APPENDIX H

ERDC Report: Shale Barren Mapping and Threatened and Endangered Species Survey for Raystown Lake, PA

January 2019

Shale Barren Mapping and Threatened and Endangered Species Surveys for Raystown Lake, PA: U.S. Army Corps of Engineers, Baltimore District

Prepared for USACE – Baltimore District
Raystown Lake, 6145 Seven Points Road, Hesston, PA 16647

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Abstract

This study mapped and surveyed shale barren plant communities at Raystown Lake, Huntingdon County, Pennsylvania. The location and extent of the shale barren communities were assessed, and various botanical species, including state and federal listed species were identified. An acoustic bat survey was done to revise and update a prior bat survey completed in 2014. In addition, invertebrate surveys of aquatic insects and fresh water mussels were also performed. Finally, numerous endemic Noctuid moths were collected to assess the presence or absence of state listed, or other rare and sensitive species, on the shale barrens.

A total of 73 potential shale barren areas were identified and mapped. All shale barren endemic species previously known from Huntingdon County were confirmed at Raystown Lake, with the exception of shale barren goldenrod (*Solidago arguta*). Some endemic shale barren plants located during the surveys include Kate's Mountain clover (*Trifolium virginicum*), shale barren bindweed (*Calystegia spithamaea*), shale barren evening primrose (*Oenothera argillicola*), mountain nailwort (*Paronychia fastigiata* var. *pumila*), and shale barren pussytoes (*Antennaria virginica*). New localities of some species, including low false-bindweed (*Caystegia spithamaea*) and eastern prickly-pear (*Opuntia* sp.) were noted.

Acoustic bat surveys were performed at 10 sites determined to be the most important for detecting threatened or endangered bats species based on prior acoustic surveys performed in 2014. During August 2018, the long-eared bat (*Myotis septentrionalis*), listed under ESA in 2015, was detected at 4 sites. Other species detected include the big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), and the little brown bat (*Myotis lucifugus*).

Aquatic invertebrate sampling yielded specimens of the Sparkling Jewelwing Damselfly (*Calopteryx dimidiata*), which was thought to be extirpated from Pennsylvania and represents a new county record. Some other additional rare, sensitive aquatic insects collected during this study include the Ocellated Darner Dragonfly (*Boyeria grafiana*), Tiger Spiketail Dragonfly (*Cordulegaster erronea*), and some Perlid stonefly species, *Acroneuria internata* and *Perlesta ephelida*, and the Isonychid mayfly (*Isonychia sayi*). Fresh water mussels detected include the Yellow Lampmussel (*Lampsilis cariosa*), but not the Brook Floater (*Alasmidonta varicosa*). A new detection of the Rainbow Mussel (*Villosa iris*) was documented in the Juniata River.

A total of 11,397 specimens of 349 unique species of terrestrial Lepidoptera and other insects were collected during the Noctuid moth surveys around the shale barrens. Six species identified during the moth surveys are listed by the Pennsylvania Natural Heritage Program as rare, threatened or endangered in the state including, *Xestia elimata*, *Zanclognatha dentata*, *Virbia laeta*, *Megalopyge crispata*, *Macaria promiscuata*, and *Cisthene packardii*.

Breeding birds were also surveyed using point-counts at 26 locations around Raystown Lake in May 2018. Over 400 birds of 63 species, including 16 species identified as Partners in Flight (PIF) priority species for the Appalachian Mountain Bird Conservation Region. Three individuals of the rare Cerulean Warbler (*Setophaga cerulea*) were detected.

Results of all these surveys are expected to update the knowledge and understanding of rare, sensitive, state or federal listed species on Raystown Lake. These results are discussed in relation to

potential management actions that may assist with the conservation and protection of these species and their habitats. Further, these data can now be used to update the Raystown Lake Master Plan.

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PREFACE

This study was conducted for the U.S. Army Corps of Engineers (USACE), Baltimore District, under Project 122148, "Environmental Stewardship Operations". The purpose of the study was to conduct botanical surveys on sensitive shale barren habitats for the USACE Raystown Lake project. The shale barrens were mapped and additional surveys took place including surveys of Threatened and Endangered species of bats, aquatic invertebrates, and endemic Noctuid moths associated with the shale barrens. Results of this study will improve new Master Plan updates for the Raystown Lake Project Area.

The work was performed by the Ecological Resources Branch (EEE-E), the Wetlands and Coastal Ecology Branch (EE-W), and the Aquatics and Invasive Species Branch (EE-A), of the Ecosystem Evaluation and Engineering Division (EE), U.S. Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL). At the time of publication, Dr. Jennifer Seiter-Moser was the Branch Chief (CEERD-EE-E), Ms. Patricia Tolley was the Branch Chief (CEERD-EE-W) and Dr. Tim Lewis was the Branch Chief (CEERD-EE-A), Dr. Mark Farr was Division Chief (CEERD-EE) and Dr. Al Cofrancesco (CEERD-EM-W) was the Technical Director. The Deputy Director of ERDC-EL was Dr. Jack Davis and the Director was Dr. IIker Adiguzel.

Funding for this project was provided by the USACE, Baltimore District. Ms. Avis Kennedy, USACE Nashville District, and Ms. Tara Whitsal, USACE Raystown Lake, helped to coordinate the project and provide information on past work at Raystown Lake, plus assisted with coordination of sampling efforts, monitor site conditions, and with provided access to study sites on the project lands. Mr. Glenn Werner, USACE Raystown Lake, provided important documentation on past research on the Raystown Lake project area. Dr. Nathan Beane (ERDC-EL), provided assistance in the field during fall shale barren surveys. In August, Dr. Jake Jung and Mr. Joey Minter, (both with ERDC-EL), assisted with acoustic bat surveys, while Ms. Hannah McGuire of ERDC-EL, assisted with report preparations. We also thank Mr. Nevin Welte, Pennsylvania Fish and Boat Commission, who provided confirmations of mussel identifications, Mrs. Lauren Leonard (GSI) for contributions in data management and record compilation, and USACE Raystown Lake personnel, Mr. Aiden Nagel and Mr. Hunter Maas, for assistance in Noctuid moth sample collection. Mr. Steve Johnson assisted in moth sampling and Dr. David Wagner, University of Connecticut, and Mr. Dale Schweitzer, assisted with identification of rare or difficult moth species. Collection of aquatic specimens were made under Pennsylvania Fish and Boat Commission Scientific Collection Permits 2018-02-0337 and 2018-02-0340. Mr. Bradley Lewis, Mr. Steven George, and Dr. Reese Worthington (all with ERDC-EL) provided invaluable support for both field and laboratory efforts. The authors thank Drs. Richard Fischer and Jake Jung (both with ERDC-EL), for providing internal peer review.

The Commander of ERDC was COL Bryan S. Green and the Director was Dr. David W. Pittman.

1 Survey of Mid-Appalachian Shale Barrens, Raystown Lake, Pennsylvania

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Introduction

The purpose of this survey was to identify and delineate shale barrens within the project boundaries of Raystown Lake, and characterize their plant communities with an emphasis on determining the presence of federal and state listed plant species. This report is intended to provide information on the location, extent, and condition of shale barrens and woodlands detected during the survey and support current and future management.

Background

Raystown Lake is situated in the Ridge and Valley Province, an area of alternating linear ridges and continuous valleys occurring from New York to Alabama along the Appalachian Plateau Region (USGS 2018). Ridges are underlain by rock strata that have experienced uplift and are resistant to weathering, while valleys are underlain by softer sediments, shale, and limestone that have weathered to a moderately level surface. Shale barrens occur on slopes in this province as woodlands and openings with short-statured trees, and total cover that is often sparse relative to adjacent areas. The barrens are distributed in Maryland (MD), Virginia (VA), West Virginia (WV), and south-central Pennsylvania (PA) where Upper Devonian, Ordovician, and Silurian shales outcrop (Platt 1951; Keener 1983; Figure 1-1). The shale surface layer of these barrens, combined with other site factors, severely inhibits seedling development, leading to their characteristic open vegetation structure.

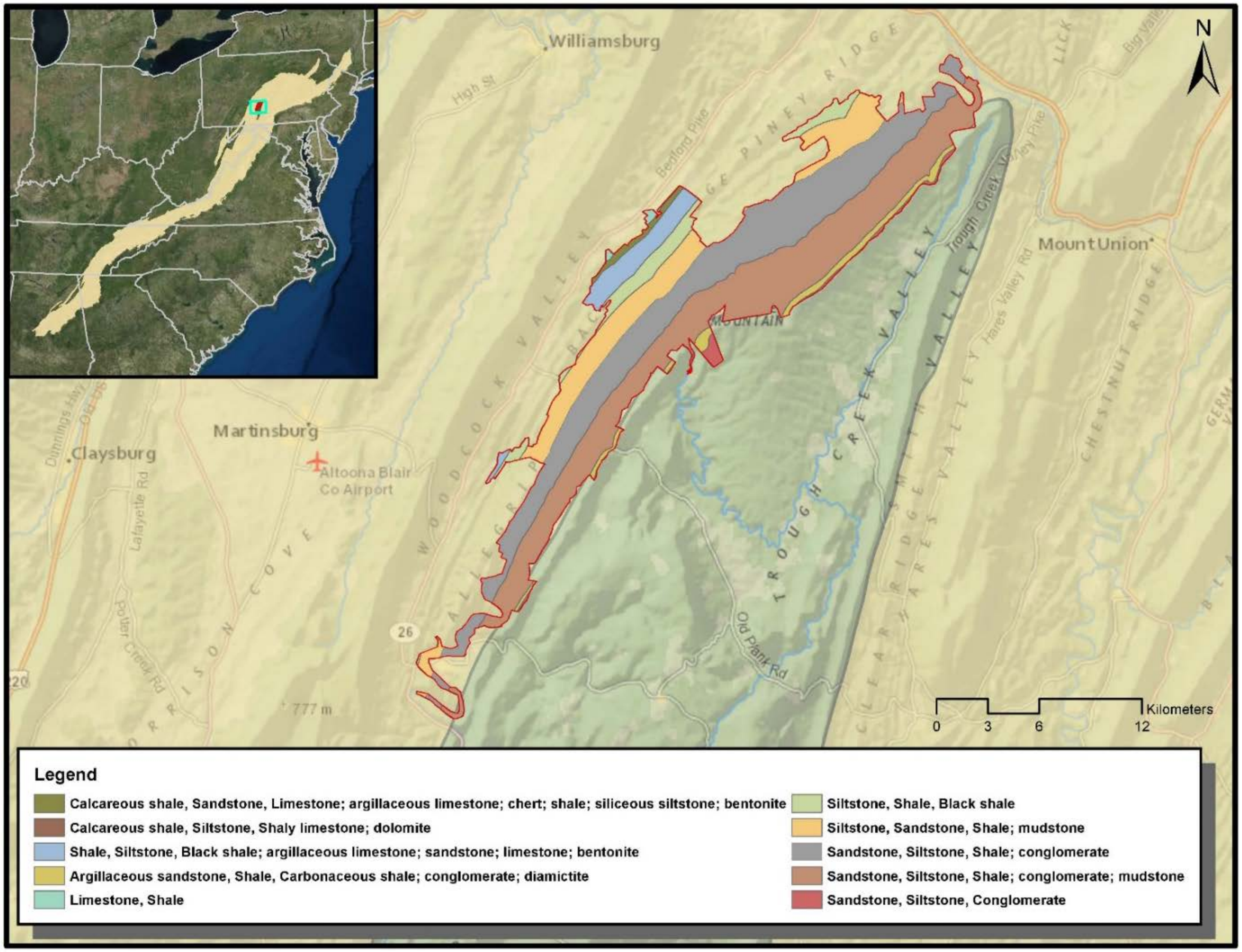

Figure 1-1. Extent of the Ridge and Valley Prince (inset map), and the Lithology of the Raystown Lake area, PA (Pennsylvania Geological Survey 2018).

Barrens typically occupy south-east to west facing exposures with inclines of 20 to 70 degrees, and are often conspicuous in aerial imagery (Keener 1983; Figure 1-2). While most sites are relatively stable, some exhibit active erosion and downslope movement of the shale fragments, especially at exceedingly steep locations. These factors reduce the accumulation of litter on the surface and may dislodge seedlings. The porosity of the coarse rock fragments allows water to infiltrate the soil horizons below, but maintains a xeric surface layer. Seedlings that do not rapidly establish their roots below the surface layer of rock fragments perish during the summer growing season. Shale barrens also experience high surface temperatures during the summer months, often exceeding 55°C for several hours per day, and have been known to reach 63°C (Platt 1951). These temperatures are greater than the tolerance level of most plants, and cause tissue damage at points of contact. Platt (1951) estimated that approximately 156 seedlings/m^2 were present on a portion of a shale barren in VA during the month of April. A return visit to the same area in mid-June resulted in an estimate of 0.04 seedlings/m^2.

Figure 1-2. Shale barrens along a southwest-facing slope, Raystown Lake, PA.

Woody plants that occupy shale barrens exhibit reduced growth when compared to adjacent non-barren areas. The same factors that affect seedling development are believed to affect the surface-feeding roots of established plants (Platt 1951). Plants cope with the xeric surface layer of the barrens by altering their root-to-shoot ratio in order to supply the required amount of nutrients and water to their above ground tissues (Keener 1983). As trees and shrubs grow larger, they require an equivalent increase in feeder roots near the soil surface. On typical sites, plants have access to moisture and available nutrients from the organic matter on the surface and the A soil horizon immediately below. Barrens lack an organic surface layer and an A soil horizon, therefore, only the C soil horizon below the shale layer supplies moisture and available soil nutrients. These conditions act as a growth limiting factor for trees and shrubs as they increase in size (Platt 1951).

Mid-Appalachian shale barrens are typically occupied by trees such as eastern red cedar (*Juniperus virginiana var. virginiana* L.), Virginia pine (*Pinus virginiana* Mill.), chestnut oak (*Quercus montana* Willd.), and pignut hickory (*Carya glabra* [Mill.] Sweet). Northern red oak (*Quercus rubra* L.) and Table-mountain pine (*Pinus pungens* Lamb.) are also known to frequently occur on barrens. White ash (*Fraxinus americana* L.) was a common component but has been dramatically reduced by the non-native emerald ash-borer (*Agrilus planipennis* Fairmaire). Shrubs are often absent entirely, patchy, or primarily line the perimeter of the barrens where they transition to other forest types. Dwarf hackberry (*Celtis tenuifolia* Nutt.), bear oak (*Quercus ilicifolia* Wangenh.), blueridge blueberry (*Vaccinium pallidum* Aiton), black huckleberry (*Gaylussacia baccata* [Wangenh.] K. Koch), and winged sumac (*Rhus copallinum* L.) are common shrub species. The herbaceous layer tends to be highly variable and can be extremely sparse or have moderate to high cover. Pennsylvania sedge (*Carex pensylvanica* Lam.), poverty oats (*Danthonia spicata* [L.] P. Beauv. ex Roem. & Schult.), and wavy hairgrass (*Deschampsia flexuosa* [L.] Trin.) are the most common graminoids, with Pennsylvania sedge likely having the highest constancy of any herb. Alum-root (*Heuchera americana* L.), rattlesnake-weed (*Hieracium venosum* L.), hairy beardtongue (*Penstemon hirsutus* [L.] Willd.), common dittany (*Cunila origanoides* [L.] Britton), and blue wood aster (*Symphyotrichum cordifolium* [L.] G.L. Nesom) are listed as forbs commonly occurring on shale barrens in PA (Zimmerman et al. 2012).

The openness of the barrens provides conditions of low competition and high available light in the herbaceous layer. Several plant species are adapted to occupy these features exclusively (shale barren endemic) and are unable to compete in other open habitats such as prairies, fields, and roadsides, while quantity and quality of light in forested areas is inadequate for their survival and reproduction (Norris & Sullivan 2002). Several other species are considered near-endemics, most frequently occurring on shale barrens but also found occupying other suitable open habitats (e.g. rock outcrops, glades). Seventeen species are regarded as shale barren endemics/near endemics and are shown in Table 1-1 (Keener 1983; PANHP 2018). Eight are known to occur in PA and are tracked by the state Natural Heritage Program (Definitions of species rankings provided throughout this report can be found in Appendix I. The remaining species, in addition to the eight known from PA, occur primarily in WV and VA.

The greater level of endemism in the south-central portion of the shale barren system is not well understood. It has been hypothesized that a combination of factors such as glaciation in the northern portion during the last glacial maximum, dispersal patterns (arriving from the southwestern United States across temporary “stepping-stones” of suitable habitat), geographic barriers, and differences in evolutionary age likely explain the current distribution of these species (Keener 1983). Lilydale onion (*Allium oxyphilum*), shale barren rockcress (*Arabis serotina*), bent milkvetch (*Astragalus distortus var. distortus*), Virginia white-haired leatherflower (*Clematis coactilis*), Millboro leatherflower (*C. viticaulis*), and Harris' goldenrod (*Solidago arguta var. harrisii*) are believed to have limited distributions because they are relatively young in origin, and have not yet expanded to their maximum distribution potential (“neoschizoendemics”). Low false bindweed (*Calystegia spithamaea ssp. purshiana*), white-hair leatherflower (*Clematis albicoma*), shale-barren wild-buckwheat (*Eriogonum allenii*), mountain nailwort (*Paronychia fastigiata var. pumila*), mountain pimpernel (*Taenidia montana*), and shale-barren ragwort (*Packera antennariifolia*) are considered “holoschizoendemics”. These species are believed to have achieved their distribution potential because they are restricted by barriers to dispersal, and/or lack additional suitable habitat. Kate's Mountain clover (*Trifolium virginicum*) and Buckley's phlox (*Phlox buckleyi*) are considered relics or "paleoendemics". These species have been restricted to the region for a long period of time, are relatively old in evolutionary age, and lack closely related living taxa. Shale barren pussytoes (*Antennaria virginica*) and shale barren evening primrose (*Oenothera argillicola*) are "patroendemics". These are species that arose from paleoendemic taxa that may or may not be extinct, and are themselves considered ancestral to at least two other living species. Smooth sunflower (*Helianthus laevigatus*) is the only "apoendemic" species in this group. Apoendemics are polyploids with a restricted distribution that derived from a more widely distributed diploid ancestor. The difference in ploidy leads to genetic incompatibility between the two closely related taxa (Keener 1983).

