exposure and biological responses to TVA's reservoir drawdown regimes. The success of the group also promotes future partnerships involving landscape-level projects that emphasize integrated management of multiple species of wildlife. For a detailed description of working group meetings and an evaluation of the effectiveness of the Regional Monitoring Coordination, see *Section 10.1 Establishing a shorebird conservation working group in the Tennessee River Valley: A project evaluation*.

4.0 DISTRIBUTION OF HABITATS IN THE TRV

4.1. Introduction

Shorebird migration is energetically demanding (Skagen and Knopf 1993). Most species found in the TRV breed in arctic and sub-arctic regions of North America and migrate to wintering grounds in southern North America, Central America, and as far south as the southernmost tip of South America (Helmers 1992; Skagen and Knopf 1993). Therefore, high-quality stopover sites along migration routes are critical for shorebird survival.

The TRV provides a mixture of habitats for shorebirds including debris-covered shorelines; shallow, free-flowing streams and rivers; shallow tailwaters found downstream of most tributary reservoirs; extensive beds of aquatic vegetation found on mainstem reservoirs; and gravel bars surrounding islands throughout the TRV. These habitats are available seasonally and in some cases, such as tailwater habitats and shorelines, throughout the year. These habitats are used by shorebirds considered to have very generalized foraging strategies, such as killdeer (*Charadrius vociferous*) and spotted sandpipers (*Actitis macularius*).

The primary stopover habitat provided by TVA's reservoir system is an extensive array of mudflats. These habitats are available at the onset of fall reservoir drawdown through the following April. Mudflats provide a diverse array of microhabitats including a vegetated zone used primarily by waterfowl and to a limited extent, shorebirds. Mud and shallow water zones create a mixture of microhabitats used by shorebirds; many of which have very specialized foraging strategies. These strategies allow shorebird species to feed in close proximity without competing for resources. Mudflat habitats provide critical foraging and resting sites for shorebirds, especially sandpipers (small, long-distance migrants), as they migrate through the interior United States.

During the ROS, the distribution and size of mudflats throughout the TRV were largely undocumented. TVA and the working group identified all mudflats throughout the reservoir system. The working group also examined similar habitats adjacent to the reservoir system to identify off-reservoir sites that may provide habitat when reservoir habitats are not available. The overall goal of this study was to identify shorebird sites throughout the TRV (See *Section 3.7, Goal 1*), and to determine mudflat sizes and their seasonal availability.

4.2. Methods

Study Area

The study was conducted from 25 March 2004 - 8 June 2009, throughout the TRV, which is located in the southeast United States (Figure 4-1). Sites were examined throughout the TRV, upstream of Kentucky Reservoir Dam.

Identification of Mudflats

The working group interviewed regional waterfowl experts and birding enthusiasts to document known shorebird habitats throughout the TRV. To identify additional sites, TVA also examined aerial photography throughout the reservoir system. All sites were digitized and acreages were calculated using ArcMap©.

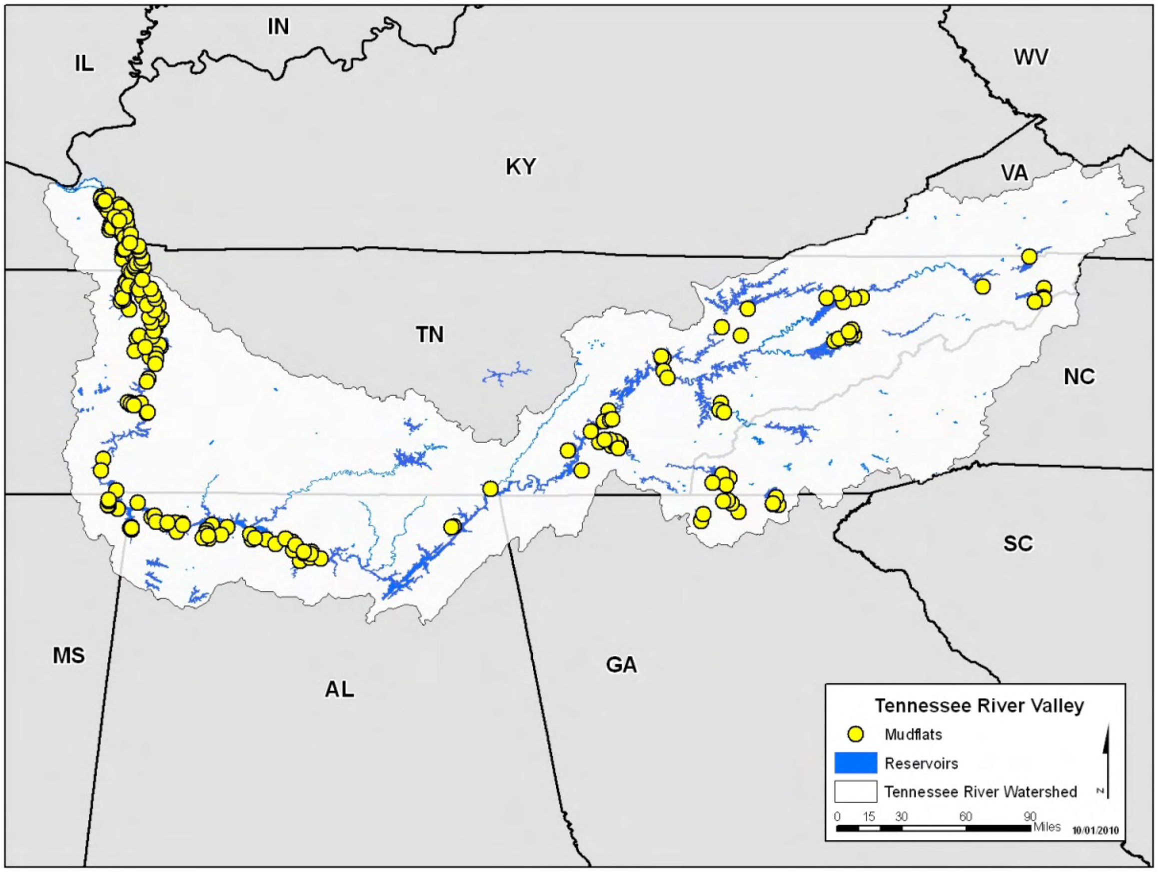


Figure 4-1. Distribution of mudflats throughout the Tennessee River Valley Watershed, USA.

Mudflats were assigned an identifying code based upon the name of the primary creek or embayment in which they were located. Sites with no primary geographic feature were classified as "unnamed". Multiple mudflats in proximity were grouped into mudflat "complexes" (See *Section 12.2 Prioritized list of sites*). Sites were grouped by reservoir and placed within the following regions:

- **West Region** - Kentucky Reservoir
- **Central Region** - North Alabama, including Pickwick, Wilson, Wheeler, and Guntersville Reservoirs.
- **East Region** - All remaining TVA reservoirs upstream of Nickajack Dam.

Prioritization of Mudflats

The working group ranked all sites in the TRV based upon size and their known importance to shorebirds; data from the ISS and state ornithological societies were also used during initial rankings. Habitats were ranked using three categories.

Priority 1. Sites have abundant suitable habitat used by numbers of shorebirds and waterfowl.

Priority 2. Sites have moderate amounts of habitat and are often used by shorebirds and waterfowl. These areas had potential to be a Priority 1 site upon inspection.

Priority 3. Sites have little suitable habitat and are seldom or irregularly used by shorebirds and waterfowl. All sites were examined at least once; priorities were modified, if results of field reconnaissance warranted.

Off-reservoir Sites

In addition to reservoir sites, the working group examined accessible off-reservoir sites; many were located on private lands. Off-reservoir sites are suitable shorebird sites not influenced by reservoir levels. These areas include fish hatcheries, ponds, irrigated sod farms, or similar habitats. Dewatering units are also included in this category as they, to some extent, are managed independently from reservoir levels.

4.3. Results

Sites by Reservoir and Region

TVA identified 270 mudflats (24,394 acres) on, and adjacent to, the TVA reservoir system (Appendix 12.2). Mudflats are unevenly distributed throughout the TRV (Figure 4-1) and vary in size ranging from 1 to 1,204 acres ($\bar{x}$ = 90.68 acres, SD = 182). Mudflats are, on average, larger on Wheeler Reservoir ($\bar{x}$ = 416.33 acres; SD = 455) than other reservoirs (Table 4-1). Kentucky Reservoir has more mudflats (57 percent, $\underline{n}$ = 153) and total acres (31 percent, $\underline{n}$ = 4,365 acres) of mudflats than other reservoirs. Collectively, Kentucky, Wheeler, Chickamauga, Douglas, and Pickwick reservoirs have more mudflats (74 percent, $\underline{n}$ = 202) and acres of mudflats (76 percent, $\underline{n}$ = 14,112 acres) than other reservoirs (Table 4-1).

Size and number of mudflats differs regionally. The majority of mudflats (73 percent) are concentrated along the Tennessee River, downstream of Huntsville, Alabama. Remaining mudflats are widely dispersed throughout the eastern half of the watershed (Figure 4-1). Total acres of mudflats are greater in east and central regions (9,496 and 8,975 acres; respectively) then in the west (5,923 acres). Mudflats are considerably larger in the central and east regions ($\bar{x}$ = 179.50 acres, SD = 298; $\bar{x}$ = 153.15 acres, SD = 152; respectively) than in the west. However, there were more mudflats in the west than in other regions combined ($\underline{n}$ = 112).

Priority of sites throughout the TRV

Of 270 sites identified, only 26 percent ($\underline{n}$ = 70) are ranked as Priority 1 habitats; 12 percent ($\underline{n}$ = 32) ranked as Priority 2 and 62 percent ($\underline{n}$ = 168) ranked as Priority 3 (Table 4-1). Most Priority 1, 2, and 3 habitats occur on Kentucky Reservoir ($\underline{n}$ = 27, 15, 111; respectively). More acres of Priority 1 mudflats occur on Wheeler Reservoir ($\underline{n}$ = 3,381 acres), followed by Kentucky and Douglas Reservoirs ($\underline{n}$ = 2,486 and 1,783 acres; respectively). Priority 1 habitats are restricted to seven of 18 reservoirs where mudflats occur.

Table 4-1. Summary of mud flat habitat provided by TVA reservoirs in regions throughout the Tennessee River Valley, USA.

Reservoirs by Region	N	Acres	% of Total Acres	Mean Acres ± SD	Priority 1[a]		Priority 2		Priority 3	
					Sites	Acres	Sites	Acres	Sites	Acres
East Region	**63**	**9496**	**39**	**153.15 ± 152.0**	**19**	**2704**	**6**	**632**	**37**	**6160**
Blue Ridge	2	621	3	310.50 ± 242.50	0	0	0	0	2	621
Boone	1	108	<1	-	0	0	0	0	1	108
Chatuge	4	656	3	164.00 ± 100.81	0	0	0	0	4	656
Cherokee	6	976	4	162.67 ±119.26	0	0	1	133	5	843
Chickamauga	16	2541	10	158.81 ± 145.77	9	797	1	175	6	1569
Douglas	8	1904	8	238.00 ± 170.73	7	1783	1	121	0	0
Hiwassee	6	510	2	85.00 ± 35.59	0	0	0	0	6	510
Norris	1	1	<1		0	0	0	0	1	1
Nottely	4	1247	5	311.75 ± 210.49	0	0	0	0	4	1247
South Holston	1	221	1	-	0	0	0	0	1	221
Tellico	2	150	1	75.00 ± 23.00	0	0	0	0	2	150
Watauga	4	43	<1	10.75 ± 5.58	0	0	0	0	4	43
Watts Bar	4	278	1	69.50 ± 70.50	1	30	2	59	1	189
Off-Reservoir Sites	4	240	1	60.00 ± 51.94	2	94	1	144	1	2
Central Region	**50**	**8975**	**37**	**179.50 ± 297.56**	**23**	**4348**	**10**	**1405**	**17**	**3222**
Guntersville	2	33	<1	16.50 ± 10.50	0	0	2	33	0	0
Pickwick	16	1555	6	97.19 ± 177.10	10	536	0	0	6	1019
Wheeler	9	3747	15	416.33 ± 455.23	6	3381	2	294	1	72
Wilson	2	77	<1	38.50 ± 2.50	2	77	0	0	0	0
Off-Reservoir Sites	21	3563	15	169.67 ± 253.71	5	354	6	1078	10	2131
West Region	**157**	**5923**	**24**	**37.7 ± 112.33**	**28**	**2674**	**16**	**444**	**113**	**2805**
Kentucky	153	4365	18	28.53 ± 62.79	27	2486	15	319	111	1560
Off-Reservoir Sites	4	1558	6	389.50 ± 466.39	1	188	1	125	2	1245
Grand Total	**270**	**24394**	**100**	**90.68 ± 182.08**	**70**	**9726**	**32**	**2481**	**168**	**12187**

N=number of mudflat sites
SD=standard deviation
[a] Sites were prioritized based upon abundance of shorebirds and overall characteristics of habitats; Priority 1 sites had abundant suitable habitat for shorebirds or waterfowl, Priority 2 sites had moderate amounts of habitat and were often used by shorebirds or waterfowl, Priority 3 sites were mudflat habitats seldom or irregularly used by shorebirds or waterfowl.

The number of Priority 1 sites is similar across regions (Table 4-1), most occur in the west region (n = 28), followed by the central (n = 23) and east regions (n = 19). However, the central region has more acres (n = 4,348) of Priority 1 mudflats. This pattern of distribution and size of mudflats was similar for Priority 2 sites as well.

The west region had more Priority 3 mudflats ($\underline{n}$ = 113) than other regions. However, there were more acres of Priority 3 mudflats ($\underline{n}$ = 6,160 acres) in the east region, especially on tributary reservoirs including Douglas and Nottely reservoirs.

Off-Reservoir Sites

Of the 270 mudflats identified throughout the TRV, 29 (11 percent) are located on lands surrounding the reservoir system (Table 4-1). Off-reservoir sites are on average larger then reservoir habitats ($\bar{x}$ = 184.86 acres, SD = 297; $\bar{x}$ = 79.3 acres, SD = 161; respectively).

Regionally, off-reservoir sites are largest in west region of the TRV ($\bar{x}$ = 389.50 acres, SD = 466). However, most off-reservoir sites (72 percent) occur in the central region around Pickwick and Wheeler Reservoirs.). Most off-reservoir sites (63 percent) ranked as Priority 3 sites. Most Priority 1 off-reservoir sites occur in the central region, in northwestern Alabama.

4.4. Discussion

The TVA reservoir system provides an extensive array of mudflat habitat for shorebirds and other wildlife; this habitat was not largely available in the region prior to construction of the reservoir system (Wirwa 2009). As TVA lowers reservoirs to winter pool levels, more than 24,000 acres of mudflats are exposed, providing important stopover habitats for shorebirds and waterfowl. This habitat is regionally important and comparable to other migratory stopover sites in coastal and interior regions of the U.S. (Wirwa 2009).

The spatial distribution of mudflat habitats through the TRV is largely influenced by topography, geology/substrate, and the resulting character of the reservoirs and their associated tributaries. Mudflats occur for the most part on mainstem reservoirs, including Kentucky, Wheeler, Chickamauga, and Pickwick reservoirs. Mainstem reservoirs were created by flooding large floodplains. These shallow reservoirs have a series of tributaries providing sediment throughout each reservoir. Tributary reservoirs were created by flooding steeply walled valleys, creating deep reservoirs with fewer tributaries; sediment deposits in these these reservoirs are largely limited to upstream portions of each reservoir. Some reservoirs exhibit both mainstem and tributary characteristics. The Nolichucky and French Broad rivers deposit large amounts of sediment in upper portions of Douglas Reservoir similar to mainstem reservoirs. It exhibits tributary reservoir characteristics in the middle and lower portions of the reservoir, having few mudflats in these areas.

Sediment deposition greatly influences the quality of a mudflat and its potential use by shorebirds and waterfowl. For instance, mudflats on the west shoreline of Kentucky Reservoir are supplied with large amounts of silt by low gradient streams, creating exemplary mudflat habitats. These mudflats provide soft substrate for shorebirds to probe for invertebrates; and they develop diverse invertebrate and vegetative communities used as food by waterfowl (Webb et al.,1988; Gunn 2003; Laux 2008; Wirwa 2009). Most tributaries that flow into embayments on the east shoreline of Kentucky Reservoir provide chert-dominated material over a clay substrate, which creates rocky substrate used infrequently by shorebirds, except for resting sites or for refuge during storms. White Oak Creek embayment is a notable exception.

The variables described above, influence the complexity of individual mudflats. Smaller mudflats are for the most part featureless, whereas larger mudflats are topographically complex with a network of drainages, ridges and depressions. Rates of surface area exposure vary among mudflats as water levels recede during drawdown. For instance, substantial surface area does not become exposed on Jonathan Creek until Kentucky Reservoir drops to 365 ft mean sea level, whereas, more than half of the mudflats on the Duck River are exposed at the equivalent elevation. For further details, see Section 10.2 *Comparison of methods to measure mudflats*.

Influences of TVA's reservoir operations

Management of TVA's reservoir system greatly influences the quality of mudflat habitats and their use by shorebirds and waterfowl. The availability and use of these habitats are dependent upon the drawdown of reservoirs. Drawdown is a complex process influenced primarily by weather and TVA's operations. Under mild weather conditions, reservoirs can be drawn down at a constant rate. Weather or TVA operations, however, can cause reservoir levels to fluctuate on a daily basis during drawdown. Mild fluctuations are beneficial for mudflat communities because brief re-inundation during reservoir drawdown expands the mud zone on the flat and promotes the development of moist soil plant communities. These frequent fluctuations also maintain moist soil plant communities over a longer period. Extended inundation, however, can be detrimental because it can kill young plants. The two primary variables affecting the development and availability of habitats are the *rate of drawdown* and the *timing or seasonality of drawdown*.

<u>Affects of Rate of Drawdown</u>

The rate of drawdown can beneficially or detrimentally affect the quality of mudflats. Slow drawdown rates prolong the availability of suitable habitat for shorebirds and other waterbirds (Rundle and Fredrickson 1981). It allows a broad "zone of invertebrates" (Figure 1-2) to become established in the drawdown zone, (Laux 2008, Wirwa 2009) and influences the composition and biomass of plant communities, favoring moist-soil species (Webb, 1988).

Fast drawdown rates allow mudflats to dry quickly, constricting the invertebrate zone to the immediate reservoir edge and replacing moist-soil plants with nuisance species such as common cockleburr (*Xanthium strumarium*). Cockleburr is a persistent problem on Douglas Reservoir. The reduction of soil moisture and the onset of soil compaction (Rundle and Fredrickson 1981) can further hamper growth of vegetation.

The rate of drawdown on some TVA reservoirs is favorable for creating high quality mudflat habitats for wildlife (Laux 2008, Wirwa 2009). For example, the rate of Kentucky Reservoir drawdown is slow enough to create ideal conditions for foraging and maximizes invertebrate availability, yet the rate is fast enough to continuously expose new mudflats and to avoid extensive vegetation establishment in the mud zone that would limit shorebird use (Wirwa 2009).

Drawdown rate, however, varies between reservoirs throughout the TRV. Laux (2008) observed that Douglas Reservoir was drawn down 5.3 times faster than Chickamauga Reservoir in 2007. Douglas Reservoir has several important shorebird stopover sites that are available early during fall migration, but in 2007, the primary habitats quickly dried due to the fast drawdown. In contrast, the slower drawdown on Chickamauga Reservoir kept a large percentage of mudflats damp allowing birds to use these areas throughout winter months. However, the *timing of exposure* affects mudflats on Chickamauga Reservoir.

Effects of Drawdown Timing

The temporal availability of mudflats is dependent on the reservoir drawdown date (Smith 2006). Prior to ROS, mudflats were available in the TRV as early as August 10. However, ROS delayed exposure of mudflats in varying degrees at several reservoirs. In addition to the reservoirs listed in Table 4-2, changes were implemented on Blue Ridge, Chatuge, Cherokee, Douglas, Fontana, Nottely, Hiwassee, Norris, South Holston, and Watauga reservoirs to maintain summer pool levels until Labor Day, except when it was necessary to modify reservoir levels in order to maintain minimum flows.

Table 4-2. Dates that mudflats would be exposed during summer drawdown on reservoirs used by shorebirds in the Tennessee River Valley.

Reservoir Operation	Reservoir (elevation in feet)				
	Kentucky (356.6)	Pickwick (411.5)	Wheeler (554)	Chickamauga (679)	Douglas (987)
Pre-ROS	08/25	09/10	09/01	10/20	08/10
Post-ROS	08/25	10/15	10/05	10/20	08/20

Note: Dates were derived from TVA's Weekly Scheduling Model. Table adapted from TVA (2004).

The timing of exposure affects the availability of stopover habitats for shorebirds, and can result in additional impacts to vegetation used by waterfowl. Shorebirds begin their fall migration in mid-July, peaking in numbers in late August and September as long-distance migrants move through the TRV. Migration peaks again in November when late migrants or overwintering birds move into the TRV (Section 6.3.1). Spring migration occurs during March, April, and May.

Figure 4-2. Photos of a mudflat habitat at Rankin Wildlife Management Area, Douglas Reservoir on October 16, 2003 and October 14, 2004. The images depict the effect of delayed exposure of mudflats during fall drawdown. Flats were exposed much earlier in 2003. The flats in the 2004 photo had been exposed for approximately 10 days.

If mudflats are not exposed during these times, the Tennessee River system provides only minimum or secondary habitat for most shorebird species, especially sandpipers and other long-distance migrants dependent upon mudflats.

The delay in exposure of mudflats affects vegetation (Figure 4-2; Webb 1988). Laux (2008) observed that vegetation becomes established on mudflats on Douglas Reservoir (during the August drawdown) while little vegetation occurs on mudflats on Chickamauga Reservoir. Chickamauga Reservoir has a later drawdown (in October). Initiating the drawdown in October does not allow seeds enough time to germinate or enough time for young plants to grow, because of the compressed growing period between October and the first frost. Additionally, the growing days are shorter and soil temperatures are lower (Laux 2008), further hampering germination and not allowing young plants enough time to develop seeds before frost. This results in a loss of food for wildlife and a seed source of future vegetation.

Laux (2008) and Wirwa (2009) noted that the reservoir system currently provides early and late exposure of habitats; both types of exposure provides benefits to wildlife. For instance, early drawdown establishes vegetative communities needed by waterfowl and provides habitat for early fall migrants. A late drawdown provides fresh mudflat habitat for late fall migrants and for overwintering birds. Both Laux and Wirwa suggested that by staggering the timing of drawdown at multiple reservoirs, habitat would be provided throughout the migratory season on a landscape scale. This situation occurs on Douglas (early drawdown) and Chickamauga (late drawdown) Reservoirs. Populations of shorebirds and waterfowl use these reservoirs accordingly.

Reservoir and Off-Reservoir Interaction

A variety of off-reservoir habitats occurs throughout the TRV. Habitats include a mixture of ponds, sod farms, fish hatcheries, flooded fields, and dewatering units. Off-reservoir sites tended to be larger than reservoir sites. In reality, this observation is inaccurate, because several of the largest sites (e.g., Savannah Bottoms) are actually large agricultural fields that are only periodically flooded, or are dewatering units that are not managed to benefit shorebirds on a large scale.

Off-reservoir sites can be classified as “unmanaged” or “managed” sites. Unmanaged sites include ponds and temporarily flooded fields. High-quality unmanaged sites occur throughout northwest Alabama, where a complex of sites often provides many acres of habitat. However, these sites intermittently available, only existing when fall seasonal rains occur. During the last half of the study, these sites were severely impacted by drought. This issue can be substantial as weather conditions can affect all off-reservoir habitats simultaneously, providing either abundant or scarce habitats.

Managed sites have control structures used to manipulate water levels. Helmers (1992) noted that managed sites provide predictable habitats and are some of the best tools for managing shorebirds. These areas are manipulated seasonally to benefit many species of wildlife. Prime examples of managed areas include Tennessee National and Wheeler National Wildlife Refuges. These sites provided habitat for high concentrations of waterfowl and shorebirds. Additionally, their location in both the Tennessee River watershed and the Mississippi Flyway makes them attractive sites for shorebirds and waterfowl traveling south along the Ohio and upper Mississippi rivers.

Dewatering units in the TRV provide minimum benefit to shorebirds as they are largely managed for waterfowl. The drawdown and fill of these units usually takes place outside of peak shorebird migration. Dewatering units can be managed, however, to benefit both (Helmers 1992). One option is to install small levees in the impoundment areas with simple, non-mechanical water control structures. These structures would be located on nonfarmed portions of dewatering units to capture water and hold it for a longer duration during drawdown. This allows the fields to dry out for planting crops (a source of food for waterfowl), while also providing water for shorebirds during spring migration. This technique was successfully implemented at several Wildlife Management Units in Kentucky (Ciuzo et al. 2005). Rankin Bottoms Wildlife Management Area on Douglas Reservoir uses a similar structure to collect surface drainage while allowing mudflats to dry. Another option for management would be to modify both the drawdown and fill dates of these units to benefit both shorebirds and waterfowl.

Quality of off-reservoir sites is greatly influenced by land use. Some sites are sources of water for livestock and sod farms. Livestock can degrade water quality; however, this degradation often leads to an increase in invertebrates favored by shorebirds. Conversely, livestock can also provide a regular source of disturbance to resting and foraging shorebirds. Some sites are also settling basins for agriculture operations, which can be a source of contaminants for shorebirds.

Shorebird management is not the primary focus of many managed off-reservoir sites. For instance, ash ponds at power generation facilities are used opportunistically by shorebirds. Daily water levels at these sites can vary greatly based upon operations at each facility. Fish hatcheries can also provide habitat for shorebirds, but this benefit is secondary to the operations of the hatchery. The operations of these sites can lead to dramatic changes in habitat quality. For instance, many fish hatcheries are gradually installing plastic liners to better control leaks in levees; this practice would eliminate foraging habitats for many species of shorebirds feeding at these sites.

Many off-reservoir sites are located on private lands, making them potentially temporary, depending on the landowner’s actions. Due to their proximity to large metropolitan areas, many off-reservoir sites are threatened by development. Lastly, off-reservoir sites can be damaged by other events. The ash ponds at Kingston Fossil Plant, formerly an excellent shorebird site was destroyed in 2008, when the primary levee failed; this site is no longer available to shorebirds nor bird watchers that frequented this site.

The relationship between off-reservoir sites and reservoir sites is very important for shorebirds. Off-reservoir sites provide habitat during the onset of fall migration when reservoir habitats are not available. Unfortunately, most of the off-reservoir sites are dependent on regular rainfall to be useful for shorebirds and waterfowl. This is especially problematic in north Alabama during fall migration, when smaller, unmanaged ponds in the central region can become dry because of evaporation and a lack of rainfall.

TVA manages its reservoirs to maintain minimum flow levels throughout the system. This operational goal can result in earlier fall drawdown in tributary reservoirs, especially during drought years. This situation occurred during the last half of the study, especially in 2008, when Douglas Reservoir and other tributary reservoirs were drawn down early to maintain minimum flow levels throughout the reservoir system, resulting in shorebird habitat on the reservoir system when off-reservoir sites were dry. The drought was so severe that several of the mainstem reservoirs, especially Kentucky Reservoir, provided habitat earlier than usual. This demonstrates the important relationship between off-reservoir and reservoir sites. Off-reservoir sites generally provide habitat when reservoir sites are not available because of a delay in drawdown or during heavy rain events. Conversely, reservoir habitats often provide habitat when off-reservoir sites are dry during drought. A diverse array of shorebird species readily uses both types of habitats.

Outcomes and Management Suggestions

Given the annual variation in reservoir drawdowns, operational changes implemented under ROS resulted in varying impacts to shorebirds, waterfowl, and their habitats. Changes on tributary reservoirs like Douglas Reservoir were minor; on average, minimum flow requirements further downstream result in exposed mudflats on Douglas Reservoir during August. Laux (2008) noted that the initial mudflat exposure date varied between years on Douglas Reservoir. It is important to note that the reservoir system is much more variable than the reservoir operation guide curves suggest.

Operational changes on Wheeler and Pickwick reservoirs were more dramatic than on Douglas Reservoir. Mudflat exposure was delayed by at least a month on both reservoirs. This outcome resulted in the loss of most mudflat vegetation on those reservoirs, and delayed the availability of mudflat habitats for early shorebird migrants (see Section 6.4). One benefit of these changes was that freshly exposed mudflats were available later in the season, benefiting late migrants.

<u>The following recommendations would improve the suitability of mudflat habitats for shorebirds and waterfowl in the TRV:</u>

1. Maintain slow reservoir drawdown rates to benefit mudflat habitats and wildlife. Slow drawdown rates allow invertebrate communities to develop along the drawdown zone, providing food for shorebirds and waterfowl. Fast drawdown rates allow mudflats to dry too quickly, reducing invertebrate communities and favoring vegetation more typically found in drier terrestrial habitats. Wirwa (2009) noted that drawdown rates of less than 4 cm of water per day are ideal.

2. Provide early and late exposure of mudflats on multiple reservoirs within each region. Initial mudflat exposure on "early" reservoirs should occur during late July or early August. Wirwa (2009) suggested that 83 hectares of mudflats should be exposed by August 15, each year on Kentucky Reservoir. It is important to note that there is a lag between the *initial drawdown date* and the *initial exposure of mudflats*. At the onset of drawdown, the reservoir must recede beyond a narrow band of woody vegetation persisting along the upper edge of mudflats before mudflat exposure begins. This process occurs mostly on mainstem reservoirs. Staggered drawdowns currently occur on the system at Kentucky/Wheeler/ Pickwick Reservoirs, and Douglas/Chickamauga Reservoirs.

3. Initiate drawdown on "late" reservoirs during late September or early October. Late drawdown on Pickwick and Chickamauga reservoirs create fresh mudflats for wintering wildlife. It is important not to delay flats exposure further on Chickamauga Reservoir, as this would negatively affect tremendous flocks of sandhill cranes (*Grus canadensis*) that aggregate at the mouth of Hiwassee River.

4. Install small levees and water control structures or excavate shallow depressions in dewatering units or large reservoir mudflats. This management technique would collect and hold water for extended periods of time during the drawdown providing habitat for shorebirds. An example of this technique occurs at Rankin Bottoms Wildlife Management Area on Douglas Reservoir.

5. Modify the drawdown of dewatering units to benefit shorebirds and waterfowl. The current operation of these units removes water too early in spring and fills the units too late during the fall to benefit many shorebird species.

6. Collaborate with other agencies to protect important stopover habitats adjacent to TVA lands, protecting these sites from future development through purchase or placement of conservation agreements. A collection of small managed units (<10 hectares each) with water control capabilities can produce more shorebird use days than a single large unit that is not carefully managed (Short 1999).

Page intentionally blank

5.0 DISTRIBUTION OF SHOREBIRDS IN THE TRV

5.1. Introduction

Forty-seven species of shorebirds migrate through North America between Arctic breeding grounds and their wintering grounds in Central and South America (Short 1999). Because shorebirds must balance the energetic demands of breeding and migration, stopover sites along migratory routes are critical for their survival. The TRV provides stopover habitats for many shorebirds during migration (Smith 2006; Laux 2008; Wirwa 2009). Many of these sites also provide habitat for wintering shorebirds, a resource rarely examined by researchers studying the ecology of migrating shorebirds in the interior U.S.

There have been few large-scale shorebird studies in the interior southeast (U.S.), and use of TVA reservoirs by shorebirds is not well documented. Short (1999) examined shorebird ecology and migration in western Tennessee near the Mississippi River. Ciuzio et al. (2005) examined shorebird management at moist-soil units in Kentucky. Pompei (2004) investigated the use of interior stopover sites by piping plovers (*Charadrius melodus*) including several sites in the TRV.

Most data reported from the region were collected during opportunistic surveys at specific sites. For instance, shorebirds have been monitored sporadically at Limestone Bay on Wheeler Reservoir and at Rankin Bottoms on Douglas Reservoir. Some off-reservoir sites such as Eagle Bend Fish Hatchery, a series of ponds in northwest Alabama, and ash ponds at power generation facilities (e.g., Colbert, Kingston, and Gallatin fossil plants) have also been surveyed opportunistically.

During the ROS, TVA biologists assessed impacts of changes in TVA's reservoir operations to shorebird resources in the TRV (TVA 2004). While accurate assessments were made based upon available shorebird literature, it became apparent that little was known about shorebird resources throughout the TRV. Shorebirds had been examined at some localities; however, extensive areas throughout the TRV had been overlooked. Also, many existing surveys used unknown methodologies, which makes comparisons of data difficult.

To address these issues, TVA committed to work with other agencies to identify shorebird resources in the TRV. The goals of this study were to identify shorebird sites and to determine both the temporal and spatial distribution of shorebirds at stopover and wintering sites throughout the TRV. The working group developed a regional monitoring plan adopting a standardized process, allowing each agency to collect comparable data (Goals 1 through 3 in Section 3.7).

TVA, USFWS, TWRA and UT collaborated to fund several studies during this project. Laux (2008) examined waterbird resources on Douglas and Chickamauga reservoirs. He observed wildlife responses to different drawdown schedules occurring on these reservoirs, and studied how these contrasting schedules affected habitat characteristics at these sites. Wirwa (2009) examined waterbird resources on Kentucky Reservoir in west Tennessee. This study analyzed waterbird use of mudflats, recording species diversity and chronology; as well as invertebrate and vegetative resources on exposed mudflats. The study also looked at activity budgets of waterbirds using these resources. These studies fill a primary void in shorebird research in the TRV.

5.2. Methods

Surveys were conducted from 25 March 2004-15 June 2009, throughout TVA's reservoir system. We used protocols established by the ISS (Shorebirdword.org) to survey shorebirds. Shorebirds were sampled primarily at Priority 1 and 2 sites (see Section 13.2); Priority 3 sites were surveyed opportunistically when birds were encountered on these sites. Annual sample periods began 15 July and ended by 15 June the following summer. Surveys took place on the 5th, 15th and 25th of each month, with a ±3 day window for each sample date. Data were recorded on ISS datasheets to ensure compatibility with other regional, national and international shorebird data.

All participants scanned flocks using binoculars (8X or 10X magnification) and spotting scopes (20-60X zoom magnification). Birds were identified by species; unidentified birds were assigned the following categories: unknown shorebird (*Calidris* sp.), unknown yellowlegs (*Tringa* sp.), unknown plover (*Pluvialis* sp.), and unknown dowitcher (*Limnodromus* sp.). These categories represent groups of shorebirds that are easily discriminated from a distance.

Total numbers of individuals for each species were recorded. To develop shorebird chronologies, we divided months into two periods, Period 1 was day 1-15 of each month, and Period 2 was day 16 until the end of the month. Data within these periods were pooled and presented as percent abundance of total number of each species. All data were pooled over the 5-year study.

To assess seasonal differences in shorebird numbers, we divided the sample season into three periods: fall (15 July - 31 October), winter (1 November - 15 March) and spring (16 March - 15 June). To test for differences in the use of sites by shorebirds throughout the TRV, we used the same regions (West, Central and East) described in Section 5.2.

5.3. Results

Abundance of Shorebirds Throughout the TRV

We performed 3,796 surveys at 150 sites in the TRV during the 5-year study. We observed 129,986 shorebirds ($\bar{x}$ 34.25 birds, SD = 80 per survey) of 37 species migrating and overwintering in the TRV (Table 5-1). Killdeer constituted 52% ($\underline{n}$ = 67,269 birds) of total shorebirds observed (Appendix 15.3). Other common species included least sandpiper (*Calidris minutilla*; 15%, $\underline{n}$ = 19,455), Wilson's snipe (*Gallinago delicata*; 6%, $\underline{n}$ = 8,410), pectoral sandpiper (*Calidris melanotos*; 5%, $\underline{n}$ = 7,008), lesser yellowlegs (*T. flavipes*; 5%; $\underline{n}$ = 5,915), dunlin (*Calidris alpina* ; 4%, $\underline{n}$ = 4,818). Collectively, these species constituted 87% of shorebirds observed during this study.

Several species of conservation concern were observed during the study. Single individuals of ruff (*Philomachus pugnax*) and red phalarope (*Phalaropus fulicarius*) were encountered as well as small numbers of red knot (*Calidris canutus*; $\underline{n}$ = 2), whimbrel (*Numenius phaeopus*; $\underline{n}$ = 3), piping plover (*Charadrius melodus*; $\underline{n}$ = 3), and Hudsonian godwit (*Limosa haemastica*; $\underline{n}$ = 3). Several of these species have declined in number throughout their range. Piping plovers are protected under the Endangered Species Act and the red knot was recently considered for listing by the USFWS. Collectively these species constituted less than 1% of shorebirds observed during this study. For further descriptions of individual species, see *Section 7.0 Species Accounts*.

Table 5-1. Total number of shorebirds observed at TVA reservoirs in the Tennessee River Valley Watershed, United States, during a 5-year multi-agency shorebird initiative, 2004-2009.