Table 1-1. Mid-Appalachian Shale Barren Endemics and their PA Natural Heritage Program Ranking (PANHP) (Keener 1983; PANHP 2018).

Species recorded from Huntingdon County, PA	PANHP Rank
Antennaria virginica Stebbins	S3 N
Calystegia spithamaea ssp. purshiana (Wherry) Brummitt	S4 N
Oenothera argillicola Mack.	S2 PT
Paronychia fastigiata var. pumila (Alph. Wood) Fernald	SP NR
Solidago arguta var. harrisii (Steele) Cronquist	S1 PE
Trifolium virginicum Small ex Small & Vail	S1 PE
Species recorded from PA counties near Raystown Lake	
Packera antennariifolia (Britton) W.A. Weber & Á. Löve	S1 PE
Taenidia montana (Mack.) Cronquist	S1 PE
Species recorded from other states	
Allium oxyphilum Wherry - (WV)	
Arabis serotina Steele – (WV/VA)	
Astragalus distortus Torr. & A. Gray - (MD/WV/VA)	
Clematis albicoma Wherry – (WV/VA)	
Clematis coactilis (Fernald) Keener – (VA)	
Clematis viticaulis Steele – (VA)	
Eriogonum allenii S. Watson – (WV/VA)	
Helianthus laevigatus Torr. & A. Gray - (MD/WV/VA/North Carolina)	
Phlox buckleyi Wherry – (WV/VA)	

Shale barrens have been studied since the early 1900's and continue to be a subject of fascination for botanists, ecologists, and amateur naturalists. Despite this relatively long period of study, there are knowledge gaps pertaining to the processes that create and maintain the characteristic vegetation structure, as well as the taxonomy of endemic/near endemic flora and fauna, their distribution, and ability to persist in the face of impacts (Keener 1983; Norris & Sullivan 2002). Barrens are unsuitable for both merchantable timber production and agricultural purposes, with primary threats from utility and transportation corridor construction, overspray/drift from pesticide applications for gypsy moths (*Lymantria dispar* L.), human foot-traffic, and non-native invasive plants (Norris & Sullivan 2002).

Methods

Areas of interest for investigation were determined using aerial image interpretation and existing records of shale barrens from the PA Natural Heritage Program. Distinct features that occurred on south-east to west slopes with estimated tree canopy cover of approximately 70 percent or less were digitized in ArcMap and assigned a unique identification number (i.e. Raystown Lake Barren 1; "RLB_01"). Areas that appeared to be maintained, developed, or mowed were excluded from further consideration. A total of 73 potential survey areas were identified and are shown in Figures 1-3 and 1-4.

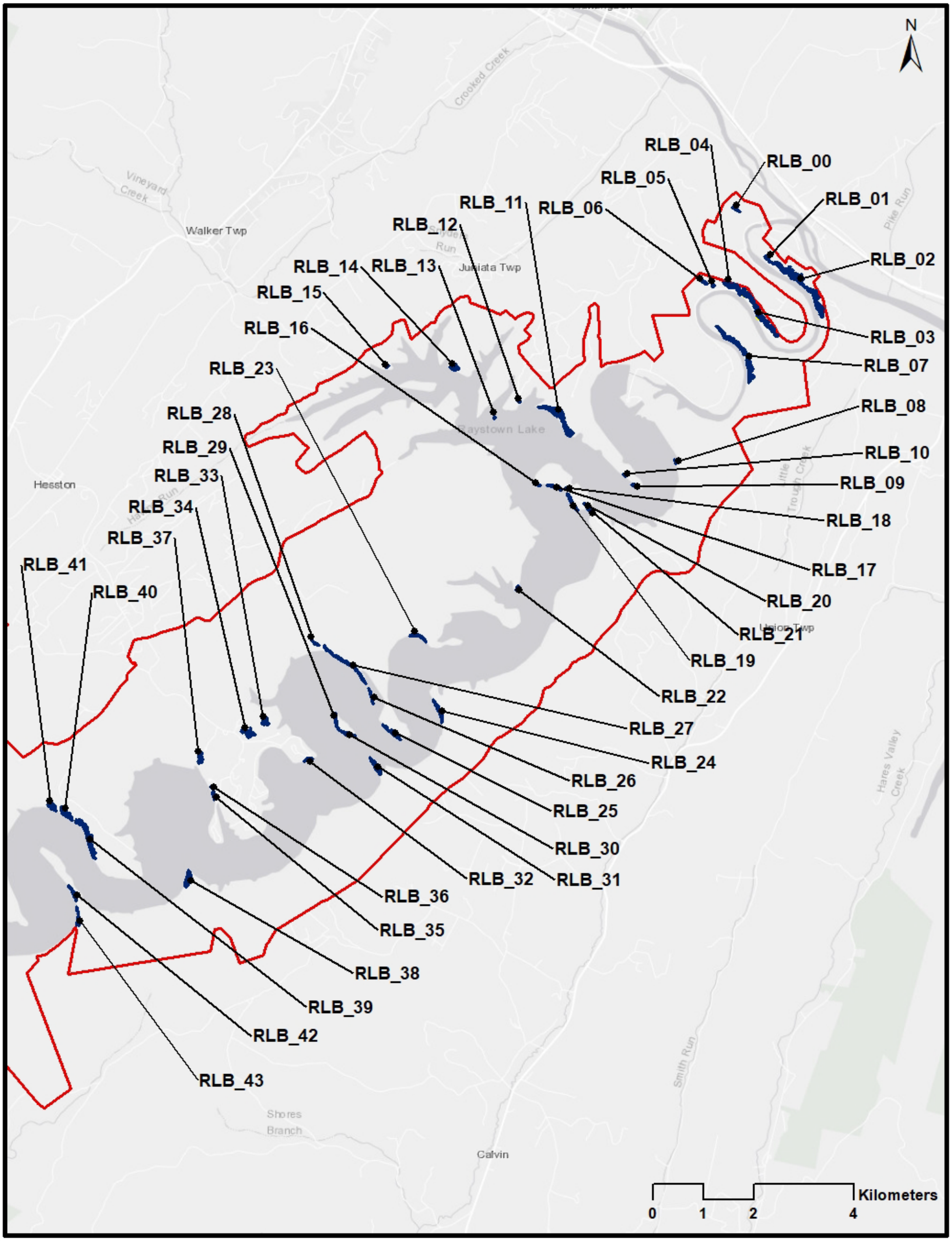

Figure 1-3. Survey areas (dark blue polygons) within the northern portion of Raystown Lake, PA.

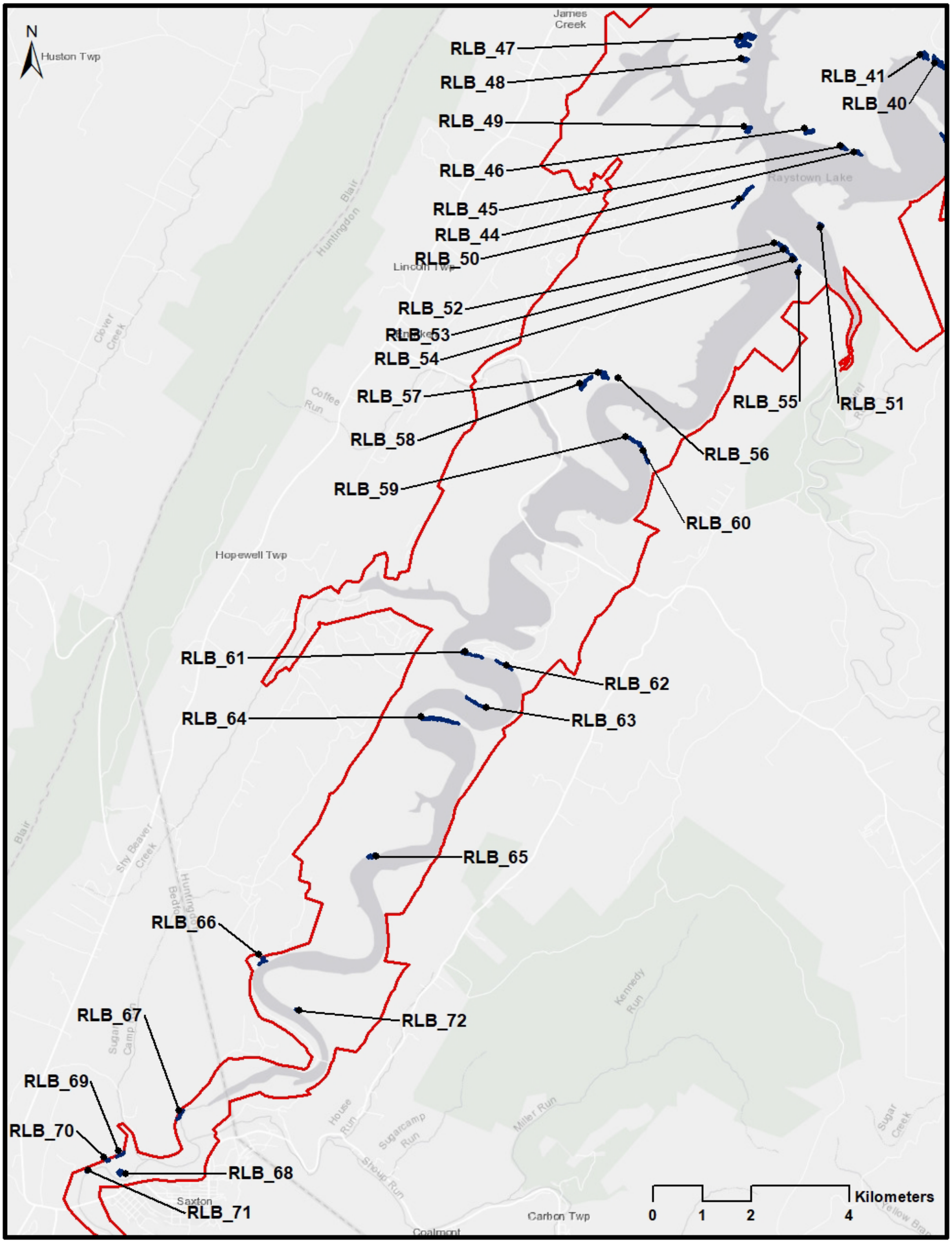

Figure 1-4. Survey areas (dark blue polygons) within the southern portion of Raystown Lake, PA.

Field data collection occurred May 16 - 21 and September 21 - 25, 2018. The extent of shale barrens and woodlands were mapped by traversing these features while using handheld GPS units. Boundaries with adjacent plant communities were determined based on species assemblages, visual tree height and cover estimates, in conjunction with thresholds of percent cover by strata. For example, if trees >5 meters in height occupied >70 percent of the total absolute cover, the area was considered "forested/non-barren". Each survey area was randomly searched for endemic/near-endemic plants listed in Table 1-1, as well as additional listed species. A subset of survey areas was surveyed utilizing a combination of randomized searches and fixed-area plots to determine species abundance and describe the plant community structure.

Results

Species of Concern

All shale-barren endemic/near-endemic species that were previously known from Huntingdon County PA were encountered at Raystown Lake, with the exception of shale-barren goldenrod. Specimens of *Solidago arguta* Aiton were encountered occasionally but lacked mature achenes that are required for determining the correct subspecies. Shale barren ragwort is documented in PA from Bedford, Fulton, and Franklin Counties but was not observed. Mountain pimpernel (*Taenidia montana*) is documented from Bedford County on shale barrens south of Raystown Lake. Plants belonging to this genus are easier to detect when flowering in spring but require mature fruits in order to confirm the species. All occurrences of *Taenidia* that were encountered during the spring were revisited during the fall to observe their fruit morphology. According to the key in Rhoads and Block (2007), the fruits of *T. montana* are 5-7mm long, 3-5mm wide, and narrowly winged. Fruits from all observed occurrences were shorter, narrower, and lacked distinct wings (Figure 1-5); therefore, these populations appear to be *Taenidia integerrima* (L.) Drude, a species common to most of the eastern U.S. (USDA - NRCS 2018). None of the endemic/near-endemic plants with known distributions limited to adjacent states were detected during this survey. Maps provided throughout this section denote survey observations as yellow circles (USACE) and records from PANHP as blue circles. Drawing order of these occurrences places historical records on top of survey observations, if they occurred at the same location.

Figure 1-5. *Taenidia integerrima* in flower (left) and its mature fruits (right), Raystown Lake, PA.

Low false-bindweed (*Calystegia spithamaea ssp. purshiana*) was recorded at four locations. This species occurred as small patches and was not flowering during the spring or fall sampling visits (Figure 1-6). The largest concentration occurred near the brink of a hazardous ledge at RLB_11. Other notable sites where it occurred were along lower slopes, with little competition from other herbaceous plants. All of these sites appear to be new localities for this species (Figure 1-7).


Figure 1-6. Low false-bindweed at, Raystown Lake, PA.

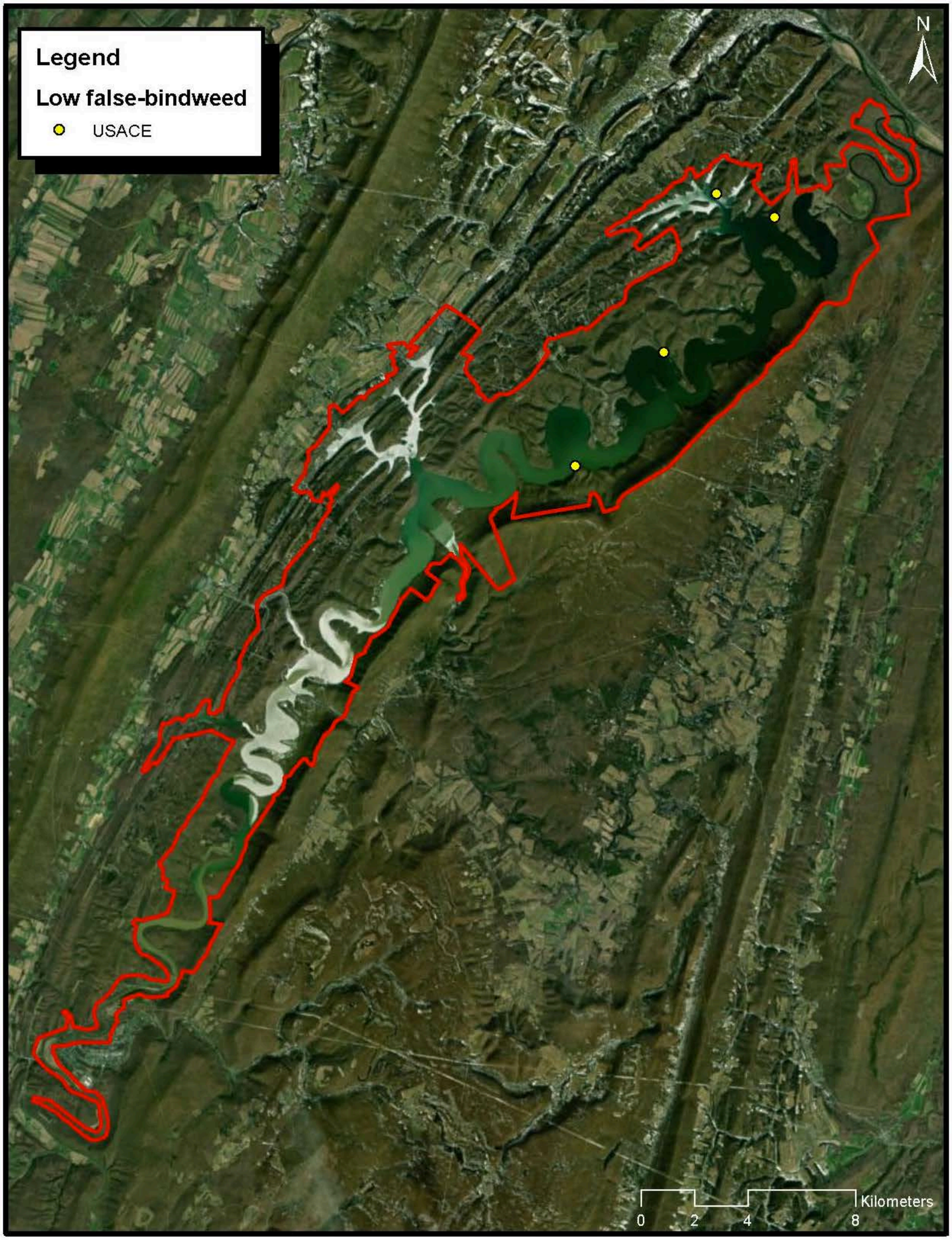

Figure 1-7. Occurrences of low false-bindweed recorded during the spring survey, Raystown Lake, PA.

Shale barren evening-primrose (*Oenothera argillicola*) was flowering and often conspicuous during the fall survey, although non-flowering individuals were also regularly encountered (Figure 1-8). This species occurred predominantly in the northern portion of the Raystown Lake area, with scattered localities farther south (Figure 1-9). Common evening-primrose (*Oenothera biennis* L.) was frequently observed along lower slopes that approached the lake. This species is considered common in PA and found throughout much of eastern North America.

Figure 1-8. (A) Shale barren evening-primrose in flower at RLB_07; (B) non-flowering specimens of shale barren evening-primrose, Raystown Lake, PA.

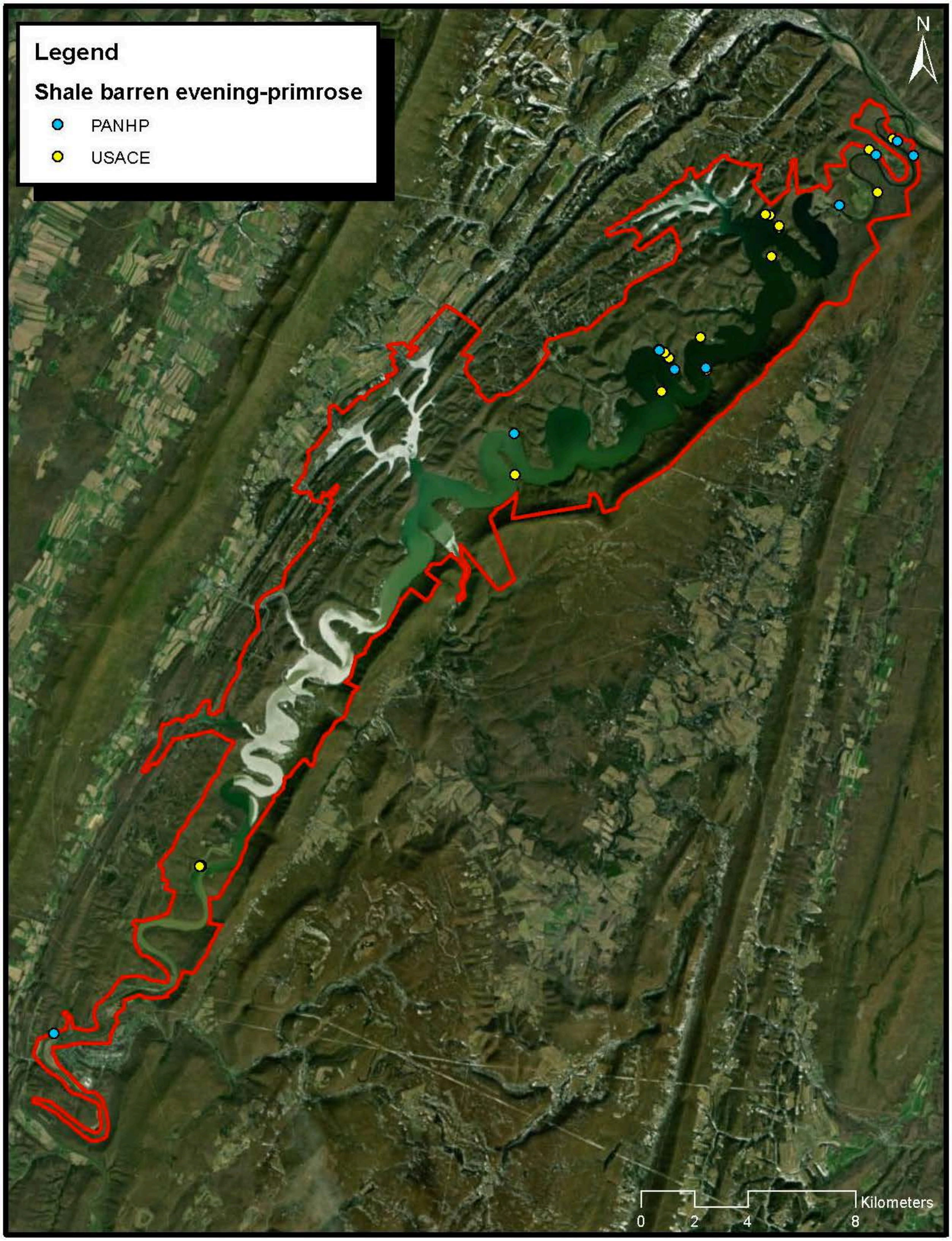

Figure 1-9. Occurrences of shale barren evening-primrose, Raystown Lake, PA.

Kate's Mountain clover (*Trifolium virginicum*) was observed in three survey areas (Figure 1-10). All but one of these locations (RLB_07) were known localities, including the largest patches (approximately 12-18 plants each) that were encountered at RLB_27. Most locations consisted of only a few individuals, and is a commonly observed pattern throughout its range (Keener 1983). Sites RLB_03 and RLB_31 have existing records, but were not detected during this survey. This species was concentrated in the northern portion of the Raystown Lake area (Figure 1-11). Specimens that were observed during the fall sampling period had developed a uniform shade of green, lacking the prominent whitish coloration present on the leaflets during the spring.

Figure 1-10. Kate's Mountain clover at RLB_27, Raystown Lake, PA.

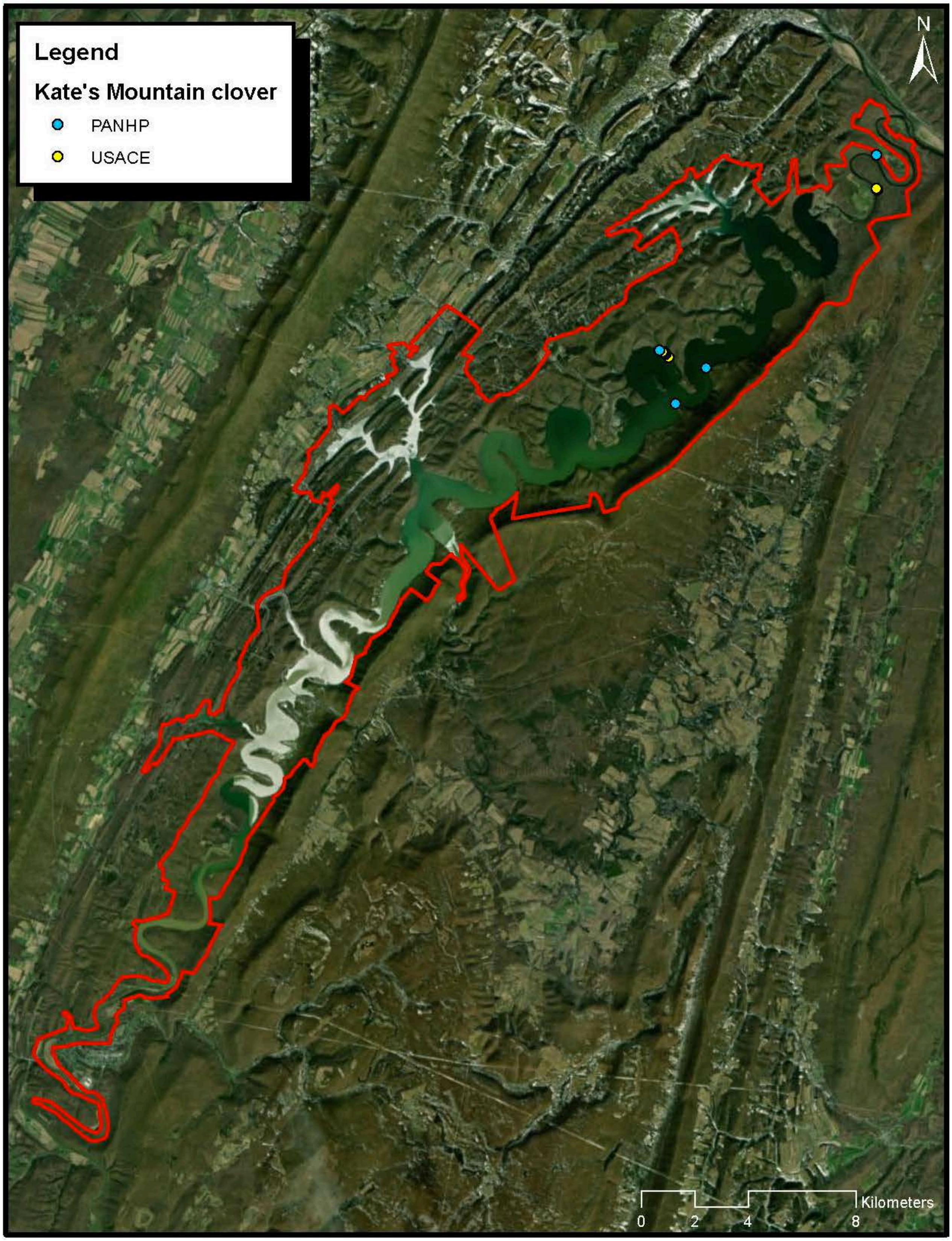

Figure 1-11. Occurrences of Kate's Mountain clover, with a new locality at RLB_07, Raystown Lake, PA.

Mountain nailwort (*Paronychia fastigiata var. pumila*) was not detected during the spring field sampling, and had begun to senesce during the fall (Figure 1-12). This annual plant was usually observed on open, sparsely vegetated areas, and rarely encountered in part shade with competing vegetation. Observations were scattered throughout the Raystown Lake area (Figure 1-13).

Figure 1-12. Mountain nailwort at RLB_07, Raystown Lake, PA.

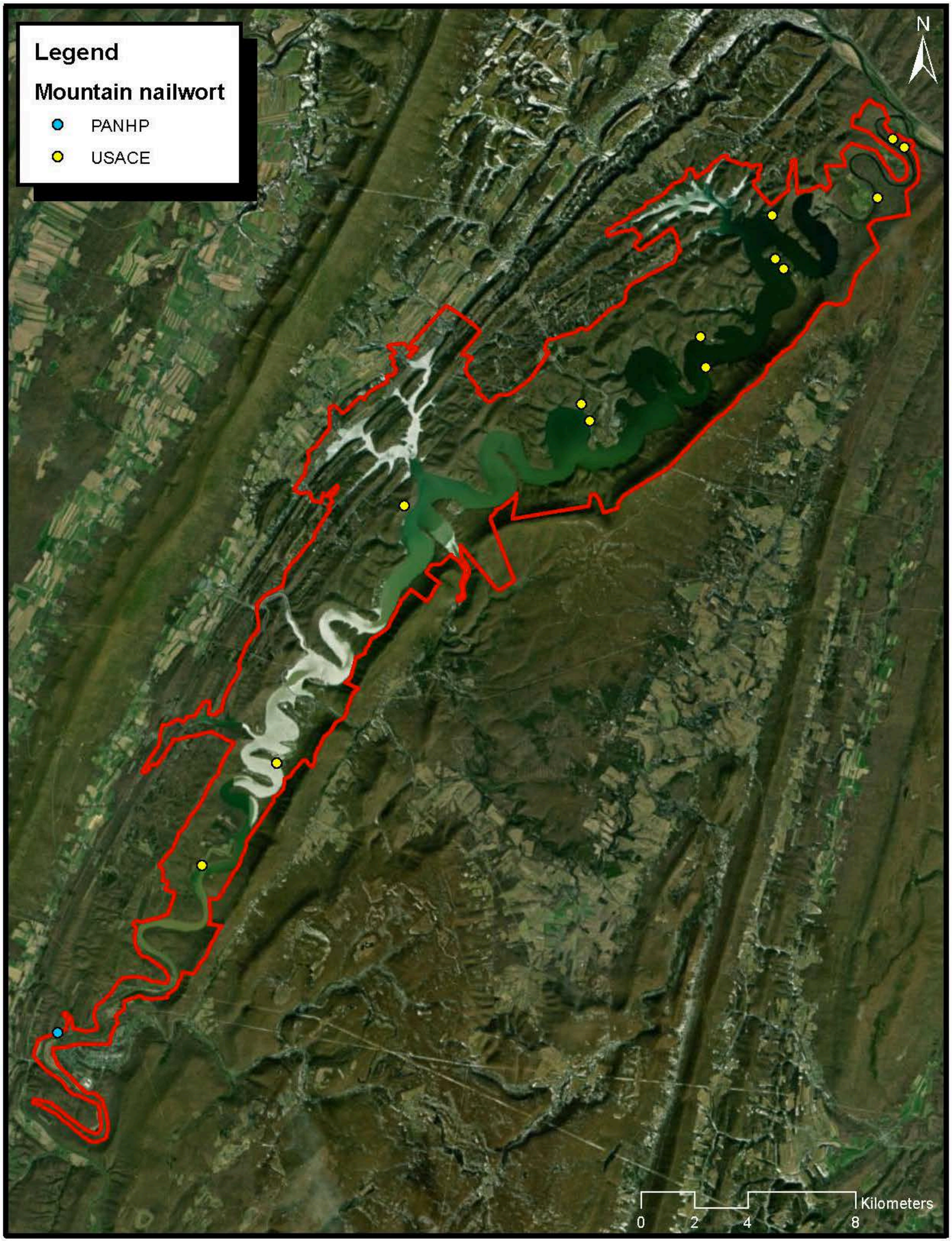

Figure 1-13. Occurrences of mountain nailwort at Raystown Lake, PA.

Shale barren pussytoes (*Antennaria virginica*; Figure 1-14) appeared to be tolerant of partial shading, frequently growing underneath eastern red cedar or Virginia pine. Plantain-leaved pussytoes (*Antennaria plantaginifolia* [L.] Hook.) and Howell's pussytoes (*A. howellii* Greene) are considered common in PA and were regularly encountered in survey areas. Many of the specimens that were observed had morphological attributes that were intermediate or shared with those described for *A. virginica* and *A. howellii*, in both Rhoads and Block (2007) and Weakley (2015). Howell's pussytoes is described as mostly producing pistillate (female) flowers, unlike the plants shown in Figure 1-14 that are predominantly staminate flowers (male). Time constraints during field sampling prohibited detailed examination of each discrete clump. In consideration of these factors, the locations provided for this taxon (Figure 1-15) should be revisited if possible to collect specimens for detailed examination and further confirmation.

Figure 1-14. Shale barren pussytoes at RLB_37, Raystown Lake, PA.

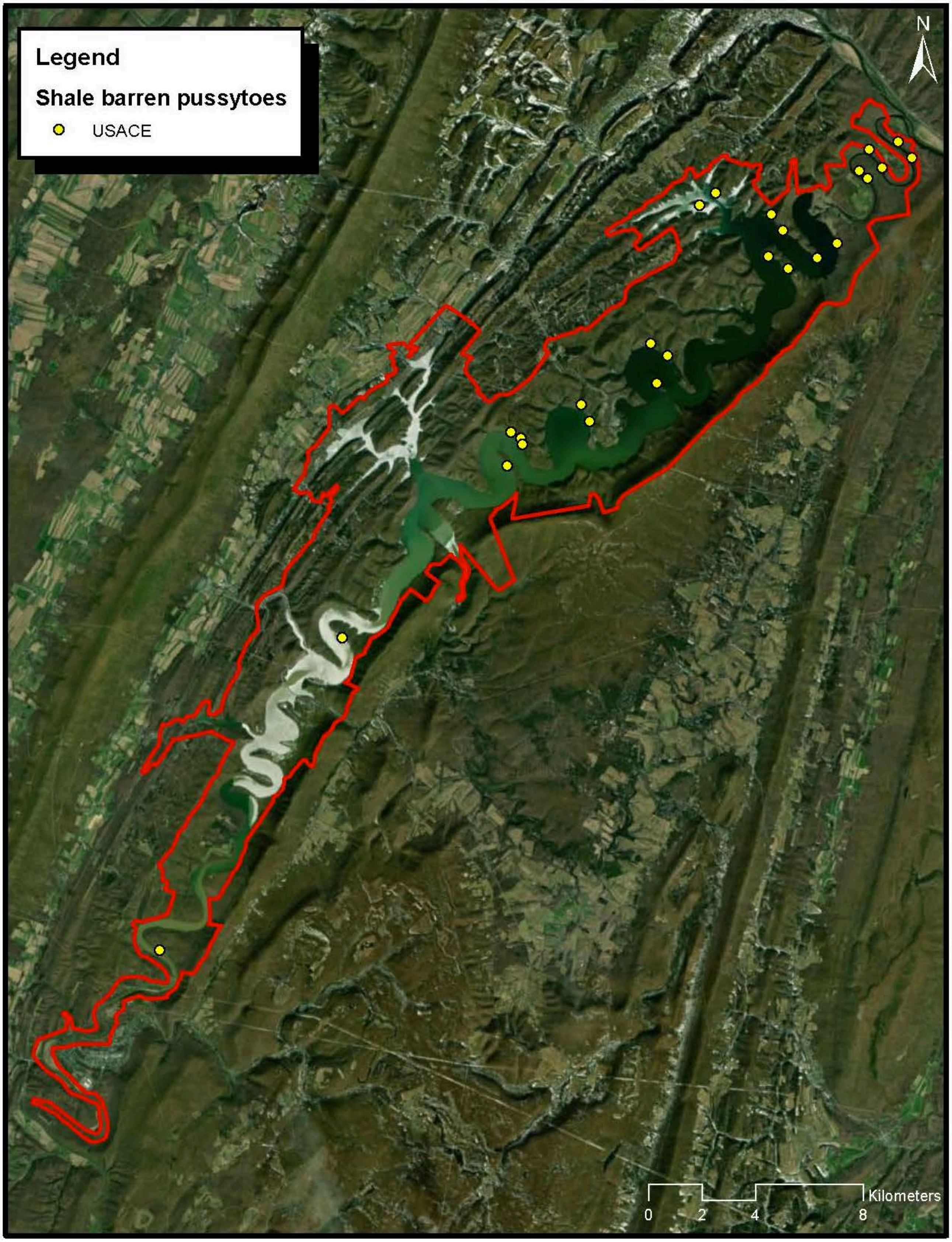

Figure 1-15. Occurrences of shale barren pussytoes at Raystown Lake, PA.

Eastern prickly-pear (*Opuntia sp.*) occurred at a single location on the lower slope of Martys Island near N 40.38672° W 78.05942° (Figure 1-16). It is listed as an S3 under the name *Opuntia humifusa* (Raf.) Raf. The specimens outwardly appear to be *O. cespitosa* Raf., which has been considered synonymous with *O. humifusa*. However, it has been indicated that its separation as a distinct species is warranted based on both morphological and molecular attributes (Majure et al. 2017; Weakley 2015). Although prickly-pear is not a shale barren endemic/near-endemic, these features provide suitable habitat with low competition for light in an otherwise densely forested landscape. Because this species occurs at a single location on a lower slope near the water, it is susceptible to extirpation from the site (and possibly the Raystown Lake area) due to potential erosion, and unsuitable conditions downslope for seeds or disarticulated cladodes ("pads") that may fall. Prickly-pear can be propagated vegetatively by half-burying cladode sections in the soil (Hartmann et al. 1997). Because this species is state listed, any attempts at propagation should be coordinated with the PANHP.