Reservoirs by Region	Total Number of Birds	Number of Surveys	Birds per Survey ± SD
East Region	**42966**	**1160**	**37.04 ± 81**
Boone	97	14	6.93 ± 8
Chickamauga	10200	526	19.39 ± 43
Douglas	21740	263	82.66 ± 143
Norris	14	1	N/A
South Holston	83	14	5.93 ± 7
Off-Reservoir	10832	342	31.67 ± 40
Central Region	**44197**	**1733**	**25.50 ± 78**
Guntersville	50	1	N/A
Pickwick	6536	164	39.85 ± 56
Wheeler	17068	291	58.65 ± 159
Wilson	3989	142	28.09 ± 57
Off-Reservoir	16554	1135	14.95 ± 39
West Region	**42823**	**903**	**47.42 ± 82**
Kentucky	32939	833	39.54 ± 64
Off-Reservoir	9884	70	141.20 ± 173
Total Off-Reservoir	**37270**	**1547**	**24.09 ± 59**
Total Reservoir	**92716**	**2249**	**41.23 ± 92**
Grand Total	**129986**	**3796**	**34.25 ± 80**

SD=standard deviation

More shorebirds were observed on Kentucky Reservoir than other reservoirs in the TRV. Substantial numbers of shorebirds were also noted on Douglas, Wheeler, and Chickamauga reservoirs. Over 62% of shorebirds were observed on these reservoirs. On average, flocks were largest on Douglas and Wheeler reservoirs ($\bar{x}$ 82.66, SD = 143; $\bar{x}$ 58.65, SD = 159; birds per survey; respectively).

Abundance of shorebirds varied throughout the year (Figure 5-1); fall migration began in July, peaked in August and September, and decreased slightly in October. The sustained fall migration can be attributed to the number of shorebird species (Figure 5-2) moving into and through the TRV over several months. A mixture of early and late fall migrants was noted.

Shorebird abundance increased sharply to their highest levels during the beginning of the winter period in November. Winter shorebird abundance increased as killdeer, Wilson's snipe (*Gallinago delicata*), dunlin (*Calidris alpina*) and least (*Calidris minutilla*) sandpipers, common winter residents, moved into the TRV. Numbers sharply decreased through remaining winter months. Spring migration occurred during March-May. Some species, such as American golden-plover (*Pluvialis dominica*) are early spring migrants whereas most sandpipers tend to move through the TRV much later in May. Fall migration was longer in duration than spring (Section 6.5).

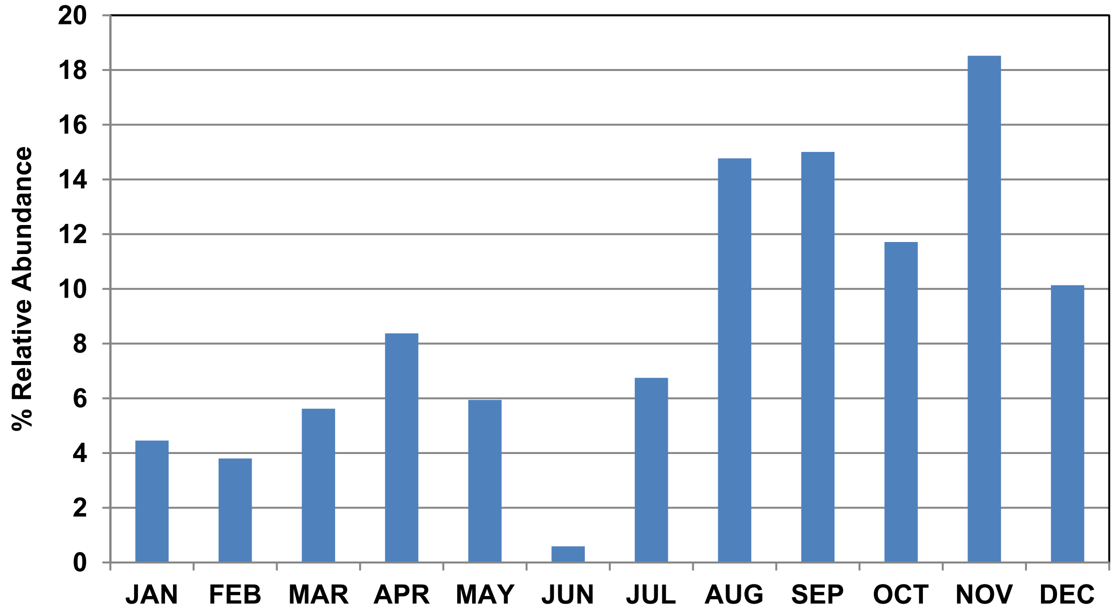


Figure 5-1. Monthly shorebird abundance in the Tennessee River Valley, March 2004-June 2009.

Species Richness

Thirty-seven species of shorebirds were recorded throughout the study. Species richness was highest during fall migration (Figure 5-2). Levels of diversity gradually increased at the onset of fall migration, peaking in August (n = 30 species) and September (n = 31 species). Diversity stayed relatively high through October (n = 26 species) and November (n = 20 species) as fall migrants were replaced by species that overwinter in the TRV (e.g., Killdeer and Wilson's snipe). Species richness decreased through winter but never dropped below eight species. As spring migration began in March, species richness increased sharply peaking in April (n = 25 species) and May (n = 25 species).

Species such as greater yellowlegs (*Tringa melanoleuca*), killdeer, and least sandpipers were detected monthly throughout sample seasons. Other species such as phalaropes (*Phalaropus* sp.), buff-breasted sandpipers (*Tryngites subruficollis*), and ruddy turnstones (*Arenaria interpres*) were detected sporadically. Many species moved casually through the TRV during fall, but passed quickly through the area during spring migration. Plovers and various sandpipers, white-rumped (*Calidris fuscicollis*), semipalmated (*Calidris pusilla*), Baird's (*Calidris bairdii*), exhibited this pattern.

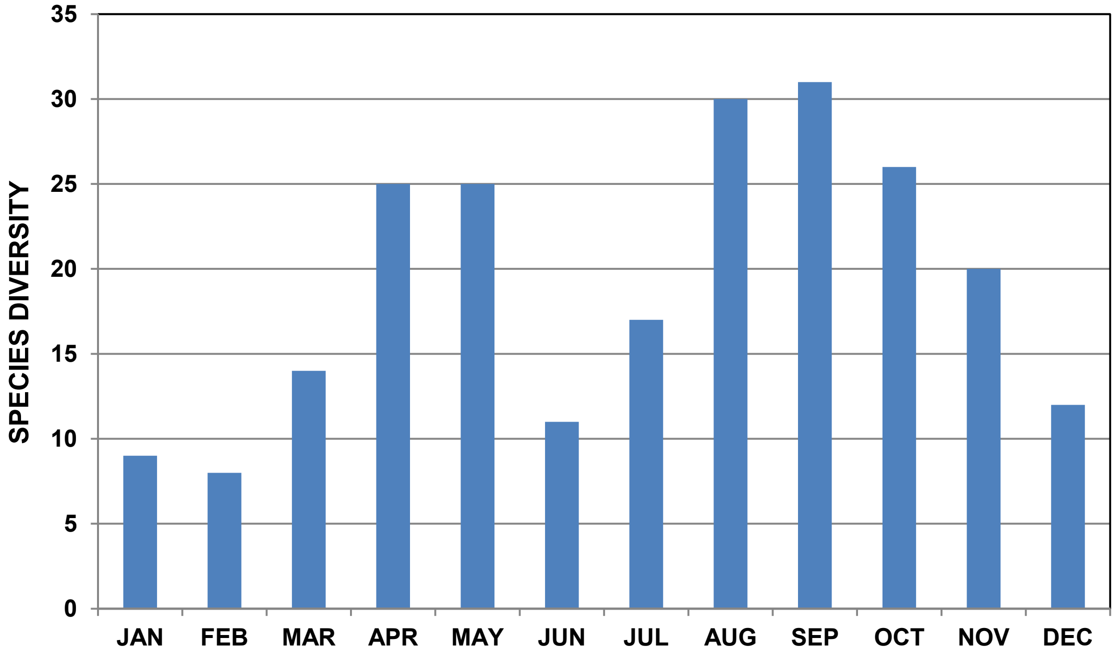


Figure 5-2. Monthly shorebird diversity in the Tennessee River Valley, March 2004 - June 2009.

Spatial and Temporal Differences in Abundance of Shorebirds

Regional Differences - Total number of shorebirds was similar among regions. Average shorebird abundance was greater in the western region ($\bar{x}$ 47.42 birds per survey, SD = 82), followed by east and central regions ($\bar{x}$ 37.04, SD = 81; $\bar{x}$ 25.50, SD = 78; birds per survey; respectively). Some shorebird species showed preferences for specific regions of the TRV (See Section 7.1).

Seasonal Differences - Shorebird numbers varied among seasons, shorebird abundance in the fall (n = 59,602 shorebirds) was almost three times higher than in spring (n = 21,766 shorebirds). Average shorebird abundance was greater in fall and winter ($\bar{x}$ 37.39, SD = 74; $\bar{x}$ 33.58, SD = 88; birds per survey; respectively) compared to spring ($\bar{x}$ 28.87, SD = 78).

Regional and Seasonal Interaction - Shorebird abundance varied among regions during fall (Figure 5-3). Abundance varied little between east and west regions (n = 25,518 and 25,189 shorebirds). Abundance was much lower in the central region during fall (n = 10,975 shorebirds) compared to other regions as reservoir habitats are not available there until October. Shorebirds overwintered in all three regions; however, a latitudinal pattern occurs. More shorebirds overwintered in the central region (n = 25,189), than other regions combined (n = 23,429). Spring migration was shorter in duration than fall migration. Average spring shorebird abundance was substantially greater in the west ($\bar{x}$ 127.67, SD = 176) than in central and east regions ($\bar{x}$ 19.40, SD = 57; $\bar{x}$ 17.35, SD = 27; birds per survey; respectively).

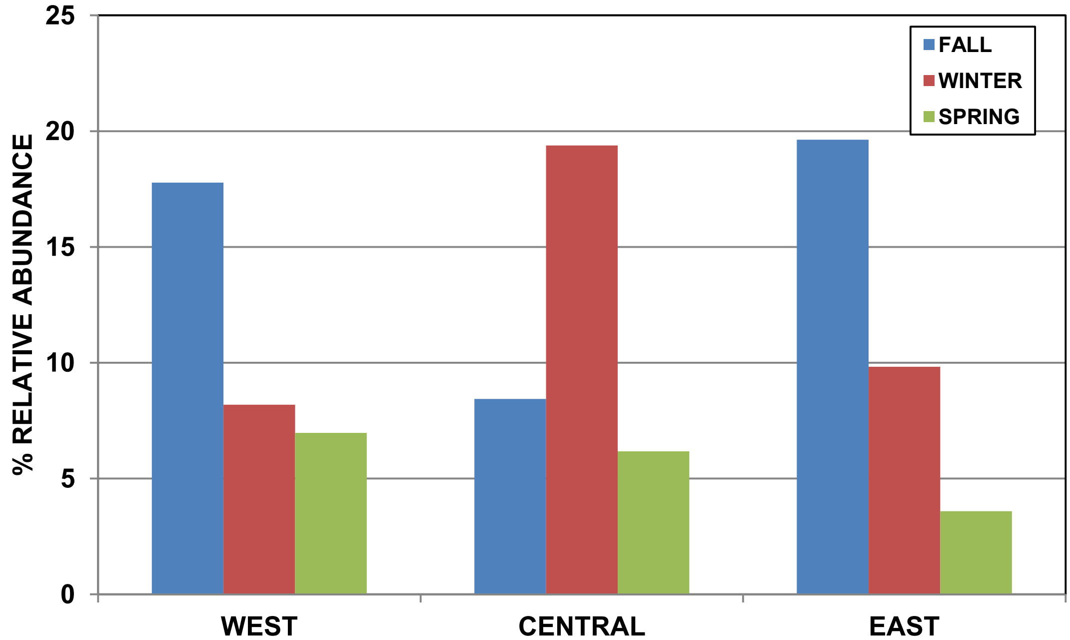


Figure 5-3. Seasonal mean daily shorebird abundance in three regions of the Tennessee River Valley, March 2004-June 2009.

Abundance of Shorebirds at Reservoir and Off-reservoir habitats

Shorebird abundance was greater at reservoir habitats (n = 92,716) than off-reservoir habitats (n = 37,270). This pattern occurred through fall and winter (Figure 5-4). However, during spring migration, shorebirds were more abundant at off-reservoir habitats.

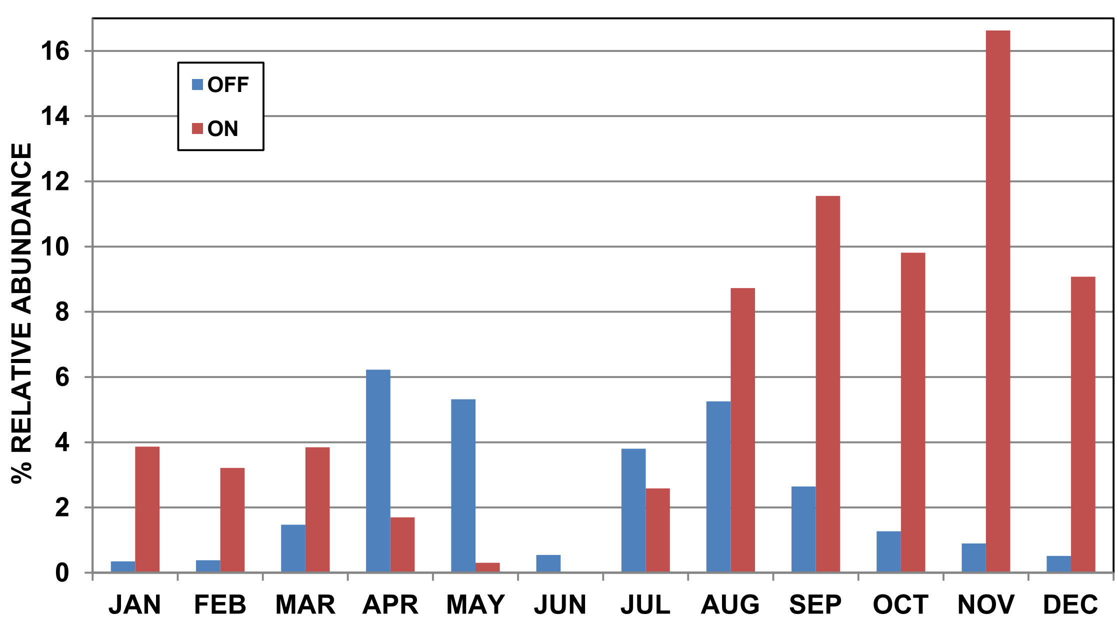


Figure 5-4. Monthly abundance of shorebirds at reservoir and off-reservoir habitats in the Tennessee River Valley, March 2004 - June 2009.

5.4. Discussion

The TRV provides a diversity of shorebird habitats. During this 5-year study, we identified more than 24,000 acres of potential shorebird habitat throughout the Valley. Shorebird resources using these habitats are diverse. We encountered 37 species of shorebirds that migrate or overwinter in the TRV. This level of diversity exceeds those reported from other interior regions in the United States (Andrei et al. 2006; Short 1999; Twedt et al. 1998; Davis and Smith 1998). Results of this and associated studies (Wirwa 2009; Laux 2008) indicate that TVA's reservoir system and the remaining TRV provides important stopover and wintering habitat for shorebirds. Populations that use nearby Cumberland River system may further increase the significance of the region for shorebirds. However, shorebird resources on the Cumberland River are not well documented.

Shorebirds spent more time feeding than resting at stopover sites, especially early in fall migration (Laux 2008; Wirwa 2009). These foraging activities are critical for maintaining energy and building up fat (Ashkenazie and Safriel 1979; Drent and Piersma 1990; Kersten and Piersma 1987; Short 1999). Shorebirds can increase their body mass up to 100 percent at stopover sites (Davidson and Evans 1989). The success of this increase in mass directly affects the reproductive potential of individual birds when they reach their breeding grounds (Ashkenazie and Safriel 1979; Davidson and Evans 1989). As wetlands decrease throughout the interior U.S., stopover sites like those found in the TRV have become increasingly important for shorebirds. T

Shorebird Abundance

We observed 129,986 shorebirds ($\bar{x}$ 34.25 birds, SD = 80 per survey) of 37 species migrating through and overwintering in the TRV (Table 5-1). Killdeer, least sandpiper, Wilson's snipe, pectoral sandpiper, lesser yellowlegs, and dunlin were the most abundant species in the TRV. Species composition varied annually but was similar to compositions reported in other studies. Ciuzio et al. (2005) reported that killdeer, pectoral sandpiper, lesser yellowlegs, least sandpiper and greater yellowlegs were the most common species using moist-soil units in Kentucky. Short (1999) found that pectoral sandpipers, least sandpipers, lesser yellowlegs, semipalmated sandpipers and American golden-plover were the most common species along the Mississippi River; however her study excluded killdeer. Differences in species composition observed in these studies can be attributed to the lack of winter surveys, when killdeer, Wilson's snipe and dunlin are common in the region. Although results vary, these data indicate that the Mississippi and Tennessee rivers and nearby stopover sites in the interior southeast U.S. are important habitats for the species listed above, especially killdeer and pectoral sandpipers, which do not occur in large numbers along coastal areas as other shorebirds do.

Shorebird Reservoirs in the TRV.

Shorebird abundance on Kentucky Reservoir was 1.5 times higher than on other reservoirs. The abundance of habitat on Kentucky Reservoir, its location within the Mississippi Flyway and the early initial exposure of mudflats, relative to other reservoirs, attracts large numbers of shorebirds. Islands and embayments on Kentucky Reservoir provide diverse habitats in a relatively concentrated area. Large numbers of shorebirds use mudflats at Big Sandy, Blood River, Jonathan Creek, Duck River, Eagle Creek, White Oak Creek and islands at New Johnsonville, Tennessee. Large numbers of waterfowl, gulls, white pelicans (*Pelecanus erythrorhynchos*) and wading birds also occur here.

The drawdown on Kentucky Reservoir was not altered by TVA's ROS. The timing and rate of drawdown on Kentucky Reservoir are favorable for shorebirds and waterfowl. Wirwa (2009) noted that mudflats on Kentucky Reservoir are initially exposed at elevation 357 ft. (New Johnsonville gage). Exposure of mudflats varies among individual sites due to differences in topography (see Section 10.2). Mudflats on Kentucky Reservoir were initially exposed in late July through early September in 2006 and 2007. However, large amounts of habitat (>20 ha) were not available until early September. The availability of habitats and favorable timing of drawdown on Kentucky Reservoir makes it important for shorebirds.

Shorebird abundances were also high on Douglas and Chickamauga reservoirs. Laux (2008) observed that species richness was two times greater on Douglas Reservoir than Chickamauga Reservoir, conversely, shorebird abundance was two times greater on Chickamauga Reservoir than Douglas Reservoir. Initial exposure of mudflats on Douglas Reservoir occurred in mid-July through early August in 2006 and 2007 at Rankin Bottoms Wildlife Management Area and at the mouth of Nolichucky River. As habitats began to dry on these mudflats, new habitats developed just downstream at "Dutch Bottoms". Laux (2008) noted that mudflats on Douglas Reservoir were largely abandoned by shorebirds in late September, when reservoir levels became restricted to the primary river channel. This observation was accurate for mudflats at Rankin Wildlife Management Area. However, Laux (2008) did not report the availability of habitats further downstream used by shorebirds during late fall and early winter. This collection of "early and late" exposure of mudflats on Douglas Reservoir makes it an important stopover site for shorebirds in the east region.

Shorebird abundance was high on Chickamauga Reservoir, despite its later October drawdown. Although the reservoir does not provide much shorebird habitat during early fall, it provides substantial habitat for late migrants and overwintering birds (Laux 2008). The relationship between Douglas and Chickamauga reservoirs is important. Laux (2008) described the reservoirs as providing early and late exposure of mudflats. He noted that mudflats on Chickamauga Reservoir become available as those on Douglas Reservoir begin to dry. We observed that several species of shorebirds overwinter on Chickamauga Reservoir, particularly in the Rogers, Candies, South Mouse, and Sugar Creek embayments. The proximity of Douglas (early drawdown) and Chickamauga (late drawdown) reservoirs, and their abundance of available habitats, makes these reservoirs a significant stopover and overwintering site for shorebirds and other avian species at the landscape level. A similar relationship occurs between Kentucky and Wheeler/Pickwick Reservoirs.

Wheeler Reservoir provides the most total acreage of shorebird habitat in the TRV (see Section 5.0). Abundance of shorebirds is high on this reservoir, despite its delayed availability of habitats (initiated in October). Historically, Wheeler Reservoir provided a number of stopover sites (e.g., Limestone and Beulah bays) for migratory shorebirds during fall migration. However, due to changes implemented during ROS (TVA 2004), the Lake Improvement Plan (LIP; TVA 1990), and other operational changes, this reservoir currently only provides habitat for late migrants and overwintering birds, except during extreme drought. This is still an important resource for shorebirds, as more shorebirds overwinter on Wheeler Reservoir than anywhere else in the TRV. This is likely due to Wheeler Reservoir being one of the southernmost reservoirs in the TRV, where winter weather tends to be milder than at reservoirs located further north. However, the delay in fall exposure of mudflats on Wheeler Reservoir (and Pickwick Reservoir) during ROS resulted to impacts to shorebird resources in the TRV.

Lastly, several sites within the TRV such as Savannah Bay on Chickamauga Reservoir and Pace Point on Kentucky Reservoir historically provided habitat for shorebirds. These areas no longer provide optimum habitat for shorebirds because they are now flooded later in the year than under previous reservation drawdown schedules. While these areas currently provide habitat for gulls (*Larus* sp.), grebes (Podicipedidae), loons (*Gavia* sp.), diving ducks (Anatidae), and overwintering shorebirds, these areas are no longer available to shorebird species that migrate earlier except during extreme drought.

Changes implemented on Douglas Reservoir highlight a similar issue. Before ROS, the drawdown schedule provided habitat to shorebirds near a popular observation point (Rankin Bottoms WMA) by early August. Currently, shorebird habitat is not available at this site until mid-August, except during drought events. The changes observed under ROS had little impact on shorebirds, because other mudflats are available at higher elevations. The changes resulted in impacts to birdwatchers that recreate in the area, because the shorebirds are not as accessible in early August from favorite birding locations.

Species Richness

Species richness in the TRV (n = 37 species) exceeded levels reported at other major stopover sites in the Mississippi Alluvial Valley (22-29 species) and Southern High Plains (20-30 species) in the interior U.S. (Andrei et al. 2006; Short 1999; Twedt et al. 1998; Davis and Smith 1998). Differences in these observations may be that some studies missed several late migrants that overwinter in the TRV. In addition, we recorded several accidental or vagrant species that are not frequently recorded in the interior U.S. such as ruff (*Philomachus pugnax*) and red phalarope (*Phalaropus fulicarius*); see Species Accounts, Section 7.0.

Species diversity in the TRV was greatest during August and September. Typically, TVA reservoirs do not provide habitat until mid-August under current drawdown regimes nor under the previous LIP, except during years with drought as observed in 2007-2009. However, the system did provide habitat earlier in summer months prior to adjustments implemented by these studies (Section 6.4.2). Current drawdown regimes provide only limited habitat for species that move quickly through the TRV in late July and early August. Likewise, most TVA reservoirs are filled to summer levels by mid- to late April, providing little habitat for species that migrate through the TRV in late April and May, when species diversity is highest in spring.

Shorebird chronology (Section 6.5) showed that species moved through the TRV during different times. Numbers of willet (*Tringa semipalmata*) and solitary sandpiper (*Tringa solitaria*) peaked early during fall migration. Western (*Calidris mauri*), least (*Calidris minutilla*), buff-breasted (*Tryngites subruficollis*), and stilt (*Calidris himantopus*) sandpipers peaked in late August and September. Most killdeer, dunlin and Wilson's snipe moved into the TRV in October and November, much later than other species. Black-bellied plover (*Pluvialis squatarola*) and least sandpiper exhibited a bi-modal fall pattern. Killdeer, greater yellowlegs and least sandpipers were observed during every month throughout the sample period.

Spatial and Temporal Interactions

Shorebird abundances were similar among regions. The west region is comprised of one reservoir (Kentucky Reservoir). The location of this region within the Mississippi Flyway, which is a major shorebird and waterfowl migration corridor, contributed to its high shorebird abundance. Additionally, Kentucky Reservoir has more mudflats than other reservoirs in other regions and provides habitat through fall and winter.

Thirty-seven percent of shorebirds (n = 42,966) were observed in the east region. This region has reservoirs with early and late drawdowns, providing habitats throughout the fall and winter months. The extended availability of habitats in this region contributes to overall shorebird numbers.

The central region had more total numbers of shorebirds than other regions. This region historically provided habitat for shorebirds during early fall. However, with the delay in exposure of mudflats implemented in ROS, the central region only provides habitat during late fall and winter months. In addition, this region was impacted severely by drought during the latter half of the study, greatly reducing the viability of off-reservoir habitats and overall number of shorebirds.

The central region provides important overwintering habitat for several species of shorebirds. Greater numbers of shorebirds reside in the central region during winter than in the west region, despite the presence of abundant habitat on Kentucky Reservoir. The mudflats in the central region are newly exposed in winter, while those on Kentucky Reservoir tend to be drier in winter. However, we routinely observed suitable habitat used by few birds on Kentucky Reservoir, this may be due to latitudinal differences between the west and central regions. The central region is further south than Kentucky Reservoir, and mudflats on Kentucky tend to be concentrated on the northern half of the reservoir, further accentuating this relationship.

A similar relationship exists between Douglas and Chickamauga reservoirs (Laux 2008), which shows the importance of providing "late" habitats further south in the system. These observations also suggest that the central region could provide substantially more habitat for shorebirds than the other regions if drawdown initiation dates are earlier, or if off-reservoir sites in this region are managed for shorebirds.

Shorebird abundance varied among seasons; more birds moved through the TRV during fall than during spring. A bimodal pattern in shorebird abundance occurs during fall. Long distance migrants moved through the TRV during late July through early September (Wirwa 2009). Short distance migrants that tend to overwinter in the interior U. S. moved into the TRV during October and November.

Shorebird activity was greatly reduced in spring. Average shorebird abundance was substantially larger in the west region during the spring than in other regions. This was attributed to the much larger flocks encountered per survey in the west region during spring. However, under TVA's current drawdown schedule, mudflats in all regions are flooded before the end of spring migration. Although species, such as spotted sandpipers (*Actitis macularia*), readily forage along the margins of the reservoirs in late spring, most spring activity is presently restricted to off-reservoir sites or in tailwaters when dams are releasing minimum flows.

Off-Reservoir

Several off-reservoir sites adjacent to the TVA reservoir system are used extensively by shorebirds. Large numbers of shorebirds occur at managed sub-impoundments at Tennessee and Wheeler National Wildlife Refuges. However, most off-reservoir sites are smaller temporary ponds that require regular rainfall to be useful for shorebirds and waterfowl. This is especially problematic in north Alabama during fall migration when smaller, unmanaged ponds in the central region can become dry due to lack of rainfall or evaporation and subsequently become useless for waterbirds.

Numbers of shorebirds are highest on off-reservoir sites during July when reservoir mudflats are not available. Shorebirds sites at Tennessee National Wildlife Refuge provide much of the habitat during early migration. Off-reservoir sites become less useful to shorebirds as fall migration progresses. When TVA begins to draw down Douglas and Kentucky reservoirs, shorebirds tend to shift from off-reservoir areas to reservoir habitats. The greatest numbers of shorebirds were observed on the reservoir system, particularly during winter months. This is an important observation because reservoir habitats tend to provide refuge for shorebirds and waterfowl during winter as shallow, off-reservoir sites freeze.

During spring migration, shorebirds use both off-reservoir and reservoir habitats. Most reservoir habitats are unavailable by mid-April. Consequently, many shorebirds migrating northward through the area use off-reservoir habitats or rest along the margins of reservoirs. Exposed reservoir margins around islands are also used extensively by shorebirds in late spring, before reservoirs reach summer pool levels.

The shorebird use of reservoir and off-reservoir sites is greatly influenced by rainfall. This was especially noticeable earlier in the study, when heavy rains kept reservoir levels high and off-reservoir sites recharged. Shorebirds were observed at off-reservoir sites during this time. During drought years, an opposite pattern was noted. Off-reservoir sites were dry for much of the fall season during 2007-2009, and TVA's minimum flow commitments resulted in earlier drawdowns on some tributary reservoirs, providing habitat to shorebirds earlier than during years with normal levels of rainfall. Shorebirds occurred on reservoir habitats during this time. As reservoir mudflats became exposed, shorebirds shifted to these habitats, usually as the off-reservoir sites began to dry. The availability of both types of habitats greatly benefits shorebirds as they migrate through the TRV.

Outcomes and Management Suggestions to improve shorebird use in the TRV.

The TVA reservoir system provides a diversity of habitats for shorebirds. On a landscape level, the system provides a mixture of early and late habitats benefitting these resources. Historically, some reservoirs provided habitats early during shorebird migration. However, as reservoir management scenarios have changed, exposure of these habitats was progressively delayed and the reservoir system no longer provides substantial shorebird habitat during the onset of migration except during drought years.

TVA strives to balance competing demands on the reservoir system, with its primary focus on navigation, flood control, renewable hydropower, and on sources of cooling water for power generation systems. Given the importance of shorebird stopover and overwintering habitats on TVA reservoirs, considerations for these wildlife resources are also important. Currently, no reservoirs provide mudflat habitat during July and rarely during early August, except during drought years as was observed during the latter half of this study (see annual variability in reservoir levels graphed in Figure 8-3). Long-distance migrants and some species of concern move through the TRV during late July and early August.

However, the reservoir system provides habitat during a substantial portion of the shorebird migration season, especially when shorebird numbers peak in the TRV; the reservoir system also provides important habitat for late migrants and overwintering shorebirds.

Future changes in reservoir operations should consider shorebird resources and their habitats. Drawdown rate and timing are critical factors to examine. The following modifications to current reservoir operations would benefit shorebird and waterfowl resources in the TRV.

1. Provide habitat earlier in fall and later in the spring on select reservoirs such as Wheeler and Chickamauga reservoirs. Modify the operational guide curve to allow for a gradual decrease in reservoir levels starting in July, which would provide habitat earlier in the season and benefit long-distance migrants and shorebird species of concern (Wirwa 2009). These types of shorebirds tend to move through the region during early fall and late spring (May). This option would also create reservoirs with early and late drawdowns in close proximity (Wheeler vs. Pickwick) within the central region.

2. A second option would be to alternate annually between pre- and post-ROS reservoir operation regimes on Wheeler. To further enhance this option, incorporate an earlier drawdown on Wilson Reservoir when reservoir levels are high on Wheeler Reservoir. Minor changes in reservoir operations in the central region could substantially boost shorebird numbers in the Valley.

5.5. Species Chronology

Migratory Period	Winter					Spring								Fall							Winter				
	January		February		March		April		May		June		July		August		September		October		November		December		
Bi-monthly Period	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	Total Birds
Number of Surveys	87	143	127	100	200	159	191	163	101	95	47	25	83	88	211	205	252	233	217	278	267	212	204	108	
Black-bellied Plover							0.3%	0.7%	1.0%	4.0%	0.3%				0.3%	27.9%	3.7%	3.0%	12.8%	10.1%	25.8%	4.4%	5.7%		298
American Golden-Plover					16.7%	8.3%	22.0%	0.8%								2.3%	4.5%	27.3%	12.1%	3.0%	3.0%				132
Killdeer	2.1%	4.1%	3.2%	1.3%	2.1%	0.9%	0.5%	0.4%	0.5%	0.5%	0.7%	0.3%	2.9%	5.6%	6.8%	9.2%	7.6%	4.3%	4.9%	6.4%	10.5%	10.7%	8.0%	6.6%	67269
Semi-palmated Plover								3.9%	19.1%	10.9%	0.2%			1.3%	4.3%	16.1%	30.7%	9.9%	3.2%	0.3%					1152
Piping Plover															33.3%	66.7%									3
Black-necked Stilt										75.0%									12.5%	12.5%					8
American Avocet								8.8%								33.3%	18.6%	3.9%	2.0%	22.5%	8.8%			2.0%	102
Greater Yellow legs	0.3%	1.6%	1.1%	1.9%	2.6%	6.7%	29.6%	14.4%	3.5%	0.4%			0.9%	0.3%	0.3%	2.5%	6.1%	1.8%	5.4%	6.5%	6.4%	3.5%	0.1%	3.9%	3634
Lesser Yellow legs		0.1%	0.1%	0.2%	0.6%	7.1%	10.9%	30.3%	13.3%	0.4%			4.0%	1.3%	1.0%	4.4%	9.9%	6.7%	6.0%	2.1%	0.5%	0.1%	0.1%	0.9%	5915
Solitary Sandpiper					0.1%	0.5%	11.4%	26.7%	18.0%	1.2%	0.1%		1.2%	12.0%	11.5%	9.3%	6.1%	1.1%	0.3%	0.3%	0.1%				1041
Spotted Sandpiper							1.0%	5.7%	17.6%	6.6%	0.1%	0.1%	3.0%	10.2%	16.5%	21.8%	12.0%	3.0%	1.7%	0.5%	0.2%	0.1%			1138
Willet								35.8%	39.2%				8.5%			7.4%	5.7%	2.8%	0.6%						176
Marbled Godw it							10.6%	80.9%	2.1%							2.1%		4.3%							47
Hudsonian Godw it																	100.0%								3
Whimbrel										66.7%						33.3%									3
Long-billed Curlew																		20.0%				80.0%			5
Upland Sandpiper								33.3%								50.0%		16.7%							6
Buff-Breasted Sandpiper															4.4%	36.8%	51.8%	7.0%							114
Ruddy Turnstone										5.9%						23.5%	23.5%	35.3%		5.9%	5.9%				17
Sanderling										10.1%				7.7%	0.6%	13.1%	47.0%	17.3%	4.2%						168
Red Knot																	100.0%								2
Dunlin	0.5%	5.0%	2.3%	2.7%	5.3%	2.2%	0.5%	0.2%	2.5%	0.6%						0.3%			0.4%	10.7%	38.9%	20.0%	2.4%	5.6%	4818
Pectoral Sandpiper		0.1%			2.0%	9.3%	12.6%	7.2%	1.5%	1.7%	0.1%		0.3%	6.0%	8.2%	16.9%	18.7%	10.7%	2.8%	1.2%	0.5%				7008
White-rumped sandpiper								1.0%	14.0%	69.4%	4.2%				0.3%		8.5%	1.0%	1.0%	0.3%	0.3%				307
Baird's Sandpiper						8.6%		1.4%	2.1%	25.7%	2.9%			0.7%	5.7%	5.0%	12.1%	8.6%	3.6%	10.7%	9.3%	3.6%			140
Semipalmated Sandpiper					0.4%			0.3%	8.7%	23.9%	1.1%			2.9%	4.6%	27.6%	23.6%	5.0%	0.8%	0.7%	0.1%				2014
Western Sandpiper	0.1%		0.1%	0.1%	0.1%		0.3%	0.4%	7.5%	10.9%			1.3%	0.7%	3.3%	34.5%	20.3%	12.8%	3.3%	1.1%	1.7%	0.6%	0.7%		718
Least Sandpiper	0.8%	1.7%	1.2%	1.5%	1.7%	2.8%	2.7%	2.4%	6.3%	2.3%			2.6%	3.3%	3.1%	8.0%	11.8%	6.4%	9.7%	9.4%	10.6%	5.6%	3.4%	2.6%	19455
Stilt Sandpiper							0.2%	0.7%	1.6%	1.8%			0.5%	3.8%	2.7%	19.7%	41.1%	21.5%	4.1%	2.3%					559
Long-billed Dow itcher					2.6%	11.6%		1.3%	1.3%					3.2%	0.6%	1.3%	0.6%		10.3%	18.7%	34.2%	11.0%	3.2%		155
Short-billed Dow itcher				0.2%		0.2%	0.4%	1.4%	9.0%	7.0%			4.3%	2.1%	1.4%	29.4%	26.5%	1.4%	1.2%	2.9%	12.5%				487
Ruff							100.0%																		1
Wilson's Snipe	1.6%	4.5%	3.2%	5.7%	11.2%	11.8%	20.7%	1.2%	0.1%							0.3%	0.4%	0.2%	1.3%	6.8%	13.5%	7.7%	5.7%	4.0%	8410
American Woodcock																				25.0%				25.0%	4
Wilson's Phalarope									3.7%	7.4%				3.7%	3.7%	37.0%	44.4%								27
Red-necked Phalarope																85.7%	14.3%								7
Red Phalarope								50.0%										100.0%							1

% Total Bird per Species = <1% ; 1.1-5% ; 5.1-10% ; 10.1-15% ; 15.1-20% ; >20.1%

Figure 5-5. Biweekly relative abundance of shorebird species observed throughout the Tennessee River Valley during April 2004-June 2009.

Page intentionally blank

6.0 SPECIES ACCOUNTS

6.1. Introduction

Species accounts provide a basic description of each species observed during this study. The distribution of species, total number and maximum count per occurrence are also noted. References such as Palmer-Ball (2003), Brown et al. (2001), Morrison et al. (2001), Nicholson (1997), and Robinson (1990) were reviewed for additional details. See Section 6.5 for shorebird chronologies. We used abundance categories as defined by the American Birding Association; categories are defined as follows:

- *Common* - Found in moderate to large numbers, and easily found in appropriate habitat at right time of year.
- *Fairly Common* - Found in small to moderate numbers, and usually easy to find in appropriate habitat at the right time of year.
- *Uncommon* - Found in small numbers, and usually - but not always - found with some effort in appropriate habitat at the right time of year.
- *Rare* - Occurs annually in very small numbers. Not expected on any given day, but may be found with extended effort over the course of the appropriate season(s).
- *Accidental* - Represents an exceptional occurrence that might not be repeated again for decades.

Black-bellied Plover *(Pluvialis squatarola)*

Black-bellied plovers are medium-sized shorebirds that forage in a variety of habitats. They frequently forage on drier portions of mudflats. The species is considered uncommon throughout the TRV ($\underline{n}$ = 298 birds). Black-bellied plovers had an extended migration in fall and winter; species abundance peaked in late August followed by a second sustained increase in numbers during October and November. Robinson (1990) noted that this species occurs in Tennessee during April-May and August-November. We saw similar patterns however; we encountered birds into December. Substantially more black-bellied plovers were observed in the west than in other regions combined. The maximum count was 69 individuals observed on 24 August 2006, at New Johnsonville Island on Kentucky Reservoir.

American Golden-Plover *(Pluvialis dominica)*

This species is similar in size and behavior as black-bellied plovers. We observed American golden-plovers on mudflats and irrigated sod farms. Robinson (1990) considered this species as fairly common. Our data suggests that this species is uncommon, because we encountered it less frequently ($\underline{n}$ = 132 birds) than black-bellied plovers, another uncommon species.

American Golden-plovers migrate throughout the TRV, but numbers tend to be greater in the west region. Golden-plovers are an early spring migrant, moving through the TRV earlier (March-early April) than most shorebirds. Fall migration begins in late August, peaking during late September and early October.

The maximum count for golden-plovers was 24 individuals observed on 1 April 2005, at Tennessee National Wildlife Refuge on Kentucky Reservoir.

Killdeer *(Charadrius vociferus)*

Killdeer are very common in the TRV, it was the most abundant species observed (n = 67,269 birds), constituting 52 percent of all shorebirds. These medium-sized shorebirds forage over a broad array of habitats including shallow water, exposed mud, dry shoreline, in vegetation, and away from reservoirs.

Killdeer were found year-round, using mudflat habitats throughout the sample season. During fall, we observed two peaks in abundance; numbers were greatest in August and November. This was one of the most common species overwintering in the TRV, especially in north Alabama. Relatively few killdeer were observed during the spring.

Despite the prevalence of this species in the TRV, killdeer populations are significantly declining overall (Sanzenbacher and Haig 2001; Bart et al. 2007). Because of this decline, the large number of killdeer observed in the TRV is of particular significance. The TRV provides an important inland site for killdeer. This species is not prevalent along the Gulf Coast, as most shorebirds tend to be. The maximum count (1,747 birds) was observed on 17 December 2005, at Wheeler National Wildlife Refuge on Wheeler Reservoir.

Semipalmated Plover *(Charadrius semipalmatus)*

Semipalmated plovers are very similar to killdeer in appearance, but are much smaller and less abundant. This species is fairly common in the TRV (n = 1,152 birds), especially in west and east regions. Wirwa (2009) noted that semipalmated plovers were the fourth most abundant shorebird (behind killdeer, pectoral, and least sandpipers) encountered on Kentucky Reservoir. Semipalmated plovers are late spring migrants, peaking in numbers in May. Numbers were greatest in late August and early September during fall migration. The maximum count was 38 individuals observed on 15 May 2006, at Tennessee National Wildlife Refuge on Kentucky Reservoir.

Piping Plover *(Charadrius melodus)*

This small shorebird is protected under the Endangered Species Act. There are three distinct populations of piping plovers - the Atlantic Coast, Northern Great Plains, and Great Lakes populations. The USFWS (2003) lists the Atlantic Coast and Northern Great Plains populations as threatened. The Great Lakes population is considered endangered. Female plovers tend to migrate during July, and adult males and juveniles migrate during late August and early September (USFWS 2003; Pompei 2004).

The piping plover is a rare fall migrant and extremely rare spring migrant in the region (Robinson 1990, Palmer-Ball, Jr. 2003). The species is not encountered annually in the TRV, only three individuals were observed during 3,796 surveys in the 5-year study. These individuals were encountered in the east and west regions. Individual birds were observed on Douglas (Dutch Bottoms) and Kentucky (New Johnsonville Island) reservoirs on 20 and 23 August; respectively, in 2007. A third individual was observed at Rankin Bottoms Wildlife Management Area on Douglas Reservoir on 9 August 2008. The most recent report of the species prior to this study was from Rankin Bottoms on 1 September 2003. Piping plovers average two days per stay at interior stopover sites (Pompei 2004) and rarely linger in the TRV.

In the TRV, the species is occasionally observed at Rankin Bottoms Wildlife Management Area. Piping plovers are more routinely observed on islands in the Mississippi River near Memphis, and the Ohio River (Falls of the Ohio State Park) along Indiana's southern border.

Jeff Wilson, a well-known shorebird enthusiast, reports that the species is typically observed irregularly on the Mississippi River during two periods July 15-Aug. 1 and the first week in September. He has recorded piping plovers on six dates in July, nine dates in August and five dates in September (Jeff Wilson, unpublished data).

We examined 93 historical records (1935-2003) of piping plovers from various sources including Robinson (1990), Palmer-Ball, Jr. (2003), Pompei (2004), and *The Migrant,* and personal communications (Dwight Cooley, Greg Jackson, Damien Simbeck). Of these records, 50 percent were from the TRV; including observations from Gallatin, Kingston and Colbert fossil plants and other off-reservoir sites. Most records in the TRV are from localities on TVA reservoirs. Fifteen percent of the records were reported in late spring; the remaining records are from fall (Figure 6-1). The majority of historical records (58 percent) were from August and September.

Although the winter and breeding habits of piping plovers is well known, little is known about the migration ecology of piping plovers. Pompei (2004) examined use of stopover sites by piping plovers migrating between winter and breeding sites. She reported that this plover does not concentrate in large numbers during migration; most sightings involved individual birds, also that most migrate during August through mid-September; peak numbers were during the second week in August, followed by the last week in August and first week in September (Figure 6-2).

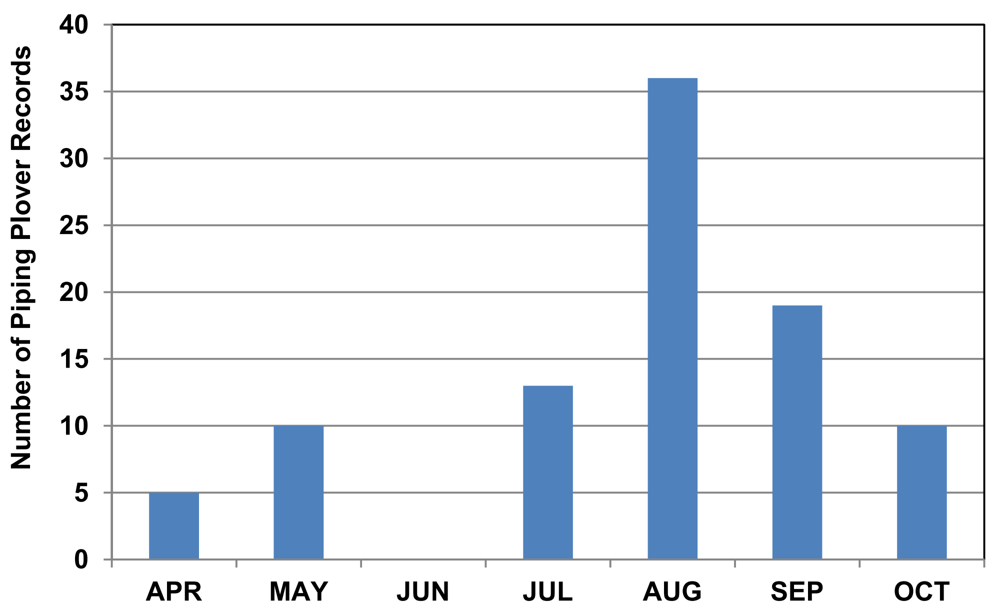


Figure 6-1. Number of monthly observations of piping plovers (n=93) in the interior southeastern United States between 1935-2003.

Pompei (2004) noted that although the species uses a variety of habitats, most interior sites used by piping plovers included reservoir shorelines. She noted that piping plovers move quickly through the interior U.S. during spring, often overflying southern states.

Regarding habitat availability, Pompei (2004) noted that over 50 percent of historic sites were not used, despite the presence of suitable habitat and other shorebirds. She determined that migrating piping plovers were flexible in their habitat requirements. She also noted that piping plovers select stopover sites opportunistically and that protection of individual sites was not warranted, as long as other habitats were available at the landscape level. Currently, stopover habitat is available on TVA reservoirs as the majority of piping plovers migrate through the area.

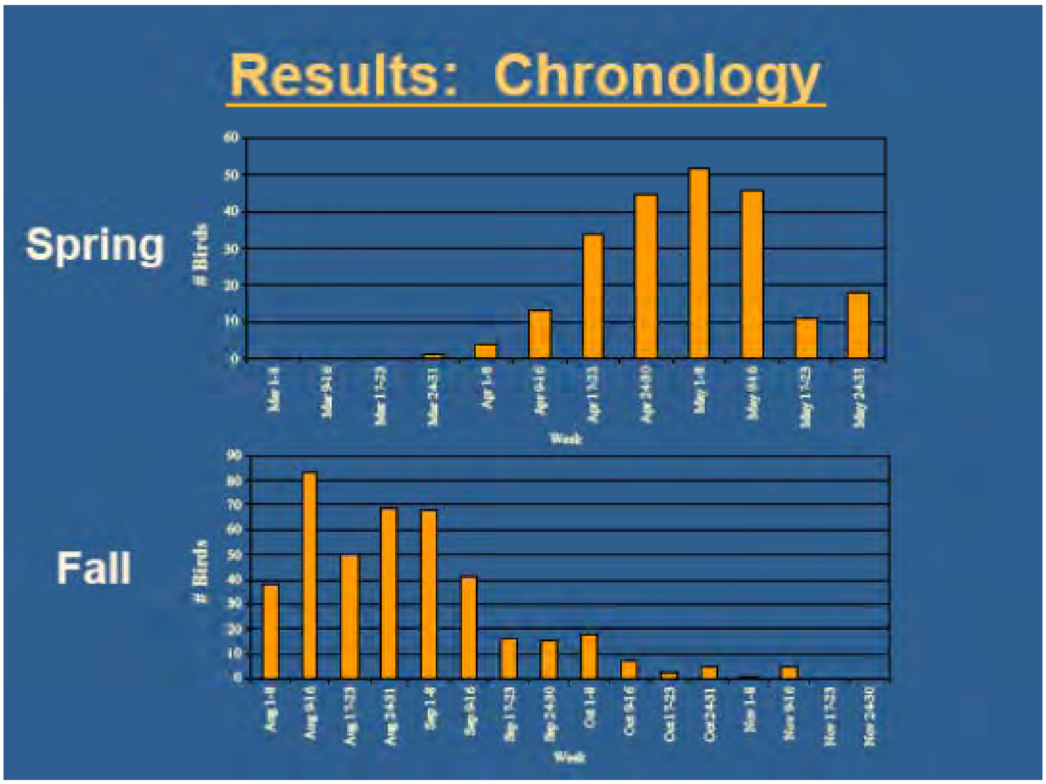


Figure 6-2. Chronology of piping plovers at interior stopover sites (Source: Pompei 2004)

Black-necked Stilt *(Himantopus mexicanus)*

Stilts are larger shorebirds similar to small wading birds; they usually forage in shallow water. Although the species breeds on the Mississippi River, stilts are not known to breed in the TRV.

Black-necked stilts are rare in the TRV; we encountered only eight individuals during the 5-year study. Stilts were observed in west and central regions during late May and October. The maximum count was two individuals on 16 May 2009, at Marthaler Pond in north Alabama, and on 23 May 2008, at Tennessee National Wildlife Refuge on Kentucky Reservoir.

American Avocet *(Recurvirostra americana)*

Avocets are uncommon in the TRV (n = 102 birds); they typically forage in shallow water. Robinson (1990) noted that the species occurs more frequently in east Tennessee; we observed a similar pattern. Most birds were observed during the fall, peaking in numbers in late August through early September, and again in late October. The maximum count was 13 individuals observed on 25 August 2007, at Dutch Bottoms on Douglas Reservoir.

Greater Yellowlegs *(Tringa melanoleuca)*

Greater yellowlegs are fairly common in the TRV (n = 3,634 birds). They typically forage in the mud zone of mudflats but can also forage in tailwaters or ponds. The species migrates throughout the TRV but they tend to be more common in west and central regions.

Robinson (1990) noted that there were few reports of greater yellowlegs in winter in Tennessee; however, we observed the species throughout the sample season. Greater yellowlegs were most abundant during spring; they are an early spring migrant, peaking in numbers during mid-March. During the fall season, their numbers peaked in early September; followed by a second more prolonged period of abundance in October through early November. The maximum count was 178 individuals on 7 April 2004 at Tennessee National Wildlife Refuge adjacent to Kentucky Reservoir.

Lesser Yellowlegs *(Tringa flavipes)*

Lesser yellowlegs are common in the TRV (n = 5,915 birds). We observed this species routinely, usually in low numbers, mixed with other shorebirds on mudflats. However, the species is not limited to foraging at mudflats, as are most shorebirds (e.g., sandpipers). Lesser yellowlegs also forage in shallow tailwaters, ponds and fish hatcheries.

The species was most abundant during spring migration from mid-March to mid-May; largest numbers were observed in late April. During fall, the species was most abundant during September and October. Lesser yellowlegs migrate throughout the TRV, but numbers tended to be higher in the west region. The maximum count was 247 individuals on 24 April 2009 at the “Sinks” near Wheeler reservoir.

Solitary Sandpiper *(Tringa solitaria)*

The solitary sandpiper is a fairly common migrant (n = 1,041 birds) although they are only found in small numbers or individually. Solitary sandpipers are one of the first species to move through the TRV during fall migration; their numbers peaked in late July and early August. Numbers of solitary sandpipers dropped substantially by mid-September; the species was not observed during winter. During spring migration, the species was most abundant in April through mid-May, and continued to move through the TRV during June.

While most sandpipers are strongly dependent on mudflat habitats in the TRV, solitary sandpipers forage in a variety of habitats including ponds, ditches, tailwaters and rivers. This species was most prevalent in the west region. The maximum count was 39 individuals on 5 May 2006 at Tennessee National Wildlife Refuge adjacent to Kentucky Reservoir.

Spotted Sandpiper *(Actitis macularius)*

The spotted sandpiper is fairly common in the TRV (n = 1,138 birds). Spotted sandpipers breed in the TRV to a limited extent (Robinson 1990); there are isolated breeding records reported from Tennessee and Kentucky (Nicholson 1997; Palmer-Ball 1996).

Numbers of spotted sandpipers increases in July as fall migrants move into the TRV. The species is most abundant during late August, when numbers dropped substantially through November. Spotted sandpipers did not over-winter in the TRV. This species is a late spring migrant, moving through the TRV during April and May.

Similar to the solitary sandpiper in foraging preferences, the spotted sandpiper forages in a variety of habitats. We routinely observed this species foraging along debris-covered shorelines on reservoirs at full summer pool level and among exposed rocks on tributary streams and tailwaters. Spotted sandpipers were more prevalent in west and east regions. The maximum count was 36 individuals on 5 May 2008 at Tennessee National Wildlife Refuge adjacent to Kentucky Reservoir.

Willet *(Catoptrophorus semipalmatus)*

Willets are rare in the TRV; 176 individuals were encountered during the study. Spring migration was much shorter than fall; almost 75 percent of willets were observed during late April through early May. We encountered this species (in breeding plumage) resting on island gravel bars on Kentucky Reservoir, mixed within flocks of terns and gulls. Fall migration was more prolonged than spring migration. Willets occurred in all regions, but were more prevalent in the east. The maximum count was 53 individuals on 28 April 2008 at Riverport, an off-reservoir site in east Tennessee.

Marbled Godwit *(Limosa fedoa)*

Marbled godwits are extremely rare in the TRV ($\underline{n}$ = 47 birds). Numbers were greater in the west region, more than other regions combined. More than 90 percent of marbled godwits were observed in spring. The maximum count was 37 individuals on 19 April 2007, on the beach at Kentucky Dam State Park, Kentucky Reservoir.

Hudsonian Godwit *(Limosa haemastica)*

Hudsonian godwits are extremely rare in the TRV; the species is considered accidental to the region, especially during the fall. Three individuals were observed on 12 September 2008, at Big Sandy embayment on Kentucky Reservoir. Fall observations of Hudsonian godwits in the interior U.S. are extremely rare, because most birds migrate over the Atlantic Ocean to wintering grounds in South America during Fall.

Whimbrel *(Numenius phaeopus)*

Wimbrels are extremely rare migrants in the TRV. Three individuals were observed in the east region. One specimen was observed during August. Two individuals (which was also the maximum count) were observed on 27 May 2006, at Kingston Fossil Plant adjacent to Watts Bar Reservoir.

Long-billed Curlew *(Numenius americanus)*

Long-billed curlews are extremely rare migrants in the TRV. Five individuals were observed in east and central regions. The maximum count was four individuals on 23 November 2007, at Round Island Creek, on Wheeler Reservoir.

Upland Sandpiper *(Bartrania longicauda)*

Upland sandpipers are uncommon migrants in the TRV, typically found in grasslands and fields; habitats that we did not frequent during this study. Six individuals were observed throughout the TRV. The maximum count was three individuals on 25 August 2006, at Gnat Pond Sod Farm near Pickwick Reservoir.

Buff-breasted Sandpiper *(Tryngites subruficollis)*

Buff-breasted sandpipers are uncommon in the TRV (n = 114 birds). This species occurs among vegetated portions of mudflats, making it more difficult to detect. Buff-breasted sandpipers moved through the TRV briefly during the fall, peaking in numbers during early September. We did not observe buff-breasted sandpipers during the spring, when most migrate through the U.S. west of the Mississippi River (Robinson 1990). The maximum count was 19 individuals on 30 August 2005, at Gnat Pond Sod Farm.

Ruddy Turnstone *(Arenaria interpres)*

Ruddy turnstones are extremely rare in the TRV; only a few were encountered (n = 17 birds) during the 5-year study. The species was encountered as individuals or in small groups. Eighty percent of the birds were observed during late August through September. Smaller numbers were observed in late May. Ruddy turnstones were only reported from both the west and east regions. The maximum count was three individuals on 9 September 2007, at Taylors Bend on Douglas Reservoir.

Sanderling *(Calidris alba)*

Sanderlings are uncommon in the region (n = 168 birds); they were usually encountered in small flocks. This species occurred sporadically from late July through mid-October.

During spring migration, sanderlings moved through the TRV during a 2-week period in late May. More birds were observed in the east region than in other regions combined. The maximum count was 19 individuals on 23 September 2008, at Blood River on Kentucky Reservoir.

Red Knot *(Calidris canutus)*

Red knots occur accidentally in the TRV. One red knot was observed at Dutch Bottoms on Douglas Reservoir on 3 September 2007. A second red knot was observed on 10 September 2007, at Jonathan Creek on Kentucky Reservoir.

Dunlin *(Calidris alpina)*

Dunlin were the sixth most abundant species (n = 4,818 birds), comprising 4 percent of shorebird numbers. This species favored mudflat habitats, foraging along the shoreline at moderate water depths.

This late fall migrant was rarely observed before October; their numbers peaked in November. They were distributed throughout the TRV, but numbers tended to be higher in the east and central regions. The maximum count was 355 individuals on 4 November 2007 at Swan Bridge on Douglas Reservoir.

Pectoral Sandpiper *(Calidris melanotos)*

Pectoral sandpipers were the fourth most abundant species, comprising 6 percent (n = 7,008 birds) of shorebird numbers. The species forages on mudflats along the shoreline; however, unlike most shorebirds, they frequently foraged at drier portions of the flats, among vegetation.

Pectoral sandpipers are early spring migrants, with numbers peaking in late March and early April. This species was encountered throughout the fall, especially during late August and early September. Pectorals were distributed throughout the TRV but were most abundant in west and east regions. The maximum count was 195 individuals on 1 September 2006 at Rankin Bottoms Wildlife Management Area on Douglas Reservoir.

White-rumped Sandpiper *(Calidris fuscicollis)*

White-rumped sandpipers are uncommon spring migrants and rare fall migrants. We observed 307 individuals throughout the study. A late spring migrant, over 69 percent were observed during the first half of May. Spring migration was short (mid- April through mid-June), compared to fall migration (early August through mid-November).

Considerably more white-rumped sandpipers were observed in the central and east regions than the west. The maximum count was 87 individuals on 25 May 2009 at the Sinks in north Alabama.

Baird's Sandpiper *(Calidris bairdii)*

Baird's sandpipers are uncommon in the TRV. We observed 140 individuals during the 5-year study. Small numbers were observed throughout fall migration, peaking in abundance during early September and late October. Baird's were late spring migrants, peaking in abundance during late May after most reservoir habitats were flooded.

Most Baird's sandpipers were observed in the central and east regions, with considerably fewer numbers observed in the west. Most occurred on off-reservoir habitats. The maximum count was 30 individuals on 27 May 2006 at Kingston Fossil Plant (on a flooded sports field) adjacent to Watts Bar Reservoir.

Semipalmated Sandpiper *(Calidris pusilla)*

This common sandpiper was observed throughout the TRV (n = 2,014 birds). Semipalmated sandpipers foraged along reservoir shorelines on mudflats. Most were observed in the west and east regions. This species was most abundant during fall migration in late August through September. Semipalmated sandpipers were late spring migrants, with numbers peaking in May. The maximum count was 143 individuals on 19 May 2005 at Tennessee National Wildlife Refuge adjacent to Kentucky Reservoir.

Western Sandpiper *(Calidris mauri)*

This uncommon sandpiper was detected less frequently (n = 2014 birds) than semipalmated sandpipers. However, western sandpipers tended to be observed over longer periods during spring and fall migration. This species peaked in numbers during May and late August through September like most other sandpipers. Western sandpipers were more abundant in the west and east regions; considerably fewer were observed in the central region.

It can be very difficult to differentiate between western and semipalmated sandpipers, especially once these species molt into winter plumage. The majority of birds categorized as "unknown small shorebirds" were likely these two species (n = 3,923 birds). The maximum count was 40 individuals on 29 August 2007 at Dutch Bottoms on Douglas Reservoir.

Least Sandpiper *(Charadrius minutilla)*

The least sandpiper was the second most abundant shorebird in the TRV (n = 19,455 birds), constituting 15 percent of shorebirds in the study. This common species was detected during every sample period. Collectively, killdeer and least sandpipers constituted 67 percent of shorebirds observed in the TRV.

The majority of least sandpipers were observed during fall migration when their numbers increased in late August and remained high through November. Least sandpipers overwinter in the TRV. During spring, least sandpiper numbers peaked in April. The species was rarely observed in May, unlike other sandpiper species. The maximum count was 260 individuals on 12 November 2007 at the Swan Bridge on Douglas Reservoir.

Stilt Sandpiper *(Calidris himantopus)*

This medium-sized shorebird forages primarily in shallow water adjacent to mudflats. Stilt sandpipers are considered uncommon in the TRV (n = 559 birds). Most were observed in the west and east regions; considerably fewer numbers were reported from the central region. The majority of stilt sandpipers were observed during fall migration, peaking in numbers during late August and September. As noted by Robinson (1990), considerably fewer stilt sandpipers were observed during spring migration, when most birds were observed in May. The maximum count was 104 individuals on 14 September 2006 at Rankin Bottoms Wildlife Management Area on Douglas Reservoir.

Long-billed Dowitcher *(Limnodromus scolopaceus)*

These large shorebirds are globally more abundant than short-billed dowitchers; however, they occur less frequently in the TRV. Long-billed dowitchers are rare in the TRV (n = 155 birds); however, they can be found annually with some effort. Most individuals were observed in the central and west regions. This species was an early spring migrant, peaking in numbers during March. Long-billed dowitchers migrated through the region much later than short-billed dowitchers during fall migration, and peaked in numbers during early November.

The two species of dowitchers can be difficult to differentiate. Approximately 219 individuals were classified as “unknown dowitchers.” Their morphology allows dowitchers to forage in deeper water than most shorebirds found along the edge of exposed mudflats. The maximum count was 35 individuals on 2 November 2005 at Kimbourgh Slough on Wheeler Reservoir.

Short-billed Dowitcher *(Limnodromus griseus)*

The species was considered to be uncommon in the TRV (n = 487 birds). Short-billed dowitchers were late spring migrants, peaking in number during May. In fall, the species was most abundant during late August and early September. Short-billed dowitchers were most common in the east and west regions. The maximum count was 60 individuals on 3 November 2005 at the Duck River Levee at Tennessee National Wildlife Refuge, Kentucky Reservoir.

Ruff *(Philomachus pugnax)*

Ruff are considered to be rare vagrants in the U. S. and accidental in the TRV. This species breeds outside of North America (Brown et al. 2001). One individual was observed on 11 April 2007 at Town Creek Marsh on Wilson Reservoir. This observation was a substantial record for the region.

Wilson's Snipe *(Gallinago delicata)*

This common species overwinters in the TRV. Snipe were the third most abundant species encountered (n = 8,410 birds), constituting 6 percent of shorebirds in the study. Snipe migrated into the TRV during late October, peaked in November, much later than most other shorebirds. This species was an early spring migrant, peaking in number during March and early April.

Snipe are very cryptic and difficult to detect, remaining motionless for long periods among vegetation and debris. Their numbers were likely underrepresented in the study. The maximum count was 240 individuals on 5 April 2006 at Wheeler National Wildlife Refuge adjacent to Wheeler Reservoir.

American Woodcock *(Scolopax minor)*

Woodcocks are uncommon in the TRV; however, the species can be easily overlooked. Woodcocks were reported (n = 4 birds) from the east and central regions. Single individuals were detected during late October, late December, and late April.

Wilson's Phalarope *(Phalaropus tricolor)*

Wilson's phalarope are considered rare in the TRV. We observed 27 individuals; mostly in the west and east regions. Phalaropes occur in deeper water than other shorebird species. This species was observed during late spring and early fall, the majority were recorded in late August and early September. The maximum count was seven individuals on 6 September 2007, at the mouth of the Duck River on Kentucky Reservoir.

Red-necked Phalarope *(Phalaropus lobatus)*

This pelagic (oceanic) species is considered rare in the TRV. Seven individuals were observed throughout the study; this species was only observed in the east region. Additionally, red-necked phalarope were only observed during fall migration in late August, and early September. The maximum count was three individuals on 28 August 2008 at Kingston Fossil Plant ash pond adjacent to Watts Bar Reservoir.

Red Phalarope *(Phalaropus fulicarius)*

This pelagic species is rarely observed within the interior U.S. and is considered accidental in the TRV. Only one specimen was observed during the 5-year study; this observation occurred on 25 September 2008, at Dutch Bottoms on Douglas Reservoir.

7.0 DISTRIBUTION OF WATERFOWL IN THE TRV

7.1. Introduction

TVA's reservoir system is used by numerous species of waterfowl. Several species breed in the region, and nest in the abundant wetlands and riparian zones found throughout the TRV. Common breeding species include wood duck (*Aix sponsa*), hooded merganser (*Lophodytes cucullatus*), mallard (*Anas platyrhynchos*) and Canada goose (*Branta canadensis*). Most waterfowl in the TRV are migratory, only residing in the Valley during fall and winter.

The TRV provides a variety of habitats for waterfowl. Open water habitats are used by large flocks of diving ducks including canvasback (*Aythya valisineria*), ring-necked duck (*A. collaris*) and scaup (*A. marila and A. affinis*). Shallow embayments with a mixture of open water and areas dominated by aquatic vegetation attract large aggregations of waterfowl throughout most mainstem reservoirs. These areas are abundant on Kentucky, Wheeler and Guntersville reservoirs. Dabbling ducks, including mallard, gadwall (*Anas strepera*), and green-winged teal (*Anas crecca*) are common throughout these areas.

During the ROS, several stakeholder groups were concerned by the potential loss of mudflat habitats used by waterfowl in the region. Although our study focused on shorebirds, we examined waterfowl resources in the TRV that use mudflat habitats. Wirwa (2009) and Laux (2008) examined several aspects of waterfowl ecology related to mudflats. Their studies are referenced throughout this summary (Also see Sections 10.4 and 10.5).

7.2. Methods

State agencies in Alabama, Tennessee and Kentucky annually survey wintering waterfowl populations throughout the migratory season; the dates of these surveys vary. These agencies and the USFWS perform a coordinated monitoring effort during mid-winter when waterfowl numbers are highest in the southeastern region. TVA examined the results of the mid-winter counts to determine overall abundance of waterfowl in the TRV, and to determine which reservoirs provide the most waterfowl habitats.

The USFWS performs systematic surveys at Wheeler and Tennessee National Wildlife Refuges. Many of these surveys include aerial surveys, performed over many years. Some data are available on refuge websites. The USFWS Migratory Bird Office in Memphis, Tennessee compiles data from all federal and state surveys.

7.3. Results and Discussion

The TRV is a significant resource used by migratory waterbirds. Approximately 1,688,390 ducks, geese, swans, American coot (*Fulica americana*), and sandhill crane (*Grus canadensis)* were counted during mid-winter waterfowl counts performed by federal and state agencies in the TRV during 2005-2009. Waterfowl, ducks and geese, constitute79 percent (n = 1,331,487 birds) of the total waterbirds observed.

Of the 11 reservoirs that are routinely monitored, the majority of waterfowl (52 percent) uses Kentucky, Guntersville and Wheeler reservoirs. The west region, Kentucky Reservoir, was used by more waterfowl (68 percent, n = 899,958 birds) than other regions combined. Numbers of waterfowl were high in north Alabama (31 percent, n = 407,724 birds) but relatively low in east Tennessee (<2 percent, n = 23,805 birds).

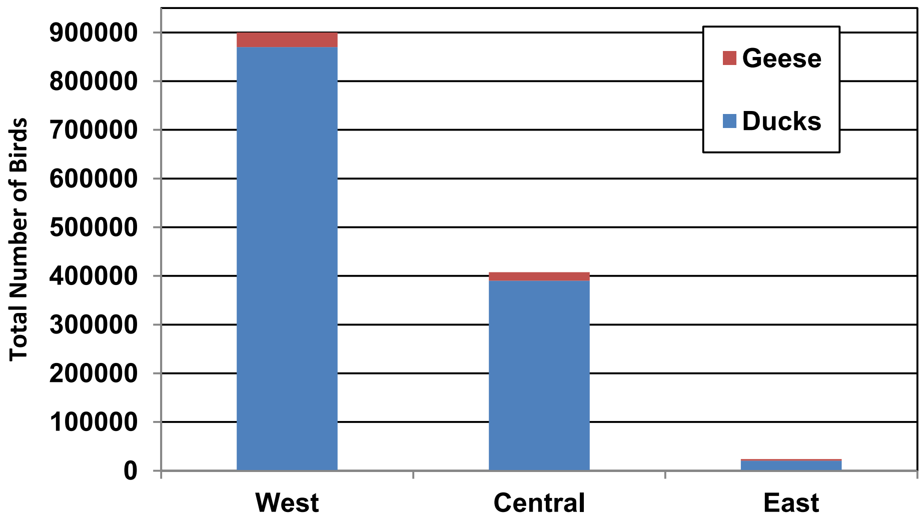


Figure 7-1. Total number of geese and ducks estimated during mid-winter waterfowl surveys in three regions of the Tennessee River Valley, USA, 2005-2009. Data obtained from the USFWS Migratory Bird Office, Memphis, Tennessee.

Ducks made up the majority of waterfowl (96 percent, n = 1,280,653) in the TRV. Dabbling ducks were the most abundant group of waterfowl; the most common species were mallard (55 percent, n = 725,108), gadwall (17 percent, n = 221,313), northern pintail (*Anas acuta*; 5 percent, n = 62,209), green-winged teal (4 percent, n = 51,261), and American wigeon (*Anas americana*; 3 percent, n = 43,767). Common diving ducks included ring-necked duck (5 percent, n = 64,892), scaup (1 percent, n = 18,102) and canvasback (<1percent, n = 12,646), particularly on Kentucky Reservoir.

Geese made up <4 percent of waterfowl in the TRV. Canada geese were the most common species (3 percent, n = 37,461). While resident geese occur throughout most reservoirs in the system, the greatest numbers of migratory geese were found on Kentucky and Wheeler reservoirs. Fairly large numbers of snow geese (*Chen caerulescens*;<1 percent, n = 11,291) interspersed with greater white-fronted geese (*Anser albifrons*) are were found on Kentucky and Wheeler reservoirs during winter months.

Wirwa (2009) had similar results, but species composition differed from those observed during the mid-winter counts. In his study, gadwall were the most common species observed on Kentucky Reservoir. Other species included mallard (29 percent) and green-winged teal (15 percent). His species list did not include several of the species tracked in the mid-winter waterfowl counts. The discrepancy in species composition could be largely due to the different techniques used to estimate waterfowl numbers. Wirwa (2009) surveyed waterfowl from fixed locations on mudflats; this technique tends to detect dabbling ducks. Mid-winter waterfowl surveys are often performed from aircraft over reservoirs, where large flocks of diving ducks are frequently encountered.

Gadwall are common in the TRV; large flocks can be observed foraging on aquatic vegetation in most shallow embayments on Guntersville and Wheeler reservoirs. Their flocks often include large numbers of American coot and smaller numbers of American wigeon, hooded merganser, bufflehead (Bucephala albeola), mallard, northern shoveler, teal and pied-billed grebes (*Podilymbus podiceps*). We observed gadwall and blue-winged teal (*Anas discors*) foraging on dense swarms of aquatic invertebrates (*Corixidae*; water boatmen) in water less than 2-inches deep along the margins of mudflats on Kentucky Reservoir. TVA mainstem reservoirs provide significant habitat for these and other dabbling ducks.

As we observed in the shorebird study, waterfowl species composition varies throughout migration. Wirwa (2009) observed that in August, the most common waterfowl were resident Canada geese (33 percent), wood duck (9 percent), and mallard (4 percent). Blue-winged teal were the most common migrant (53 percent) in August.

During September, blue-winged teal and Canada geese were most common. Green-winged teal, gadwall, northern pintail, and northern shoveler arrived in the TRV in September.

Most waterfowl species arrive in the TRV during October-December (Reid et al. 1989; Benedict and Hepp 2000). In October, gadwall (30 percent), green-winged teal (19 percent) mallard (18 percent), blue-winged teal (14 percent) and Canada geese (12 percent), were the most common species. During November and December, gadwall (38 percent), mallard (33 percent), and green-winged teal (19 percent) were the most common species (Laux 2008; Wirwa 2009).

Wirwa (2009) and Laux (2008) reported greater numbers of blue-winged teal than mid-winter waterfowl counts. Blue-winged teal was one of the earliest species to migrate into the TRV. They and Canada geese were two of the most common species observed during August and September. The low number of blue-winged teal during the mid-winter waterfowl counts was likely the result of the timing of these surveys. This species may also be mis-identified as green-winged teal during aerial surveys.

Of the three reservoirs providing the most waterfowl habitat in the TRV (Kentucky, Wheeler and Guntersville reservoirs), Guntersville and Wheeler reservoirs are most similar. Both are shallow, linear reservoirs with occasional embayments. Guntersville Reservoir has extremely lush growths of aquatic vegetation, providing ample food for dabbling ducks (Benedict and Hepp 2000). This prevalence of aquatic vegetation also attracts the largest numbers of American coot in the TRV. The managed sub-impoundments on Wheeler National Wildlife Refuge also provide large amounts of habitat for dabbling ducks. Waterfowl numbers are greater on the refuge than on the other portions of Wheeler Reservoir.

Kentucky Reservoir is the largest in the system (160,300 acres). While it lacks the relative abundance of aquatic weeds observed on Guntersville Reservoir, it has an extensive network of shallow embayments, islands along the river channel, and mudflats, many of which are actively managed for waterfowl. The abundance of waterfowl on Kentucky Reservoir during winter months is largely due to this diverse habitat and its location within the Mississippi Flyway. Aquatic invertebrates, aquatic vegetation, and moist-soil seeds on Kentucky Reservoir provides substantial sources of food for migrating waterbirds (Wirwa 2009). Kentucky Reservoir is also used by large flocks of diving ducks. Substantial flocks of canvasback are routinely observed in portions of the Big Sandy embayment.

In Section 5.4, reservoir operations effect on mudflats and associated vegetation was discussed. The drawdown rate and timing can affect the establishment of vegetation on mudflats (Webb 1988; Section 9.0). If mudflats are exposed too rapidly, mudflats dry too fast providing habitat for undesirable vegetation such as rough cockleburr (*Xanthium strumarium*). If mudflats are exposed too late in the season, only sparse vegetation becomes established. The management suggestions noted in Section 5.4 would benefit waterfowl and other species that utilize mudflat habitats in the TRV.