Figure 1-16. (A) Eastern prickly-pear on Martys Island (yellow circle); (B) clumps of prickly-pear at RLB_29, Raystown Lake, PA.

Smallflower phacelia (*Phacelia dubia* [L.] Trel.) is listed as an S3S4 and was observed frequently during the spring field sampling (Figure 1-17). It was among the most abundant herbs encountered at locations such as RLB_02, RLB_27, and RLB_39. According to del Castillo (1994), this species exhibits wide oscillations in its abundance from year to year.

Figure 1-17. Smallflower phacelia at RLB_39, Raystown Lake, PA.

Veiny-pea (*Lathyrus venosus* Muhl. ex Willd.) is listed as an S2 and was observed at RLB_27 along the ridge crest near a hiking trail (Figure 1-18). Three small clumps were also encountered at RLB_57. Both of these locations appear to be new localities based on data provided by PANHP. A previous record from 1889 located near the dam appears to be inundated by the lake.

Figure 1-18. Veiny-pea along the upper slope of RLB_27, Raystown Lake, PA.

Leonard's skullcap (*Scutellaria parvula* Michx. *var. missouriensis* [Torr.] Goodman & C.A. Lawson) was recorded at three survey locations (RLB_27, RLB_39, and RLB_50). This species is tracked by the state (but not ranked) under the synonym *Scutellaria leonardii* Epling, which was rejected in 2011 (https://www.itis.gov/). The lack of a ranking, yet continued tracking is likely due to recent taxonomic changes, and need for clarification on existing collections within the state. This species may be underreported and overlooked due to its diminutive size (Figure 1-19).

Figure 1-19. Leonard's skullcap at RLB_39, Raystown Lake, PA.

Common prickly-ash (*Zanthoxylum americanum* Mill.) occurred as a colony of shrubs along a ridge bald at the northern terminus of RLB_50 (Figure 1-20). It is ranked as an S4 and was only encountered at this location, which appears to be a new locality. A PANHP record indicates this species is also known from RLB_03. The armed twigs and branches, along with lemon-scented foliage are distinctive for this member of the Citrus family (Rutaceae).

Figure 1-20. Common prickly-ash at RLB_50, Raystown Lake, PA.

Invasive/non-native species

Despite the inherent edaphic factors that inhibit the establishment of most seedlings, shale barrens are susceptible to colonization by non-native species. Prior disturbance or proximity to maintained areas and roads may facilitate introduction. Managing these species can be accomplished through a variety of physical, mechanical, and chemical methods that are beyond the scope of this report. The presence of some noteworthy species was recorded. The following section provides a description of these species, important locations where they were encountered, and representative photos.

Oriental bittersweet (*Celastrus orbiculatus* Thunberg) was occasionally observed within portions of RLB_02 and RLB_07. This woody vine is capable of forming thickets, and is now considered more common than the American bittersweet (*Celastrus scandens* L.; Weakley 2015). Tree-of-heaven (*Ailanthus altissima* [Mill.] Swingle) occurred occasionally, and typically as a scattered shrub or seedling, with the exception of one area at RLB_31. No mature, fruit-producing individuals were observed within any of the survey areas, although they likely occur in nearby plant communities. Hand-pulling small seedlings and herbicide applications or injections for shrubs and trees are recommended (https://extension.psu.edu/tree-of-heaven).

Stringy stonecrop (*Sedum sarmentosum* Bunge) occurred infrequently but was often locally abundant on lower portions of slopes near the lake (Figure 1-21). This species is considered native to China and is capable of rooting from nodes and forming dense mats that may preclude the establishment of other species. Its bright yellowish-green color is distinctive and can often be detected from a considerable distance when en masse. Notable locations for this species included RLB_32 and RLB_62.

Figure 1-21. Stringy-stonecrop forming extensive colonies on lower slopes of RLB_62, Raystown Lake, PA.

German knotweed (*Scleranthus annuus* [Knawel]) was frequently encountered and occasionally abundant near areas that were previously disturbed or frequented by human foot-traffic (RLB_35 and RLB_36; Figure 1-22). It is a winter annual, completing its lifecycle before the barrens reach their highest surface temperatures and moisture deficit during the summer.

Figure 1-22. German knotweed at RLB_35, Raystown Lake, PA.

Crown-vetch (*Securigera varia* [L.] Lassen) is an herbaceous legume capable of forming dense mats (Figure 1-23). It occurred frequently along the margins of survey areas near hiking trails, footpaths, and access roads. This species has an affinity for disturbance but can spread to adjacent areas by seeds and rhizomes http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_010284.pdf).

Figure 1-23. Crown-vetch along the upper edge of RLB_35, Raystown Lake, PA.

Spotted knapweed (*Centaurea stoebe ssp. micranthos* [Gugler] Hayek) was observed infrequently. It was most abundant near areas with frequent human foot-traffic. Noteworthy locations include RLB_35, RLB_36, and the crest of Ridenour overlook (RLB_11; Figure 1-24). Its seeds are dispersed by humans, animals, and wind. This species develops a deep taproot that can make hand-pulling problematic (http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_010255.pdf).

Figure 1-24. Clump of spotted knapweed near the crest of Ridenour, Raystown Lake, PA.

Bush honeysuckle (*Lonicera maackii* [Rupr.] Herder) was encountered occasionally along boundaries of survey areas that were adjacent to roads and trails (RLB_02 and RLB_03; Figure 1-25). It is capable of forming dense shrub thickets that outcompete native species and shade out herbaceous plants. It breaks dormancy in late winter/early spring before most native plants and is tardily deciduous, retaining leaves into late fall/early winter. This extended period of carbon assimilation gives it a competitive advantage, yet also provides an opportunity for chemical control while minimizing or eliminating damage to non-targeted species. Weese and Barnes (2017) were able to achieve effective control of *Lonicera sp*. with herbicide applications timed on sufficiently warm days after leaf-fall of native deciduous species from October to April, with no perceivable damage to desirable plants. Japanese honeysuckle (*Lonicera japonica* Thunb.), a climbing or sprawling woody vine, was also observed occasionally along upper boundaries of survey areas, and infrequently within interior portions (RLB_02).


Figure 1-25. Bush honeysuckle at RLB_02, Raystown Lake, PA.

Asiatic tearthumb (*Persicaria perfoliata* [L.] H. Gross) is an annual sprawling vine, with reflexed prickles and distinctive blue fruits (Figure 1-26). This species was observed at RLB_07, but was also noted along the edge of RLB_02, adjacent to a public road which may provide a seed source for continual infestations. Repeated herbicide applications or removal may be required before exhausting its seed bank (https://www.invasive.org/alien/fact/pdf/pepe1.pdf). This locality may be a new county record for PA.


Figure 1-26. Asiatic tearthumb at RLB_02, Raystown Lake, PA.

Yellow toadflax (*Linaria vulgaris* Mill.) was observed along margins, and occasionally within survey areas that were near trails and roads. It may also be referred to locally as “butter-and-eggs” or “butter-and-bread” due to the contrasting yellow and white flowers. This species was abundant at RLB_35 and RLB_36, and is capable of forming dense mats that compete with native plants (Figure 1-27).

Figure 1-27. Yellow toadlflax at RLB_35, Raystown Lake, PA.

Survey Areas

The following section describes findings from each survey area, including endemic/near-endemic plant species, invasive species, and other noteworthy information regarding plant community structure. Locations where state-listed wildlife species were encountered are provided as well. Twenty of the 73 identified survey areas were not visited due to access limitations, time constraints, weather conditions, and survey efforts that focused on larger features that would be more likely to have species of concern. These sites include RLB_00, RLB_05, RLB_06, RLB_12, RLB_13, RLB_15, RLB_22, RLB_28, RLB_46, RLB_47, RLB_48, RLB_49, RLB_69, RLB_70, and RLB_71.

- RLB_00 was not surveyed.
- RLB_01 was an extension of the western end of RLB_02, dominated by eastern red cedar.
- RLB_02 was a relatively large eastern red cedar dominated shale barren (27.5 acres) adjacent to Corbin Road, and bisected by an unnamed tributary of Raystown Branch (Figures 1-28 and 1-29). Shale barren pussytoes, shale barren evening-primrose, and mountain nailwort occurred here. Non-native species including bush-honeysuckle, Japanese honeysuckle, Asiatic tearthumb, and tree-of-heaven were observed.


Figure 1-28. Central portion of RLB_02, Raystown Lake, PA.


Figure 1-29. Southeastern portion of RLB_02, Raystown Lake, PA.

- RLB_03 was predominately a rock outcropping feature adjacent to Point Road. The majority of the area appeared to be on private property; however, shale barren pussytoes and shale barren evening primrose were observed. Bush honeysuckle was the only invasive species noted.
- RLB_04 was primarily a series of rock outcroppings with interbedded shale layers (Figure 1-30). The vegetation components were variable with areas dominated by eastern red cedar, while others were dominated by various herbs and shrubs such as Carolina rose (*Rosa carolina* L.), fragrant sumac, and ninebark (*Physocarpus opulifolius* [L.] Maxim.). Shale barren pussytoes was recorded along with several patches of shale barren evening-primrose.

Figure 1-30. Rock outcropping at RLB_04, overlooking Raystown Branch, Raystown Lake, PA.

- RLB_05 and RLB_06 were not surveyed.
- RLB_07 was a relatively large feature (21.2 acres) with several distinct vegetation zones. Virginia pine and chestnut oak dominated a small area along the eastern portion, while the central and western portion was dominated by eastern red cedar (Figure 1-31). The central portion also had a well-developed shale outcropping with sparse tree cover (Figure 1-32). Kate's Mountain clover, shale barren pussytoes, mountain nailwort, and shale barren evening-primrose were recorded here. Chestnut oak dominated a substantial area east of a utility corridor crossing. This area had a sparse understory, which appears to be characteristic of most shale barren features at Raystown Lake where chestnut oak is dominant. The western-most portion was dominated by eastern red cedar with an understory of little bluestem.

Figure 1-31. Eastern red cedar dominated portion of RLB_07, Raystown Lake, PA.

Figure 1-32. Well-developed barren area near the central portion of RLB_07, Raystown Lake, PA.

- RLB_08 was a shale outcropping feature just above the dam structure along the east side of the lake. Shale barren pussytoes was the only species of concern recorded here.
- RLB_09 and RLB10 were small Virginia pine dominated features (2.1 and 0.3 acres respectively) with a single patch of shale barren pussytoes recorded at each.
- RLB_11 encompassed shale barrens and vertical rock outcroppings in an area known as Ridenour overlook (Figure 1-33). This feature is exceedingly steep in many locations with discontinuous ledges that were too hazardous to traverse without technical climbing gear. Shale barren pussytoes, shale barren evening-primrose, low false-bindweed, and nailwort were observed. A large clump of spotted knapweed was recorded near the upper edge of the overlook, adjacent to a trail.

Figure 1-33. Rocky outcrops and cliffs along the base RLB_11, Raystown Lake, PA.

- RLB_12 and RLB_13 were not surveyed.
- RLB_14 was a shrub dominated community of bear oak (Figure 1-34). Herbaceous cover was sparse, however, shale barren pussytoes and low false-bindweed occurred along lower slopes.

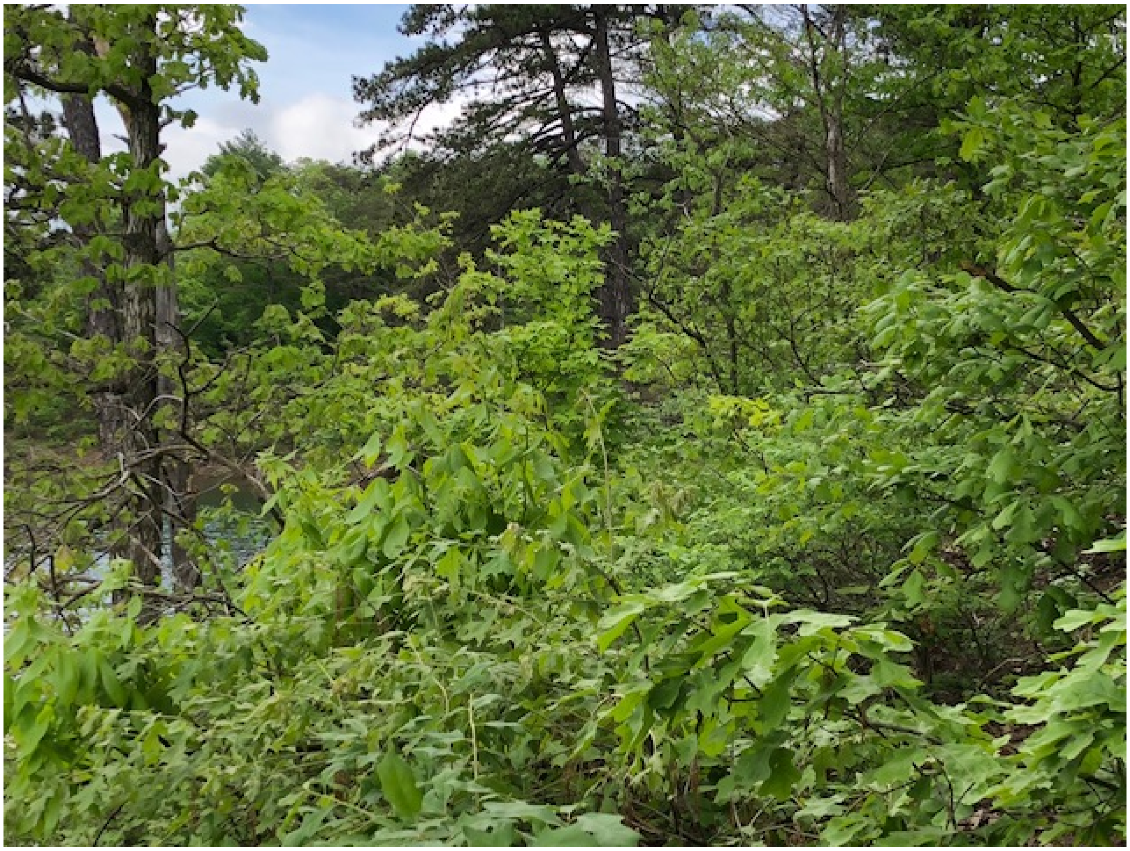

Figure 1-34. Shrub dominated area of bear oak at RLB_14, Raystown Lake, PA.

- RLB_15 was not surveyed.
- RLB_16 was a shale woodland located along the western tip of Hawn's Peninsula (Figure 1-35). No species of concern were recorded.


Figure 1-35. Southwestern tip of Hawn’s Peninsula, RLB_16, Raystown Lake, PA.

- RLB_17 was a Virginia pine dominated shale woodland located along the western portion of Hawn’s Peninsula. A small patch of shale barren pussytoes, mountain nailwort, and a few individuals of shale barren evening-primrose were recorded on the west side of the survey area (Figure 1-36).
- RLB_18 was a small opening dominated by various shrubs, located along the center of Hawn’s Peninsula. No species of concern were noted.

Figure 1-36. Sparsely vegetated area within RLB_17, Raystown Lake, PA.

- RLB_19 was a shale outcropping feature dominated by shrubs and chestnut oak along the southern portion, then transitioned to Virginia pine throughout the northern portion (Figures 1-37 and 1-38). Mountain nailwort was the only species recorded here. Areas along the ridge and northeast facing slope had dense stands of barberry (*Berberis thunbergii* DC.), bush honeysuckle, and Japanese honeysuckle.

Figure 1-37. Shrub dominated area at RLB_19, Raystown Lake, PA.

Figure 1-38. Virginia pine dominated area at RLB_19, Raystown Lake, PA.

- RLB_20 was a graded embankment along an abandoned road bed with no distinct outcroppings of shale. An Eastern box turtle (*Terrapene carolina carolina*; S3S4) was observed here. Dense stands of bush honeysuckle occurred south of this area.
- RLB_21 was the remnants of a rock-covered dam at Hawn's Peninsula.
- RLB_22 was not surveyed.
- RLB_23 was a shale barren abutting an unimproved access road. Shale barren evening-primrose and mountain nailwort were observed. Bush honeysuckle was the only invasive species recorded.
- RLB_24 was a shale barren feature with Kate's Mountain clover, shale barren evening-primrose, and mountain nailwort (Figure 1-39). Yellow toadflax was the only invasive species recorded here.

Figure 1-39. Herb dominated opening at RLB_24, Raystown Lake, PA.

- RLB_25 was a patchy woodland strip near the shoreline with minor shale outcropping. No species of concern were recorded.
- RLB_26 was located on an island dominated by rock outcrops. Shale barren evening primrose was noted at a single location near the center.

- RLB_27 was an eastern red cedar dominated shale barren feature with evening-primrose, shale barren pussytoes, Kate's Mountain clover, and veiny-pea present (Figure 1-40). This survey area had the largest concentration of Kate's Mountain clover that was observed at Raystown Lake. Crown-vetch, autumn olive, tree-of-heaven, bush honeysuckle, and spotted knapweed were observed near the hiking trail that borders the upper slope of this survey area.

Figure 1-40. Eastern red cedar dominated area at RLB_27, Raystown Lake, PA.

- RLB_28 was not surveyed.
- RLB_29 was a shale barren along the west-facing slope of Marty's Island. Shale barren pussytoes and eastern prickly pear were observed.
- RLB_30 was a shale barren and rock outcrop feature along the southern tip of Marty's Island. Shale barren evening-primrose was the only species of concern that occurred**.**
- RLB_31 was a woodland with minor areas of shale outcropping. No endemic/near-endemic species were recorded, although Kate's Mountain clover has been observed here (PANHP). Significant mortality and crown die-back of various tree species (i.e. *Celtis*, *Pinus*, *Quercus*) was observed, with tree-of-heaven appearing to colonize the site (Figure 1-41).