8.0 MUDFLAT VEGETATION DYNAMICS AT EAGLE CREEK EMBAYMENT, KENTUCKY RESERVOIR 2005-2008. ALAN MAYS

8.1. Introduction

Various studies have examined vegetative communities on mudflats throughout the TRV. Webb et al (1988) reported on the mudflats flora and vegetation of six mainstem reservoirs. Amundsen (1994) reported on the ecology and dynamics of flats and riparian communities on Watts Bar Reservoir. Guinn (2003) performed a comprehensive survey of mudflat vegetation on Kentucky Reservoir and off-reservoir sites within the Duck River Unit of Tennessee National Wildlife Refuge. These studies found that mudflat communities in the TRV are dominated by annual plant species, several of which complete compressed life cycles between the start of each annual summer drawdown and first frost (TVA 2004).

The drawdown of TVA's reservoirs influences composition and biomass of plant communities on exposed mudflats throughout the TRV (Webb 1988). Changing the initiation of drawdown can either compress or lengthen the growth period, which ends at first frost. The rate of drawdown can directly influence the amount of moisture in soils used by plants as they grow.

Plant communities along the shoreline of most TVA mainstream reservoirs fall within two categories (1) an emergent community of herbaceous perennials that often exists in the shallow margins along the summer shoreline and (2) a mudflat community comprised of perennials and annuals which develop on the exposed sediments as reservoir levels recede. Woody species of plants are intolerant to flooding (Hall and Smith 1955); only those species that favor damp soils [e.g., bald cypress (*Taxodium distichum*), black willow (*Salix nigra*), buttonbush (*Cephalanthus occidentalis*)] survive along the margins of the drawdown zone.

During this study, surveys of plant communities were conducted on Kentucky Reservoir. The objective was to describe the plant community established on mudflats as they are exposed. Specifically, these questions were examined:

- What species of plants develop on mudflat habitats over time?
- How does species composition vary throughout the mudflat?
- What factors may contribute to these differences?
- How much biomass (food source) is produced in a given length of time?

Laux (2008) and Wirwa (2009) performed similar studies on Douglas and Kentucky Reservoirs, respectively. These studies are referenced to provide further details.

8.2. Methods

The study was conducted at Eagle Creek Embayment, Kentucky Reservoir, Tennessee during 2005-2008. A transit and level were used to identify sample points along an elevation gradient at 6-inch intervals from the summer shoreline and the edge of the exposed mudflat; seven zones were identified along the gradient (Figure 8-1).

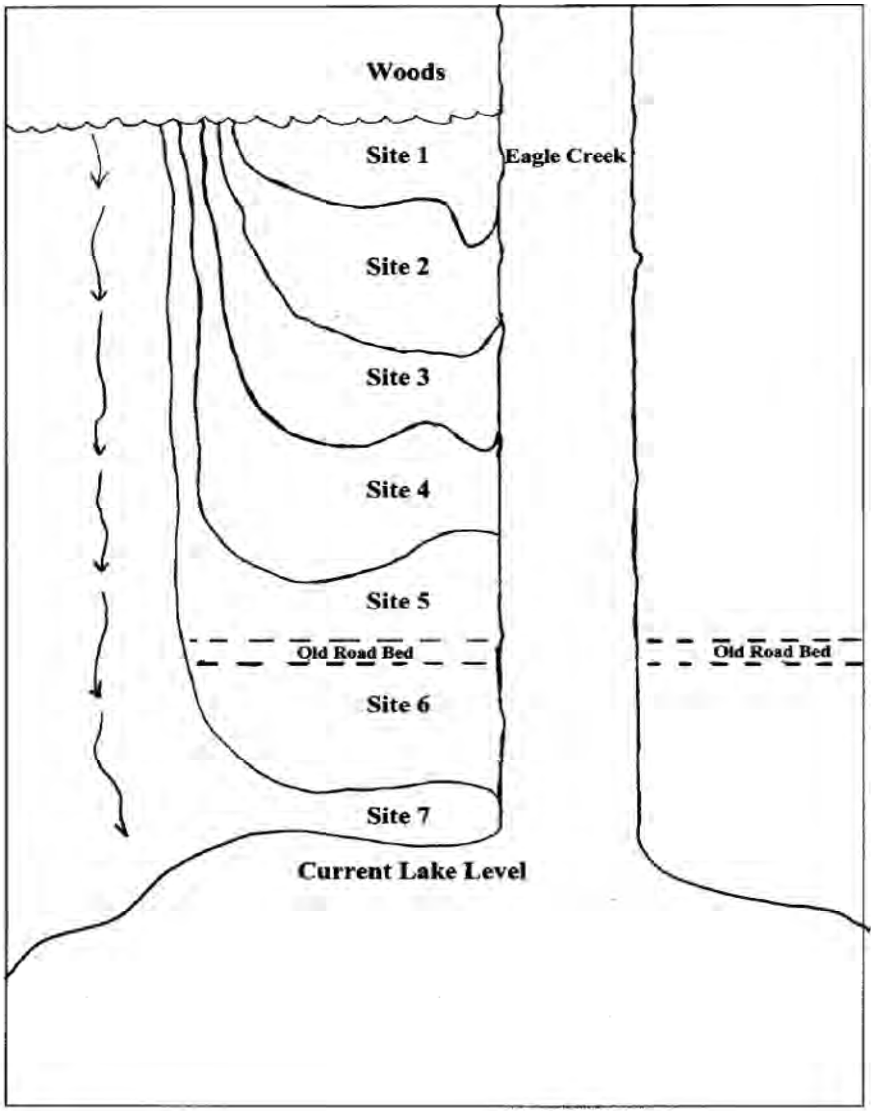


Figure 8-1. Generalized schematic of the vegetation sampling sites at Eagle Creek, November 1, 2005.

Using TVA's reservoir data (Johnsonville gauge), the elevation at water's edge and the elevation for each 6-inch increment along the gradient was determined. These data permitted the calculation of exposure times for each of the sampling zones.

At random sampling points within each zone, a 1-m square template was used to estimate the relative contribution of each species within the sample point (the total percentage of plants may exceed 100 percent due to differing layers of vegetation). Estimates of average total height and biomass of vegetation were also recorded. To quantify above-ground biomass, all plant material within the template was clipped at ground level and returned to the laboratory, where it was dried at 65˚C and weighed. Digital images were taken of each plot, as well as a panoramic view of the entire transect.

8.3. Results and Discussion

Species Composition

Plant communities throughout the mudflat were botanically diverse. In general, site and species relationships were noted. Mudflat communities are first colonized by least spike-rush (*Eleocharis acicularis*) a major component in most sites, except the highest (and driest) locations in the mudflat (Site 1). This vegetation develops into a thick “carpet” that is so extensive that it is easily visible in aerial photographs (see photo on report cover). The species propagates by rhizomes and/or seeds, and is adapted to the fluctuating water levels experienced on the mudflats. Seeds and stems of least spike-rush are important food for waterfowl and mammals. Least spike-rush provides habitat for amphibians and fish (when flooded) and helps to stabilize mudflat surfaces. Intermediate sites were dominated by lowland toothcup (*Rotala ramosior*), scarlet ammannia (*Ammannia coccinea*), three-lobed beggarticks (*Bidens tripartita*), chufa flatsedge (*Cyperus esculentus*), teal lovegrass (*Eragrostis hypnoides*), and marsh seedbox (*Ludwigia palustris*). On the driest sites (Sites 1 and 2), common water-willow (*Justicia americana),* marsh aster (*Aster simplex*), and alligator-weed (*Alternanthera philoxeroides*) form such dense stands that very little sunlight reaches the sediment surface.

Wirwa (2009) and Laux (2008) found similar species composition on mudflats on Kentucky and Douglas reservoirs. Wirwa (2009) found that *E. acicularis*, *R. ramosior* and *A. coccinea* were prevalent on multiple mudflats on Kentucky Reservoir. He also noted that seed production on Kentucky was similar to seed production that Laux (2008) reported from Douglas Reservoir. However, Laux (2008) noted that rough cockleburr dominated moist-soil plants on Douglas Reservoir. This was attributed to the rapid drawdown on Douglas Reservoir. Wirwa (2009) noted that overall seed yield on TVA mudflats was lower than estimates in moist-soil units in the southeast (Gray et al. 1999; Kross et al. 2008).

Species composition changed during the course of the study along the length of the transect (Appendix 12.5). These changes can be attributed to species competitiveness and to extended exposure times on higher portions of the mudflat. Extended exposure times were due to severe drought during the latter half of the study. Over the course of the project, the following observations were made:

- Stands of alligator-weed invaded much of the mudflat vegetation in 2006, 2007, and 2008, replacing common water-willow and marsh aster in all but the most regularly inundated sites (Figure 8-2). Small isolated stands of alligator-weed were observed even in transition areas between Sites 3 and 4.

- Although bald cypress saplings were found along the periphery of the mudflats (most likely planted), no other woody species were found during earlier surveys largely due to constant inundation of the mudflat. However, in 2006 and 2007, black willow saplings moved into Zones 1-3 (background of Figure 8-2).

- A number of previously unrecorded species became established on the mudflat in 2007, particularly at sites 1-3 (Appendix 12.5).

Figure 8-2. Dense stands of *Alternanthera philoxeroides* in swales along portions of Site 2 on Eagle Creek Embayment, Kentucky Reservoir, Tennessee, USA. Note *Salix nigra* in the background; neither of these species occurred on the mudflat in 2005.

Exposure Times

Length of exposure influences the growth of vegetation on mudflats. Number of species increased over time. By day 20, only four species occurred on mudflats on Kentucky Reservoir; only 3 percent of surface area was covered by vegetation. By day 41, six species had been identified with 94 percent cover of the sample unit (1-m sq.). By day 62, 9 species were detected with 98 percent cover of the sample unit (B. Hart, unpublished data).

Timing of exposure also influences growth of vegetation. If mudflats are exposed later in the growing season, growing days are much shorter and soil temperature is lower; these factors reduce the growth rate of vegetation (Wirwa 2009).

In 2006, total exposure times for each sampling site along the mudflat transect were not significantly different from the year before. However, due to lake level fluctuations during drawdown, some sample sites were flooded for short periods of time during the seasonal drawdown (around September 1 in 2005 ,and September 24 in 2006). These periods were usually two to seven days in duration. When comparing differences in the length of exposure times since the last inundation period for some of the mid-gradient sites, it appears that in 2006, Sites 3 and 4 experienced an additional three weeks of exposure, which may have facilitated the growth of some plant species. During 2007, the duration of exposure for practically all of the mudflat sites was increased due to a record drought within the Tennessee River watershed. This likely promoted the expansion of woody vegetation and alligator-weed onto the mudflat.

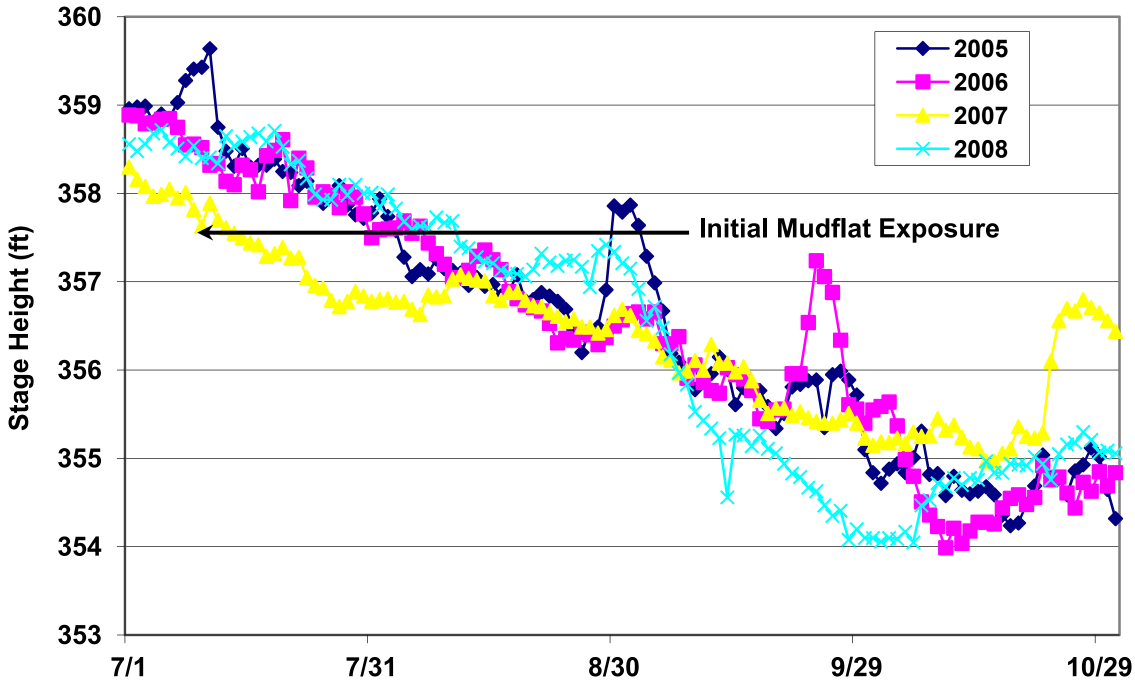


Figure 8-3. Comparison of Kentucky Reservoir elevations at Johnsonville Gage Station, Tennessee River Mile 100.5 during 2005-2008. Note variation in number of days that each sample site was exposed during fall drawdown (2005-2007). The variation was due to flood events in 2005-2006, and severe drought in 2007-2008.

Biomass

Biomass estimates varied annually with the greatest biomass located on the highest mudflat contours. Higher contours are exposed for greater periods of time allowing more species to become established and mature before first frost. Wirwa (2009) reported similar findings elsewhere on Kentucky Reservoir. He noted that needle spike rush comprised the greatest biomass across contours. Regarding seed yield, Wirwa (2009) reported that Vahl's fimbry, scarlet (valley) ammannia, and lowland toothcup (rotala) produced seed during 2006 and 2007 contributing to the overall biomass on mudflats. He also noted that no seeds were produce at lower contours.

9.0 ADDITIONAL STUDIES SUPPORTED BY THIS INITIATIVE

9.1. Mitchell, J. M. 2009. Establishing a shorebird conservation working group in the Tennessee River Valley: A project evaluation. *Land and Water Stewardship, U.S. Tennessee Valley Authority, Knoxville, TN*

Abstract

Shorebird populations have declined significantly in the U.S. Shorebirds depend on inland stopover sites to meet the energetic demands of migration. Mudflats exposed by seasonal drawdowns of TVA reservoirs provide important habitat for thousands of migratory shorebirds. In 2004, the Tennessee Valley Authority (TVA) altered the drawdown schedule on several reservoirs to maximize public recreation benefits. Concern regarding potential impacts to shorebird populations led TVA to establish a 5-year working group comprised of federal and state agencies, non-governmental organizations, and volunteers to learn more about shorebird resources in the Tennessee River Valley (TRV).

In 2009, the working group was evaluated to determine the project's effectiveness and to identify improvements for similar future initiatives. Project accomplishments include over 2000 hours of shorebird monitoring (3639 surveys at 127 sites), resulting in the largest shorebird monitoring effort ever undertaken in the TRV. TVA leveraged 94K in associated cost sharing projects and 47K from in-kind and volunteer support. Additionally, several associated research projects were completed. In an online questionnaire, all working group members indicated that they were satisfied with the results of this initiative and all felt that the group should continue beyond its original 5-year mission. Establishment of an interagency working group provides an example of how agencies can successfully collaborate to answer ecological questions for policy decisions and achieve collective goals, and how similar initiatives could strengthen interagency and public interaction.

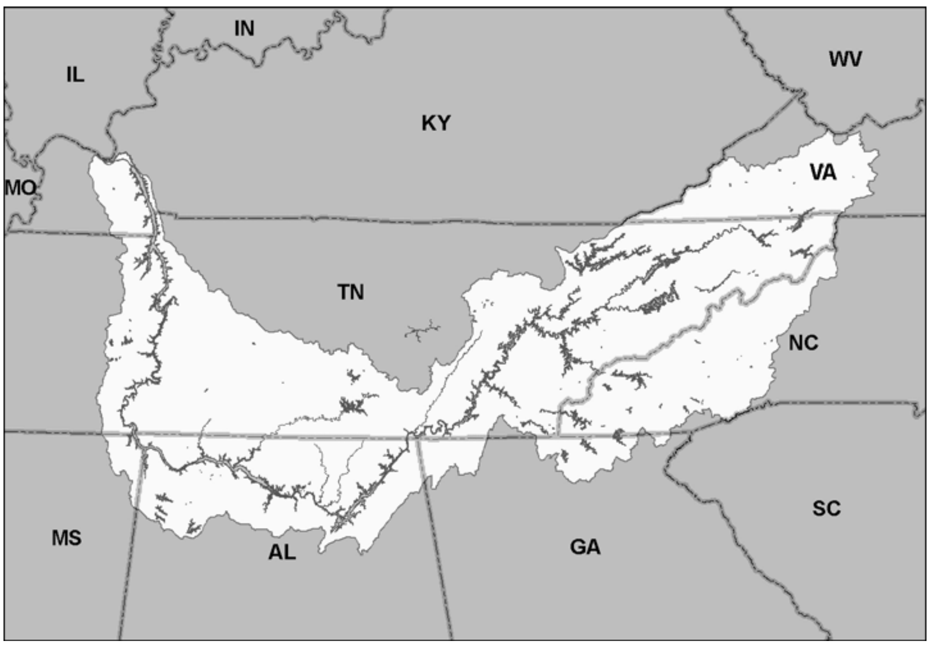
I. **DESCRIBE SITUATION AS IT EXISTED BEFORE THE PROJECT** (Condition A)
Shorebirds (*Charadriiformes*) include sandpipers, plovers, oystercatchers, avocets, and stilts. Shorebird populations have declined significantly in the U.S. due to a variety of factors. This decline likely began with market hunting of some species in the late 1800's. Today, the declines are primarily attributed to loss of habitat.

Because many shorebirds migrate long distances between their breeding and wintering grounds, stopover sites along the way provide important resting and foraging sites that help them meet energetic demands. In the spring and early summer thousands of shorebirds migrate north from their wintering grounds through the Tennessee River Valley (TRV) (Figure 1) to their breeding grounds. Approximately 28 regularly occurring shorebird species travel through the TRV. During the spring, rain creates large areas of exposed wet ground (e.g., wetlands and flooded agricultural fields) across the TRV, providing important resting and foraging habitat for shorebirds. Due to seasonally low precipitation in the late summer and fall, these same areas are often dry as shorebirds travel back south to their wintering grounds.

As Tennessee Valley Authority (TVA), reservoir levels are reduced in mid-summer and fall to provide flood control; thousands of acres of seasonally inundated shoreline are exposed, creating extensive mudflats that provide quality resting and foraging habitat for migratory shorebirds when many off-reservoir shorebird habitats are dry. In 2004, TVA completed the River Operation Study (ROS) and modified reservoir operations to provide greater recreational opportunities on several reservoirs along the Tennessee River. The ROS included delaying the start of the fall drawdown on most reservoirs until September, after the majority of shorebirds migrate through the TRV. This operational change reduced the amount of available mudflat habitat on TVA reservoirs during the fall shorebird migration period.

During the ROS, TVA scientists reviewed the available data on shorebird use of reservoir mudflat habitat across the reservoir system. TVA found that little shorebird data had been collected systematically throughout the Valley. TVA and other agencies recognized the need to gather more information about shorebirds resources in the TRV. As a result of these issues and public concern for shorebirds, TVA committed to establishing a five-year working group comprised of federal and state agencies, non-governmental organizations, and volunteers to learn more about shorebird resources in the TRV and their relationship to reservoir drawdowns, and to identify ways to enhance shorebird resources.

Figure 1. The Tennessee River Valley (TRV), USA



Source: TVA, 2009

II. **DESCRIBE SITUATION AS IT EXISTS NOW** (Condition B)
At the time this assessment was submitted to North Carolina State University's Natural Resources Leadership Institute (NRLI) in May 2009, the working group was completing data collection for the five-year endeavor. A final working group meeting and project report was planned for fall 2009 (See Section III, Working Group Meeting #6).

In October 2008, I administered a questionnaire to six working group members that participated in all project activities for the duration of the initiative (See Appendix 1). The purpose of the questionnaire was to evaluate the following outcomes of the project: (1) the extent to which the project met its designed intention; (2) how well meetings were facilitated; and (3) how working group members perceive the value of the project.

Question one of the questionnaire administered to the working group summarizes how the working group describes the situation as it existed in fall 2008 (Table 1).

Table 1. Establishing a Shorebird Conservation Working Group in the Tennessee River Valley: Questionnaire Question One

"Early in the project, the team finalized a mission statement along with goals and objectives. Please indicate whether you believe the team did or did not achieve each of the following stated goals."

Goal	Achieved	Not Achieved	No Opinion
Goal 1: Identified past and present shorebird use sites throughout the Tennessee River Valley	100.0%	0.0%	0.0.%
Goal 2: Developed a regional plan to accomplish shorebird monitoring goals of cooperators	83.3%	16.7%	0.0.%
Goal 3: Determined the temporal and spatial distribution of shorebirds at stop-over and wintering sites in the Tennessee River Valley	83.3%	16.7%	0.0.%
Goal 4: Explored ways to enhance and develop shorebird habitats within the Tennessee River Valley	50.0%	50.0%	0.0.%

Overall, the working group indicated that the goals of the project had been achieved. Responses indicated that some working group members believed some goals were not achieved. Fifty percent of the working group indicated that goal four was not achieved. Although the working group discussed goal four at several meetings, no implementation activities related to that goal were undertaken.

Comments from questionnaire question seven *"What were the three most beneficial parts of this initiative?"* included several benefits associated with the information and data gathered during the project. In addition, the following responses to question seven illustrate the importance of relationships that were developed during the project.

- **"Developing the common goals between the agencies…"**
- **"Improved communication between agencies…"**
- **"…Establishing and maintaining a strong working relationship with other agencies…"**
- **"Opportunity to network with various agency representatives who have similar goals"**
- **"I got a chance to work more with some colleagues in other organizations"**
- **"Better understanding of the partners' missions and objectives"**

III. **DESCRIBE THE PROJECT** (Details)

A. Actions taken and/or activities conducted (meetings, workshops, change in procedure, including description of facilitative process where applicable, …)

In 2004, TVA's ROS was completed with a commitment to form a working group and to study shorebirds in the TRV. A project work plan was finalized, and peer agencies were contacted requesting their participation. All contacted agencies, with the exception of one, agreed to participate.

Six facilitated working group meetings occurred from 2005-2009. In 2009, a project evaluation, including an online questionnaire administered to the working group (Appendix 1), was completed as part of a practicum to satisfy the graduation requirements of NRLI. The practicum involves applying skills acquired at the NRLI to seek collaborative solutions to a natural resource issue with others who have a stake in the outcome, then, following-up with an assessment of that work.

All meetings were pre-planned, included an agenda, and were held at centralized locations. Meeting dates were coordinated with participants to ensure the greatest number of participants were available to attend. Working group members were queried for a list of agenda items prior to each meeting. All meetings were facilitated and began with introductions of participants, as needed. Participants were given opportunities to comment during each stage of the agenda, and were allowed to continue with their comments and discussions so long as they did not deviate substantially from the agenda topic.

Minutes and action items were distributed following each meeting for the working group members' review and were revisited at the start of each subsequent meeting. A number of minor topics were discussed at each meeting that are not covered here (e.g., planning the next meeting). Annual monitoring (progress) reports were distributed to the working group members.

Table 2 outlines the mission, process, and strategy used to accomplish the overall goals of the project. Table 3 summarizes major tasks in the project timeline from 2004-2009. Each of the six meetings is described in detail.

Table 2. Establishing a Shorebird Conservation Working Group in the Tennessee River Valley: Overview of Project Mission, Process, and Strategy		
Mission: to learn more about Tennessee River Valley shorebird resources and identify ways to enhance these resources		
		Process
Strategy	Communication Coordination Partnerships Information Exchange	• Develop a work plan (i.e., needs assessment) • Approach stakeholders individually • Convene a meeting of potential partners • Form a team. Determine the common interest of the partners (i.e., a shared sense of need and/or urgency) • Develop a charter including, mission, goals, objectives, and priorities • Train observers in field identification and data collection protocols • Collect and analyze data • Perform habitat analyses • Implement cost share projects • Submit final recommendations

Working Group Meeting #1: Establishing a Working Group and Monitoring Plan
On January 11, 2005 the first working group meeting was held at the headquarters of the Tennessee Wildlife Resources Agency (TWRA) in Nashville, Tennessee. The one-day meeting began with a discussion of the project's origin and ongoing shorebird monitoring activities in the TRV. Conversations focused on determining each agency's expectations

for the working group, identifying each agency's ongoing shorebird monitoring efforts, and determining actions needed to accomplish shared goals.

Developing a monitoring plan was a theme of this meeting. The following topics were discussed: research needs, adopting a standard data collection protocol, resource allocation and constraints, using volunteers, when, where, and how often to survey, existing data, and how the working group fits into regional and national efforts. The team decided to adopt the standard protocols of the International Shorebird Survey (ISS).

Table 3. Establishing a Shorebird Conservation Working Group in the Tennessee River Valley: A Project Timeline, 2004-2009	
2004	• TVA's Reservoir Operations Study is completed with a commitment to form a shorebird conservation working group • A project work plan is finalized • Peer agencies are contacted requesting their participation
2005	• Kick-off meeting in Nashville, TN: *Establishing a Working Group and Monitoring Plan* • Working group meeting in Memphis, TN: *Training the Observers* • Shorebird monitoring and research projects begin • Simultaneous Valley-wide fall shorebird count • Annual monitoring report is completed
2006	• Working group meeting in Nashville, TN: *Mission, Goals, and Objectives* • Working group meeting in Memphis, TN: *Data Collection Results and Priorities and Identification Workshop* • Annual monitoring report is completed
2007	• Working group meeting in Paris, TN: *Ongoing Research and Future Research Needs* • Annual monitoring report is completed
2008	• Coordination is accomplished via telecommunication • Simultaneous Valley-wide fall shorebird count • Annual monitoring report is completed
2009	• Working group meeting (location to be determined): *Project Completion and Future of the Working Group* • Shorebird monitoring and research projects are all completed • Final monitoring report is completed

Working Group Meeting #2: Training the Observers
The second working group meeting was held on May 10-11, 2005 at the Ducks Unlimited National Headquarters in Memphis, Tennessee. The two-day meeting began with a presentation by U.S. Fish and Wildlife Service (USFWS) biologist Randy Wilson discussing the implementation of a regional shorebird monitoring initiative – *The Lower Mississippi Joint Venture*. The purpose of Randy's presentation was to provide the working group with a framework for how the group might go about accomplishing their goals.

The working group discussed the development of a mission statement, goals, and objectives. While progress was made on this effort, further work was needed.

A central theme of this meeting was to train the observers. In addition to the working group members, several biologist from participating agencies attended a training session led by

Brian Harrington, lead shorebird scientist at MANOMET Center for Conservation Sciences. Brian used an in-house presentation to instruct approximately 30 state and federal biologists on techniques used to identify and census shorebirds. His presentation included details on the ISS.

A two-hour break-out session was organized to help the team identify and prioritize potential areas of high quality shorebird habitat in the TRV. The teams were broken-out by the region that each biologist represented: east Tennessee, north Alabama, west Tennessee, and Kentucky. Topographic maps and a matrix datasheet were used to identify and record the site name, manager, accessibility, known concentrations of shorebirds, and any existing data sources for the site. Once the list was complete, teams were asked to rank the sites in order of their level of shorebird use and their conservation importance, and to determine who might be the most appropriate person or organization to monitor the area. Each team reported their results to the group.

On May 11, the entire group traveled to Ensley Bottoms in west Memphis along the Mississippi River, a known area of shorebird concentrations, for a field training exercise on shorebird identification and censusing. Brian Harrington and Jeff Wilson, a regional shorebird authority, led the field exercise.

Working Group Meeting #3: Mission, Goals, and Objectives

The working group held a one-day meeting on February 27, 2006 at headquarters of the TWRA in Nashville, Tennessee. The main focus of this meeting was to complete the mission, goal, and objective statements for the working group and to provide a summary review of the first field season. The discussion of mission, goals, and objectives had begun at the first meeting. At each of the first two meetings, and between meetings, progress had been made on reaching consensus toward completing this task. After revising a number of statements during the meeting, it was decided that changes would be made to the master document, the document would be coordinated with some regional and national sister programs, and a copy would e-mailed to the working group for one final review.

The team reviewed a summary of the 2005-06 monitoring effort and outcomes. The group further prioritized monitoring sites identified during the last meeting's break-out session. The working group also heard updates on several TVA initiatives. These included:

- *Spatiotemporal modeling of shorebird habitat availability at Rankin Wildlife Management Area, Tennessee* (Smith, 2006). This project used *LIDAR (**Li**ght **D**etection **a**nd **R**anging)* work on Douglas Reservoir to illustrate animated reservoir drawdown scenarios and corresponding changes in amounts shorebird foraging habitat
- Preliminary results of a project monitoring the response of mudflat vegetation to reservoir drawdown in 2004-05 included temporal changes in vegetation coverage and species diversity
- An update on a TVA funded project at the University of Tennessee-Knoxville (UTK) – *Waterbird responses to drawdown of two east Tennessee River Valley Reservoirs* (Laux, 2008)
- A potential cost share agreement between TVA and USFWS to support a shorebird research project on Kentucky Reservoir
- A phenology depicting seasonal richness and abundance of shorebirds in the TRV, and

- A brief summary of the U.S. Shorebird Conservation Plan Summit held in Galveston, Texas on February 22-25, 2005.

The working group developed a list of future research needs before adjourning.

Working Group Meeting #4: Data Collection Results and Priorities and Identification Workshop
The fourth working group meeting was held May 4-5, 2006 at TWRA's Bartlett Hunter Education Center in Memphis, Tennessee.

Shorebird monitoring results from July 2005 through April 2006 were presented. Seasonal richness and abundance by species, habitat, and geography were presented. Other project updates included LIDAR work on Kentucky, Douglas, and Chickamauga Reservoirs. The presentation included timing and density of vegetation establishment on mudflats and the effect of the 2004 hurricanes on shorebirds and their habitat. John Laux and Matt Gray, with the UTK's Department of Forestry, Wildlife, and Fisheries, presented preliminary results from Laux (2008).

A segment of the meeting was devoted to data collection procedures. This discussion included data collection protocols, priorities, survey improvements, timing of surveys, locations to be surveyed, documenting site conditions, assignment of future surveys, and data submission.

This two-day meeting again focused on training participants of the valley-wide shorebird census. Jeff Wilson instructed approximately 25 participants from various agencies in an afternoon of classroom training on the 4th and a morning of field training on the 5th.

Working Group Meeting #5: Ongoing Research and Future Research Needs
The fifth working group meeting was held on February 21, 2007 at Tennessee National Wildlife Refuge in Paris, Tennessee.

At this one-day meeting the team reviewed progress toward their established goals and objectives. There was discussion on the content of the final product of the working group for 2009. Other topics focused on ongoing research in the Valley. These included:

- Reports from regional biologists on data collected
- A review of two TVA-sponsored UTK research projects Laux (2008) and *Waterbird use and food resource response to drawdown of Kentucky Reservoir* (Wirwa, 2009)
- A summary of shorebird richness and abundance in the TRV in the 2007 winter season, and
- An expanded phenology depicting seasonal richness and abundance of shorebirds in the TRV.

The meeting closed with a discussion of future research needs, potential future projects, and ongoing TVA and USFWS cost-sharing projects.

Working Group Meeting #6: Project Completion and Future of the Working Group
The sixth and final working group meeting for the five-year project is planned for fall 2009 (location to be determined). A draft final report will be sent to working group members for their review prior to this meeting.

Plans are to invite everyone that has participated in the project to a central location for this meeting. The purpose of the meeting will be to review accomplishments and to discuss the future of the working group. A summary of the project will be presented and a discussion of future needs will follow. Several presentations are expected from researchers that have participated in the project. A facilitated discussion will be held to discuss any needed modifications to the final report and to explore continuing the working group beyond its original mission.

B. Stakeholders involved

An effort was made to bring stakeholders together that directly managed land for shorebirds, monitored shorebirds, had knowledge of shorebirds resources in the TRV, or held regulatory authority of shorebirds. The working group consisted of a core group of individuals throughout the process. In addition, there were some stakeholders that were more peripherally involved. There was high turnover in personnel among some stakeholders groups. Stakeholders involved in the project are listed in Table 4.

Table 4. Establishing a Shorebird Conservation Working Group in the Tennessee River Valley: Stakeholders Involved
• U.S. Tennessee Valley Authority • U.S. Fish and Wildlife Service • University of Tennessee-Knoxville • Tennessee Wildlife Resources Agency • Kentucky Department of Fish and Wildlife Resources • American Bird Conservancy • MANOMET Center for Conservation Sciences • Volunteers

C. Your role

Key project personnel included me and Travis Henry. Mr. Henry was the project leader and I was the meeting facilitator. Mr. Henry made initial contact with stakeholders to query them on their interest and to invite them to our first regional meeting. Roger Tankersley, TVA geographer, provided a lead role in project development, especially geospatial components.

My role was to plan, coordinate, and implement regional meetings in a manner that allowed the group to work efficiently and effectively. An important role as the facilitator was to ensure that conversations on potentially contentious issues were structured productively. An effort was made to ensure all stakeholders were represented and engaged in the process. I strived to remain impartial, to advocate for fair, open, and inclusive discussions and to foster collaborative decision-making.

D. Problems, barriers or challenges encountered and approaches taken to resolve problems:

1. What strategies were least effective in enhancing overall collaborative learning and understanding?

On several occasions members of the working group were tasked with contacting outside experts or stakeholders. Although the working group was updated about the outcome of these contacts, there were breakdowns in communication and understanding among the group and the outside party contacted. First and second table dialogue could have been improved to help the working group communicate better with their staffs and constituents.

The working group took on a considerable task. This often required fast-paced meetings to ensure that all topics of discussion were considered. While this may be efficient in some ways, it can impede collaborative learning, understanding, and discussion.

2. What strategies did not support involvement of others or may have prevented achieving workable solutions?

An unclear distinction of roles and responsibilities among the group members slowed decision-making. The membership roles of advisor, data collector, trainer, and decision-maker were sometimes unclear. In future endeavors, this should be clarified during project initiation.

A more developed strategy for engaging and training volunteers might have brought more stakeholders into the group. By asking “Who is affected?” “Can they affect the outcome?” and “Can they bring resources to the table?” more stakeholders likely would have been identified. A grassroots recruitment effort of volunteers would likely have been beneficial to both the short- and long-term survivability of the working group. The trade-off is that this recruitment is time intensive and that volunteers are often engaged for only a short period of time.

Comments from questionnaire question eight *“What were the three least beneficial parts of this initiative?”* included a few shortfalls in project outputs and processes. In addition, these summarized comments from questions eight and nine outline collaboration challenges.

- **Some members impeded progress of the group**
- **More support from other agencies would have been beneficial**
- **Volunteer coordination could have been better**
- **The turn-over of key working group members was problematic**
- **Resource limitations need to be outlined during project initiation**

In future endeavors the following ideas and concepts may be useful in coordinating the team.

- Set clear expectations of team members
- Clearly define the roles and responsibilities of team members
- Understand that volunteer coordination requires a substantial and ongoing time investment
- Be prepared for turnover in the working group
- Be realistic about the time required to achieve the project’s mission

E. Activities, events, or particular approaches that assisted the process
    1. What strategies were most effective in enhancing overall learning and understanding?

In questionnaire question three, respondents were asked their opinion of how well the facilitator fulfilled key responsibilities over the course of the initiative (Table 5). All respondents reported favorably. Respondents either agreed or strongly agreed with each of the statements listed in Table 5. No opinion was marked by one respondent on two responsibilities.

Table 5. Establishing a Shorebird Conservation Working Group in the Tennessee River Valley: Questionnaire Question Three	
"Please indicate the extent of your agreement with each of the following statements relating to how well the meeting facilitator fulfilled these responsibilities over the course of the initiative."	
• Stayed on schedule • Relayed information in a clear and understandable manner • Maintained confidentiality • Showed respect to participants • Adapted the training to your learning style	• Remained impartial • Enforced ground rules • Kept the group focused • Encouraged participation • Promoted civil discussion • Coordinated meeting logistics • Was organized and prepared

One respondent answered question nine *"Please provide any additional thoughts or suggestions on how coordination or facilitation of similar future initiatives might be improved"* with the following comment: "I thought the coordination and facilitation of this initiative was exemplary and provided a paradigm for similar future endeavors."

Most working group members (83.3%) felt that receiving a copy of the meeting minutes following each meeting was helpful in maintaining an understanding of the progress and direction of the working group (questionnaire question 5, part g).

As facilitator, one strategy that was particularly useful in helping to enhance overall learning and understanding was to help the working group members recognize what was gained or lost by working together. This was particularly helpful early in the process, when potential partners were considering "joining" the group. The agencies all have different missions and goals; however, they each shared the common interest of shorebird conservation. Once this common interest was identified, the team was able to move forward and address their needs collectively.

Useful tools and processes that aided in learning and understanding were:

- Detailed preparation for meetings and communicating effectively aided in establishing and maintaining the working group
- Review of minutes at each meeting enhanced communication and reinforced roles
- Coordinating communication via e-mail was helpful when holding a regional meeting would be inefficient
- Visual aids (flip charts, slides, handouts, and overhead projector) helped the group to learn and understand together
- Research projects that developed out the working group provided insight into how to solve problems (e.g., LIDAR and thesis projects)
- Adopting previously standardized protocols allowed the group to progress more quickly (e.g., ISS Protocol)
- Training surveyors in shorebird identification and field survey techniques improved the quality of data and improved the confidence of surveyors

- Dinning together during evenings of regional meetings helped to foster better communication and friendships
- Defining common goals aided in the development of project goals. (It was important that individual goals of working group members were transparent in order to foster trust.), and
- Establishing TVA's legitimacy, fostering empowerment among the group, and inclusion of all members encouraged teamwork.

2. What strategies encouraged those involved to engage and work toward productive and implementable solutions?

Full participation and mutual understanding led to inclusive solutions and shared responsibility, particularly in the development of the mission, goals, and objectives. Some particularly useful facilitation techniques used to engage team members are listed in Table 6.

Table 6. Establishing a Shorebird Conservation Working Group in the Tennessee River Valley: Facilitation and Problem Solving Techniques Used
Facilitation Techniques • **Facilitated Meetings** allowed for impartial, fair, open, and inclusive discussions • **Paraphrasing** helped everyone to know that they were heard and fostered understanding • **Drawing People Out** aided in helping the group members to clarify their comments • **Mirroring** ensured that all views were heard and understood • **Encouraging** provided a means for steady flow of conservation • **Balancing** supported minority views and comments • **Making Space** offered a mechanism for engaging all participants • **Staking** was important in maintaining the flow of conversation • **Tracking** ensured that simultaneous ideas and comments were not overlooked • **Listening for Common Ground** allowed me to capitalize on common goals and interest Problem Solving Techniques • **Matrix Diagram** aided decision-making (e.g., shorebird survey site selection) and simplified complex decisions • **Breakout Sessions** were use to tackle large assignments • **Meeting Minutes and Action Items** were used to ensure transparency and accountability • **Brainstorming** aided in developing new ideas on how to accomplish goals with limited resources (e.g., cost sharing projects) • **Negotiation** was used in working with others to join the partnership and in associated projects and activities • **Framing Issues** helped to bring the team together to address a common concern (e.g., shorebird conservation)

IV. **BUDGET AND EXPENDITURES**

A. Funds requested/approved of/by NRLI
B. Other funds (i.e. estimate other source of direct funding)
C. In-kind support (i.e. estimate volunteer hours, facility use, etc)

D. Total budget

Table 7 presents the project budget, cost sharing, and estimated in-kind and volunteer contributions to the project. TVA direct monies were used for project management and coordination, data collection and analysis, and reporting. Cost sharing dollars funded LIDAR studies and support for three UTK research projects. In-kind and volunteer contributions to the project included training by Jeff Wilson and Brian Harrington, meeting and training attendance by shorebird surveyors and working group members, facility use and equipment, and data collection by agency personnel (other than TVA) and volunteers.

An estimated 3,769 shorebird surveys across 150 sites were completed during the project. Volunteers contributed 798 hours of survey time. This includes regional birding listserve observations. The TWRA and USFWS contributed 108 in-kind survey hours. UT and TVA completed 1.105 survey hours. All total, 2.011 survey hours were performed from 2004-2009. Seventy-three volunteers, three surveyors from other agencies, and 17 TVA surveyors participated in data collection. In total, 154K was used toward project cost-sharing and 47K was contributed from in-kind and volunteer support.

Table 7. Establishing a Shorebird Conservation Working Group in the Tennessee River Valley: Estimated Annual Budget Expenditures and Contributions (in Thousands of Dollars)

Source	2004	2005	2006	2007	2008	2009	Total
NRLI (none requested)	0	0	0	0	0	0	0
TVA Direct	30	125	125	130	68	68	546
Subtotal	30	125	125	130	68	68	**546**
Cost Sharing							
TVA			20	20	20		60
UTK			10				10
USFWS			64	20			84
Subtotal			94	40	20		**154**
In-kind and Volunteers							
Training Volunteers		1.1	0.4				1.5
Meeting & Training Attendance		11.9	7.8	1.2		2.5	23.4
Facility Use and Equipment		0.2	1.2	1.1	1	0.1	3.6
Data Collection	0.2	1.9	5	4.3	3.4	3.7	18.5
Subtotal	0.2	15.1	14.4	6.6	4.4	6.3	**47**
Annual Spending	30.2	140.1	233.4	176.6	92.4	74.3	**747**

The values of in-kind hours were calculated using 2007 U.S. Department of Labor figures for agency personnel and 2007 Independent Sector national figures for volunteers. 2009 data collection dollars were forecasted based on efforts of previous years.

V. **OUTCOMES: IMMEDIATE AND LONG-TERM -** Given the dynamic and long-term nature of most collaborative initiatives, documenting immediate and long-term outcomes as well as the impact to the resource remains essential and difficult. In the following section, please take the time to determine what the short-term outcomes of this project are; anticipate any long-term outcomes, and potential impacts to the resource(s).

Respond to those questions that are applicable to the practicum.

A. Immediate outcomes

1. Whether desired situation was reached

    a) Your perceptions of the process

    The project, as planned, is expected to be completed on time and within budget in fall 2009. Cost sharing opportunities were maximized. Several research projects, including three thesis projects were completed during this initiative (Smith, 2006; Laux, 2008; Wirwa, 2009). One important measure of success will be how well the final deliverables match the goals of the project. The final measure of success will be to assess how the information learned during this project informs the policy-making process (i.e., reservoir water level changes) and affects shorebird conservation.

    In a conversation with Merrick Hoben of The Consensus Building Institute (CBI) on May 29, 2008, Merrick challenged me to assess outcomes by asking "Are the group and the resource better off?" In this context, my answer is clearly yes for the shorebird project. The group reached consensus on a number of issues and strengthened communication and relationships among its members. The group is better informed. A substantial amount of information has been learned about the shorebird resources of the TRV. Long-term, this should benefit the resource through better decision-making. Merrick also stated that "The relationships are more important that the outcome." Merrick's criteria make sense intuitively, and using these criteria, I believe that this project was successful. As we saw in Section II, the working group also spoke to the importance of relationships. In Section V.C. I report that working group members also believe that the resource will be better off.

    Table 8 outlines measures of collaborative success and compares my assessment of those measures to how the working group answered the same questions in the questionnaire.

Table 8. Establishing a Shorebird Conservation Working Group in the Tennessee River Valley: Measures of Collaborative Success

Measure of Success	Measure Achieved?	
	My Assessment	Working Group Questionnaire
All invited parties were represented and engaged in regional working group meetings throughout the project.	Yes. Everyone in attendance was engaged. Good information exchange.	Yes. 83.3%
There was team consensus on the mission, goal, and objective statements	Yes. This was the most difficult and most vital part of the process.	Yes. 100.0%
All parties actively participated in planning and data gathering	Yes. More participation by other agencies was desired.	Yes. 66.7%

throughout the project		
Cost sharing conservation projects were beneficial to the project's mission	Yes. Valuable information was obtained through cost sharing projects.	Yes. 83.3%
The established goals of the project were met	Yes. Goal 4 (Table 1) was probably not fully achieved.	Yes. See Table 1
The working group continues beyond its 5-year mission	I see a need to continue (to be discussed at meeting six).	100% indicated a need to continue.

b) Other stakeholders' perceptions of the process (interview several stakeholders, in particular someone who may not fully support – include what would have worked for them and why)

In questionnaire question six, working group members were asked to *"Please indicate your overall level of satisfaction with the results of this initiative."* All respondents indicated that they were either satisfied (66.7%) or strongly satisfied (33.3%) with the results of this initiative. Overall questionnaire results indicate that working group members were pleased with the process, outputs, and outcomes of the initiative. In questionnaire question 4 part b respondents strongly agreed (66.7%) or agreed (33.3%) that *"Participating in this initiative was a good investment of my time."* This was supported by the enthusiasm and turnout at working group meetings.

2. Examples of changes or new developments in individual stakeholders and yourself

a) Knowledge

In questionnaire question 4 part c, all working group members indicated that they increased their knowledge about shorebirds by participating in this project. Two shorebird identification workshops and numerous projects and presentations throughout this initiative provided ample learning opportunities for participants.

I increased my knowledge, skills, and abilities related to facilitation, negotiation, shorebird identification and conservation, and reservoir operations through participation in this project. The success of this project was directly related to maintaining good communication with partners and colleagues. The importance of exercising good interpersonal skills in the development of a working group cannot be overstated. While it is important to fulfill the key responsibilities as a facilitator (Table 5), exercising flexibility and patience are central in forming a collaborative and durable relationships. In conversations with Merrick Hoben, he stated that "Good leaders (facilitators) know when to push the group to go beyond self-interest so that the group begins considering how they can benefit as a whole." This concept will be important in facilitating working group members at their final meeting when they consider whether to continue their efforts beyond the original five-year mission.

b) Attitude

It was noted in the questionnaire responses that some members impeded progress of the group (Section III.D.2). While some slowdowns were evident, no overall impact to the group's mission and success were evident. In fact, all parties indicated that they felt involved in working group decisions (questionnaire question 4, part f) and that they were willing to be involved in another similar initiative if it were relevant to their organization's mission (questionnaire question 4, part e).

c) Participatory behaviors or skills

When asked whether the training opportunities provided during the two Memphis shorebird identification workshops, were beneficial to their organization (question 4 part h), all members either strongly agreed (66.7%) or agreed (33.3%). Some participants that were reluctant to participate when the project began became interested in the project when the group examined the research interests of each agency and identified common concerns that could be addressed collectively.

3. Examples of changes or new developments observed in work groups

a) Working relationships

In questionnaire question 4, part a, working group members strongly agreed (83.3%) or agreed (16.7%) that *"Participating in this initiative strengthened relationships among the parties involved."* Open-ended questionnaire comments also revealed that relationship building was an important project outcome (See Section II).

b) Networking (communication, understanding, sharing practices)

All working group members indicated that there was good communication among the working group between working group meetings (questionnaire question 5, part h). Ensuring that accurate and timely meeting minutes were distributed to the group aided in good communication.

c) Cooperation (needs and efforts matched to avoid duplication of effort)

In questionnaire question 5, part a, most respondents (83.3%) believed that all invited parties were represented and engaged in regional working group meetings throughout the project. However, there was some disagreement (16.7%) on this question. Perhaps some clarification in the question might have helped. My observation was that all participating parties were engaged, but there were parties not participating in the endeavor that had a stake in the outcome.

d) Coordination (share resources to address common issues or start something new)

One-third (33.3%) of the working group disagreed with the statement in questionnaire question 5, part c *"All parties actively participated in planning and data gathering throughout the project."* As stated above, some apparent stakeholders did not participate in the initiative.

e) Coalitions (new alliances or partnerships among people and organizations)

New alliances were formed through partnerships with volunteers. Volunteers helped in data collection and in training other data collectors. These alliances not only helped reduce project costs (See Table 7), but were the beginning of new contacts and friendships.

f) Collaboration (develop a shared vision and work together to accomplish it)

All working group members agreed that there was team consensus on the mission, goal, and objective statements (questionnaire question 5, part b). A number of stakeholders (Table 4) worked together to achieve a common goal.

4. Examples of changes observed in organizations

a) Management of resource (new or revised method)

In questionnaire question 4 part d, most working group members (83.3%) indicated that *"Unexpected benefits to me or my organization resulted from this collaboration."* Some of the shared benefits among organizations included several research projects and publications (e.g., Smith, 2006; Laux, 2008; and Wirwa, 2009), new data and information (e.g., shorebird phenology), and improved communication and coordination among agencies.

b) Rules and regulations (new or revised)

Most working group members (83.3%) indicated that they developed a better understanding of their peer agencies' missions and goals during this project (questionnaire question 4, part g). This understanding helped the group to become more aware of the rules, regulations, and constraints of other organizations.

c) Services provided (new or revised)

A majority of working group members (83.3%) thought that cost sharing conservation projects were beneficial to the project's mission (questionnaire question 5, part f). The amounts of both in-kind and cost-sharing monies contributed to the project are an indicator of organizational support and interest (See Table 7).

d) Cross-training opportunities

5. Examples of changes observed in communities

a) Level of cohesion or pulling together
b) Social norms
c) Policy change or level of participation in policy change

Once the project is completed, information gained from this study will be used to inform the policy process (i.e., reservoir water level changes).

d) Socio- economic- environmental conditions
e) New (or reestablishing) partnerships or linkages

New partnerships were formed during this initiative. TVA had not previously (at least recently) partnered with MANOMET Center for the Conservation Sciences, USFWS shorebird scientists, American Bird Conservancy, and several participating volunteers.

B. Long-term or anticipated outcomes

1. If desired outcome was not reached

a) Do you anticipate reaching a desired outcome later?

Some participants felt that the working group had not achieved all of its goals (Table 1). All participants indicated that they thought the working group should continue and that this project had been a success thus far (questionnaire questions 2 and 6). I expect the team to continue their mission and work toward their goals as well as establishing new goals in the future.

b) Do other stakeholders anticipate reaching a desired outcome (interview several stakeholders, in particular someone who may not fully support the decisions – include what would have worked for them and why)?

2. Examples of anticipated changes expected in individual stakeholders and yourself

a) Knowledge
b) Attitude
c) Participatory behaviors or skills

Over time, I expect working group members to develop a greater appreciation and understanding of organizational missions and constraints.

3. Examples of anticipated changes in work groups

a) Working relationships
b) Networking (communication, understanding, sharing practices)
c) Cooperation (needs and efforts matched to avoid duplication of effort)
d) Coordination (share resources to address common issues
e) Coalitions (new alliances or partnerships formed)
f) Collaboration (develop a shared vision and work together to accomplish it)

4. Examples of anticipated changes in organizations

a) Resource use
b) Rules and regulations
c) Services provided
d) Cross-training opportunities

The development of this working group fostered relationships that will improve future collaborations on shorebird conservation and other similar initiatives.

5. Examples of anticipated changes in communities

a) Level of cohesion or pulling together
b) Social norms
c) Policy change or level of participation in policy change
d) Socio- economic- environmental conditions
e) New (or reestablishing) partnerships or linkages

The working group has demonstrated their interest in shorebird resources. This interest has been recognized by other agencies, individuals, and the community.

C. Impacts to the resource or anticipated impacts to the resource (short and long-term examples could include)

1. Acquiring needed resources such as donated land
2. Insure resources are accessible and used effectively
3. Resources attainable to those who need them
4. Improved public commitment to protect/enhance/improve resource

In question 5, part e, all respondents either strongly agreed (50%) or agreed (50%) that *"Improved decision-making will result from information gained during this project."*

5. Improving the condition, character, or abundance of the resource

A majority of working group members (83.3%) believed that regional shorebird populations will benefit as a result of the collaboration, learning, and understanding created over the last five years through this working group (questionnaire question 5, part d). The working group completed over 2000 hours (3639 surveys at 127 sites) of shorebird monitoring, resulting in the largest shorebird monitoring effort ever undertaken in the TRV. The data and information gathered during this project has produced a collective picture of the resource.

D. Other documented or anticipated benefits to the community and/or organization

VI. **FUTURE ACTIONS**

A. Describe any expected or anticipated planned actions or activities (include potential people and organizations and their future roles)

Several additional publications are expected as a result of the research conducted during this project. With the strong interest expressed in continuing the working group, I plan to facilitate the team in a discussion of how to move forward at meeting six in the fall 2009.

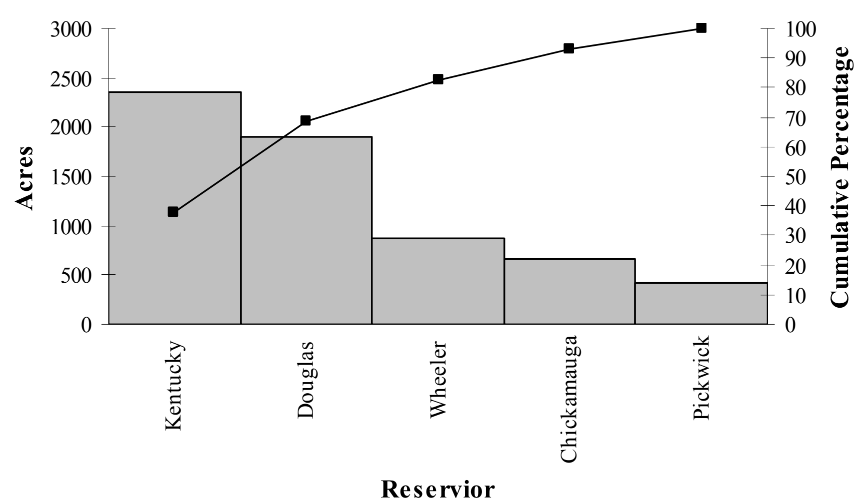
B. Your recommendations (including timeframes)

I will recommend to the team that they strongly consider continuing the working group. With five years of work completed, I believe that the team should revisit their charter.

Field surveys and research projects provided insight into how changes in reservoir levels influenced the availability of shorebird habitat (mudflats). As work on this project progressed, it became clear that there were key areas where shorebird habitat occurred along the Tennessee River. I researched tools that might aid in focusing shorebird management efforts by highlighting the relative importance of problem areas and by focusing on those causes that could have the greatest impact if solved.

The Pareto principle is often applied in quality improvement. The principle states that 80% of problems usually stem from 20% of the causes. An analysis was conduct to determine whether the Pareto principle applied to the core focus of this project. Figure 2 is a Pareto chart illustrating the estimated acres of available shorebird habitat (mudflats) on TVA Reservoirs following drawdown under current reservoir operation guidelines. The chart indicates that the principle does apply – only two reservoirs provide most of the mudflats. Therefore, concentrating improvement efforts, or optimizing water levels, on these reservoirs for shorebirds could have the greatest impact or potential for improvement, and perhaps could be more efficient or cost-effective than undirected efforts. This analysis does not take into account what factors may be most important in operating the reservoir (e.g., flood control and navigation) or what impact reservoir changes might have on other natural resources or the goals of the agency and its stakeholders. It should be noted that other TVA reservoirs do provide habitat for shorebirds; however, their relative contribution is small and they were not included in this example. Perhaps this will provide an aid in directing future efforts of the working group.

Figure 2. Estimated Acres of Available Shorebird Habitat (Mudflats) on TVA Reservoirs Following Drawdown



In question two of the questionnaire respondents were presented with the following question "*The team developed goals for a 5-year mission. Do you see a need for this working group to continue beyond its 5-year mission? Please explain your opinion.*" All working group members (100%) indicated "Yes", they see a need for the group to continue. Some of the explanations included:

- **"We still need greater resolution of bird use in North Alabama sites, especially the refuge areas."**

- **"Because of the complexity of the shorebird and drawdown issues associated with the Reservoir Operations Study, it will probably take many years to develop solutions."**

- **"Although many of the goals were achieved during the five-year survey period, we still know very little about some shorebird species…"**

- **"…To adequately consider hard and active conservation measures and practices for such long-distance migrants, I strongly believe that more information is needed…"**

- **"There is still a need to determine how shorebird habitat can be maintained and/or enhanced throughout the Valley. Since weather conditions were extreme (drought) during the study period, additional data collection would be needed to determine shorebird habits and habitats during wet years…"**

- **"Would require additional resources to really accomplish the mission of this group, but we should continue to try to fulfill the objectives…"**

- **"The threats to shorebird habitat in the Tennessee Valley continue to be an issue. We may be at a point where the team needs to put more focus on enhancing and developing habitat."**

Bibliography

Brassard, M. and D. Ritter. The memory jogger II: a pocket guide of tools for continuous improvement and effective planning. First edition. GOAL/QPC. Salem, New Hampshire, USA.

Brown, S., C. Hickey, B. Harrington, and R. Gill, editors. 2001. The United States shorebird conservation plan. Second edition. Manomet Center for the Conservation Sciences. Manomet, Massachusetts, USA.

Independent Sector. 2008. Research: value of volunteer time for 2007. Available: http://www.independentsector.org. Accessed: January 08, 2008.

International Shorebird Surveys. 2009. Survey guidelines. Available: http://www.shorebirdworld.org. Accessed: January 08, 2009.

Kaner, S. 2007. Facilitator's guide to participatory decision-making. Second edition. Jossey-Bass. San Francisco, California, USA.

Laux, John. W. 2008. Waterbird responses to drawdown of two east Tennessee River Valley Reservoirs. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

Smith, Matthew D. 2006. Spatiotemproal modeling of shorebird habitat availability at Rankin Wildlife Management Area, Tennessee. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

Tennessee Valley Authority. 2004. Tennessee Valley Authority reservoir operations study. Final programmatic environmental impact statement. Knoxville, Tennessee, USA

U.S. Department of Labor. Bureau of Labor Statistics. National occupational employment and wage estimates, May 2007. National estimates for zoologist and wildlife biologist.

Wirwa, Drew W. 2009. Waterbird use and food resource response to drawdown of Kentucky Reservoir. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

9.2. Tankersley, R. and T. H. Henry. 2009. A comparison of methods used to measure mudflat exposure.

Introduction

Mudflats appear to have uniform shapes with a linear progression of habitat exposure correlated to decreasing reservoir levels. In reality, mudflats are comprised of ridges and swales creating complex drainage patterns. The pattern of habitat availability can be extremely complex, with widely different acreages exposed at each change in reservoir level, influenced by topography, geology, soils and drainage patterns. This complexity differs at each mudflat resulting in unique progressions of habitat exposure at each site as reservoir levels recede, which in turn influences the establishment and persistence of vegetative and development of invertebrate communities used by wildlife.

During the ROS, it was difficult to calculate amounts of mudflat habitat exposed during reservoir drawdown. Techniques used for these calculations vary in accuracy, cost and labor. We explored five methods for developing accurate digital elevation models (DEM) for estimating acres of mudflat habitat exposed during drawdown on Douglas Reservoir. This project summary reviews the technologies and approaches available.

To aid in assessing the availability of mudflat habitats for migrating shorebirds in the TRV, we developed an accurate Digital Elevation Model (DEM) to determine the amount of acres exposed at 0.5-foot intervals on various mudflats throughout the TRV.

Methods

We developed DEM's for mudflats in the Tennessee River in the southeast U.S (Appendix 12.7). Our study was conducted from 2005-2007 at Douglas, Wheeler, Pickwick and Kentucky Reservoirs. We explored the following five techniques for developing an accurate mudflat elevation model:

- Light Detection and Ranging (LIDAR)
- Global Positioning System (GPS) surveying
- time-series aerial photography
- stereoscopic aerial photography interpretation
- Sound Navigation and Ranging (SONAR)

We evaluated the applicability of these techniques at Rankin Wildlife Management Area (Rankin Bottoms) in 2005, located at the junction of the French Broad and Nolichucky Rivers on Douglas Reservoir in northeast Tennessee, USA. This site is used extensively by migrant shorebirds during fall and spring migration. We selected and applied the best technique (see below) to develop a DEM for Rankin Bottoms in 2005. Further details are presented in Smith, 2006 (abstract provided in Section 11.3).

TVA maintains a database of reservoir levels containing daily elevations over the history of Douglas and other reservoirs. We used records covering three management scenarios dating back to 1972: 1972-1991 management; Lake Improvement Plan (LIP, 1992-2003); and projected ROS levels.

We modeled daily habitat availability under different TVA management scenarios to determine how the timing and extent of habitat changed over the past 30 years, and how it is likely to change under ROS. Our model accounted for each day, and computed the amount of habitat available at the reservoir level recorded for each day. After exposure, mudflats gradually dry and become unusable by shorebirds due to a lack of invertebrate food supply and the inability of the birds to probe hardening substrate. We assumed that habitats were suitable for 10 days following exposure.

Modeling involved three steps:

1) Query historic data for daily reservoir levels.
2) Using the daily level, query the DEM to determine the acreage of mudflat habitats exposed at that reservoir level.
3) Tally the acreage of all areas that have been exposed for less than 10 days, store the acreage in a new database and apply the model to the next day.

The model for each day can be represented as

$$\text{Habitat Area (acres)} = \Sigma\ [(X) \geq \text{locations} \leq (Y) * (9.1827 * 10^{-5})]$$

Where X = the daily elevation value, Y = the elevation value from 10 days prior, and the final factor is the conversion from pixel area to acreage. We then examined the overlap between the shorebird chronology and the availability of mudflat habitat to determine whether each scenario provided habitat at the proper time.

In March 2006, we expanded the study to include five of the largest mudflats on Kentucky Reservoir; including Birdsong Creek, Big Sandy, and the mouth of the Duck River, all located in Tennessee. We also examined Jonathan Creek and Blood River, large embayments located further downstream in Kentucky. Reservoir operations on Kentucky Reservoir were not modified under ROS, therefore we modeled habitat availability under two TVA reservoir management scenarios (1966-1980; 1980-present, excluding the stair-step drawdown in 1991-1992) to quantify how well each scenario met the habitat needs of migrating shorebirds.

In March 2007, we developed DEM's on Wheeler and Pickwick Reservoirs. Mudflats included Limestone and Beulah Bay (Swan Creek) on Wheeler Reservoir and Bear Creek on Pickwick Reservoir; located in north Alabama. We modeled habitat availability under three TVA reservoir management scenarios (1970-1990; 1991-2003; 2004-2006) to quantify how well each scenario met the habitat needs of migrating shorebirds.

We conducted our analysis using ESRI ArcInfo GIS software, and developed programming models with Arc Macro Language. These applications provided results in GIS data and Excel spreadsheets.

To evaluate habitats at Rankin WMA, we contracted with Tuck Mapping Solutions, Inc. to obtain aerial photography and LIDAR data for fully exposed flats during February 2005. We contracted with Aerotec, Inc. to obtain aerial photography and LIDAR data on Kentucky Reservoir during March 2006 and Wheeler and Pickwick Reservoirs during March 2007.

Evaluation of Methods Evaluated for Developing DEM's.

Light Detection and Ranging (LIDAR)

LIDAR is a remote sensing method similar to RADAR. However, instead of sound, LIDAR uses a laser to judge distance between small aircraft and the ground. The system acquires 15,000 points per second or 1 point every square meter on the ground. Typical accuracy is ±4-6 inches vertically and ±12-30 inches horizontally.

LIDAR is the most technologically advanced system for collecting elevation data, producing a highly accurate, comprehensive DEM in a short period. The equipment is advanced and expensive, requiring a helicopter or light aircraft to complete data collection.

Large areas >2,000 acres can be covered in one day. Given that mobility is not limited, multiple mudflats can be examined in one excursion, saving on mobilization fees. A finished DEM including LIDAR data and associated aerial photography can be delivered in approximately four weeks. Data are collected when mudflats are fully exposed. Coordination is essential to ensure availability of equipment (which must be mobilized) and full mudflat exposure.

GPS Surveying

Global Positioning System (GPS) technology uses orbiting satellites to triangulate a position on the earth's surface. We used a Trimble GeoXT Digital GPS unit to provide accuracy within 10-feet and a GPS receiver in combination with Arcpad 6.0.2 software to generate elevation contours on mudflat habitats (see Smith 2006).

Measurements are best collected during spring fill, as habitats along the shoreline during fall drawdown are unconsolidated, severely hampering data collection. We tested the applicability of this technique on two occasions, 7 April and 11 April 2005.

The accuracy of the GPS data was excellent. Contours were accurate, nearly identical to the same elevation as depicted by LIDAR (Figure 1); and clearly reflected the complexity of the mudflats.

This technique has several disadvantages. Considerable time and labor are required to collect field data and generate the DEM. Timing of data collection is critical, as spring filling of reservoirs can occur quickly due to heavy spring rains. Vegetation combined with relatively low relief can obscure the actual shoreline making it difficult to delineate its exact position.

In addition, the available GIS interpolation methods approximate a continuous surface between contours using a simple linear model, whereas areas within contours are much more complex. This technique would be especially useful on small, isolated flats where LIDAR is impractical but access is relatively easy. It can be especially useful to fill in data gaps associated with the following techniques.

Figure 1: GPS shoreline overlaid on LIDAR derived water level, showing accuracy of the GPS method. Photo is of the partially submerged mudflat at Rankin Wildlife Management Area on Douglas Reservoir, Tennessee, USA.

Time-Series Photography

Aerial photography can be used to create contours at multiple lake elevations. A collection of aerial photography from different years and at different elevations (Figure 2) can be combined to estimate a DEM. Photos of mudflat areas can be scanned and geo-rectified, converting images to a digital format. The shoreline from these images can then be determined, similar to the field GPS method. Historic reservoir data can be cross-referenced to determine corresponding lake elevations from specific.

This method is the least expensive and most efficient discussed in this review, *provided multiple images with different lake elevations exist for the area.* Using existing photos removes the cost of flying new images. However, given that mudflats are dynamic, the usefulness of older photos is limited. The limitation of this method is that it is only valid for locations where a representative coverage of photographs at different reservoir levels is available. In areas with good but incomplete coverage, GPS surveys of shoreline contours can fill in missing elevations. Coverage of aerial photography at Rankin Bottoms was not adequate to use this methodology.

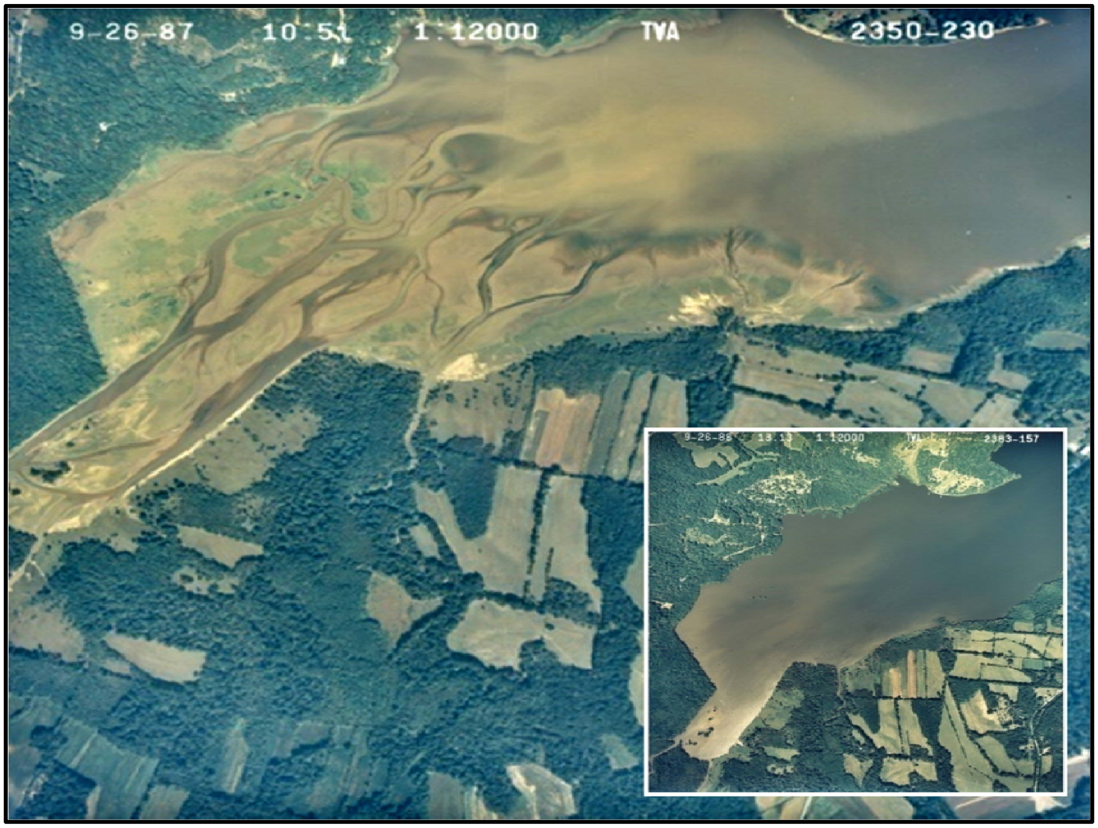


Figure 2: Image showing aerial photography at two reservoir elevations on Blood River Embayment on Kentucky Reservoir. These images show the minimum (inset) and maximum extent of this mudflat, additional images depicting intermediate elevations would be needed to develop a comprehensive DEM. The primary photo shows the complexity of mudflats due to numerous drainages crossing the site.

Stereoscopic Aerial Photography Interpretation

Two overlapping aerial photos of the same area create *parallax*, allowing an interpreter to view overlapping photographs as a three-dimensional scene. If the images are taken at low altitude—and therefore have a large scale—it is possible to use the photos to create a DEM. Overlapping images taken at full mudflat exposure are necessary to produce stereo effect for the mudflat area. Images taken along a flight line need to have 50-60% overlap to maximize the effectiveness of this technique. ERDAS Imagine software contains an algorithm that automates this process, and can create DEMs at sub-foot accuracy, *provided there are many accurately surveyed ground control points*.

The photography must be captured by a camera with GPS capability, and with accurate correction for location, altitude, and attitude of the aircraft to create a true orthophoto. The orthophoto stereo pair is then used with a large group of surveyed ground control points to create a three dimensional surface. Survey points are needed both for georectification and to provide elevation data to create the DEM. The cost of photography and surveying approaches the cost of collecting LIDAR. There was no stereo-photography for Rankin Bottoms.

The cost would increase rapidly when surveying larger areas which require surveyors on the ground navigating through difficult terrain (often knee-deep mud) with equipment. Habitat trampling is a likely result of this effort, and surveying crews would not be able to use vehicles in the field area. The interpretation in the office is time-intensive and highly specialized. The amount of post-processing is significantly greater than any of the previously discussed methods.

Sound Navigation and Ranging (SONAR)

SONAR devices measure the amount of time it takes for a sound wave to travel to the substrate and return to a SONAR receiver. This method is advantageous because existing equipment and personnel can be used to complete the project, and the field work is non-invasive to mudflat habitat.

However, the use of this technique has limited applicability for measuring mudflats. SONAR becomes increasingly inaccurate as water depth decreases. Many of the mudflats examined are in 1 to 5-feet of water at full summer pool levels; SONAR is unusable at these depths. Data collection would occur when the mudflats are fully inundated. SONAR might be useful for flats under several feet of water and with a total area less than 100 acres; larger or shallower flats should use other technology.

Results and Discussion

Applying the Best Technology

Each method is useful given the right circumstances. Table 1 provides summary information and cost estimates for each method. The GPS survey method is ideal for smaller sites with good access if personnel are available to complete the data collection during the spring fill. Stereoscopic interpretation has limited applicability. Aerial photography must be coupled with intensive ground surveys to ensure adequate quality control. More importantly, the cost and quality of the data obtained from the aerial photography technique are similar to LIDAR. SONAR is not applicable as most embayments to too shallow to allow accurate soundings. For all but the largest mudflats, we recommend combining the time-series aerial photography and GPS survey techniques if data gaps exist.

LIDAR provides the most accurate and complete data; but this technique is expensive. For large flats like Rankin Bottoms, no other method captured the subtle complexity of mudflat habitats (Figure 3). LIDAR is also useful in areas where many small mudflats are in close proximity and could be flown in a single mission.

Table 1. Advantages and disadvantages of different methods for creating a DEM of mudflat habitats. Cost is computed for Rankin Wildlife Management Area.

Light Detection and Ranging (LIDAR)		
Advantages	**Disadvantages**	**Cost**
Processes large or numerous small sites rapidly. Least invasive, most accurate and comprehensive.	Most expensive	**Total Cost:** $21,000

GPS Survey		
Moderately inexpensive based on location.	Time consuming and physically demanding. Field intensive and weather dependent	**Field Expense:** $7,850 (12 visits by 2 employees, 10 hours per visit) **Post Processing:** $800 (24 hours total processing time) **Total Cost:** $8,650
Time-Series Photography		
Least expensive, fast.	Complete multi-year aerial coverage does not exist for most sites.	**Scanning:** $2,700 (12 sets of 3 photos) **Digitizing:** $2,600 **Total Cost:** $5,300
Stereoscopic Interpretation		
Relatively Inexpensive if photography exists.	Requires photo-interpretation Requires field intensive quality controls to achieve accurate results.	**Photography:** $10,000 **Field Survey:** $6,000 ($2,000/day, approx. 3 days) **Post-processing:** $1,300 (40 hours) **Total Cost:** $17,300
Sound Navigation and Ranging (SONAR)		
Relatively Quick. Non invasive.	Untenable for most mudflats due to shallow water	**Field and Office Expense:** $5,000 minimum for small flats.

Habitat Assessment at Rankin Wildlife Management Area

Data acquired from LIDAR produces very accurate results; small variations in elevations are easily observed. The products developed by vendors allow a variety of display options including digital elevations combined with aerial photography (Figure 3). Other techniques need further processing to create similar images and few match the level of detail acquired by LIDAR.