Figure 1-41. Area of significant tree mortality at RLB_31, Raystown Lake, PA.

- RLB_32 was a relatively small area of shale outcropping near a recreation area. No species of concern were recorded.
- RLB_33 and RLB_34 appeared to be recently thinned forested areas with no distinct outcroppings of shale.
- RLB_35 was a Virginia pine dominated shale barren feature adjacent to a recreation area (Figure 1-42). One small patch of shale barren pussytoes and mountain nailwort were observed. Spotted knapweed, German knotweed, Bradford pear, Japanese honeysuckle, toadflax, and crown-vetch were observed along the upper slopes of this feature.
- RLB_36 was a small extension of RLB_35. No species of concern were recorded.


Figure 1-42. Herbaceous dominated opening within RLB_35, Raystown Lake, PA.

- RLB_37 was a Virginia pine dominated shale woodland (Figure 1-43). Mountain nailwort and two small clumps of shale barren pussytoes were observed.

Figure 1-43. Virginia pine dominated shale woodland at RLB_37, Raystown Lake, PA.

- RLB_38 was a chestnut oak dominated feature with a small clump of low false-bindweed along the lower slope. Stringy stonecrop was the only non-native species recorded here.
- RLB_39 was an eastern red cedar dominated shale barren occupying approximately 13.0 acres, with areas of rock outcropping along the southern boundary (Figure 1-44). Some locations appeared to be influenced by seeps during the spring, and had abundant herbaceous cover. Shale barren pussytoes and Leonard's skullcap were observed here.


Figure 1-44. Eastern red cedar dominated area at RLB_39, Raystown Lake, PA.

- RLB_40 was an eastern red cedar dominated feature with several patches of shale barren pussytoes. Tree-of-heaven was noted along lower slopes.
- RLB_41 was a chestnut oak dominated feature with a sparse understory (Figure 1-45). No species of concern were recorded.

Figure 1-45. Chestnut oak dominated shale barren at RLB_41, Raystown Lake, PA.

- RLB_42 was an eastern red cedar dominated feature. A small patch of shale barren evening-primrose was observed.
- RLB_43 was an eastern red cedar dominated feature with shale barren pussytoes occurring as two small clumps. Patches of stringy stonecrop were observed along lower slopes.
- RLB_44 and RLB_45 were Virginia pine dominated features separated by a small cove. No species of concern were recorded. Tree-of-heaven was noted along upper slopes.
- RLB_46, RLB_47, RLB_48, and RLB_49 were not surveyed.
- RLB_50 was predominantly a bald, where herbaceous plants and shrubs occurred on shallow soils over bedrock along the south-facing crest (Figure 1-46). Shale outcroppings were immediately downslope within forested communities and within a chestnut oak and northern red oak dominated woodland near the center of this feature (Figure 1-47). Leonard's skullcap and mountain nailwort were observed. Common prickly-ash was recorded at the northernmost portion of this survey location. Crown-vetch was also noted near the ridge crest.

Figure 1-46. Herb and shrub dominated bald along the northern portion of RLB_50, Raystown Lake, PA.

Figure 1-47. Shale woodland dominated by chestnut oak at RLB_50, Raystown Lake, PA.

- RLB_51 was a forested area along the shoreline with no discernable shale outcropping. No species of concern were recorded.
- RLB_52, RLB_53, RLB_54, and RLB_55 occurred as a series of openings along the shoreline. No species of concern were recorded.
- RLB_56 was a Virginia pine dominated shale barren feature. No species of concern were recorded.
- RLB_57 was a shale woodland with two distinct vegetation zones. The central portion was dominated by chestnut oak (Figure 1-48), while the western and eastern portions were dominated by Virginia pine. Veiny pea and shale barren evening-primrose were recorded.

Figure 1-48. Chestnut oak dominated area at RLB_57, Raystown Lake, PA.

- RLB_58 was a bald along a ridge crest dominated by dwarf hackberry, fragrant sumac, and various herbs (Figure 1-49). Openness at this location appears to have been enhanced by recent tree fall gaps and ash mortality. No species of concern were recorded.

Figure 1-49. Ridge bald at RLB_58, Raystown Lake, PA.

- RLB_59 was a small extension of RLB_60. No species of concern were recorded.
- RLB_60 was a Virginia pine dominated shale barren. Shale barren pussytoes was the only species of concern observed.
- RLB_61, RLB_62 (Figure 1-50), RLB_63, and RLB_64 were narrow shale outcroppings near the shoreline. No species of concern were recorded.

Figure 1-50. Sparse understory at RLB_62, Raystown Lake, PA.

- RLB_65 was a shale barren and rock outcrop community largely dominated by Virginia pine (Figure 1-51 and 1-52). Inclusions of eastern red cedar were occasionally observed along particular shale strata. Shale barren evening-primrose and mountain nailwort were frequently encountered. Yellow toadflax, stringy stonecrop, and crabgrass (*Digitaria sp*.) were observed.

Figure 1-51. RLB_65 with shale barren evening-primrose in the understory, Raystown Lake, PA.

Figure 1-52. Rock outcropping within an eastern red cedar dominated area at RLB_65, Raystown Lake, PA.

- RLB_66 and RLB_67 were rock outcrops with no distinct shale barren features.
- RLB_68 appeared to be a mining scar.
- RLB_69, RLB_70, and RLB_71 were inaccessible, with posted signs indicating that it was private property, despite appearing to occur within the boundaries of Raystown Lake.
- RLB_72 was a relatively small shale woodland immediately downslope from Tressler Road (Figure 1-53). Shale barren pussytoes was the only species of concern recorded here.

Figure 1-53. Shale woodland at RLB_72, Raystown Lake, PA.

<u>Classification and Extent of Shale barrens</u>

Areas identified as shale barrens varied considerably in plant community structure, species abundance, and presence of endemic/near-endemic plants. This variation occurred both between sites and within individual survey areas. Datasheets from representative communities are included in Appendix II.

The National Vegetation Classification System (USNVCS) lists three mid-Appalachian shale barren associations as reported or potentially occurring in PA. Two are listed as "confident or certain" and include the *North-Central Appalachian Acidic Shale Woodland* and the *Central Appalachian Circumneutral Barrens*. These associations differ in substrate pH which leads to differences in species composition and structure. The *Central Appalachian Xeric Shale Woodland* association is listed as "potential" in PA, with documented sites in MA and VA. Some areas at Raystown Lake appeared to belong to this association and were classified as such (RLB_7, RLB_38, RLB_41, RLB_50, and RLB_57). A brief description of each association from the NVCS (2018) is provided below. Electronic versions of this report are hyperlinked to the NVCS and PANHP descriptions.

North-Central Appalachian Acidic Shale Woodland (*Virginia Pine - Eastern Red-cedar - Northern Red Oak / Shale Barren Goldenrod - Eastern Prickly-pear Woodland*; PANHP = *Virginia pine - mixed hardwood shale woodland*)

This association occurs over acidic shale, often with sandstone outcroppings or bedrock. The community structure is typically an open woodland with small patches of closed canopy forest, scattered shrubs, and sparsely vegetated openings. Virginia pine is dominant or co-dominant in the overstory, along with eastern red cedar, chestnut oak, and northern red oak. The herbaceous layer is typically sparse, and less species rich than the *Central Appalachian Circumneutral Barrens*.

Central Appalachian Circumneutral Barrens (*Eastern Red-cedar - White Ash / Pennsylvania Sedge - Hairy Lipfern Open Woodland*; PANHP = *Red-cedar - mixed hardwood rich shale woodland* or *Red-cedar - prickly pear shale shrubland*)

This association occurs over calcareous shale with occasional bedrock outcroppings. The overstory is typically dominated by eastern red cedar. Other tree species such as Virginia pine, pignut hickory, chestnut oak, northern red oak, and white ash frequently co-occur. Shrubs are patchy or sparse, and the herbaceous layer varies from sparse to extensive (up to 90% cover). High frequencies of eastern red cedar, dwarf hackberry, and white ash, along with the presence of hairy lip fern (*Cheilanthes lanosa* [Michx.] D.C. Eaton), smallflower phacelia, and clasping Venus' looking-glass (*Triodanis perfoliata* [L.] Nieuwl) are considered probable indicators of this association.

Central Appalachian Xeric Shale Woodland (*Chestnut Oak / Bear Oak / Poverty Oatgrass Woodland*)

This community occurs as open woodlands dominated by chestnut oak that are usually stunted and contorted. Pignut hickory and northern red oak frequently occur as minor components in the tree and shrub layers. Conifers such as Virginia pine and eastern red cedar are usually scarce or absent. The herb layer is typically sparse or patchy, and sometimes dominated by chestnut oak seedlings.

The majority of feature boundaries initially identified as survey areas for investigation corresponded with approximate shale barren community boundaries based on height and cover criteria outlined in the methods section above. These communities were concentrated in the northern portion of the Raystown Lake area, with smaller features scattered throughout the southern portion (Figure 1-54). Upper slopes of these features often had an abrupt boundary where they transitioned to forest, however, the bottom and lateral portions often graded slowly into other community types. A total of 200.3 acres were classified as shale barrens and with some inclusions of closed canopy forest, shrublands, and rock outcrops. Areas classified as *North-Central Appalachian Acidic Shale Woodland* occupied 51 acres. Many of these features had a sparse understory and lacked endemic/non-endemic plants. *Central Appalachian Circumneutral Barrens* occupied 139 acres, and commonly held at least one of the endemic/near-endemic species. Areas classified as *Central Appalachian Xeric Shale Woodland* occupied approximately 10.3 acres. These communities typically had a sparse understory and rarely contained any endemic/near-endemic species or species of concern. Inclusions of this type likely occur in other features and could potentially be separated with additional field work and observations. A table of all survey areas and their classification is provided in Appendix III.

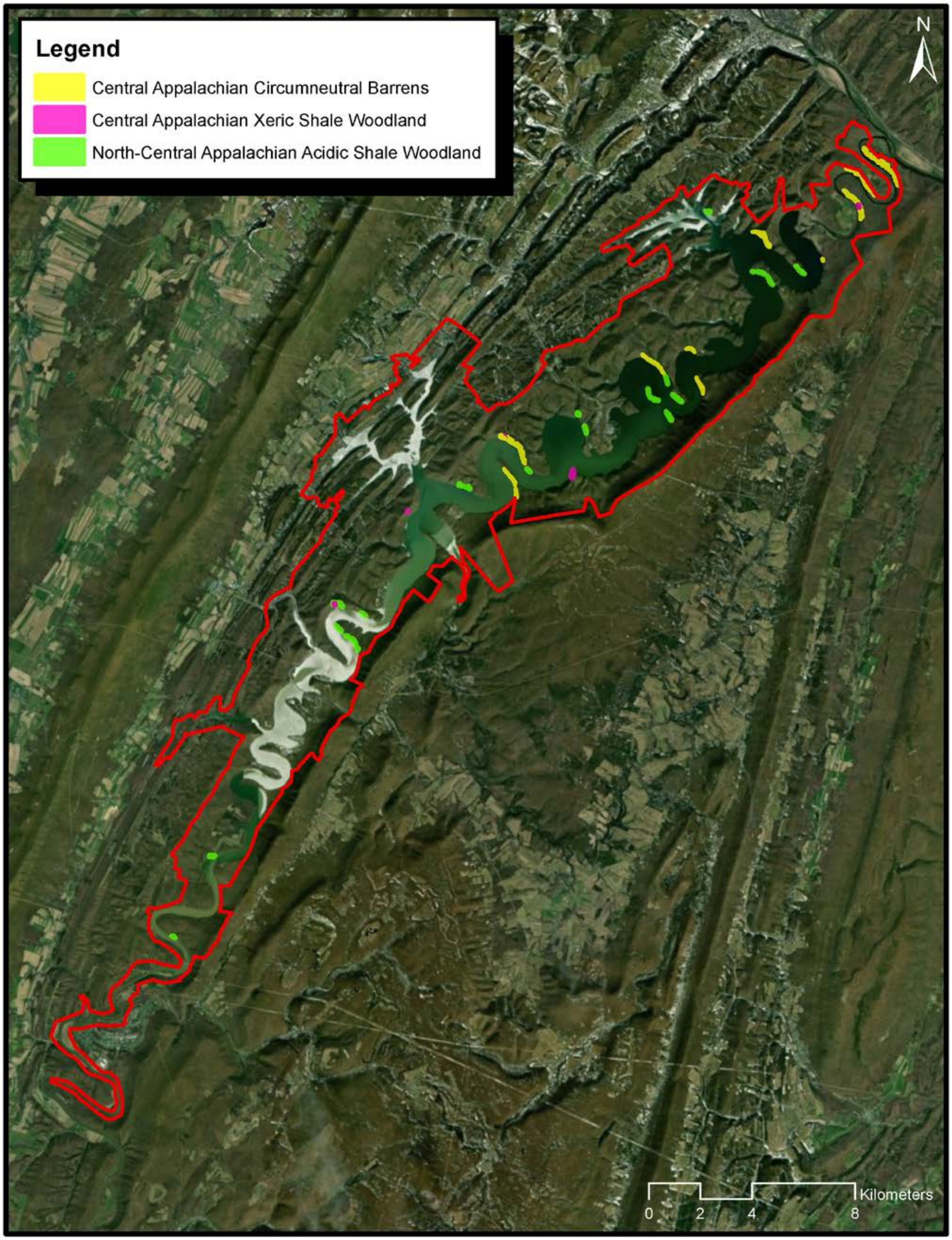

Figure 1-54. Extent of shale barren communities mapped and classified at Raystown Lake, PA.

Discussion

The distribution of shale barren endemic/near-endemic plant species recorded at Raystown Lake was irregular, with many suitable areas found to be unoccupied, or with only one endemic/near-endemic species present. These observations are repeated in findings made by other studies within the mid-Appalachian shale barren region, and likely explained by their inherent seed dispersal mechanisms, probability of colonization at a suitable location, and long term survival and reproduction (Keener 1983). Some sites had conditions that outwardly appeared to be similar to occupied sites in regard to openness, shale substrate, and co-occurring plant species, but may have only recently developed these characteristics. The construction of the lake caused permanent inundation of areas that were previously forested. Mortality of these flooded trees increased the amount of light reaching areas immediately upslope that were previously shaded. Beaver (*Castor canadensis* Kuhl) activity was frequently observed at survey areas, and appeared to increase openness, especially along lower slopes. Most of these sites were likely too far from the river and its adjacent wetlands, and thus too energetically expensive to attract beavers prior to construction of the lake. Some sites had increased openness due to ash mortality caused by emerald ash borer. It may be valuable to return to these sites periodically in the future to assess the potential of recent colonization and/or changes in the vegetation structure.

Observed anthropogenic effects to the shale barrens largely resulted from foot-traffic near roads and trails. These areas also had the highest abundance of non-native plant species. Signage may be helpful to encourage visitors to stay on designated trails to minimize direct impacts and potential introduction of invasive species. Evidence of tree harvesting and branch removal from eastern red cedar was frequently observed (Figure 1-55). It is unclear when harvesting occurred or why these trees were targeted but it could be speculated that their contorted forms are attractive for decorative objects, walking sticks, etc. Additionally, these areas may have been utilized historically by the local population as a source for eastern red cedar wood, which has several homestead applications due to its decay-resistance and insect-repelling qualities (Weakley 2015).

Shale barren communities are considered self-sustaining and require no landscape-level processes such as fire, grazing, or human involvement for their continued existence (Keener 1983). Management practices involve little more than establishing buffers to prevent anthropogenic impacts, and occasional monitoring for invasive species. Buffers for these communities should ideally encompass the crest of the ridge above, to the toe slope below. Impacts to these areas have the potential to influence the inherent erosional processes and act as vectors for invasive species. Lateral extent of buffers should extend into the woodland/forest transitional zone at a minimum.

Figure 1-55. Evidence of tree harvesting (left) and branch removal (right) at survey areas, Raystown Lake, PA.

Summary

The shale barren communities that were surveyed and classified at Raystown Lake are representative of the northern extent of a unique system restricted to the central Appalachian region. Many of the endemic/near-endemic species approach their northernmost distribution in this area. Several new localities for these species were established, including the state endangered Kate's Mountain clover. Additionally, new localities for other state listed plant species such as veiny-pea and common prickly-ash were documented.

The best examples of shale barrens occurred in the northern portion of the Raytown Lake area, especially along the Raystown Branch between the dam and the confluence with the Juniata River. These features were relatively large, intact, and contained multiple endemic/near-endemic species. Shale barrens throughout the southern portion of the Raystown Lake area were mostly small features, often with invasive species, and usually with fewer species of concern. Limiting anthropogenic impacts through establishment of buffers, along with periodic monitoring and control of invasive species is recommended for managing these communities.

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2 Acoustic Bat Surveys at Critical Locations for Determination of Presence of Threatened and Endangered Species, Raystown Lake, Pennsylvania

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Introduction

Bat conservation and management has become a major concern on state, federal, and private lands throughout the United States. Bats represent an important component of many ecosystems and contribute significantly to an area's biodiversity. Bats have a higher proportion of species that are considered rare, sensitive, threatened or endangered within some regulatory or assessment framework than any other group of mammals in North America. Reasons for these listings range from loss of roosting and/or foraging habitat, pesticides, persecution, and disturbance of hibernacula (Racey and Entwistle 2003).

Recently, wind energy development (Johnson et al. 2003; Fiedler 2004; Arnett et al. 2008) and White-nose Syndrome (WNS) have emerged as additional threats (USGS, 2008). WNS is an emerging disease that is responsible for the death of over 6 million hibernating bats. These declines has resulted in the listing of the once common northern long-eared bat (*Myotis septentrionalis*) as federally threatened in 2015. Mortality rates observed at wind energy production facilities have been variable, but at 1 facility in West Virginia, > 40 bats per turbine per year have been killed, including the Lasurine or "tree" species not believed to be impacted by WNS (Arnett et al. 2008). As bat populations continue to experience stress from these sources, understanding bat distributions becomes more important.

Bats in the eastern United States use echolocation to orient to their surroundings and to locate prey. Ultrasonic detectors are now widely available and allows researchers to detect echolocation calls to assist in studies of bat ecology. Research has shown the presence of species-specific echolocation calls exists for many species (Krusic and Neefus 1996; Britzke et al. 2011). Ultrasonic detectors have many advantages over mist netting, including detection of more species at a site than mist nets (Murray et al. 1999; O'Farrell and Gannon 1999), sampling multiple sites without a researcher present, and sampling habitats that lack a constricted flyway necessary for traditional capture techniques. Use of ultrasonic detectors has the potential to increase detectability of some species, thereby improving the efficiency of bat surveys. This has prompted the US Fish and Wildlife Service (USFWS) to incorporate acoustic surveys into the survey guidance for federally listed bats species in the eastern United States.

In order to inform natural resource personnel at Raystown Lake about bat species presence on their project, we initiated a bat survey using ultrasonic detectors in August 2018.

Methods

Raystown Lake covers approximately 30,000 acres in Huntingdon County, Pennsylvania. Bat sampling was conducted for listed bat species following the USFWS 2018 Bat Survey guidance. Bat activity was recorded using the SD2 Anabat II bat detector system (Titley Scientific; www.titley-scientific.com). Prior to initial deployment, units were calibrated using an ultrasonic pest repeller following Larson and Hayes (2000). Sampling was only conducted on nights when temperatures were high enough to maintain bat activity, there was no precipitation, and wind speed was minimal.

Stationary units were placed at a suitable locations within the forested habitats at sites in which previous sampling had detected various *Myotis* species. Detectors were housed in a weatherproof box on a tripod (Figure 2-1) and were set to record from sunset to sunrise.

Figure 2-1. Example of Anabat bat detector setup for recording at Raystown Lake, PA, August 2018.

Data analysis

Upon completion of 2 nights with suitable weather conditions, equipment was picked up and the CF card was removed. The CFCRead program was used to download the data on a laptop computer for later analysis. The software saves bat echolocation files (calls) that are separated by 2 seconds to individual files, thereby providing an index of general bat activity at the site. However, since it is impossible to determine if a single bat flew by multiple times or multiple bats flew by once, activity measures are only useful for coarse assessment of bat activity at the site. Files were organized by site and analyzed using the EchoClass automated analysis program. The program filters files, extracts parameters, and classifies files based on statistical comparison to a known call library. The species set was picked to include all 6 species of Myotis present in the eastern United States. An output file is created that summarizes the bat activity at the site. Because of accuracy rates below 100% it is impossible to determine the exact number of files produced by a species. Therefore, we can simply determine presence/probable absence of a species using a maximum likelihood estimator (Britzke et al. 2002). Files were then visually examined to support species presence designations.

Results

A total of 10 points were sampled in August 2018 (Table 2-1; Figure 2-2). Recording resulted in sampling of 14,469 files (mean = 498; range 7-2480 files / night). A total of 5 bat species were detected: big brown (*Eptesicus fuscus*), eastern red *(Lasiurus borealis*), hoary *(Lasiurus cinereus*), little brown (*Myotis lucifugus*), and northern long-eared (*Myotis septentrionalis*). Red bats were detected at all 10 sites and big brown bats were detected at 8 sites. Little brown bats were detected at site 10 (Figure 2-3), while northern long-eared bats were detected at 4 sites (Table 2-2; Figure 2-4).

Table 2-1. GPS location of the 10 sites sampled for bats at Raystown Lake, PA, August 2018.

Site	Latitude	Longitude
1	40.242596	-78.222405
2	40.245291	-78.221707
3	40.332189	-78.171263
4	40.325585	-78.174529
5	40.409541	-77.99957
6	40.405732	-78.010555
7	40.409144	-78.00978
8	40.41188	-78.010059
9	40.421767	-77.987268
10	40.420758	-77.989733

Figure 2-2. Map showing location of sites 1-4 sampled with Anabat detectors at Raystown Lake, PA, August 2018.

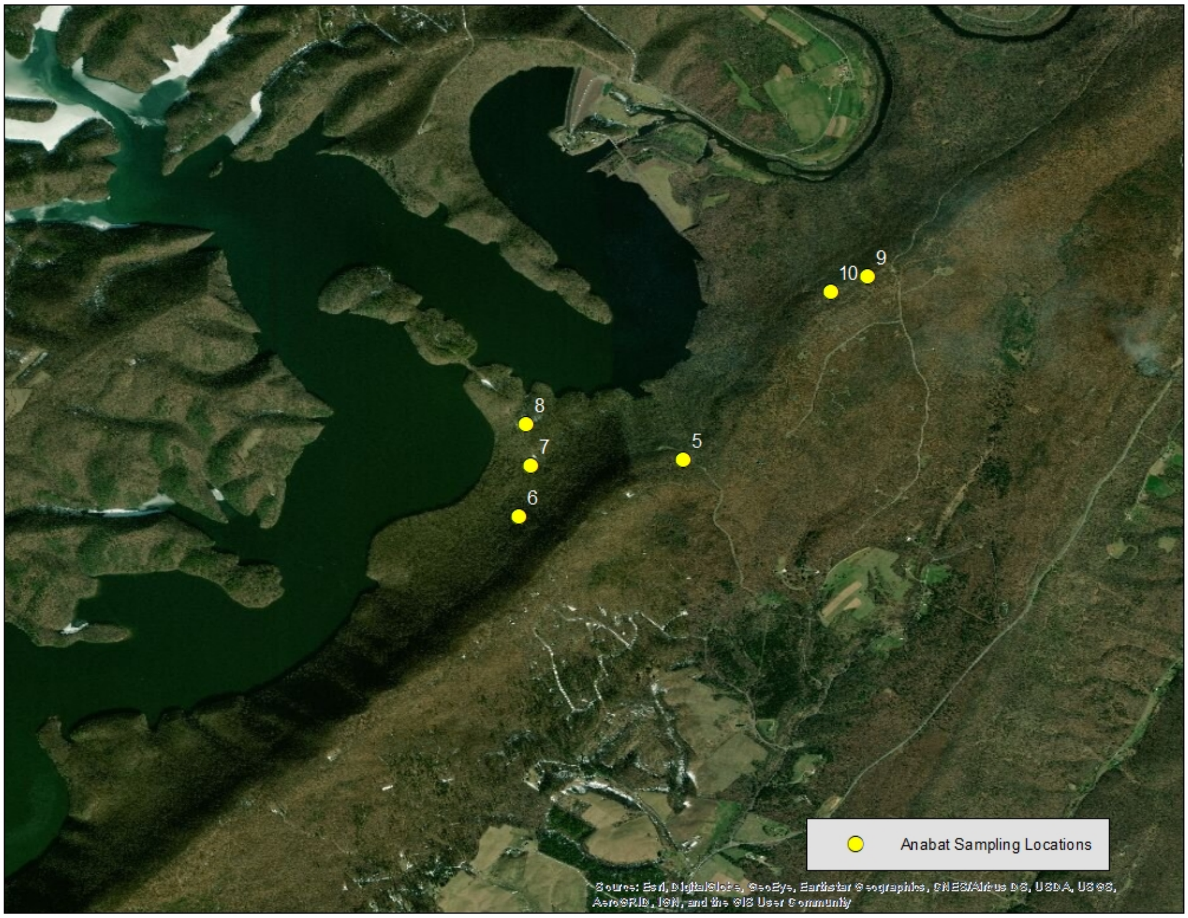

Figure 2-3. Map showing location of sites 5-10 sampled with Anabat detectors at Raystown Lake, PA, August 2018.

Table 2-2. Results of the Anabat bat survey conducted in Raystown Lake, PA, August 2018.

Location	Date	Total # of files	Bat species detected
Site 1	08/07/2018	39	Eastern Red
	08/08/2018	36	Eastern Red, Big Brown
Site 2	08/07/2018	125	Eastern Red
	08/08/2018	18	Eastern Red
	08/09/2018	131	Eastern Red, Big Brown
Site 3	08/07/2018	2480	Eastern Red, Big Brown
	08/08/2018	1677	Eastern Red, Big Brown
	08/09/2018	1968	Eastern Red, Big Brown
Site 4	08/07/2018	682	Eastern Red, Northern Long-eared
	08/08/2018	1001	Eastern Red, Big Brown, Northern Long-eared
	08/09/2018	494	Eastern Red
Site 5	08/07/2018	337	Big Brown
	08/08/2018	523	Hoary Bat
	08/09/2018	314	Eastern Red, Big Brown
Site 6	08/07/2018	86	Northern Long-eared
	08/08/2018	23	Northern Long-eared
	08/09/2018	1947	Eastern Red
Site 7	08/07/2018	55	Eastern Red, Big Brown
	08/08/2018	16	Eastern Red
	08/09/2018	41	Eastern Red, Northern Long-eared
Site 8	08/07/2018	53	Eastern Red
	08/08/2018	7	Eastern Red
	08/09/2018	44	Eastern Red

Site 9	08/07/2018	316	Eastern Red, Big Brown
	08/08/2018	218	Eastern Red, Big Brown, Northern Long-eared
	08/09/2018	602	Eastern Red, Big Brown
Site 10	08/07/2018	766	Eastern Red, Big Brown
	08/08/2018	97	Eastern Red, Big Brown
	08/09/2018	373	Eastern Red, Big Brown, Little Brown

Figure 2-4. Map showing sampling sites in which the little brown bat (*Myotis lucifugus*) was detected during acoustic sampling of Raystown Lake, PA, August 2018.

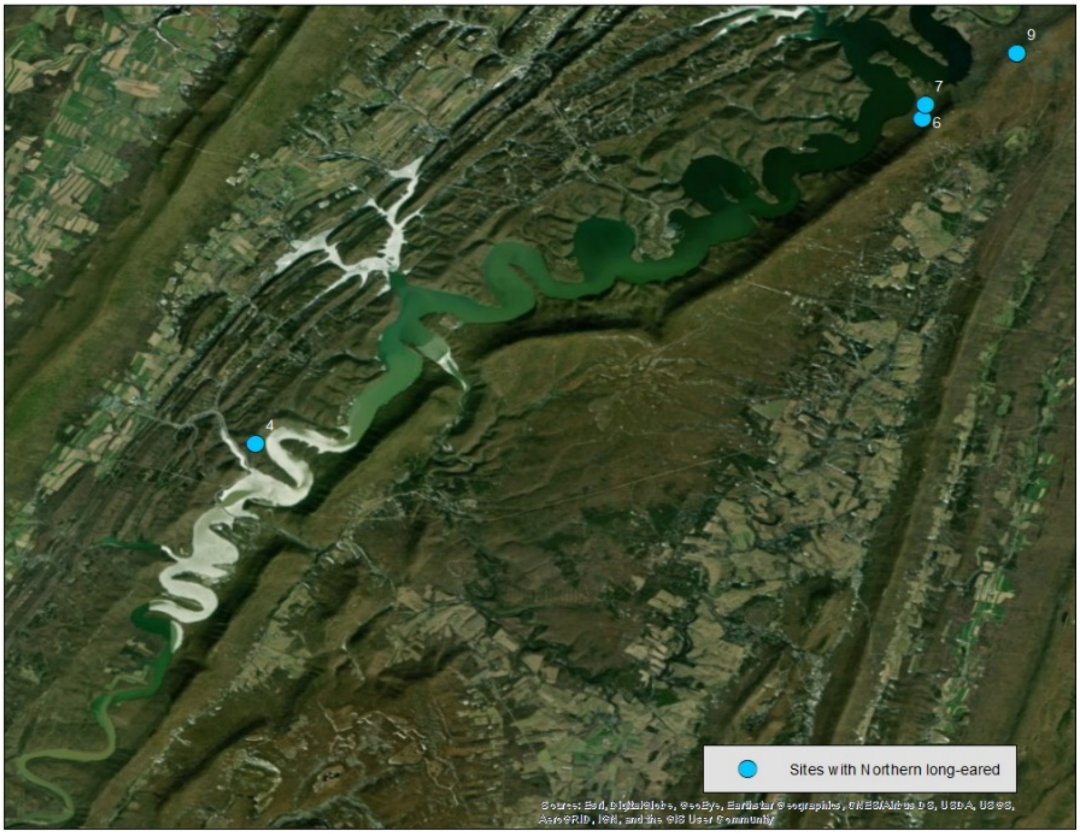

Figure 2-5. Map showing sampling sites in which the northern long-eared bat (*Myotis septentrionalis*) was detected during acoustic sampling of Raystown Lake, PA, August 2018.

Discussion

Activity levels varied substantially throughout the sites sampled during this project, but in general, activity was very high. As expected, the red bat and big brown bat were commonly detected during this sampling event. Detection of the federally threatened northern long-eared bat at multiple sites was surprising given the dramatic decline of this species in recent years. Additional sampling in these areas can determine the distribution and extent of this species on the Raytown Lake project area.

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3 USACE Raystown Lake Aquatic Invertebrate Survey, Huntingdon County, Pennsylvania

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Introduction

The purpose of this effort was to conduct aquatic invertebrate sampling in the Raystown Lake Project Area, specifically below the dam structure on the Raystown Branch of the Juniata River, in order to confirm the presence or absence of state-listed Odonata (Insecta) species and Unionidae (Mollusca: Bivalvia) species. These taxa include the Appalachian Jewelwing Damselfly (*Calopteryx angustipennis*), Spine-crowned Clubtail Dragonfly (*Gomphus abbreviatus*), Brook Floater Mussel (*Alasmidonta varicosa*), and the Yellow Lampmussel (*Lampsilis cariosa*), which were identified as species of concern in the Juniata River, and potentially occurring in the project area.

The Spine-crowned Clubtail (*G. abbreviatus*) (Figure 3-1) is one of six members of the subgenus *Hylogomphus* occurring in North America. Larvae of this species, as well as those of other *Hylogomphus* species, are known to occur in fine substrates associated with riffles in medium-large rivers in the region (Needham et al. 2000). Adults can be distinguished from closely related species by the presence of a yellow face without dark crossbands, and the presence of a flattened medial carina at the apical end of the male posterior hamule. Larvae are distinguished from other *Hylogomphus* species by the presence of small end hooks on the labial palpae and the presence of small dorsal hooks on the posterior margins of abdominal segments 8 and 9 (Needham et al. 2000). Emergence periods for this species occur between May – June in Pennsylvania and surrounding states.

Figure 3-1. Male Spine-crowned Clubtail (*Gomphus abbreviatus*). Photo credit: Tom Murray.

The Appalachian Jewelwing (*C. angustipennis*) (Figure 3-2) is also a riverine species occurring within Appalachian streams and rivers in the region, although seldom collected (Johnson 1974). It is a large, clear-winged species that is found association with riffles. Adults can be separated from closely related species based on wing patterning (Westfall and May 2006). Larvae can be separated from other *Calopteryx* species based on the presence of low tubercles behind the eyes, and comparison of length ratios of antennal flagella and gills. (Tennessen 1984; Westfall and May 2006). Emergence period for this species ranges from May – June in Pennsylvania and surrounding states.

Figure 3-2. Male Appalachian Jewelwing Damselfly (*Calopteryx angustipennis*). Photo credit: Kyle Kittelberger.

The Brook Floater (*Alasmidonta varicosa* (Lamarck)) (Figure 3-3) is a freshwater pearly mussel known to occur in Atlantic drainages, ranging from the Gulf of St. Lawrence to Georgia (NatureServe 2018; Spoo 2008). It is known to occur in the Potomac, Susquehanna, and Delaware River drainages in Pennsylvania, occurring in streams and rivers with permanent flowing conditions, including the Juniata River and its tributaries (Nedeau et al. 2000). The Brook Floater is associated with gravel or mixed sand and gravel substrates in clean water. Fertilization is thought to occur in summer with glochidial release during the following spring;

known hosts include Slimy Sculpin (*Cottus cognatus*), Golden Shiner (*Notemigonus crysoleucas*), Longnose Dace (*Rhinichthys cataractae*), and Pumpkinseed Sunfish (*Lepomis gibbosus*) (Spoo 2008). This species can be separated from closely related species by its distinctive radial ridging on its posterior slope, and indentation on the ventral margin (Nedeau 2008; Spoo 2008).

Figure 3-3. Brook Floater Mussel (*Alasmidonta varicosa*). Photo credit: E. Nedeau. https://wildlife.state.nh.us/wildlife/profiles/brook-floater-mussel.html

The Yellow Lampmussel (*Lampsilis cariosa* (Say)) (Figure 3-4) is a pearly mussel occurring in the Atlantic region, known from Nova Scotia to Georgia (NatureServe 2018; Spoo 2008). In Pennsylvania, this species has been collected in the Susquehanna and Delaware basins, including the Juniata River and its tributaries. The Yellow Lampmussel is associated with riffle habitat, where it buries itself in fine gravel and mud (Spoo 2008). This species is a long-term brooder, with fertilization occurring in summer followed by glochidial release during the following spring (NatureServe 2018). More research is needed to understand species interactions for the Yellow Lampmussel, however in coastal areas, White Perch (*Morone americana*) and Yellow Perch (*Perca flavescens*) have been reported as glochidial hosts. This species can be distinguished from closely related species based on the lack of rays, glossy yellow shells, and truncate females (Welte 2018).

Figure 3-4. Yellow Lampmussel (*Lampsilis cariosa*) displaying lure. Photo credit: Jeffrey Cole, USGS.