Mudflats at Rankin Bottoms are extensive; LIDAR measured over 900 acres at this site. One of the most useful products of our model is a series of maps that depict how much habitat is available at each reservoir elevation. We developed a Macromedia Flash visualization tool to present animations of these maps coupled with data derived from our shorebird chronologies. This tool is available on CD and will run on any desktop computer. For a thorough analysis of Rankin Bottoms see Smith 2006, Appendix 10.3.

Rankin Bottoms was examined under three management scenarios. Changes implemented under ROS were not largely different from the LIP; both of these scenarios provide little habitat in July. The 1972-1990 management scenario provided habitat during July. LIP and ROS both delayed drawdown, eliminating most exposure of mudflats during July (see Smith 2006 for further details).

As the reservoir recedes into the primary river channel, the mudflat at Ranking Bottoms dries rapidly (Laux 2008). However, 15-20 acres of overwinter habitat is maintained by perennial streams crossing a portion of the mudflat. It is important to note that this habitat is maintained under all scenarios. In addition, TWRA installed a small berm on the upper portion of the mudflat to hold water longer providing some shorebird habitat until the mudflat is covered by vegetation.

Using LIDAR at Rankin Wildlife Management Area, we showed that the ROS management scenario on Douglas Lake is not significantly different from the Lake Improvement Plan (LIP). However, both ROS and LIP scenarios are substantially different from the 1972-1991 scenario and both result in substantially less habitat in July.

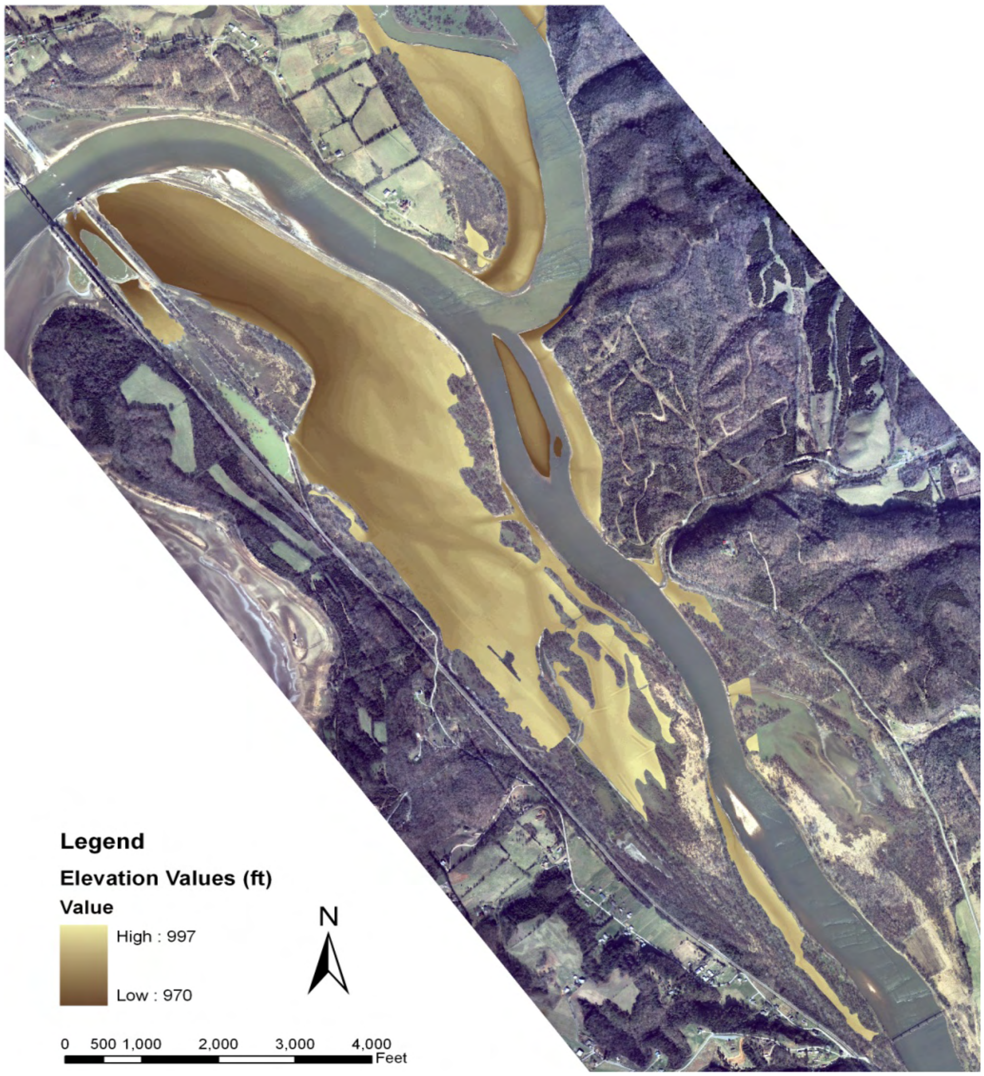


Figure 3: Aerial photography and LIDAR-derived DEM of Rankin Wildlife Management Area, Douglas Reservoir, Tennessee, USA.

Modeling Additional Habitat Availability Under Different Management Scenarios

We determined amount of mudflat habitat exposed at each contour for mudflats on Kentucky, Pickwick and Wheeler Reservoirs (Appendix 12.7). We contrast availability of habitats under different reservoir management scenarios as modeled through time under two different management regimes on Kentucky Reservoir

Kentucky Reservoir

We examined five mudflat habitats on Kentucky Reservoir, western Tennessee: Big Sandy, Duck River; Big Sandy, and Birdsong Creek in Tennessee; and Blood River and Jonathan Creek in Kentucky. We modeled habitat availability under two TVA reservoir management scenarios (1966-1980; 1980-2004, excluding the 1991-1992 stair-step test).

Figures 11-15 present the results of scenario modeling for two management periods on Kentucky reservoir: 1966-1980, and 1980-2004. This latter period excludes the years 1991-1992, during which an experimental stair-step drawdown was tested. On all flats, the 1966-1980 management regime provided habitat earlier in migration than the 1980-2004 regimes.

Figures 16-20 present a series of maps that depict how much habitat is available at each reservoir elevation, and where that habitat is located. The patterns vary widely between mudflats, and all are complex and non-intuitive; mapping the distribution of flats at each elevation is crucial.

Wheeler, Pickwick and Chickamauga Reservoirs

We modeled the interaction between reservoir level and amount of mudflat habitat available to migrating shorebirds under three TVA reservoir management scenarios on Wheeler, Pickwick and Chickamauga Reservoirs. We examined two mudflat habitats on Wheeler Reservoir (Limestone Bay and Beulah Bay/Swan Creek), one mudflat habitat on Pickwick Reservoir (Bear Creek), and one mudflat on Chickamauga (Gunstocker Creek).

We modeled the interaction between reservoir level and amount of mudflat habitat available to migrating shorebirds under two different TVA reservoir management scenarios. We then modeled habitat availability under three TVA reservoir management scenarios (1970-1990; 1991-2003; 2004-2006) to quantify how well each scenario met the habitat needs of migrating shorebirds. Our results suggest that the present ROS scenario provides less habitat during migration on these mudflats.

Historic elevation levels under the three scenarios are shown in Figures 1 and 2 for Wheeler and Pickwick Reservoirs. These graphs clearly show that higher reservoir elevations are maintained under the ROS. In all cases, the 1970-1990 management regime provided habitat earlier in migration than the other regimes.

The complexity of these graphs highlights the complexity of the mudflats themselves. Notice that on all flats (figures 1-10), a great deal of habitat is exposed with very small changes in reservoir elevation; the mudflats have relatively little relief, and entire sections are exposed with as little as 0.5-foot drawdown. This low relief means that flats are frequently exposed and re-covered, yielding the complexity of available habitat through time (figures 11-15). Small changes in drawdown scheduling can have profound impacts to available habitat, as even 0.5-foot changes can be the difference between completely inundated and completely uncovered. Using the models and data we have developed, we can evaluate any future management scenarios on Wheeler and Pickwick reservoirs. Elevation models of these mudflats are available in ESRI GRID format.

Conclusion

The complexity of these graphs highlights the complexity of the mudflats. On all flats (figures 1-10), a great deal of habitat is exposed with very small changes in reservoir elevation; the mudflats have relatively little relief, and entire sections are exposed with as little as a 0.5-foot drawdown. This low relief means that flats are frequently exposed and re-covered, yielding the complexity of available habitat through time (figures 11-15). Small changes in drawdown scheduling can have profound impacts to available habitat, as even 0.5-foot changes can be the difference between completely inundated and completely uncovered.

Summary of Flats Habitat Assessment

1) TVA examined a variety of methods for quantifying flats habitat. For large flats on the TVA reservoir system, Light Detection and Ranging (LIDAR) was the most economical and comprehensive technique for quantifying mudflat shape and extent. For smaller flats, Global Position System (GPS) tracing of shorelines at various elevations is a viable option.

2) Using LIDAR at Rankin Bottom WMA, TVA determined that the River Operation Study (ROS) operation policy for Douglas Lake is not significantly different from the previous operation policy. However, both drawdown rates under recent operation policies differ largely from drawdown rates under 1972-1991 operations. The 1972-1991 drawdown on Douglas Reservoir provides habitat throughout shorebird migration, beginning in mid-July. Recent operation policies only provide habitat from mid-August through the end of migration.

Works Cited:

Loesch, C. R., D. J. Twedt, K. Tripp, W. C. Hunter, and M. S. Woodrey. 2000. Development of Waterfowl and Shorebirds in the Mississippi Alluvial Valley. USDA Forest Service Proceedings RMRS-P-1

9.3. Smith, M. D. 2006. Spatiotemporal modeling of shorebird habitat availability at Rankin Wildlife Management Area, Tennessee. Unpublished MS Thesis, University of Tennessee, Knoxville, Tennessee, USA.

Abstract

This study examines spatiotemporal patterns of shorebird stopover habitat availability at Rankin Wildlife Management Area (Rankin Bottoms) on the Douglas Reservoir, Tennessee, USA. Rankin Bottoms is a key stopover site for fall migrating shorebirds traveling through the Tennessee River Valley (TRV). In the TRV, the majority of shorebird habitats consist of mudflats created along reservoirs in the fall as the Tennessee Valley Authority (TVA) lowers reservoir levels to prepare for winter and spring rains. Occasional changes to the annual reservoir management cycle enacted by TVA have affected the timing of mudflat exposure and thus the timing of mudflat exposure anad thus the timing of availability of stopover habitats for migrating shorebirds in the TRV.

I used high-resolution LIDAR elevation data of the lake bottom along with recorded reservoir stage values from 1972 to the present in a Geographic Information System (GIS) to model mudflat exposure at Rankin Bottoms. I defined model parameters that allow me to report values for shorebird habitat availability as it changes through the migration period, and modeled these values for three reservoir management scenarios including the current management scenario. I used average reservoir stage data for the 1972-1990 and 1991-2003 reservoir management scenarios and a predictive reservoir stage data for the current ROS management regime as input into this model. My results suggest that changes made in 1991, and more so in 2004, delay the creation of habitat at Rankin Bottoms to the beginning of August, but extended habitat availability further into the winter. Under the most recent management scenario implemented by TVA in 2004, the 15 species of shorebirds known to potentially arrive in the TRV in July will find their habitat at Rankin Bottoms inundated upon their arrival. Based upon these models, shorebird-optimal reservoir management guidelines have been prepared for TVA to consider as part of their adaptive management plan.

The findings of this study are presented in the *Rankin Wildlife Management Area Shorebird Habitat Viewer*, a visualization tool, which offers 3-Dimensional animations of habitat availability at Rankin Bottoms. Using this tool, interested parties can compare and contrast the amount of available habitat for any day of the migration period under the historic and current management regimes.

The models generated for this study can help TVA's reservoir managers to assess the habitat impacts of proposed reservoir management activities now and in the future. The methods developed in this study are not specific to the phenomenon of shorebird migration or to the TVA river system. They may be used by reservoir and wildlife managers elsewhere to assess the habitat consequences of different management strategies and ultimately determine the optimal management strategy for species of concern.

9.4. Laux, J. W. 2008. Waterbird responses to drawdown of two east Tennessee River Valley Reservoirs. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

Abstract

Waterbirds rely on stopover sites in the interior United States to meet the energetic demands associated with migration. Mudflats exposed during annual drawdowns of reservoirs in the Tennessee River Valley (TRV) provide stopover habitat for thousands of migratory waterbirds. Timing of drawdowns may significantly affect waterbird use of TRV mudflats. Thus, I quantified the impacts of drawdown date for Douglas (1 August) and Chickamauga (1 October) Reservoirs on mudflat acreage and characteristics, food availability and waterbird use. I also quantified waterbird activities on TRV mudflats to determine their functional role to migratory waterbirds. From August 2005/06 - January 2006/07, I conducted waterbird surveys twice weekly at four mudflats each in Douglas and Chickamauga Reservoirs. I sampled mudflat acreage weekly; vegetation, seeds and aquatic invertebrates twice monthly; water depth and quality twice monthly; and soil moisture, compaction and temperature twice monthly. I documented 68 waterbird species using east TRV mudflats. Shorebirds were more abundant at Douglas Reservoir in August - September and at Chickamauga Reservoir from October - January. Total shorebird abundance was twice as great at Chickamauga Reservoir, and the community as composed of short-distance migrants. Shorebird richness was twice as great at Douglas Reservoir, and most species were longer-distance migrants of greater conservation concern. Waterfowl abundance and richness were greater at Chickamauga Reservoir, peaking November - December. Exposed mudflat acreage was greater at Douglas Reservoir from August - October; no mudflats were exposed in Chickamauga Reservoir during August - September either year. All vegetation parameters were greater on Douglas mudflats. Differences in seed biomass, soil characteristics, and water depth and quality were not detected between reservoirs. Invertebrate analyses were not included in the thesis because they are ongoing. Shorebird abundance was positively associated with mudflat acreage and negatively associated with horizontal cover of vegetation and water depth. Primary waterbird activities included foraging, locomotion and resting. My results suggest that early and late drawdowns of TRV reservoirs benefit waterbirds. Thus, I recommend sequential drawdowns of reservoir, such that ne mudflats are continuously exposed from late July - November in the TRV. When possible, reservoir drawdown rate should be as slow as possible (e.g., $\leq$1 cm/day).

9.5. Wirwa, D. W. 2009. Waterbird use and food resource response to drawdown of Kentucky Reservoir. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

Abstract

Mudflats associated with rivers in mid-continental United States are important for waterbirds to rest and replenish energy reserves during migration. Kentucky Reservoir is the largest reservoir in the Tennessee River Valley (TRV), and extensive mudflat acreage is exposed during annual drawdowns. It has been proposed that timing of drawdowns will significantly affect waterbird use of TRV mudflats. Thus, I quantified influences of drawdowns of Kentucky Reservoir on waterbird use, available food resources, and mudflat characteristics. From August - December 2006 and 2007, I conducted waterbird surveys twice weekly at 9 mudflats in Kentucky Reservoir. I quantified temporal and spatial changes at mudflat sites by sampling mudflat acreage weekly and vegetation, aquatic invertebrates, soil characteristics, and water depth twice monthly. Initially mudflat exposure occurred in early to mid-August; mean mudflat acreage was 35 ha. I recorded 26 species of shorebirds, 20 species of waterfowl, and 25 species of other waterbirds (e.g., herons, gulls) using mudflats in Kentucky Reservoir. Mean shorebird abundance, richness, and diversity were greatest during September, while mean shorebird density was greatest during August when mudflat acreage was lowest. Most long-distance migrant shorebirds of high conservation concern were recorded during August and September; whereas shorter- distance migratory shorebirds and waterfowl were most common October - December. Invertebrates were the most abundant food resource available to shorebirds and waterfowl (1.5 - 3.6 g m^{-2}); Chironomidae was the most common taxa. Vegetation establishment and seed production decreased with decreasing mudflat elevation, which was related to duration of mudflat exposure. Soil moisture and compaction, water depth, and invertebrate density results revealed that optimal foraging conditions for shorebirds occurred within a 20-m band centered on the waterline. Shorebirds and waterfowl using mudflats spent the majority of their time feeding, while all other waterbirds spent most of their time resting. My results indicate that Kentucky Reservoir mudflats provide important foraging and resting habitat for a diverse assemblage of waterbirds. I recommend that mudflats in Kentucky Reservoir be exposed by 1 August (New Johnsonville gage height, 108.81 m [357 ft] MSL) to provide habitat for rare long-distance migratory shorebird and to facilitate vegetation establishment and seed production for waterfowl.

10.0 LITERATURE CITED

Allen, S. A. 2006. Restoration of native plants through chemical control of alligator-weed (*Alternanthera philoxeroides*) at Eufaula National Wildlife Refuge. Unpublished M. S. Thesis, Auburn University, Alabama 109 pp.

Amundsen, C. C. 1994. Reservoir riparian zone characteristics in the Upper Tennessee River Valley. Water, Air and Soil Pollution. 77:460-593.

Andrei, A. E., L. M. Smith, D. A. Haukos, and J. G. Surles. 2006. Community composition and migration chronology of shorebirds using the saline lakes of the Southern Great Plains, USA. Journal of Field Ornithology 77:372-383

Ashkenazie, S., and U. N. Safriel. 1979. Time-energy budget of the semipalmated sandpiper *Calidris pusilla* at Barrow, Alaska. Ecology 60:783-799.

Bart, J., S. Brown, B. Harrington, and R. I. G. Morrison. 2007. Survey trends of North American shorebirds: population declines or shifting distributions? Journal of Avian Biology 38:73-82.

Baskin, C. C.; J. M. Baskin and E. W. Chester. 2004. Seed germination ecology of the summer annual *Cyperus squarrosus* in an unpredictable mudflat habitat. Acta Oecologica, 26(1): 9-14.

Baskin, C. C.; J. M. Baskin and E. W. Chester. 1993. Seed germination ecophysiology of four summer annual mudflat species of Cyperaceae. Aquatic Botany 45(1): 41-52.

Baskin, C. C.; J. M. Baskin and E. W. Chester. 2002. Effects of flooding and temperature on dormancy break in seeds of the summer annual mudflat species *Ammannia coccinea* and *Rotala Ramosior* (Lythraceae). *WETLANDS,*22(4):661-668.

Benedict, R. J., Jr., and G. R. Hepp. 2000. Wintering waterbird use of two aquatic plant habitats in a southern reservoir. Journal of Wildlife Management, 64:269-278.

Brown, S., C. Hickey, B. Harrington, and R. Gill, editors. 2001. The United States shorebird conservation plan. Second edition. Manomet Center for the Conservation Sciences. Manomet, Massachusetts, USA.

Ciuzio, Elizabeth, R. M. Morton, and N, Ranalli. 2005. Implementing shorebird conservation on public lands. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 59:183-190.

Davis, C. A., and L. M. Smith. 1998. Ecology and management of migrant shorebirds in the playa lakes region of Texas. Wildlife Monographs 140:1-45.

Davidson, N. C., and P. R. Evens. 1989. Prebreeding accumulation of fat and muscle protein by arctic-breeding shorebirds. roceedings of the International Ornithological Congress 19:342-352.

DeBerry, D. A. and J. E. Perry. 2005. A drawdown flora in Virginia. CASTANEA 70(4): 276-286.

Drent, R., and D. T. Piersma. 1990. An exploration of the energetics of leap-frog migration in arctic breeding waders. In: *Bird migration: Physiology and Ecophysiology* (E. Gwinner, ed.), pp. 399-412. Springer-Verlag, Berlin.

Gray, M. J,. R. M. Kaminski, G. Weerarkkody, B. D. Leopold, and K. C. Jensen. 1999. Aquatic invertebrate and plant responses following mechanical manipulations of moist-soil habitat. Wildlife Society Bulletin 27:70-779.

Gunn, S. M. 2003. The vascular flora of the Tennessee National Wildlife Refuge's Duck River Unit, Humphreys County, Tennessee. M. S. Thesis. Austin Peay State University. Clarksville, TN. 67 pp.

Hall, T. F. and G. E. Smith. 1955. Effects of flooding on woody plants, West Sandy Dewatering Project, Kentucky Reservoir. Journal of Forestry, 53:281-285.

Helmers, D. L. 1992. Shorebird Management Manual. Western Hemisphere Shorebird Reserve Network, Manomet, Massachusetts, USA.

Kersten, M., and T. Piersma. 1987. High levels of energy expenditure in shorebirds; metabolic adaptations to an energetically expensive way of life. Ardea 75:175-187.

Laux, John. W. 2008. Waterbird responses to drawdown of two east Tennessee River Valley Reservoirs. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

Loesch, C. R., D. J. Twedt, K. Tripp, W. C. Hunter, and M. S. Woodrey. 2000. Development of Waterfowl and Shorebirds in the Mississippi Alluvial Valley. USDA Forest Service Proceedings RMRS-P-16.

Kross, J., R. M, Kaminski, K. J. Reinecke, E. J. Penny, and A. T. Pearse. 2008. Moist-soil seed abundance in managed wetlands in the Mississippi Alluvial Valley. Journal of Wildlife Management 72:707-714.

Morrison, R. I. G., R. E. Gill, Jr., B. A. Harrington, S. Skagen, G. W. Page, C. L. Gratto-Trevor, S. M. Haig. 2001. Estimates of shorebird populations in North America. Occasional Paper No. 104, Canadian Wildlife Service, Ottawa, Ontario. 64 pp.

Nicholson, C P. 1997. Atlas of the breeding birds of Tennessee. Univ. Tenn. Press, Knoxville. 426 pp.

Palmer-Ball, Brainard L. 1996. The Kentucky breeding bird atlas. Univ. of Kentucky Press, Lexington. 372 pp.

Palmer-Ball, Brainard L. 2003. Annotated checklist of the birds of Kentucky. The Kentucky Ornithological Society, Gateway Press, Louisville, Kentucky. 189 pp.

Pompei, V. D. 2004. Migration stopover sites used by Great Lakes piping plovers (Charadrius melodus). Thesis, University of Minnesota, Twin Cities, Minnesota.

Reid, F. A., J. R. Kelley, Jr., T. S. Taylor, and L. H. Fredrickson. 1989. Upper Mississippi Valley wetlands - refuges and moist-soil impoundments. Pages 181-202 *in* L. M. Smith, R. L. Pederson, and R.M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock, Texas, USA.

Robinson, J. C. 1990. An annotated checklist of the birds of Tennessee. Univ. Tenn. Press, Knoxville. 274 pp.

Rundle, W. D., and L. H. Fredrickson. 1981. Managing seasonally flooded impoundments for migrant rails and shorebirds. Wildlife Society Bulletin, 9:80-87.

Sanzenbacher, P. M., and S. M. Haig. 2001. Killdeer population trends in North America. Journal of Field Ornithology 72:160-169.

Short, M. R. 1999. Shorebirds in western Tennessee: migration ecology and evaluation of management effectiveness. M. S. Thesis, University of Tennessee, Knoxville, Tennessee.

Smith, Matthew D. 2006. Spatiotemproal modeling of shorebird habitat availability at Rankin Wildlife Management Area, Tennessee. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

Snyder, D. H. 1988. Proceedings of the first annual symposium on the natural history of lower Cumberland and Tennessee River Valleys. The Center for Field Biology of Land Between the Lakes, Austin Peay State University, Clarksville, TN.

Skagen, S. K., and F. L. Knopf. 1993. Toward conservation of midcontinental shorebird migrations. Conservation Biology, 7(3):533-541.

Tennessee Valley Authority. 1990. Lake Improvement Plan, Tennessee River and Reservoir System Operating and Planning Overview. Final Environmental Impact Statement. (TVA/RDG/EQS-91/1.)

Tennessee Valley Authority. 2004. Final Programmatic Environmental Impact Statement: Tennessee Valley Authority Reservoir Operations Study. Federal Register 69:105. http://www.tva.gov/environment/reports/ros_eis/

Twedt, D. J., C. O. Nelms, V. E. Rettig, and S. R. Aycock. 1998. Shorebird use of managed wetlands in the Mississippi Alluvial Valley. American Midland Naturalist 140:140-152.

U.S. Fish and Wildlife Service. 2003. Recovery Plan for the Great Lakes Piping Plover (*Charadrius melodus*). Ft. Snelling, MN. 151p.

Webb, D. H., W. M. Dennis, and A. L. Bates. 1988. An analysis of the plant community of mudflats of TVA mainstem reservoirs. Pp. 177-198 *In*: Proceedings of the first annual symposium on the natural history of lower Cumberland and Tennessee River valleys (D. H. Snyder, ed.). The Center for Field Biology of Land Between the Lakes, Austin Peay State University, Clarksville, TN.

Wirwa, Drew W. 2009. Waterbird use and food resource response to drawdown of Kentucky Reservoir. Thesis, University of Tennessee, Knoxville, Tennessee, USA.

APPENDICES

10.1. Goals and Objectives of the Tennessee River Valley Shorebird Working Group, Developed in 2005.

GOAL 1 IDENTIFY PAST AND PRESENT SHOREBIRD USE SITES THROUGHOUT THE TRV

Objective 1.1 Document known historical shorebird use sites and determine their current status - **Completed**
Objective 1.2 Develop spatial datasets to remotely identify potential shorebird sites - **Completed**
Objective 1.3 Examine each site and determine shorebird use - **Completed**
Objective 1.4 Identify important shorebird habitat - **Completed**
Objective 1.5 Prioritize stop-over and wintering sites in the TRV - **Completed**
Objective 1.6 Describe all shorebird sites in the TRV - **Completed**

GOAL 2 DEVELOP A REGIONAL MONITORING PLAN TO ACCOMPLISH SHOREBIRD MONITORING GOALS OF COOPERATORS

Objective 2.1 Identify collective goals encompassing each cooperators needs - **Completed**
Objective 2.2 Identify and adopt standard shorebird monitoring protocol to be used by all cooperators - **Completed**
Objective 2.3 Design a large-scale coordinated shorebird monitoring effort - **Completed**
Objective 2.4 Identify survey personnel to participate in monitoring effort - **Completed**
Objective 2.5 Assign responsibility of monitoring specific sites to survey personnel - **Completed**
Objective 2.6 Host an annual workshop to improve shorebird identification skills of survey participants - **Completed**
Objective 2.7 Develop a process for reporting data to cooperators and ensure that data are integrated and support regional, national and international shorebird conservation initiatives - **Completed**

GOAL 3 DETERMINE THE TEMPORAL AND SPATIAL DISTRIBUTION OF SHOREBIRDS AT STOP-OVER AND WINTERING SITES IN TRV

Objective 3.1 Identify, collect and computerize existing and historical shorebird survey data - **Partially Completed**
Objective 3.2 Collectively monitor shorebird populations - **Completed**
Objective 3.3 Document species diversity and shorebird populations at stop-over and wintering sites - **Completed**
Objective 3.4 Document long-term population trends for each species at local and regional levels - **Completed**
Objective 3.5 Develop comprehensive migration chronology for each species - **Completed**

Objective 3.6 Describe shorebird distributions throughout the TRV - **Completed**

GOAL 4 EXPLORE WAYS TO ENHANCE AND DEVELOP SHOREBIRD HABITATS WITHIN THE TRV

Objective 4.1 Identify factors that may limit use of habitats by shorebirds - **Completed**
Objective 4.2 Document food availability at specific sites - **Completed**
Objective 4.3 Identify research needs and opportunities for enhancement of shorebird habitat - **Partially Completed**
Objective 4.4 Identify existing habitat areas with greatest management potential
Objective 4.5 Identify potential habitat that could be modified/managed to support shorebirds - **Completed**
Objective 4.6 Identify funding sources for shorebird habitat improvement and development - **Partially Completed**
Objective 4.7 Determine current amounts of shorebird habitat and identify those with potential for management - **Completed**

10.2. Prioritized list of sites identified by the Shorebirds Committee as potential habitat for shorebirds and waterfowl in the Tennessee River Valley. Sites are listed by Region and Reservoir. The period that flats are exposed is noted for each reservoir. Total number of birds recorded per site or complex is also provided, sites that were not surveyed are indicated (NS).

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
WEST REGION						
KENTUCKY RESERVOIR						
Anderson Creek Complex[a]	**21**	**-**	**-**	**3**	**-**	**Callaway, KY**
Anderson Creek	18	-88.12665	36.71992	3		
Unnamed Flat	3	-88.12456	36.71926	3		
Bass Bay (Crooked Creek)	**18**	**-87.97898**	**36.26596**	**3**	**-**	**Benton, TN**
Beaverdam Creek	**18**	**-88.02985**	**36.06257**	**1**	**650**	**Benton, TN**
Big Bear Creek Complex	**103**	**-**	**-**	**3**	**-**	**Marshall, KY**
Malcolm Creek	16	-88.24389	36.90256	3		
Malcolm Creek 2	2	-88.23245	36.89748	3		
King Creek	14	-88.23118	36.89166	3		
Cap Spring	54	-88.22085	36.87756	3		
Bear Creek	17	-88.22049	36.87413	3		
Big Sandy Complex	**345**	**-**	**-**	**1**	**2937**	**Henry, TN**
Big Sandy Flats	330	-88.10129	36.24821	1	2937	
Big Sandy Boat Ramp	15	-88.09598	36.23654	2		
Big Sulphur Creek	**23**	**-87.96469**	**36.18448**	**3**	**-**	**Benton, TN**
Birdsong Creek	**157**	**-88.06166**	**35.95765**	**2**	**33**	**Benton, TN**
Blanks Hollow Complex	**21**	**-87.92807**	**36.13750**	**3**	**-**	**Benton, TN**
Blood River Complex	**520**	**-**	**-**	**1**	**8230**	**Calloway, KY**
Wild Cat Creek	65	-88.14523	36.60833	1		
Unnamed Blood River Flat	22	-88.13298	36.59479	1		
Blood River	433	-88.14169	36.57610	1		
Blue Creek	**23**	**-87.92288**	**35.86878**	**3**	**-**	**Humphreys, TN**
Boyd's Branch	**30**	**-88.07874**	**36.60453**	**2**	**-**	**Calloway, KY**
Brush Creek Complex	**76**	**-**	**-**	**3**	**-**	**Calloway, KY**
Little Sugar Creek	16	-88.13054	36.64810	3		
Unnamed Flat	3	-88.12723	36.64501	3		

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
Sugar Creek	47	-88.14139	36.64403	3		
Brush Creek	10	-88.13660	36.63930	3		
Byrd Bay	**22**	**-88.01126**	**36.58017**	**3**	**0**	**Stewart, TN**
Cane Creek	**48**	**-87.92368**	**36.30736**	**3**	**2**	**Houston, TN**
Curtess (Cypress-North) Creek Complex	**11**	**-**	**-**	**3**	**-**	**Henry, TN**
Cypress Creek	4	-88.09923	36.49651	3		
Betsy Branch	1	-88.09841	36.49602	3		
Prairie Branch	6	-88.08487	36.48798	3		
Cypress Creek Complex	**85**	**-**	**-**	**1**	**1155**	**Benton, TN**
Cypress Creek 1	79	-88.04819	36.03862	1		
Cypress Creek 2	6	-88.04707	36.04303	1		
Decaturville Complex	**67**	**-**	**-**	**3**	**-**	**Decatur/Perry, TN**
Beech River RM 3	3	-88.05654	35.60319	3		
Cypress Creek	22	-88.01860	35.60934	3		
Lost Creek	11	-88.06721	35.59330	3		
Rushing Creek 1	1	-88.08713	35.60266	3		
Rushing Creek 2	2	-88.08648	35.60136	3		
Rushing Creek 3	2	-88.08748	35.59882	3		
Rushing Creek 4	7	-88.08873	35.60237	3		
Beech River RM 6.8	2	-88.08971	35.60483	3		
Beech River RM 7.0	4	-88.09173	35.60764	3		
Beech River RM 7.5	1	-88.09252	35.60992	3		
Beech River RM 7.6	2	-88.09336	35.60916	3		
Beech River RM 7.9	9	-88.09533	35.61178	3		
Beech River RM 8.8	1	-88.10594	35.61080	3		
Dry Creek Complex	**32**	**-**	**-**	**3**	**-**	**Humphreys, TN**
Dry Creek	22	-87.92115	36.10117	3		
Little Dry Creek	10	-87.93268	36.08930	3		
Duck River Complex	**687**	**-**	**-**	**1**	**4236**	**Humphreys, TN**
Large Island DRRM 1.9	154	-87.92845	35.95678	1		
Island DRRM 2.1	20	-87.91982	35.96067	1		
Dike Shoreline DRRM 1.0-4.0	422	-87.92350	35.96770	1		
Right Bank DRRM 2-3	17	-87.91520	35.96006	1		
Chalk Hollow Flat	13	-87.90629	35.97486	1		

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
Island DRRM 4.2	18	-87.90801	35.97851	1		
DRRM 6	33	-87.88878	35.98894	1		
DRRM 5.1	10	-87.90223	35.98908	1		
Duncan Branch Complex	**30**	**-**	**-**	**2**	**5**	**Humphreys, TN**
Sycamore Landing	10	-87.91934	35.93503	2		
Duncan Branch	20	-87.91607	35.90486	2		
Eagle Creek (South)	**49**	**-87.95868**	**35.91719**	**1**	**517**	**Benton, TN**
Eagle Creek Complex (North)	**167**	**-**	**-**	**1**	**2178**	**Henry, TN**
Eagle Creek	124	-88.12127	36.42074	1		
Unnamed Flat	8	-88.11673	36.41438	2		
Little Eagle Creek	35	-88.10384	36.43087	1		
Ginger Bay Complex	**16**	**-**	**-**	**3**	**-**	**Stewart, TN**
Ginger Creek	13	-88.03107	36.63480	3		
Unnamed Flat	3	-88.03180	36.62983	3		
Greenbrier Creek	**8**	**-87.92565**	**36.23176**	**3**	**-**	**Humphreys, TN**
Harmon Creek	**16**	**-87.94923**	**36.1504**	**2**	**21**	**Benton, TN**
Hughes Creek	**12**	**-88.01609**	**36.55747**	**3**	**0**	**Stewart, KY**
Hurricane Creek	**10**	**-87.93452**	**36.33321**	**3**	**-**	**Houston, TN**
Jonathan Creek Complex	**330**	**-**	**-**	**1**	**7192**	**Marshall, KY**
Ruff Creek	34	-88.20298	36.82339	1		
Olive Branch	49	-88.22337	36.81284	1		
Unnamed Flat 1	1	-88.22716	36.79360	1		
Jonathan Creek	215	-88.23182	36.77188	1		
Unnamed Flat 2	1	-88.22209	36.78431	1		
Clear Creek	30	-88.21572	36.78559	1		
Leatherwood Creek	**6**	**-87.95574**	**36.37712**	**3**	**1**	**Stewart, TN**
Ledbetter Creek Complex	**36**	**-**	**-**	**3**	**-**	**Marshall/Calloway KY**
Terrapin Branch	4	-88.13559	36.76571	3		
Cool Creek	8	-88.14572	36.75739	3		
Ledbetter Creek	24	-88.14332	36.74214	3		
Lick Creek	**24**	**-88.01175**	**36.32562**	**1**	**886**	**Benton, TN**
Little Bear Creek Complex	**21**	**-**	**-**		**-**	**Marshall, KY**
Unnamed	2	-88.25221	36.94314	3		
Little Bear Creek	19	-88.26109	36.93326	3		

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
Little Turkey Creek	**21**	**-87.91454**	**36.20189**	**3**	**-**	**Humphreys, TN**
Mayberry Branch Complex	**44**	**-**	**-**	**3**	**-**	**Decatur/Perry, TN**
Kelly Landing 1	10	-87.98117	35.53931	3		
Cedar Creek	25	-87.97506	35.54673	3		
Kelly Landing 2	9	-87.98178	35.54078	3		
Near Jonathan Creek Complex	**69**	**-**	**-**	**3**	**-**	**Marshall, KY**
West Bee Creek	15	-88.19636	36.85798	3		
Unnamed Flat 1	12	-88.18564	36.84765	3		
Bee Creek	12	-88.17610	36.83465	3		
Unnamed Flat 2	6	-88.16714	36.83154	3		
Unnamed Flat 3	6	-88.16874	36.82688	3		
Mainstem Island	18	-88.16741	36.84548	2		
Newburg Flat	**16**	**-88.09717**	**36.69298**	**3**	**-**	**Calloway, KY**
New Johnsonville Island	**57**	**-87.99544**	**36.04391**	**1**	**1503**	**Benton, TN**
Pace Point	**16**	**-88.05857**	**36.40709**	**2**	**125**	**Henry, TN**
Panther Bay Complex	**38**	**-**	**-**	**3**	**1**	**Stewart, TN**
Dry Fork	14	-88.00182	36.52948	2		
Panther Bay	24	-87.99813	36.51787	3		
Pisgah/Smith/Duncan Complex	**83**	**-**	**-**	**3**	**4**	**Lyon, KY**
Dodds Creek	11	-88.16852	36.94241	3		
Pisgah Creek	19	-88.15390	36.92806	3		
Smith Bay Combined	7	-88.16008	36.90579	3		
Smith Creek	21	-88.13582	36.91287	3		
Duncan Combined	20	-88.12292	36.89102	3		
Duncan Bay	5	-88.13679	36.88139	3		
Richland Creeks Complex	**43**	**-**	**-**	**2**	**99**	**Humphreys, TN**
Big Richland Creek	39	-87.88436	36.17431	2		
Little Richland Creek	4	-87.89164	36.15919	3		
Roan/Toms Creek Complex	**25**	**-**	**-**	**3**	**-**	**Perry, TN**
Roan Creek	7	-87.96924	35.77413	3		
Toms Creek	18	-87.97775	35.75231	3		
Robbins/Bennetts Creek Complex	**38**	**-**	**-**	**3**	**-**	**Henry, TN**

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
Robbins Creek	23	-88.04099	36.37913	3		
Bennetts Creek	15	-88.02834	36.36914	3		
Rushing Bay Complex	**34**	**-**	**-**	**3**	**5**	**Stewart, TN**
North Rushing Creek	24	-88.03799	36.66266	3		
South Rushing Creek	10	-88.03862	36.65798	3		
Shannon Creek Complex	**65**	**-**	**-**	**3**	**76**	**Calloway, KY**
Unnamed Flat	6	-88.05508	36.51257	3		
Shannon Creek	27	-88.06116	36.52169	3		
Yellow Spring Branch	8	-88.06076	36.53120	3		
TR RM 59 Islands	24	-88.04693	36.54294	3		
Simmon's Branch	**2**	**-87.99084**	**35.98602**	**3**	**16**	**Humphreys, TN**
Short Creek	**5**	**-88.00061**	**36.39842**	**3**	**-**	**Stewart, TN**
Sledd Creek Complex	**54**	**-**	**-**		**102**	**Marshall/ Livingston, KY**
KY State Park Beach	1	-88.28475	37.00135	2	102	
Taylor Creek	4	-88.28787	36.98503	3		
Grand Rivers	6	-88.24258	37.00184	3		
Sledd Creek 1	27	-88.28442	36.95961	3		
Sledd Creek 2	1	-88.25798	36.96813	3		
Sledd Creek 3	1	-88.28457	36.96484	3		
Sledd Creek 4	7	-88.27535	36.96188	3		
Sledd Creek 5	7	-88.26264	36.96585	3		
Snipe Creek	**18**	**-88.09431**	**36.68228**	**3**	**-**	**Calloway, KY**
Standing Rock Creek	**17**	**-88.00902**	**36.43853**	**3**	**44**	**Stewart, TN**
Sugar/Vickers Bay Complex	**53**			**3**	**16**	**Trigg, KY**
North Fork Sugar Creek	13	-88.11804	36.86726	3		
South Fork Sugar Creek	3	-88.12289	36.85756	3		
Higgins Branch	10	-88.11950	36.84293	3		
Unnamed Flat	3	-88.12544	36.83428	3		
Rhodes Creek	10	-88.11478	36.82551	3		
Savells Branch	2	-88.11565	36.80928	3		
Barnett Creek	12	-88.10744	36.78746	3		
Sulphur Branch	**14**	**-88.10523**	**36.39783**	**1**	**71**	**Henry, TN**
TN River Mile 56.3-57.5 Islands (3)	**14**	**-88.05066**	**36.58453**	**3**	**-**	**Calloway, KY**

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
Trace Creek	**24**	**-87.94093**	**36.05726**	**3**	**44**	**Humphreys, TN**
Turkey Creek	**18**	**-88.08641**	**36.74361**	**3**	**0**	**Trig, KY**
West Sandy Complex	**237**	**-**	**-**	**2**	**1804**	**Henry, TN**
Hastings Branch	15	-88.13469	36.30249	2		
West Sandy Creek RM 2.8	32	-88.14324	36.31465	2		
Britton Ford	33	-88.13687	36.33140	1	1380	
Swayne Road/Walker Branch	26	-88.13861	36.34508	1	424	
Swamp Creek	107	-88.14494	36.36018	2		
Unnamed Flat	24	-88.12622	36.37023	2		
White Oak Creek	**271**	**-87.89996**	**36.26225**	**1**	**101**	**Houston, TN**
OFF-RESERVOIR (West Region)						
Coffee Bottoms	**125**	**-88.27479**	**35.23105**	**3**	**-**	**Hardin, TN**
Savannah Bottoms	**1193**	**-88.28787**	**35.15455**	**3**	**65**	**Hardin, TN**
TN National Duck River Dewatering Units	**1188**	**-87.92565**	**35.98022**	**1**	**9819**	**Humphreys, TN**
West Sandy Dewatering Unit	**52**	-88.15641	36.29237	**3**	**-**	**Henry, TN**
CENTRAL REGION						
PICKWICK RESERVOIR						
Bear Creek Complex	**220**	**-**	**-**	**1**	**2368**	**Colbert, AL**
Bear Creek RM14 West	126	-88.09318	34.76968	1		
Bear Creek RM 14 East	69	-88.08467	34.77339	1		
Alt. 72 Flat	13	-88.08476	34.75939	1		
Unnamed Flat	12	-88.08105	34.76503	1		
Colbert Creek-Colbert Co.	**16**	**-87.94890**	**34.83795**	**1**	**1166**	**Colbert, AL**
Colbert Creek-Lauderdale Co.	**8**	**-87.92610**	**34.84956**	**1**	**1181**	**Lauderdale, AL**
Dry Branch	**16**	**-86.99680**	**34.61582**	**2**	**169**	**Morgan, AL**
Dry Creek	**41**	**-88.18405**	**35.01814**	**2**	**120**	**Hardin, TN**
Indian Creek	**61**	**-88.17380**	**34.89673**	**1**	**1149**	**Tishomingo, MS**
Kroger Island	**18**	**-87.91557**	**34.80617**	**3**	**-**	**Lauderdale, AL**
Second Creek	**141**	**-88.04017**	**34.93680**	**1**	**518**	**Lauderdale, AL**
Sevenmile Island	**759**	**-87.77981**	**34.74361**	**3**	**-**	**Lauderdale, AL**
Yellow Creek	**242**	**-**	**-**	**3**	**34**	**Tishomingo, MS**
Tenn-Tom RM444 East Flat	143	-88.23717	34.91721	3		

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
Tenn-Tom RM444 West Flat	84	-88.24233	34.92248	3		
Hubbard Branch	5	-88.23801	34.94552	3		
Lard Branch	10	-88.23791	34.95650	3		
WILSON RESERVOIR						
McKiernan Creek/Donnagon Slough	**36**	**-87.54098**	**34.78617**	**1**	**1038**	**Colbert, AL**
Town Creek Marsh	**41**	**-87.43836**	**34.77087**	**1**	**2785**	**Colbert, AL**
WHEELER RESERVOIR						
Beulah Bay	**255**	**-86.99835**	**34.67277**	**1**	**8105**	**Lauderdale, AL**
Flint Creek (Wheeler NWR)	**1204**	**-86.94848**	**34.54509**	**1**	**2093**	**Morgan, AL**
Garth Slough	**765**	**-86.88058**	**34.56381**	**1**	**-**	**Limestone, AL**
Mallard/Fox Creek	**86**	**-**	**-**	**1**	**3361**	**Lawrence, AL**
Fox Creek	47	-87.11437	34.65667	1		
Mallard Creek	39	-87.17416	34.68984	1		
Penny Bottoms	**72**	**-86.87740**	**34.59058**	**2**	**-**	**Limestone, AL**
Limestone Bay	**1114**	**-86.87039**	**34.60743**	**1**	**378**	**Limestone, AL**
Round Island Creek/Kimborough (90)	**43**	**-87.04805**	**34.69669**	**1**	**2262**	**Limestone, AL**
Spring Creek	**4**	**-87.28200**	**34.72615**	**3**	**100**	**Lawrence, AL**
TN River Backwater	**278**	**-86.92117**	**34.5957**	**2**	**34**	**Limestone, AL**
GUNTERSVILLE RESERVOIR						
Mud Creek Islands	**6**	**-85.92905**	**34.77400**	**2**	**-**	**Jackson, AL**
Mud Creek Flats	**27**	**-85.91506**	**34.77881**	**2**	**50**	**Jackson, AL**
OFF-RESERVOIR (Central Region)						
Buckeye Dewatering Unit	**650**	**-86.81120**	**34.56229**	**2**	**-**	**Limestone, AL**
Burns Island	**7**	**-85.66595**	**35.03089**	**3**	**-**	**Marion, TN**
Cattle Pond	**31**	**-87.73455**	**34.78967**	**3**	**-**	**Lauderdale, AL**
Church Pond	**21**	**-87.74820**	**34.78756**	**1**	**-**	**Lauderdale, AL**
Cottonwood Pond	**12**	**-87.27205**	**34.69218**	**1**	**502**	**Lawrence, AL**
Gnat Pond	**130**	**-87.58233**	**34.72945**	**3**	**-**	**Colbert, AL**
Gnat Sod Farm	**208**	**-87.57562**	**34.71431**	**1**	**-**	**Colbert, AL**
Harding Bottoms	**8**	**-87.83894**	**34.80277**	**3**	**-**	**Lauderdale, AL**

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
Hog Pond	**11**	**-87.60215**	**34.69917**	**3**	**-**	**Colbert, AL**
Hog Sod Farm	**75**	**-87.59107**	**34.70138**	**1**	**-**	**Colbert, AL**
Leighton Ponds	**187**	**-87.56113**	**34.69771**	**3**	**-**	**Colbert, AL**
Long Pond	**32**	**-87.25475**	**34.69879**	**2**	**40**	**Lawrence, AL**
Marthaler Pond	**88**	**-87.56619**	**34.71682**	**3**	**-**	**Colbert, AL**
Reynolds Pond	**31**	**-87.57809**	**34.75137**	**3**	**-**	**Colbert, AL**
Swan Creek Dewatering Unit	**753**	**-86.98058**	**34.65204**	**3**	**24**	**Limestone, AL**
The Sinks	**235**	**-87.47700**	**34.72323**	**2**	**-**	**Colbert, AL**
Unnamed Pond Lauderdale 1	**14**	**-87.85786**	**34.79179**	**2**	**-**	**Lauderdale, AL**
Unnamed Pond Lauderdale 2	**31**	**-87.78640**	**34.80307**	**2**	**-**	**Lauderdale, AL**
Unnamed Pond Lauderdale 3	**38**	**-87.76740**	**34.79306**	**1**	**-**	**Lauderdale, AL**
Walker Pond	**116**	**-87.74450**	**34.79618**	**2**	**-**	**Lauderdale, AL**
White Springs Dewatering Unit	**885**	**-86.92133**	**34.60745**	**3**	**-**	**Limestone, AL**
EAST REGION						
CHICAMAUGA RESERVOIR						
Candies Creek	**167**	**-84.84859**	**35.31949**	**1**	**3051**	**Bradley, TN**
Cottonport Complex	**650**	**-84.85162**	**35.49742**	**3**	**5**	**Rhea/Meigs, TN**
Cottonport	525	-84.90306	35.48548	3		
TN River Mile 514	58	-84.86067	35.49293	3		
Goodfield Creek	67	-84.84792	35.50063	3		
Gunstocker Creek	**75**	**-84.93512**	**35.34618**	**1**	**950**	**Meigs, TN**
Hiwassee Island	**359**	**-84.98992**	**35.41494**	**2**	**80**	**Meigs, TN**
North Mouse/Russell Spring Complex	**57**			**1**	**458**	**McMinn, TN**
North Mouse 1	33	-84.78691	35.32893	1		
North Mouse 2	24	-84.79371	35.32861	1		
Price Creek	**26**	**-84.86129**	**35.36246**	**2**	**153**	**Meigs, TN**
Rogers Creek Complex		**-84.81943**	**35.35518**	**1**	**2244**	**McMinn, TN**
Rogers Creek Flat	82	-84.82193	35.35035	1	2244	
Rogers Creek Embayment	64	-84.83052	35.33535	2		
Savannah Bay	**175**	**-85.05258**	**35.15525**	**3**	**12**	**Hamilton, TN**
Smith Bend/Clear Creek	**183**	**-84.87398**	**35.55504**	**3**	**-**	**Rhea, TN**

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
Soddy Creek	**377**	**-85.14633**	**35.28796**	**3**	**-**	**Hamilton, TN**
South Mouse Creek	**51**	**-84.80236**	**35.30356**	**1**	**1195**	**Bradley, TN**
Sugar Creek	**275**	**-84.89681**	**35.35760**	**1**	**1686**	**Meigs, TN**
BLUE RIDGE RESERVOIR						
Blue Ridge North	**68**	**-84.23452**	**34.85833**	**3**	**-**	**Fannin, GA**
Blue Ridge South	**553**	**-84.24971**	**34.81196**	**3**	**-**	**Fannin, GA**
CHATUGE RESERVOIR						
Bell Creek	**165**	**-83.74291**	**34.97170**	**3**	**-**	**Towns, GA**
Hightown Creek	**328**	**-83.72626**	**34.92128**	**3**	**-**	**Towns, GA**
Sutton Branch	**73**	**-83.76494**	**34.93433**	**3**	**-**	**Towns, GA**
Woodring Branch	**90**	**-83.76221**	**34.92885**	**3**	**-**	**Towns, GA**
NOTTELY RESERVOIR						
Nottely North Complex	**629**			**3**	**-**	**Union, GA**
Ivylog Creek	396	-84.04102	34.93343	3		
Conley Creek	123	-84.06526	34.95085	3		
Potoete Branch	110	-84.09930	34.94535	3		
Nottely South	**618**	**-83.99557**	**34.87345**	**3**	**-**	**Union, GA**
HIWASSEE RESERVOIR						
Nottely River RM 2-4	**133**	**-84.07837**	**35.05813**	**3**	**-**	**Cherokee, NC**
Hiwassee River RM 94 Left	**103**	**-84.06039**	**35.09839**	**3**	**-**	**Cherokee, NC**
Hiwassee River RM 94 Right	**25**	**-84.05678**	**35.10.359**	**3**	**-**	**Cherokee, NC**
Beech Creek	**81**	**-84.11442**	**35.07448**	**3**	**-**	**Cherokee, NC**
Grape Creek	**58**	**-84.10470**	**35.12939**	**3**	**-**	**Cherokee, NC**
Persimmon Creek	**110**	**-84.16923**	**35.07244**	**3**	**-**	**Cherokee, NC**
WATTS BAR RESERVOIR						
Swan Pond Flat	**9**	**-84.51601**	**35.92290**	**2**	**-**	**Roane, TN**
Emory River Flat	**30**	**-84.50101**	**35.91389**	**1**	**-**	**Roane, TN**
Huffine Island	**189**	**-84.47506**	**35.77553**	**3**	**-**	**Roane, TN**
Long Island	**50**	**-84.50333**	**35.82627**	**2**	**-**	**Roane, TN**
TELLICO RESERVOIR						
Harrison Island Complex	**150**			**3**	**-**	**Monroe, TN**

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
Harrison Island 1	98	-84.09565	35.54655	3		
Harrison Island 2	52	-84.12595	35.56245	3		
NORRIS RESERVOIR						
Big Ridge Boat Ramp	**1**	**-83.93571**	**36.24019**	**3**	**14**	**Anderson, TN**
CHEROKEE RESERVOIR						
Cherokee Flats Complex	**741**	**-**	**-**	**3**	**-**	**Grainger/Hawkins, TN**
Beech Ridge Flats	227	-83.26938	36.31150	3		
Holston River RM 84	389	-83.21637	36.30845	3		
Holston River RM 74	125	-83.28832	36.28542	3		
Dry Branch Cherokee Flat	**133**	**-83.16826**	**36.3204**	**3**	**-**	**Hamblen, TN**
German Creek	**14**	**-83.31998**	**36.34435**	**3**	**-**	**Grainger, TN**
Ray Creek	**88**	**-83.40291**	**36.31397**	**3**	**-**	**Grainger, TN**
DOUGLAS RESERVOIR						
Allen Creek/Taylors Bend	**326**	**-83.24749**	**36.02086**	**1**	**407**	**Cocke, TN**
Dutch Bottoms Complex	**532**	**-**	**-**	**1**	**7418**	**Cocke/Jefferson, TN**
Walters Bridge	99	-83.25287	36.04955	1		
French Broad RM 66	433	-83.24154	36.06661	1		
French Broad RM 53	**114**	**-83.35268**	**36.02719**	**3**	**-**	**Jefferson, TN**
Nolichucky Flats	**397**	**-83.23509**	**36.10046**	**1**	**581**	**Cocke, TN**
Swan Bridge (Interstate)	**107**	**-83.31951**	**36.04014**		**1740**	**Jefferson, TN**
Rankin Bottoms Complex	**754**	**-**	**-**	**1**	**11607**	**Cocke/Jefferson, TN**
Rankin Bottoms	531	-83.23228	36.07434	1		
Rankin Bottoms 2	102	-83.21562	36.06422	1		
Leadville	121	-83.25233	36.08701	2		
BOONE RESERVOIR						
Austin Springs	**108**	**-82.34979**	**36.38895**	**2**	**97**	**Washington, TN**
WATAGUA RESERVOIR						
Roan Creek	**17**	**-81.94165**	**36.37787**	**3**	**-**	**Johnson, TN**
Watauga Complex	**26**	**-**	**-**	**3**	**-**	**Johnson/Carter,**

Site Name	Acres	Longitude	Latitude	Priority	Total Birds	County
						TN
Big Dry Run	8	-81.94303	36.32081	3		
Draught Creek	3	-81.94032	36.30878	3		
Elk River	15	-82.00263	36.28659	3		
SOUTH HOLSTON RESERVOIR						
Musick's Campground/ Paddle Creek Pond	**221**	**-82.03566**	**36.59063**	**2**	**82**	**Washington, VA/Sullivan, TN**
OFF-RESERVOIR (East Region)						
Eagle Bend Hatchery	**43**	**-84.11073**	**36.11704**	**1**	**-**	**Anderson, TN**
Emory Road Wetland	**4**	**-83.97825**	**36.05842**	**3**	**-**	**Knox, TN**
Kingston Ash Ponds	**51**	**-84.51116**	**35.90865**	**1**	**4324**	**Roane, TN**
Kyker Bottoms	**144**	**-84.11447**	**35.60511**	**2**	**-**	**Blount, TN**
Morristown Hatchery	**10**			**3**	**14**	

[a] = Aggregations of sites within close proximity are noted as complexes, with individual site names, locations (decimal degrees) and county.

10.3. Total number and relative abundance of shorebirds observed during Tennessee River Valley shorebird surveys, July, 2004 - June, 2009.

Species	Scientific Name	N	%
Killdeer	*Charadrius vociferous*	67,269	52%
Least Sandpiper	*Calidris minutilla*	19,455	15%
Wilson's Snipe	*Gallinago delicata*	8,410	6%
Pectoral Sandpiper	*Calidris melanotos*	7,008	5%
Lesser Yellowlegs	*Tringa flavipes*	5,915	5%
Dunlin	*Calidris alpina*	4,818	4%
Unknown Shorebirds (Peeps)	*Calidris spp.*	3,923	3%
Greater Yellowlegs	*Tringa melanoleuca*	3,634	3%
Semipalmated Sandpiper	*Calidris pusilla*	2,014	2%
Semipalmated Plover	*Charadrius semipalmatus*	1,152	1%
Spotted Sandpiper	*Actitis macularius*	1,138	1%
Solitary Sandpiper	*Tringa solitaria*	1,041	1%
Western Sandpiper	*Calidris mauri*	718	1%
Stilt Sandpiper	*Calidris himantopus*	559	<1%
Unidentified Yellowlegs	*Tringa spp.*	492	<1%
Short-billed Dowitcher	*Limnodromus griseus*	487	<1%
White-rumped Sandpiper	*Calidris fuscicollis*	307	<1%
Black-bellied Plover	*Pluvialis squatarola*	298	<1%
Unidentified Dowitcher	*Limnodromus spp.*	219	<1%
Willet	*Catoptrophorus semipalmatus*	176	<1%
Sanderling	*Calidris alba*	168	<1%
Long-billed Dowitcher	*Limnodromus scolopaceus*	155	<1%
Baird's Sandpiper	*Calidris bairdii*	140	<1%
American Golden-plover	*Pluvialis dominica*	132	<1%
Buff-breasted Sandpiper	*Tryngites subruficollis*	114	<1%
American Avocet	*Recurvirostra americana*	102	<1%
Marbled Godwit	*Limosa fedoa*	47	<1%
Wilson’s Phalarope	*Phalaropus tricolor*	27	<1%
Ruddy Turnstone	*Arenaria interpres*	17	<1%
Black-necked Stilt	*Himantopus mexicanus*	8	<1%
Unknown Plover	*Pluvialis spp.*	8	<1%
Red-necked Phalarope	*Phalaropus lobatus*	7	<1%
Upland Sandpiper	*Bartramia longicauda*	6	<1%
Long-billed Curlew	*Numenius americanus*	5	<1%
American Woodcock	*Scolopax minor*	4	<1%
Hudsonian Godwit	*Limosa haemastica*	3	<1%
Piping Plover 0.0023%	*Charadrius melodus*	3	<1%
Whimbrel	*Numenius phaeopus*	3	<1%
Red Knot	*Calidris canutus*	2	<1%

Red Phalarope	*Phalaropus fulicarius*	1	<1%
Ruff	*Philomachus pugnax*	1	<1%
Total		**129,986**	

10.4. Total number and relative abundance of waterfowl reported during the min-winter waterfowl counts in the Tennessee River Valley, 2005-2009. A summary of data acquired from the USFWS Migratory Bird Office, Memphis, Tennessee.

Species	Scientific Name	N	%
Mallard	*Anas platyrhynchos*	725,108	54.5%
Gadwall	*Anas strepera*	221,313	16.6%
Ring-necked duck	*Aythya collaris*	64,892	4.9%
Northern Pintail	*Anas acuta*	62,209	4.7%
Green-winged Teal	*Anas crecca*	51,261	3.8%
American wigeon	*Anas americana*	43,767	3.3%
Canada goose	*Branta canadensis*	37,461	2.8%
American black duck	*Anas rubripes*	35,968	2.7%
Scaup	*Aythya sp.*	18,102	1.4%
Northern Shoveler	*Anas clypeata*	14,987	1.1%
Canvasback	*Aythya valisineria*	12,646	<1%
Snow goose	*Chen caerulescens*	11,291	<1%
Ruddy duck	*Oxyura jamaicensis*	9,007	<1%
Merganser	*Lophodytes sp.*	8,221	<1%
Bufflehead	*Bucephala albeola*	5,085	<1%
Common goldeneye	*Bucephala clangula*	4,308	<1%
Greater white-fronted goose	*Anser albifrons*	2,079	<1%
Unidentified Duck		1,778	<1%
Wood duck	*Aix sponsa*	1,492	<1%
Redhead	*Aythya americana*	497	<1%
Blue-winged Teal	*Anas discors*	12	<1%
Ross's goose	*Chen rossii*	3	<1%
Total		**1,331,487**	

10.5. Plants species identified on Eagle Creek Embayment at sample sites on Kentucky Reservoir, 2005-2008. Percent abundance is noted for each species present annually. Mean of total observation within site is also noted (). Shaded blocks indicate elevations that were inundated at time of sampling (November).

Site	Elevation	Site Description	Species	% 2005	% 2006	% 2007	% 2008
1	**357.9**	Area nearest wooded shoreline. In addition to emergent vegetation, trees and shrubs occupy some portions.	*Alternanthera philoxeroides*		**10**	**0-100 (39)**	**25**
			Aster simplex	**65-70**	**5-35**	**0-35 (14)**	**10**
			Bidens tripartite		**1-3**	**0-5 (1)**	**5**
			Bryophata sp.		**20-40**		
			Cardamine pensylvanica		**1-3**		
			Cephalanthus occidentalis			**0-15 (4)**	**<5**
			Cuscuta campestris	**30**	**1-25**	**0-30 (11)**	**5**
			Cyperus esculentus		**20-30**	**0-10 (3)**	**75**
			Echinochloa crus-galli				**1-2**
			Echinochloa cordifolius				**2**
			Eleocharis acicularis		**1**	**0-35 (18)**	**50-75**
			Eleocharis obtusa		**1**		
			Eragrostis hypnoides		**15-60**		
			Hibiscus leavis			**0-10 (3)**	**15-20**
			Justicia americana	**15**	**10-20**	**0-20 (6)**	**25-50**
			Penthorum sedoides				**10**
			Pluchea camphorate				**<1**
			Polygonum hydropiperoides			**0-60 (26)**	**<5**
			Polygonum pensylvanicum				**<1**
			Polygonum punctatum				**<1**
			Rorippa sp		**1**		
			Rotala ramosior		**5-10**		

			Salix Nigra				**<5**
			Scirpus cyperinus				**1**
			Taxodium distichum				
2	**357.4**	Area of hummocks and swales	*Alternanthera philoxeroides*		**15**	**0-70 (18)**	**10**
			Aster simplex	**25**	**33**		**10**
			Bidens tripartite	**5**	**10-60**	**0-40 (16)**	**75**
			Bryophata sp.	**20-30**	**30-50**		**60**
			Callitriche heterophylla		**1**		
			Cardamine pensylvanica		**15-25**		**<1**
			Cuscuta campestris	**15**	**15**	**0-10 (5)**	
			Cyperus esculentus	**40-45**	**35-50**	**50-70 (59)**	**80**
			Cyperus flavicomus	**20**			
			Eleocharis acicularis	**50**	**10-80 (45)**	**0-50 (26)**	
			Eleocharis obtusa	**15**			
			Echinochloa crus-galli				**<1**
			Eragrostis hypnoides	**20**	**1-15**	**0-10 (4)**	
			Fimbristylis vahlii			**0-5 (1)**	
			Justicia americana	**0-65 (35)**	**1**	**0-20 (5)**	**25**
			Ludwigia palustris		**1**		
			Polygonum pensylvanicum		**10**		**<1**
			Rotala ramosior	**40-45**	**1-25**	**0-15 (6)**	
			Salix nigra		**1**		**<1**
			Taxodium distichum				**<1**
			Xanthium strumarium				**<1**
3	**356.9**	Transitional area between sections of the mudflat that appears to be somewhat dry and inundated frequently. Dominant vegetation is a mixture of low-growing rushes, toothcup	*Alternanthera philoxeroides*		**59**	**0-70 (18)**	**25**
			Aster simplex		**22**		**5**

		and lovegrass with clumps of aster, alligator-weed, common water-willow weed and chufa (pure stands).	*Bidens tripartite*	**5**	**1-5**		**75**
			Bryophata sp.	**25**	**15-20**	**35**	**75**
			Cardamine pensylvanica	**5**	**30**		
			Cephalanthus occidentalis				**2-5**
			Cyperus esculentus		**1**		**80**
			Cyperus flavicomus	**20**		**3**	
			Eleocharis acicularis	**50**	**85**	**50**	
			Echinochloa crus-galli				**<1**
			Eragrostis hypnoides	**20-25**		**25**	
			Fimbristylis vahlii		**5**	**1**	
			Justicia americana				**10-15**
			Ludwigia palustris	**5**			
			Polygonum amphibium	**5**			
			Polygonum hydropiperoides				**<1**
			Polygonum pensylvanicum				**<1**
			Rotala ramosior	**10**	**5**	**10**	
			Sibara virginica	**1**			
			Salix Nigra				**5-10**
			Xanthium pensylvanicum	**1**			**5-10**
4	**356.4**	Low-grounding vegetation in area that appears to be inundated infrequently.	*Alternanthera philoxeroides*				**25**
			Aster simplex		**1**		**1-2**
			Bidens tripartite				**25**
			Bryophata sp.	**30-40**	**25**	**35**	**25**
			Cardamine pensylvanica		**50-70**		**15**
			Cephalanthus occidentalis				**<1**
			Cuscuta campestris				**<1**

			Cyperus flavicomus	**5**		**3**	
			Eleocharis acicularis	**50**	**60-85**	**50**	
			Eragrostis hypnoides	**20-25**		**25**	
			Eryngium prostratum		**1**		
			Fimbristylis vahlii	**1**	**1**	**1**	
			Justicia americana				**1-2**
			Ludwigia palustris				**1**
			Polygonum pensylvanicum		**1**		**5**
			Potamogeton nodosus				**<1**
			Rotala ramosior	**5-10**	**1-5**	**10**	
			Sibara virginica	**1**			
			Xanthium pensylvanicum				**<1**
5	**355.9**	Sparse vegetation. Recently inundated. Moist.	*Ammania coccinea*	**1**		**1**	
			Aster simplex				**1**
			Algae	**1**			
			Bidens tripartite				**<1**
			Bryophata sp.	**15**		**35**	**80**
			Cardamine pensylvanica				**65**
			Cyperus sp.			**3**	**5**
			Eleocharis acicularis	**5**		**50**	**5**
			Echinochloa crus-galli				**<1**
			Eragrostis hypnoides			**25**	**35**
			Fimbristylis vahlii			**1**	**40**
			Lindernia dubia				**<1**
			Polygonum pensylvanicum				
			Rotala ramosior	**1**		**10**	**35**
			Sagittaria calycina	**1**		**1**	
			Sibara virginica	**1**			

6	**355.4**	Sparse vegetation. Recently inundated. Moist.	*Aster simplex*				**<1**
			Bidens tripartite				**<1**
			Bryophata sp.	**1**			**80**
			Cardamine pensylvanica				**75-80**
			Eleocharis acicularis	**5**			**5**
			Eragrostis hypnoides				**75-80**
			Fimbristylis vahlii				
			Polygonum pensylvanicum				**<1**
			Rotala ramosior	**1**			**1**
7	**354.9**	Saturated. Little vegetation.	*Bidens tripartite*				**<1**
			Bryophata sp.				**80**
			Cardamine pensylvanica				**20**
			Cyperus sp.				**<1**
			Echinochloa crus-galli				**<1**
			Eleocharis acicularis				**<1**
			Eragrostis hypnoides				**55**
			Fimbristylis vahlii				**25**
			Polygonum pensylvanicum				**<1**
			Rotala ramosior				**<1**
Water Level	**354.6**						

10.6. Plant species identified on Eagle Creek Embayment, Kentucky Reservoir, Tennessee River, 2005-2008

Common Name	Scientific Name	2005	2006	2007	2008
Alligator-weed	*Alternanthera philoxeroides*	X	X	X	X
Scarlet ammannia	*Ammannia coccinea*	X		X	
Marsh aster	*Aster lanceolatus*	X	X	X	X
Bearded beggarticks	*Bidens aristosa*			X	X
Three-lobe beggarticks	*Bidens tripartita*	X	X		
White doll's-daisy	*Boltonia asteroides*				
Redvine	*Brunnichia ovata*				
Bryophata	*Bryophata sp*	X	X	X	X
Large water-starwort	*Callitriche heterophylla*				
Pennsylvania bittercress	*Cardamine pensylvanica*		X	X	X
Buttonbush	*Cephalanthus occidentalis*	X		X	X
Love-vine	*Cuscuta campestris*	X	X	X	X
Gronovius dodder	*Cuscuta gronovii*			X	X
Chufa flatsedge	*Cyperus esculentus*	X	X	X	X
White-edge flatsedge	*Cyperus flavicomus*	X		X	
Rusty flatsedge	*Cyperus odoratus*			X	X
Awned cyperus	*Cyperus squarrosus*			X	X
Barnyard grass	*Echinochloa crus-galli*				X
Upright burhead	*Echinodorus cordifolius*				X
Least spikerush	*Eleocharis acicularis*	X	X	X	X
Blunt spikerush	*Eleocharis obtusa*	X	X		
Ovate spikerush	*Eleocharis ovata*			X	
Teal lovegrass	*Eragrostis hypnoides*	X	X	X	X

Prostrate eryngo	*Eryngium prostratum*				
Vahl's fimbry	*Fimbristylis vahlii*	X		X	X
Indian heliotrope	*Heliotropium indicum*				
Dwarf bulrush	*Lipocarpha micrantha*				X
Halberd-leaf rosemallow	*Hibiscus laevis*	X		X	X
Swamp rosemallow	*Hibiscus moscheutos*				
Common water-willow	*Justicia americana*	X	X	X	X
Rice cutgrass	*Leersia oryzoides*			X	
Duckweed	*Lemna* sp.		X		
Yellowseed false pimpernel	*Lindernia dubia*			X	X
Primrose-willow	*Ludwigia decurrens*	X			
Marsh seedbox	*Ludwigia palustris*				X
Ditch-stonecrop	*Penthorum sedoides*			X	X
Marsh fleabane	*Pluchea camphorata*	X			X
Water smartweed	*Polygonum amphibium*	X			
Mild water-pepper	*Polygonum hydropiperoides*	X		X	X
Pennsylvania smartweed	*Polygonum pensylvanicum*				X
Dotted smartweed	*Polygonum punctatum*			X	X
Floating pondweed	*Potamogeton nodosus*			X	X
Watercress	*Rorippa nasturtium-aquaticum*		X		
Toothcup	*Rotala ramosior*	X	X	X	X
Long-lobe arrowhead	*Sagittaria calycina*	X		X	
Black willow	*Salix nigra*	X			X
Cottongrass bullrush	*Scirpus cyperinus*	X			X
Virginia rockcress	*Sibara virginica*	X			
Bald cypress	*Taxodium distichum*	X			X
Rough cockleburr	*Xanthium strumarium*	X			X

10.7. Digital Elevation Models for 10 mudflats in the Tennessee River Valley.

Big Sandy River - Kentucky Reservoir

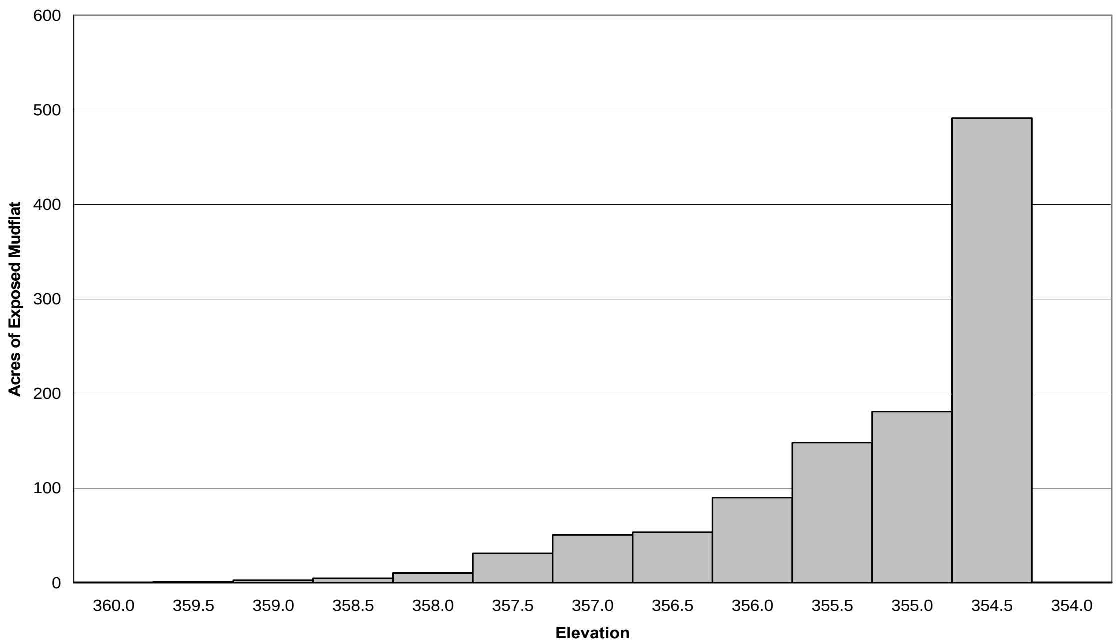


Figure 1: Acres of habitat exposed per elevation level, Big Sandy Embayment, Kentucky Reservoir.

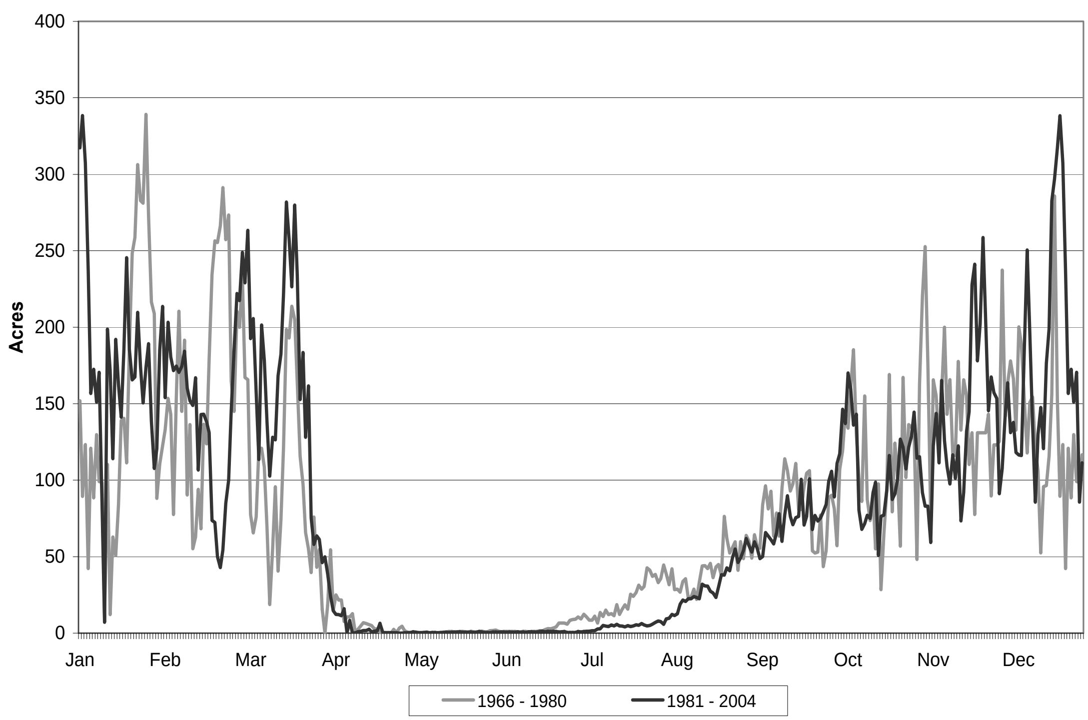


Figure 2. Acres of habitat available during each reservoir management period, Big Sandy Embayment, Kentucky Reservoir.