Site Description and Sampling Conditions

Raystown Lake is a USACE flood control project constructed in 1973, through the impoundment of the Raystown Branch of the Juniata River. The project area is located in Huntingdon County in south-central Pennsylvania. The Raystown Branch and Raystown Lake lie within the Ridge-and-Valley Appalachians, a physiological province situated between the Appalachian Plateau and Blue Ridge Mountains (Stanley 1999). The Raystown Branch of the Juniata River is one of three primary tributaries of the Juniata River, which is within the Susquehanna River Basin. The Susquehanna River Basin is known for an abundant and diverse invertebrate assemblage, with estimates of aquatic insect taxa well exceeding 100 species (Benke and Cushing 2005). With its broad channel and shallow cobble reaches, the Raystown Branch as well as other rivers in the Susquehanna Valley support a variety of functional groups of invertebrate organisms. In comparable rivers in the basin, commonly collected aquatic insects include anthopotamid, baetid, heptageniid, and isonychiid mayflies, chironomids, hydropsychid mayflies, and elmid beetles (Benke and Cushing 2005). There are thirteen known native mussel species in the Susquehanna River Basin, and ten are known to occur in the Juniata River watershed.

The Susquehanna Basin is known for its frequent flooding, and 2018 was no exception. In fact, annual precipitation rates in Huntingdon and Bedford counties far exceeded the yearly average (Figure 3-5). Precipitation levels and timing are important when considering changes to river stage, velocity rates, turbidity levels, and habitat stability, and their effects on the local biota. At the time of insect sampling, river stages were higher than average, limiting the availability of wadeable river reaches for macroinvertebrate sampling. However, every effort was taken to ensure the aquatic insect community was fully characterized. Due to the fully aquatic nature of mussels, sampling for Yellow Lampmussel and Brook Floater was delayed until river conditions were more favorable.

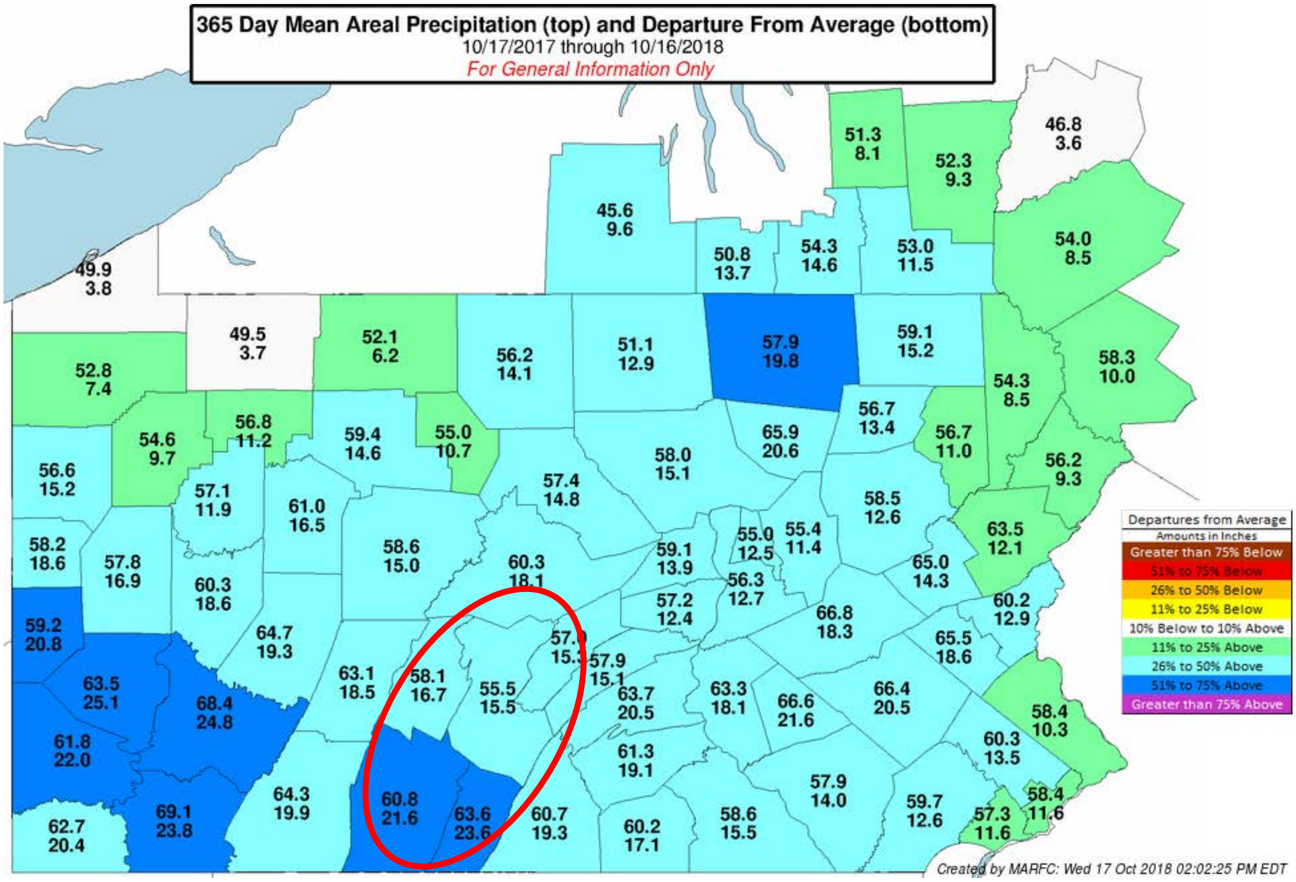

Figure 3-5. Mean annual precipitation and departure from average values (inches) from October 2017-October 2018. Pennsylvania Counties, Huntingdon, Bedford, and Fulton, are circled in red.

Methods

Insect Sampling

Field collections of aquatic insects were conducted by Dr. Audrey Harrison and Dr. Reese Worthington (Missouri Department of Conservation). Ms. Tara Whitsel (USACE – Baltimore District) provided insight on collection localities, as well as access to tributary streams. Field collections were carefully planned to occur between the last larval instar and emergence of both target species. Sampling occurred 21-24 May 2018 targeting a total of 17 sites, including Raystown Branch of the Juniata River upstream and downstream of Raystown Lake, as well as tributaries and nearby streams for comparison (Figure 3-6; Table 3-1). Sampling of upstream sites and tributaries is important, because many species have the ability to colonize the downstream reach from these nearby habitats. Unfortunately, due to river stage and high flows during the sampling window, some sampling locations were limited due to inaccessibility. Each sample station was georeferenced with a hand-held Garmin 64ST (WGS84 datum, dd.ddd).

Table 3-1. Insect sampling dates and localities in the Raystown Lake area, PA.

DATE	LOCATION	GEAR	LATITUDE	LONGITUDE
5/21/2018	Raystown Branch of the Juniata River @ Coopertsite Recreational Area @ Hopewell	N/A	40.12086097	-78.27394201
	Raystown Branch of the Juniata River @ USACE Nature Trail	Blacklight	40.43970899	-77.98132399
	Sandy Run @ Kearny Rd	Kicknet	40.12276903	-78.23025201
	Sideling Hill Creek @ Hwy 915	Kicknet	40.07156398	-78.14082004
	Yellow Creek @ Hwy 26	Kicknet	40.14111903	-78.28317502
5/22/2018	Fairfield Marriott Hotel Parking Lot	Hand	40.48780804	-78.04268296
	Raystown Branch of the Juniata River @ boat ramp downstream of span bridge	Berlese	40.45610097	-77.97860599
	Raystown Branch of the Juniata River @ boat ramp downstream of span bridge	Kicknet	40.45610097	-77.97860599
	Raystown Branch of the Juniata River @ Corbin Island Boat Access and Rec Area	Kicknet	40.42903899	-77.98985501
5/23/2018	Raystown Branch of the Juniata River under Corbin Rd Bridge	Kicknet	40.45398697	-77.98245002
	Tatman Run off Hwy 994	Kicknet	40.30483997	-78.16861502
	Tatman Run off Hwy 994	Lindgren Funnel	40.30483997	-78.16861502
	Tatman Run off Hwy 994	Malaise	40.30483997	-78.16861502
	Tatman Run off Hwy 994	Pitfall	40.30483997	-78.16861502
	Trough Creek @ Copperas Rock Campground #3	Kicknet	40.32064799	-78.12187501
	Trough Creek @ Paradise Rd Camp Area	Kicknet	40.30911399	-78.12603797
	Trough Creek @ Terrace Mtn. Trail Road	Malaise	40.33581203	-78.12294303
	Trough Creek @ Terrace Mtn. Trail Road	Sweepnetting	40.33581203	-78.12294303
	Trough Creek @ Trough Creek State Park, Picnic Area 4	Kicknet	40.32140697	-78.12343396
5/24/2018	Raystown Branch Juniata @ Warriors Path State Park picnic area	Blacklight	40.20356898	-78.26636301
	Raystown Branch Juniata @ Warriors Path State Park picnic area	Kicknet	40.20356898	-78.26636301
	Raystown Branch of the Juniata River @ confluence of Sixmile Run @ Hwy 26 & Sixmile Run Rd	Kicknet	40.16186700	-78.25481501
	Raystown Branch of the Juniata River @ Warriors Path State Park, Pavillion #2	Kicknet	40.19655299	-78.25163500
	Raystown Branch of the Juniata River @ Warriors Path State Park, Pavillion #2	Malaise	40.19655299	-78.25163500
	Raystown Branch of the Juniata River @ Warriors Path State Park, Pavillion #2	Pitfall	40.19655299	-78.25163500
	Raystown Branch of the Juniata River off Hwy 26 between Riddlesburg & Marysville	Kicknet	40.16899296	-78.24933803
	Raystown Branch of the Juniata River off Hwy	Lindgren	40.16899296	-78.24933803

	26 between Riddlesburg & Marysville	Funnel		
	Raystown Branch of the Juniata River off Hwy 26 between Riddlesburg & Marysville	Malaise	40.16899296	-78.24933803
	Raystown Branch of the Juniata River off Hwy 26 between Riddlesburg & Marysville	Pitfall	40.16899296	-78.24933803

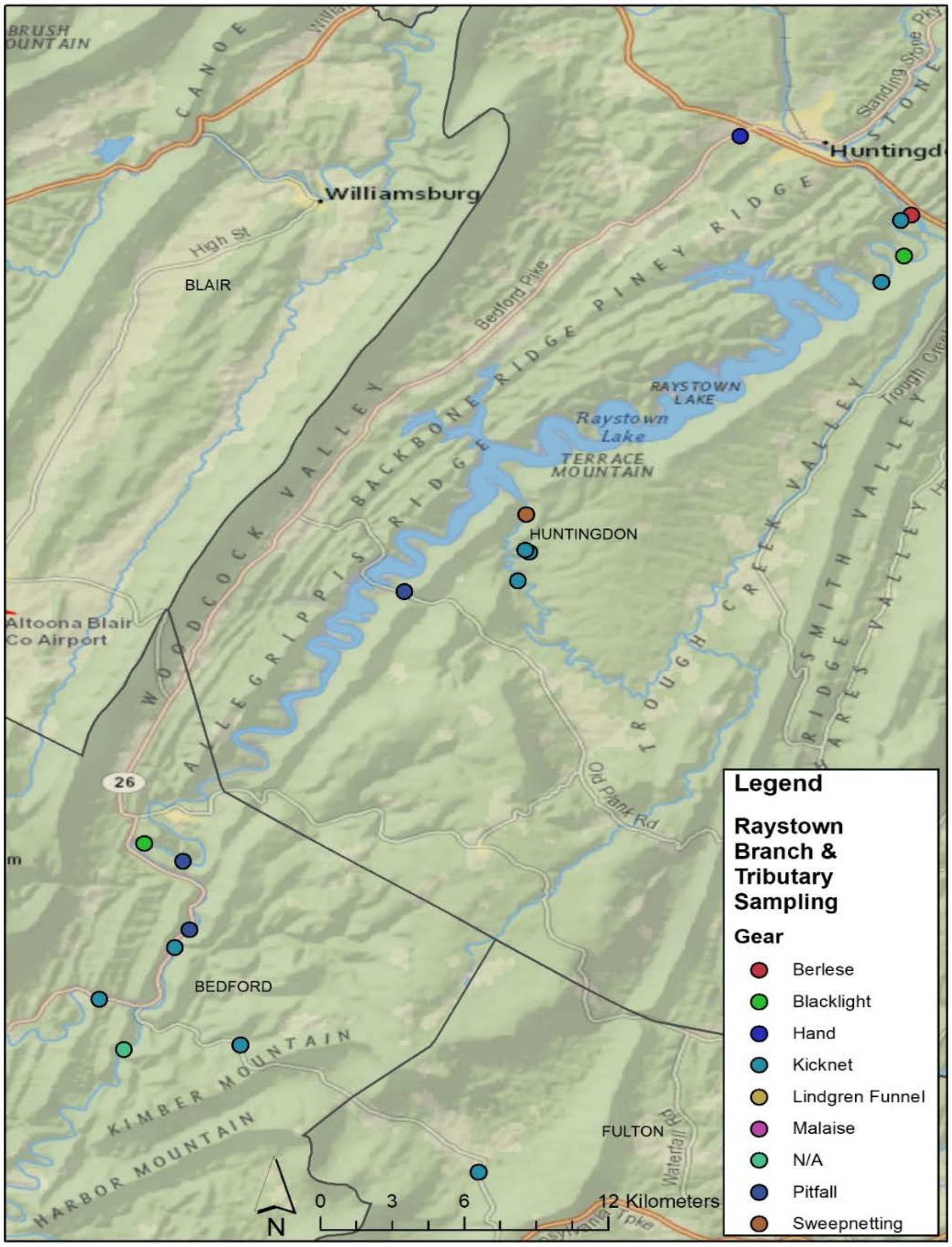

Figure 3-6. Insect sampling reach within and near the Raystown Lake Project Area, PA. Gear types used at each sample site are represented in the legend. “N/A” represents a failed attempt to sample due to hazardous river conditions, which restricted access. Map created using ArcMap version 10.

At each site, standard rectangular kicknets were used to sample for macroinvertebrates. Sampling was standardized by taking twenty 1-m kicknet samples at each site (10 standardized samples per researcher), within a 100 m reach (Figure 3-7). Additionally, in order to maximize the likelihood of capturing the taxa of interest, targeted (qualitative) kicknet sampling focused on select microhabitats listed in published literature (e.g. Needham et al. 2000; Westfall & May 2006; Paulson 2012; Lam 2004), including riffles (*C. angustipennis*) and soft bottom substrates (*G. abbreviatus*). Targeted aerial sweepnetting was used to collect adult dragonflies and damselflies. These attempts were largely unsuccessful, however, because odonate emergence had not yet begun. Therefore, with one exception, all odonates collected were in their larval stage. Specimens were fixed and preserved in 80% EtOH and returned to ERDC in Vicksburg, MS, where they were sorted, enumerated, and identified to the lowest possible taxon (genus or species) using appropriate taxonomic keys (Merritt et al. 2008; Needham et al. 2014; Westfall and May 1996). Collections are vouchered in the US Army ERDC insect collection, and specimens are available for display at the Raystown Lake Project Headquarters Building upon request. List of all species identified at each location is provided in Appendix V.

Data were compiled using Microsoft Excel. Richness and composition measures were selected from standard bioassessment protocols for wadeable rivers (Barbour et al. 1999). Univariate diversity analyses were performed using PRIMER (version 7), as were multivariate analyses including resemblance, non-metric multidimensional scaling, and similarity percentages (see Clarke et al. 2014). Diversity metrics are provided and highlighted in table columns that are color-coded using conditional formatting to highlight visually the differences in values across sites.

Figure 3-7. Dr. Reese Worthington kicknetting in Raystown Branch of the Juniata River below Raystown Lake, PA.

Additional gear types were used to further characterize insect communities (emergent aquatic and terrestrial) within and near the project area. To increase chances of capturing flying odonates, as well as other terrestrial and emergent aquatic insects, passive sampling was employed through the use of Townes-style malaise traps, which were set for 24 hours at each site, along the riverbank perpendicular to the flow, or within a natural insect flight corridor (Figure 3-8). Each night, blacklighting was used to attract positively phototactic nocturnal insects (Figure 3-9). Additionally, Lindgren funnels (Figure 3-10) were hung from tree branches to collect insects attracted to rotting wood and pitfall traps (Figure 3-11) were placed in along transects to capture ground dwelling species, for 24 hours all according to the methodology of Triplehorn and Johnson (2005). These collections are housed at the US Army ERDC in Vicksburg, MS, and can be processed upon request if funding becomes available in the future.

Figure 3-8. Townes-style malaise trap set along the LDB of Tatman Run in the USACE Raystown Lake Project Area, PA.