Birdsong River - Kentucky Reservoir

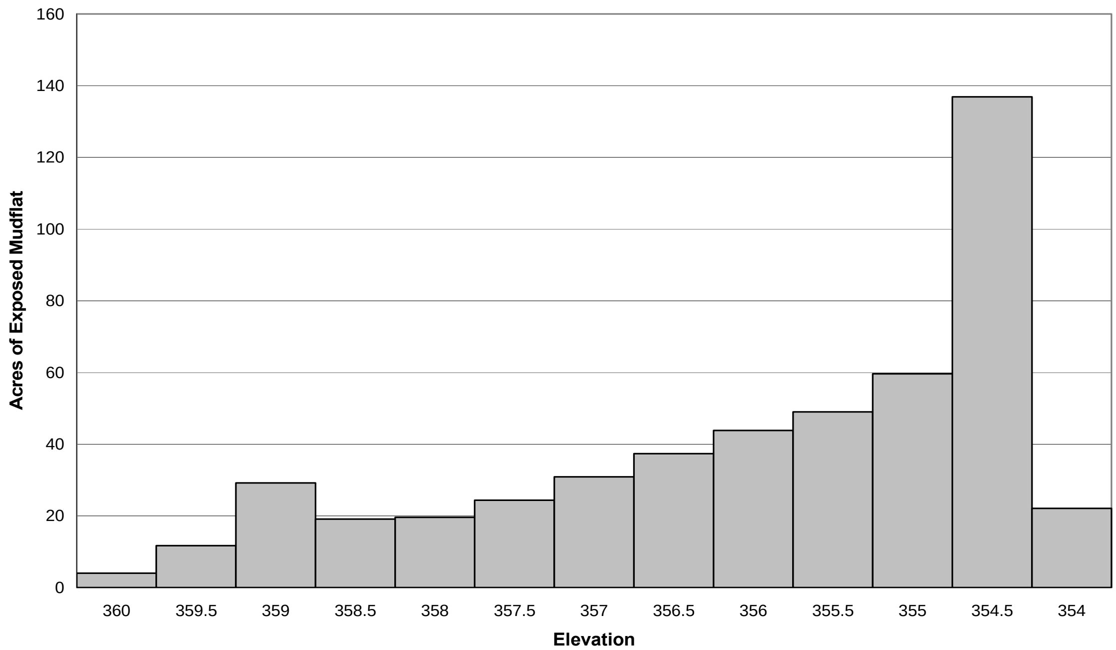


Figure 3: Acres of habitat exposed per elevation level, Birdsong Embayment, Kentucky Reservoir.

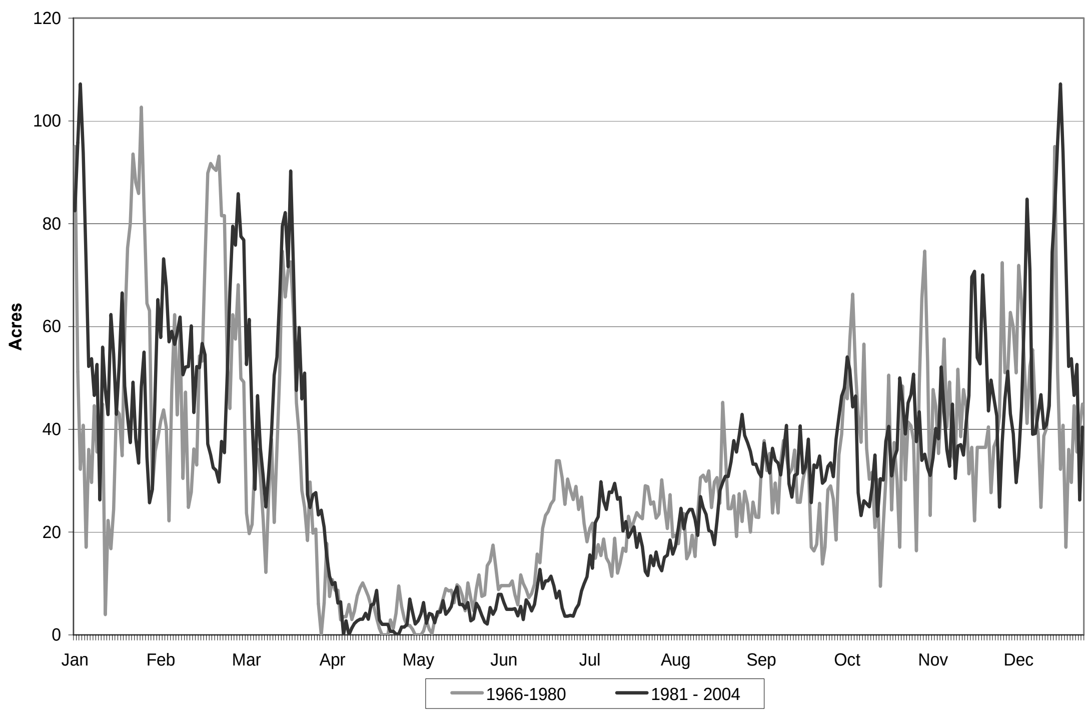


Figure 4. Acres of habitat available during each reservoir management period, Birdsong Creek Embayment, Kentucky Reservoir.

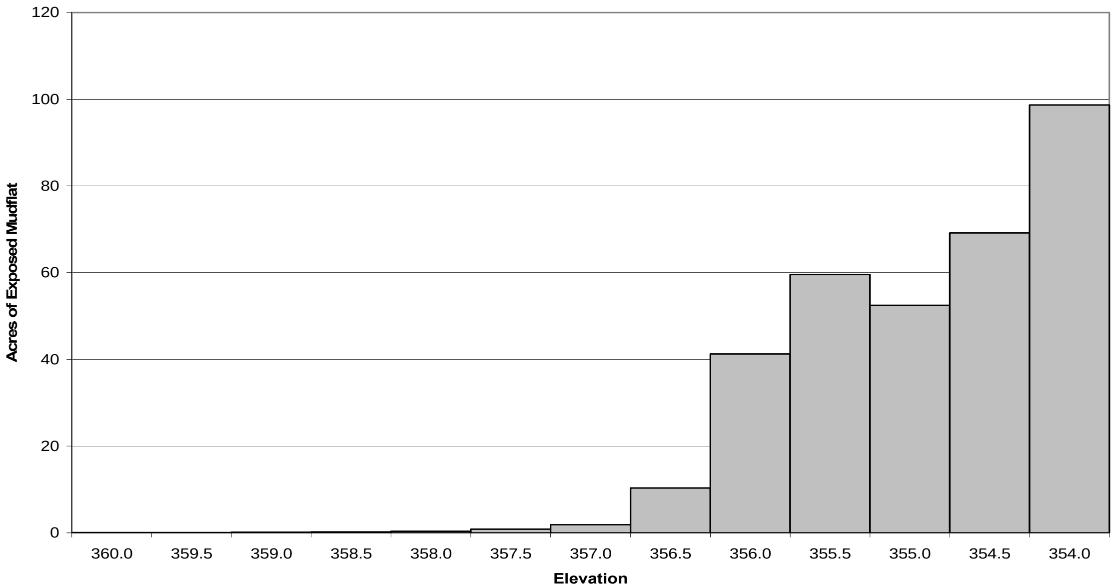


Figure 5: Acres of habitat exposed per elevation level, Jonathan Creek Embayment, Kentucky Reservoir.

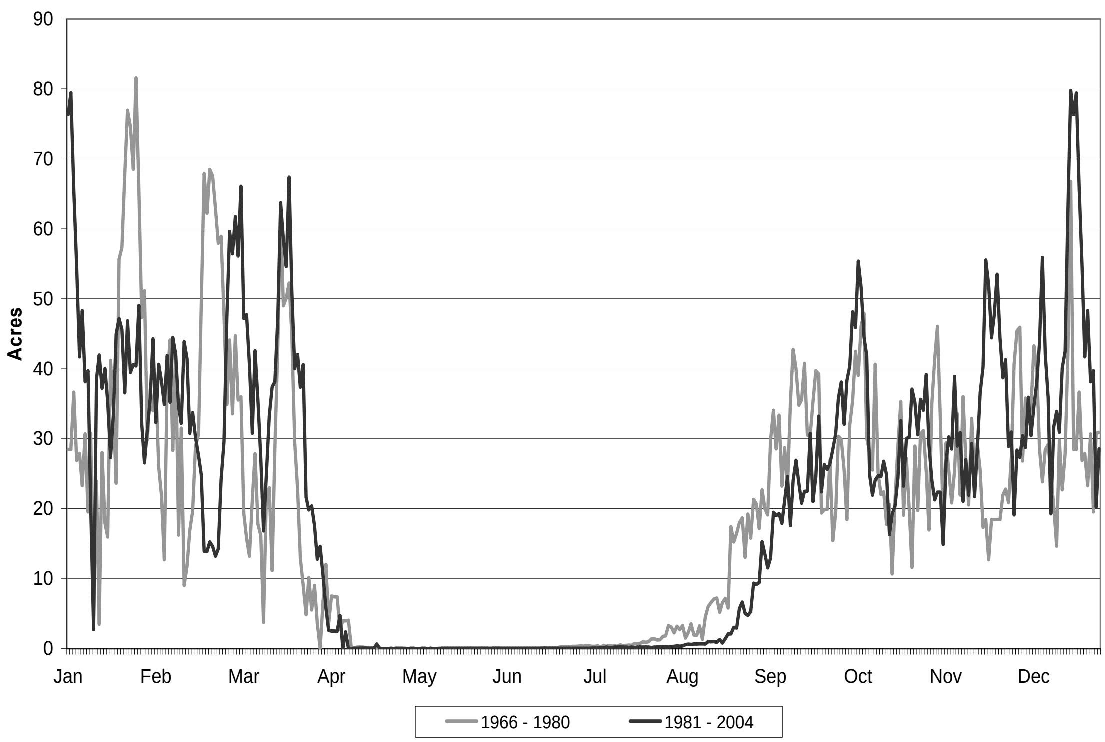


Figure 6. Acres of habitat available during each reservoir management period, Jonathan Creek Embayment, Kentucky Reservoir.

Blood River - Kentucky Reservoir

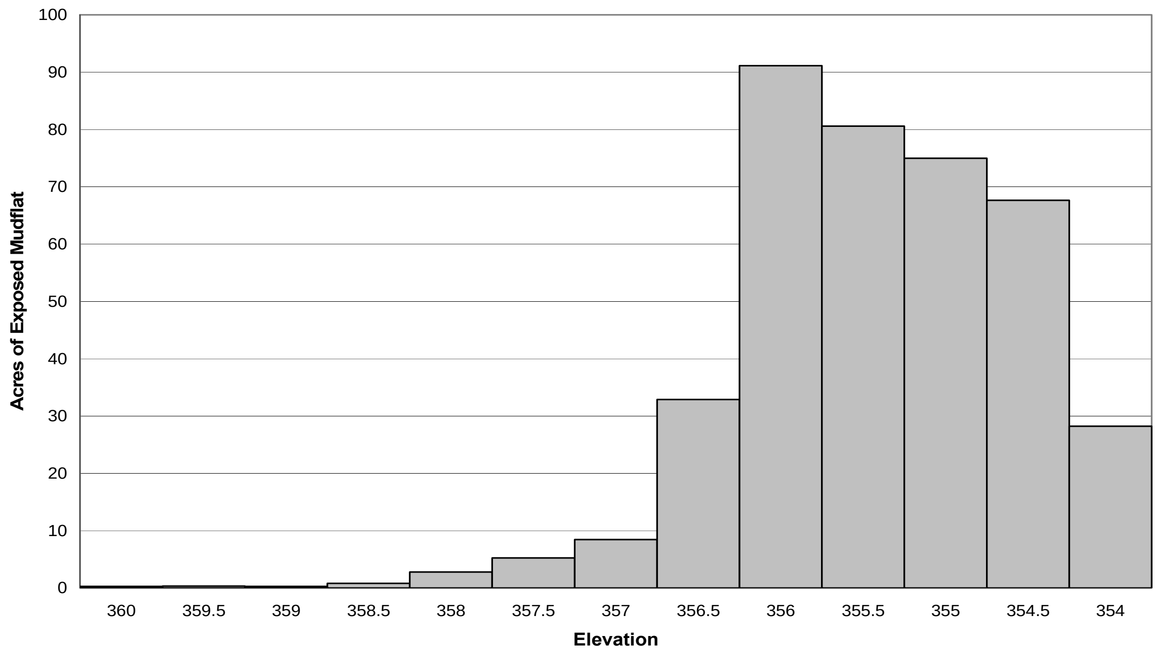


Figure 7. Acres of habitat exposed per elevation level, Blood River Embayment, Kentucky Reservoir.

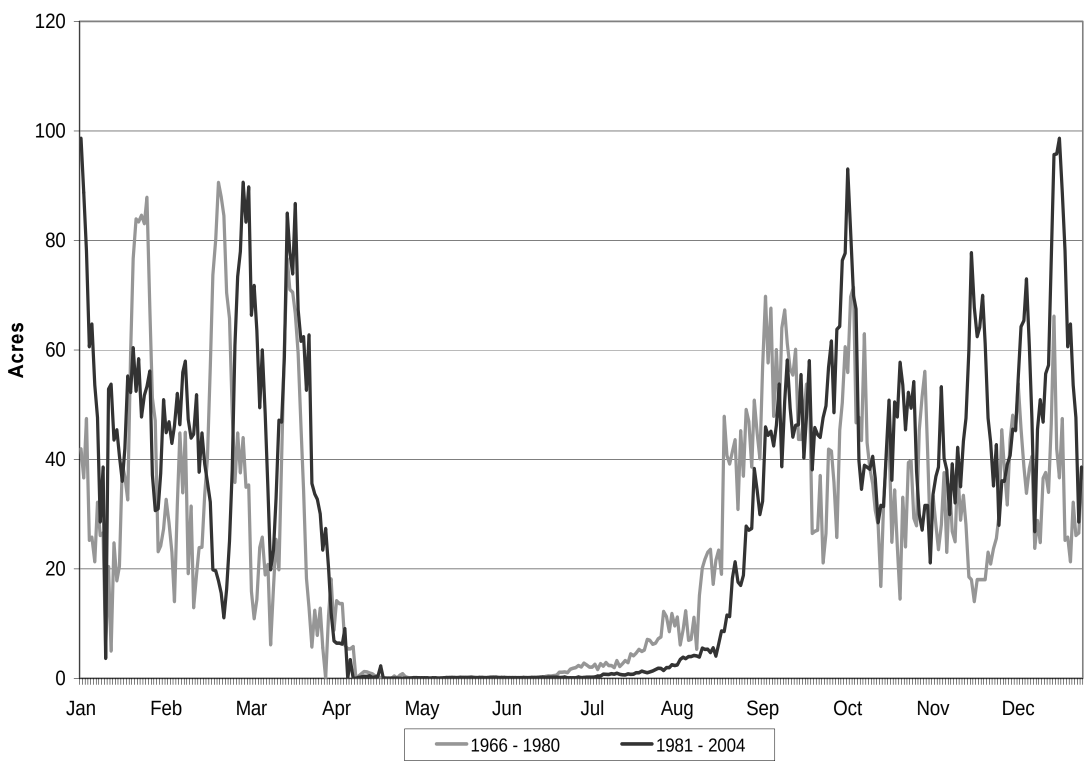


Figure 8. Acres of habitat available during each reservoir management period, Blood River Embayment, Kentucky Reservoir.

Duck River - Kentucky Reservoir

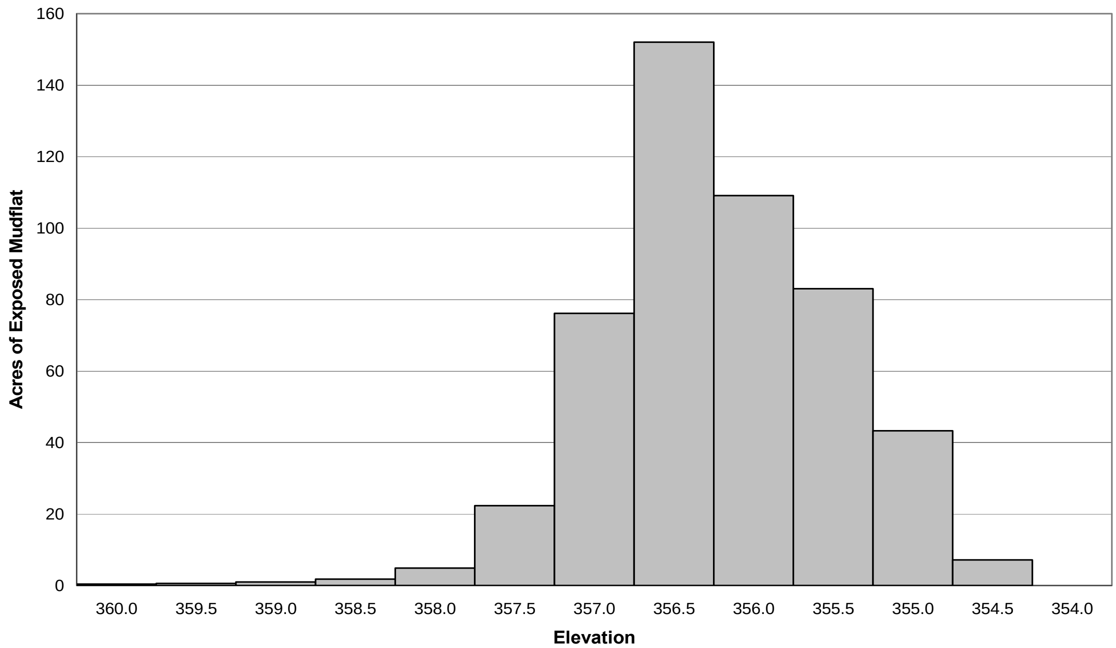


Figure 9. Acres of habitat exposed per elevation level, Duck River Embayment, Kentucky Reservoir.

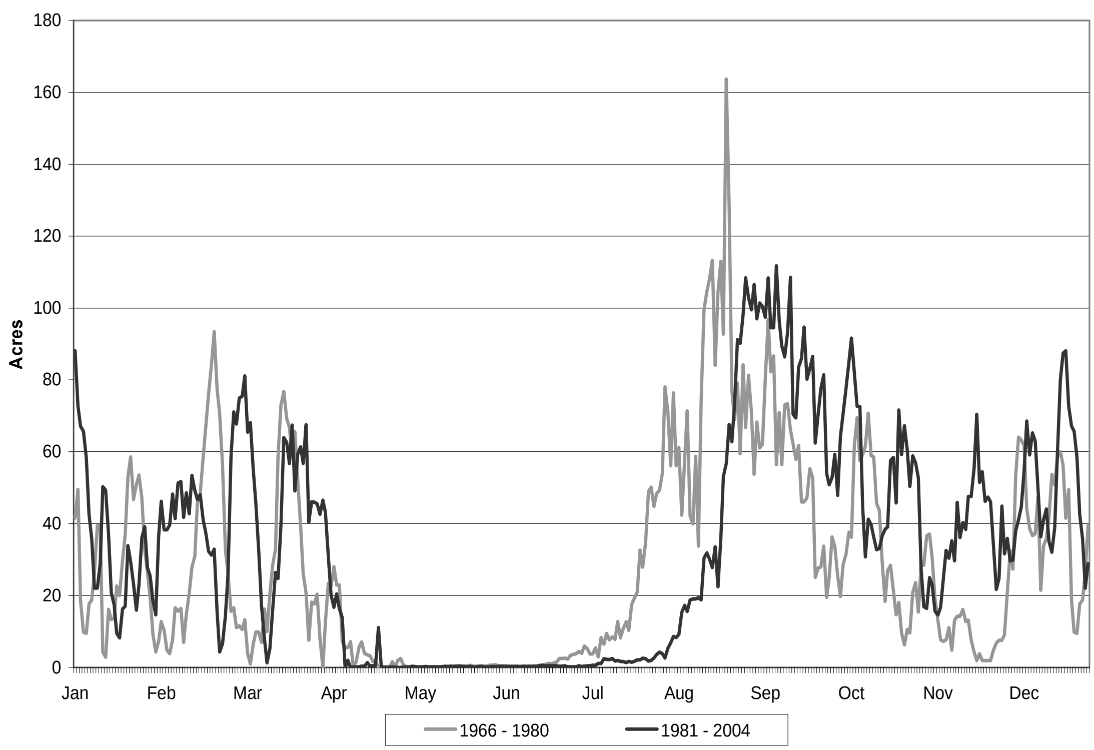


Figure 10. Acres of habitat available during each reservoir management period, Duck River Embayment, Kentucky Reservoir.

Swan Creek/Beulah Bay - Wheeler Reservoir

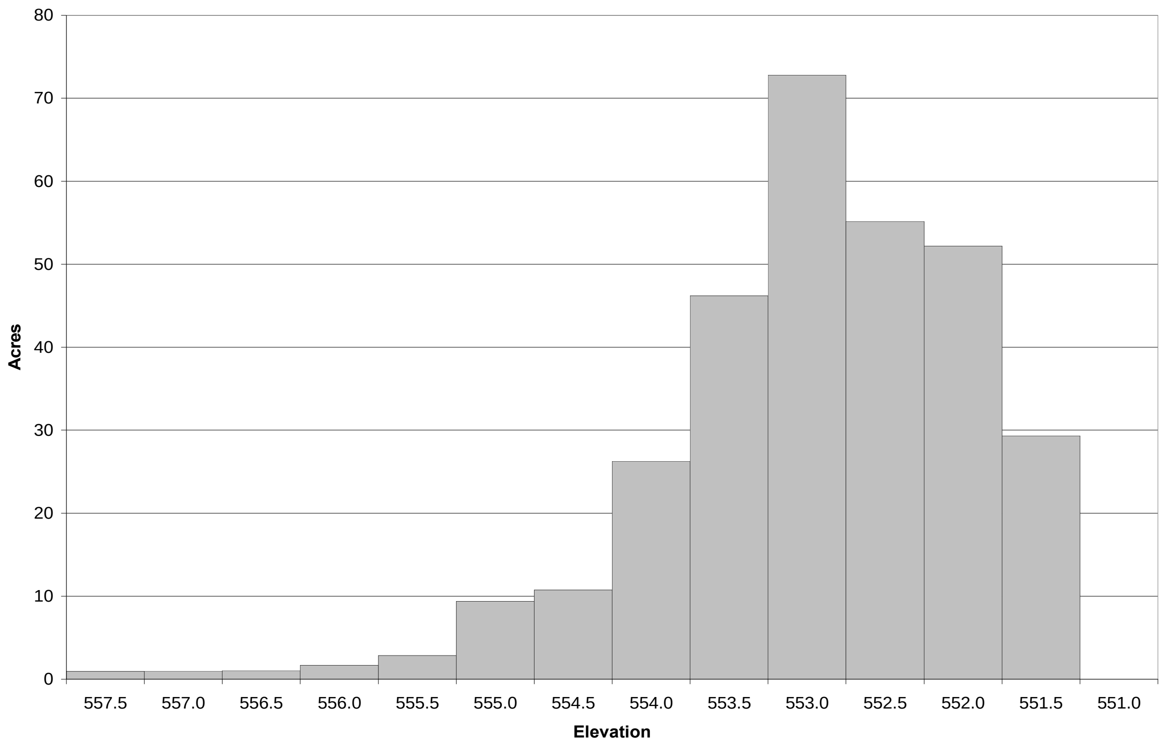


Figure 10. Acres of habitat exposed per elevation level, Swan Creek Embayment, Wheeler Reservoir.

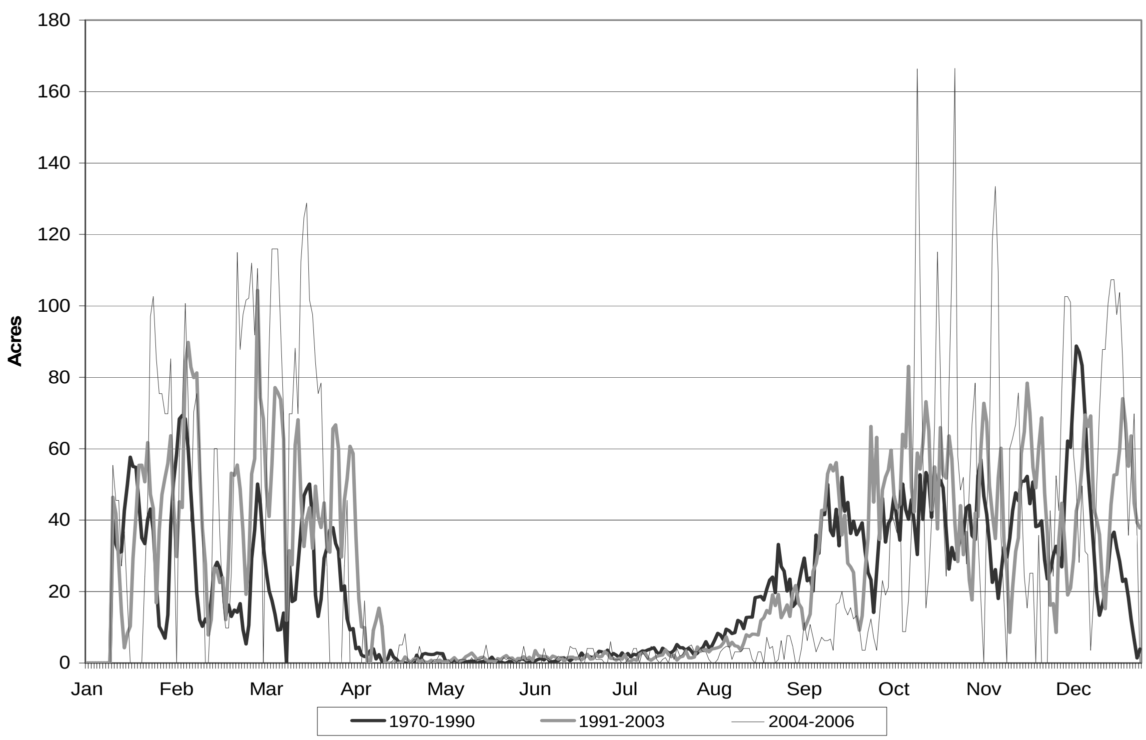


Figure 11. Acres of habitat available during each reservoir management period, Swan Creek Embayment, Wheeler Reservoir.

Limestone Bay - Wheeler Reservoir

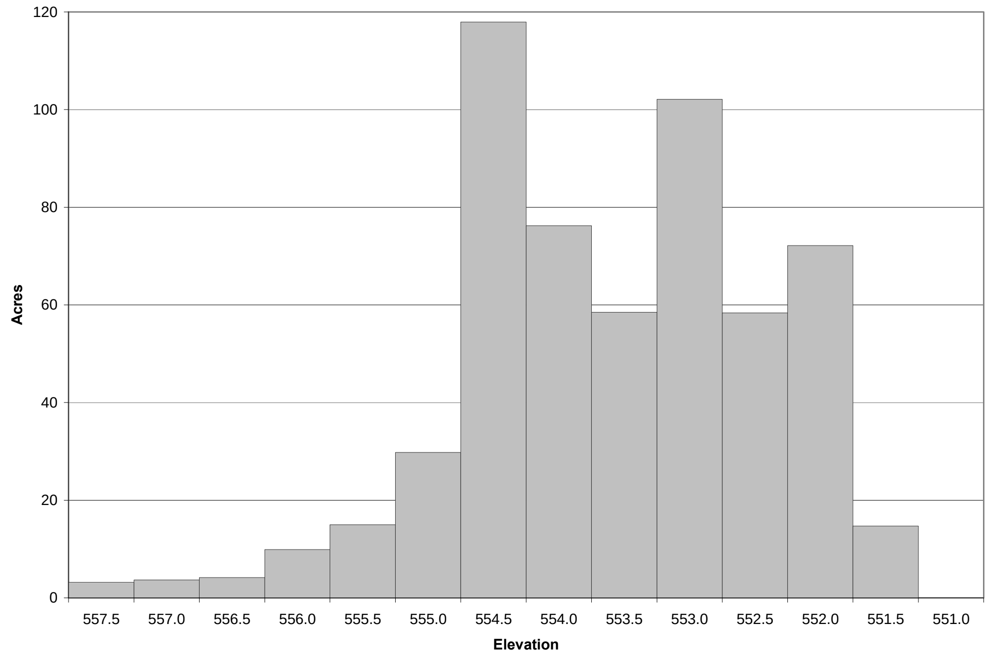


Figure 12. Acres of habitat exposed per elevation level, Limestone Bay Embayment, Wheeler Reservoi

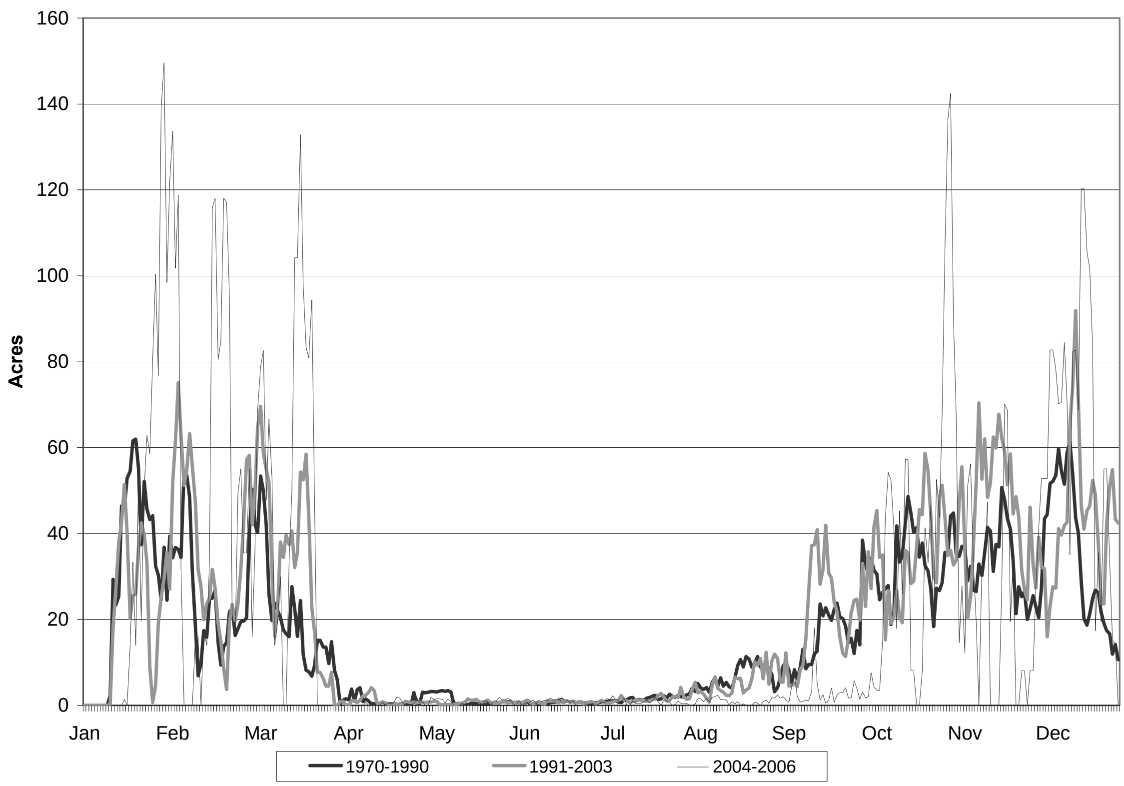


Figure 13. Acres of habitat available during each reservoir management period, Swan Creek Embayment, Wheeler Reservoir.

Bear Creek - Pickwick Reservoir

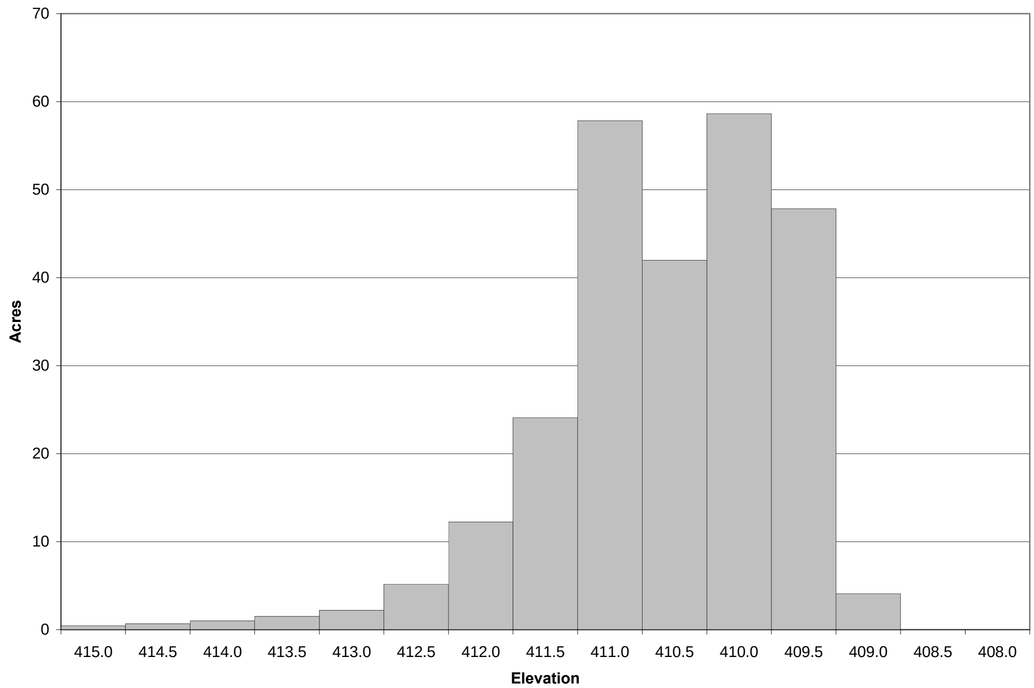


Figure 14. Acres of habitat exposed per elevation level, Bear Creek Embayment, Pickwick Reservoir

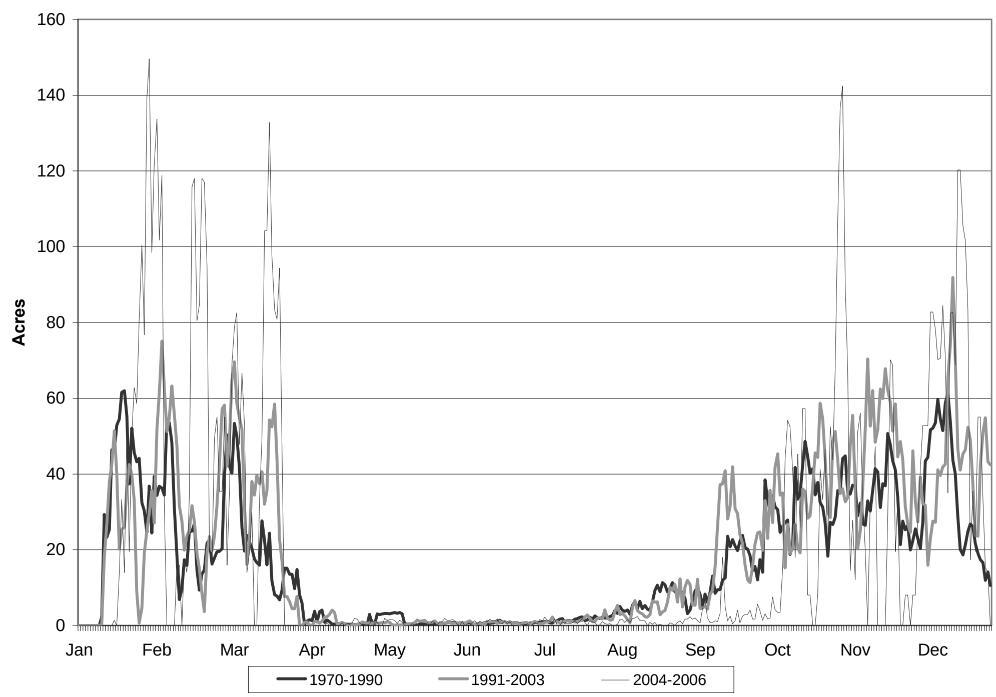


Figure 15. Acres of habitat available during each reservoir management period, Bear Creek Embayment, Pickwick Reservoir