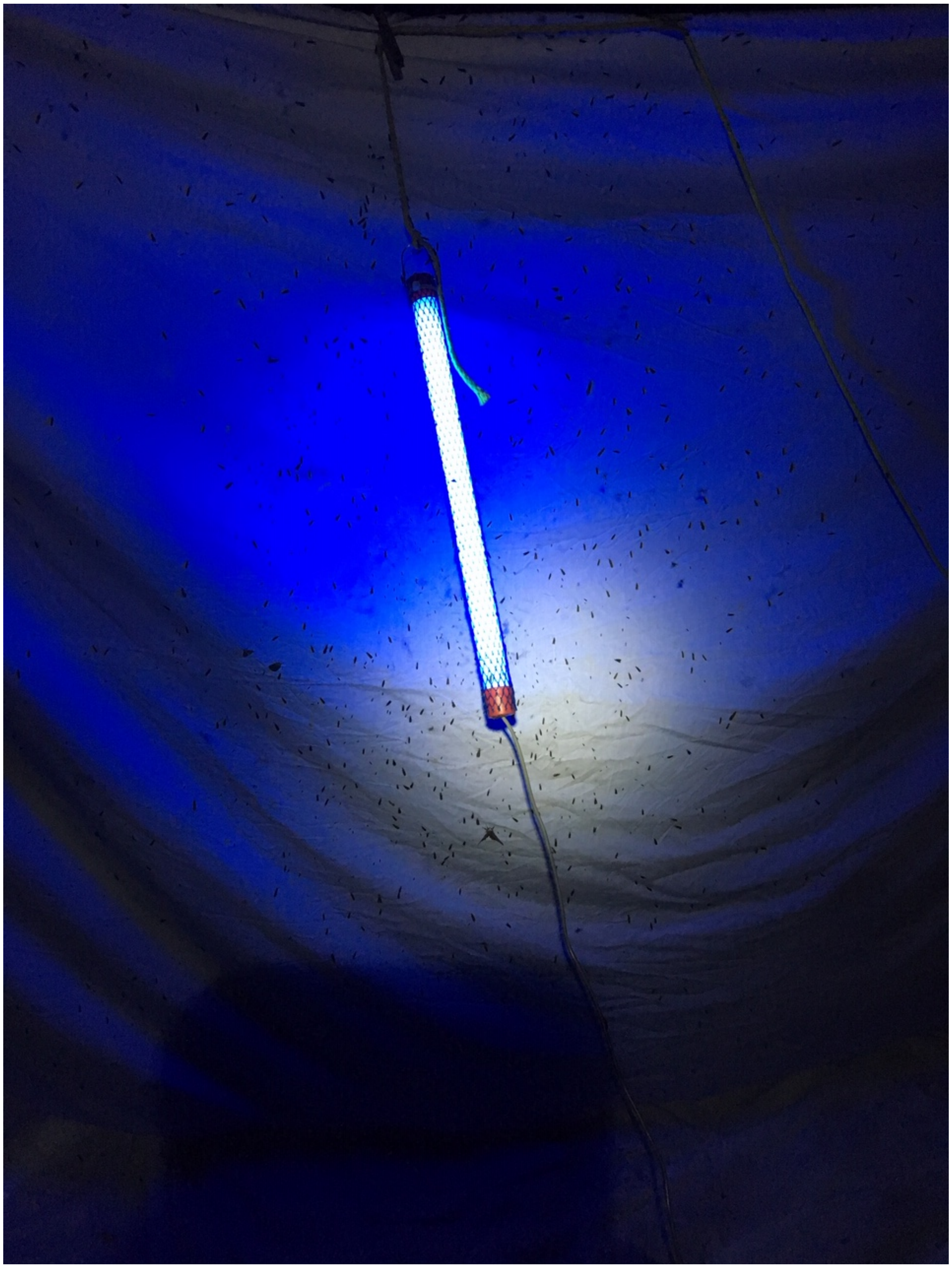

Figure 3-9. Blacklight and sheet set near the Raystown Branch of the Juniata River at the Nature Trail area in the Raystown Lake Project Area, PA.

Figure 3-10. Lindgren Funnel set at the Raystown Branch of the Juniata River at the Nature Trail area in the Raystown Lake Project Area, PA.

Figure 3-11. One of four pitfall traps set along transect near the Raystown Branch of the Juniata River at the Nature Trail area in the Raystown Lake Project Area, PA.

Mussel Sampling

Field sampling of mussels was undertaken at 13 sampling stations by Dr. Todd Slack, Steven George, and Bradley Lewis on 28-29 August 2018 (Figure 3-12, Appendix V). Semi-quantitative wadeable stream surveys were conducted in the Raystown Branch of the Juniata River to assess mussel occurrences within the designated project area. During timed searches, live mussels were located by feeling along the bottom and sifting through the substrate (i.e., polly-wog type search) (Figure 3-13). Visual searches were also conducted where water clarity permitted. In addition to searches for live mussels, shorelines and emergent portions of sand/gravel bars at each site were searched for empty shells. These general sampling strategies are described in more detail by Strayer and Smith (2003).

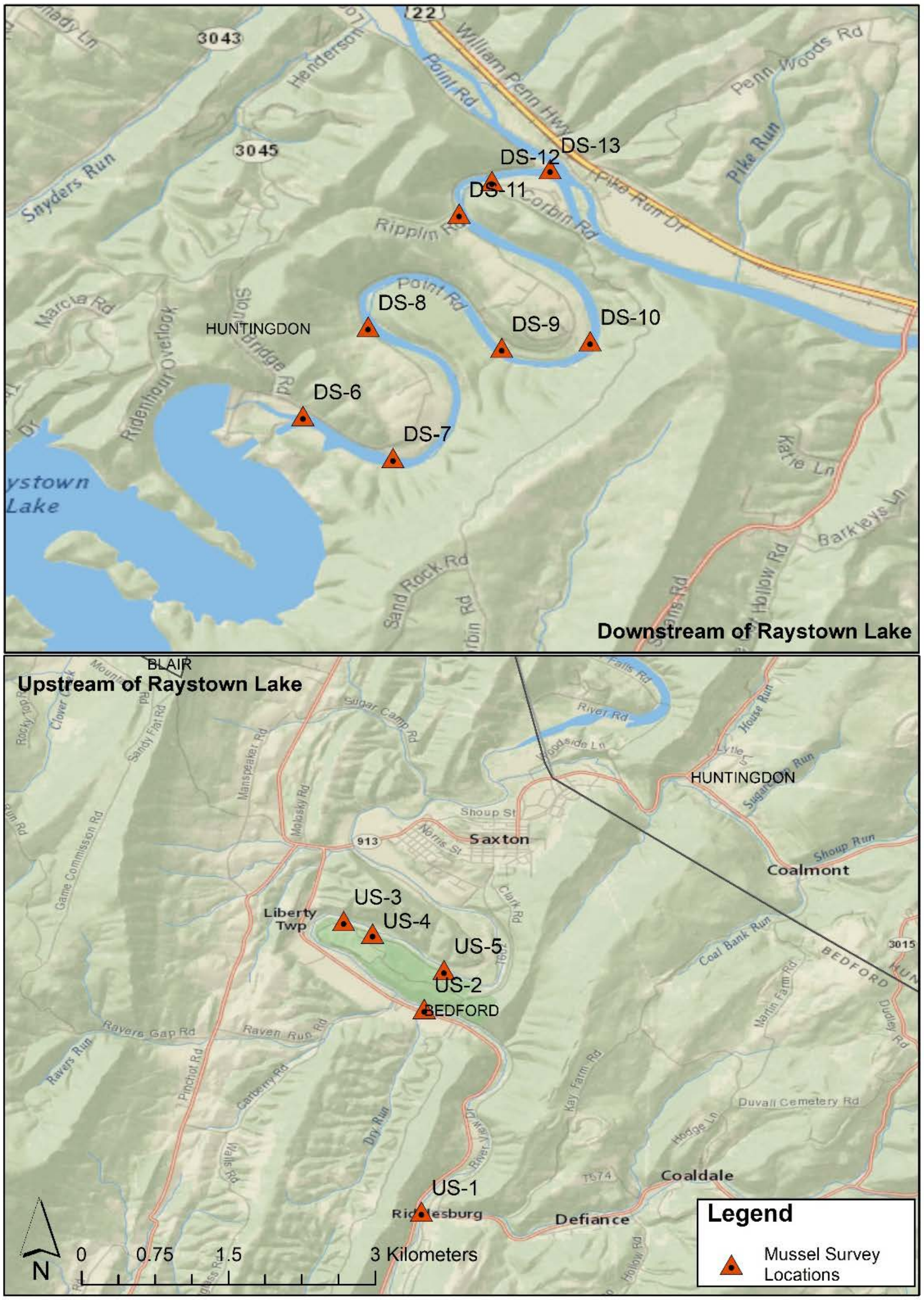

Figure 3-12. Mussel survey locations in the Raystown Branch of the Juniata River upstream and downstream of Raystown Lake, PA. Downstream sites are numbered and prefixed by “DS” and upstream sites are numbered and prefixed by “US”. Map created using ArcMap version 10.

Figure 3-13. Raystown Branch Juniata River at station DS-9, illustrating biologists Steven George and Bradley Lewis acquiring habitat transect data and performing visual scans for mussels, Raystown Lake, PA.

General stream conditions (e.g., water temperature [C], dissolved oxygen [mg/L], specific conductivity [mS/cm], pH) were measured at each sample station using a YSI ProDSS® at 5 equidistant points along a cross-channel transect (Figure 3-14). Each sample station was georeferenced with a hand-held Garmin 64ST (WGS84 datum, dd.ddd), and observations regarding predominant substrate and general weather conditions were noted and recorded (Appendix V). Following timed searches, all mussels were identified and enumerated on-site (Figure 3-15), following the nomenclature outlined by Turgeon et al. (1998). Categorizations of dead shell conditions (freshly dead, weathered dead, or relict dead), followed Haag and Warren (1998). Live specimens were returned near the point of original capture and embedded firmly into the substrate. Select voucher specimens were retained from non-living material, for confirmation of identifications in the ERDC laboratory in Vicksburg, MS, and representatives are available upon request.

Figure 3-14. Raystown Branch Juniata River at station DS-10 illustrating substrate composition and water clarity typical at stations in the reach downstream of Raystown Lake, PA. Photographed: Steven George measuring water velocity and depth along transect.

Figure 3-15. Display of sampled mussels from efforts at Corbin Island (DS-7), Raystown Lake, PA.

Results

Aquatic Insects

Sampling efforts within the 21-24 May 2018 period resulted in collection of 626 macroinvertebrate individuals comprised of 103 individual taxa (Appendix V). Specimens of the target odonate species were not encountered at any of the sampled locations, despite intensive sampling of associated microhabitats. However, sampling of the Raystown Branch of the Juniata River upstream and downstream of Raystown Lake did result in collection of a congener of one of the target species, *Calopteryx dimidiata* Burmeister, the Sparkling Jewelwing Damselfly, which was thought to be possibly extirpated in the state of Pennsylvania, and represents a new county record, extending the known range by approximately 200 km (Johnson 1974; NatureServe 2018). The Ocellated Darner Dragonfly, *Boyeria grafiana* Williamson, of which specimens were collected in Trough Creek State Park, is listed as vulnerable according to NatureServe Ranks (NatureServe 2018), as is the Tiger Spiketail Dragonfly, *Cordulegaster erronea* Hagen, of which a single specimen was collected from Tatman Run. The Perlid stonefly species *Acroneuria internata* (Walker) and *Perlesta ephelida* Grubbs and Desalt are listed for the state of Pennsylvania for the first time, as is Isonychid mayfly species *Isonychia sayi* Burks.

Composition of key taxa indicative of increased water quality and environmental stability (i.e., Ephemeroptera, Plecoptera, Trichoptera), was high across all site types sampled, whereas composition of tolerant taxa, including non-insecta and Chironomidae, were low across all sites (Table 3-2). Community-level resemblance analyses (non-metric multidimensional scaling of Bray-Curtis similarities) of macroinvertebrate collection data suggest some overall differences in taxa collected upstream vs. downstream of Raystown Lake, as well as differences in taxa present in Raystown Branch tributaries and other nearby streams (Figure 3-16). Further investigation into these differences through SIMPER analysis, suggest typifying taxa for each of these major site types differ (Table 3-3). Tributary sites were most heavily characterized by sensitive taxa (EPT – Ephemeroptera, Plecoptera, Trichoptera), as were upstream sites, compared to downstream sites, of which typifying taxa only included one EPT taxon, *Eurylophella* sp. Diversity metrics, indicate lower levels of diversity (H’) downstream of Raystown Lake than upstream or in tributaries, which had higher taxa richness and higher diversity values (Table 3-4).

Table 3-2. Richness and composition measures calculated for each of the site types, including the Raystown Branch of the Juniata River, downstream, upstream and sampled tributaries and nearby streams (i.e., other), Raystown Lake, PA.

	DOWNSTREAM	UPSTREAM	OTHER
EPT RICHNESS	24	18	38
% EPT	66.48	49.68	77.16
% NON-INSECTA	8.79	3.87	1.04
% CHIRONOMIDAE	3.3	5.16	3.46

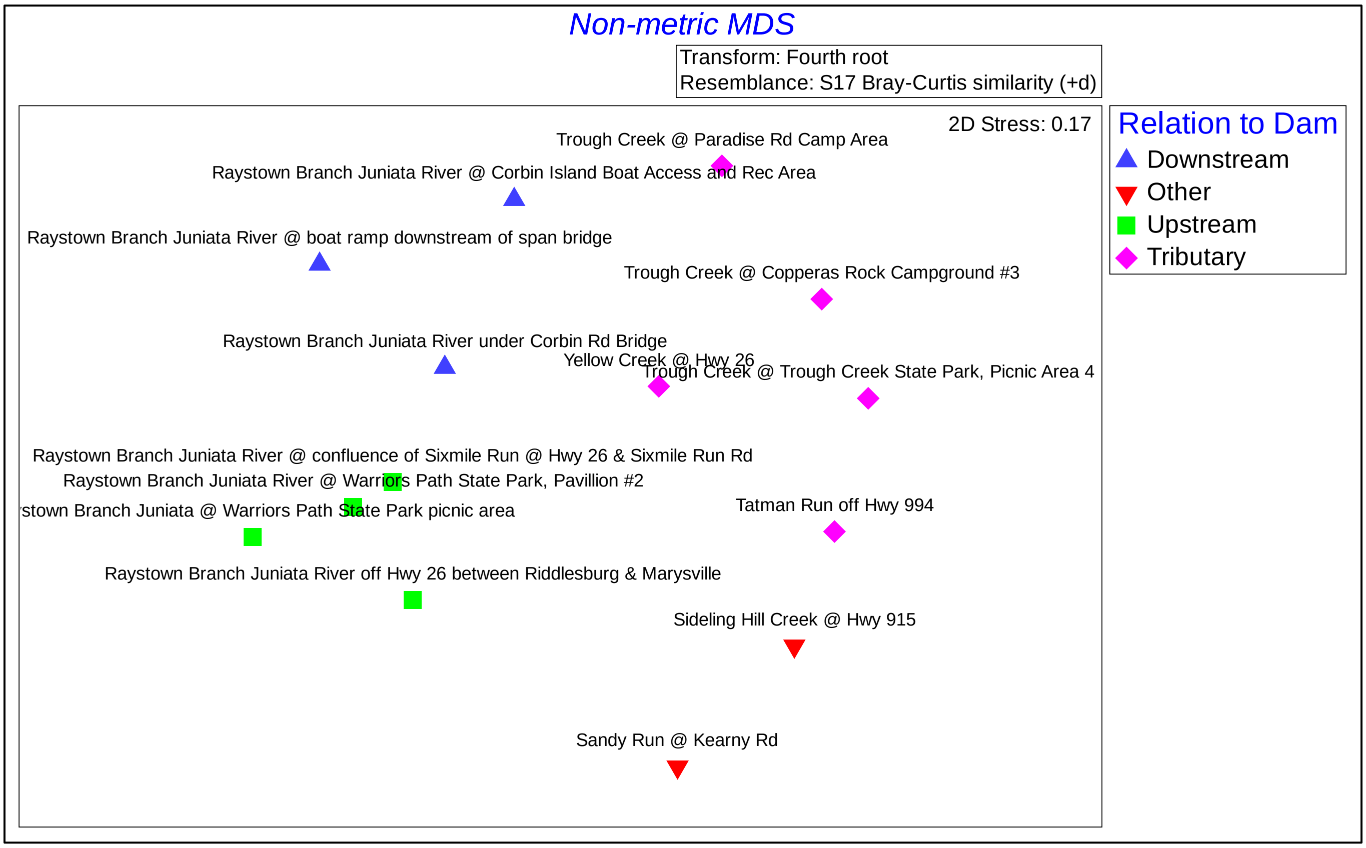

Figure 3-16. Non-metric multidimensional scaling of Bray-Curtis similarity of macroinvertebrate samples collected from/near the Raystown Branch of the Juniata River, Raystown Lake, PA.

Table 3-3. Typifying taxa for each site type based on SIMPER analysis at a 70% cutoff of similarity, Raystown Lake, PA.

Site Type	Typifying Taxa	EPT
Downstream		
	Gammaridae	
	Eurylophella	X
	Psephenus	
	Enallagma	
Upstream	*Enallagma*	
	Eurylophella	X
	Perlesta	X
	Anthopotamus	X
	Leptophlebia	X
	Peltodytes	
	Chironomidae	
Tributary	*Pycnopsyche*	X
	Penelomax septentrionalis	X
	Isonychia	X
	Siphlonurus	X
	Chironomidae	
	Maccaffertium	X
	Ephemerella	X
	Gammaridae	
	Isoperla	X

Table 3-4. Diversity metrics calculated for each sample from/near the Raystown Branch of the Juniata River, Raystown Lake, PA.

Site Type	Location	S	N	d	J'	H'(loge)	1-Lambda'
Downstream	Raystown Branch Juniata River under Corbin Rd Bridge	13	27	3.641	0.8642	2.217	0.8746
Other	Sideling Hill Creek @ Hwy 915	16	53	3.778	0.9065	2.513	0.918
Other	Sandy Run @ Kearny Rd	7	11	2.502	0.9488	1.846	0.9091
Tributary	Yellow Creek @ Hwy 26	34	125	6.835	0.882	3.11	0.9418
Downstream	Raystown Branch Juniata River @ boat ramp downstream of span bridge	5	8	1.924	0.9284	1.494	0.8571
Downstream	Raystown Branch Juniata River @ Corbin Island Boat Access and Rec Area	7	22	1.941	0.7982	1.553	0.7359
Tributary	Tatman Run off Hwy 994	34	141	6.668	0.7652	2.698	0.8794

Tributary	Trough Creek @ Copperas Rock Campground #3	12	22	3.559	0.9554	2.374	0.9394
Tributary	Trough Creek @ Trough Creek State Park, Picnic Area 4	23	45	5.779	0.9236	2.896	0.9485
Tributary	Trough Creek @ Paradise Rd Camp Area	10	17	3.177	0.9471	2.181	0.9265
Upstream	Raystown Branch Juniata River @ confluence of Sixmile Run @ Hwy 26 & Sixmile Run Rd	14	37	3.6	0.8633	2.278	0.8844
Upstream	Raystown Branch Juniata River off Hwy 26 between Riddlesburg & Marysville	23	61	5.352	0.853	2.675	0.912
Upstream	Raystown Branch Juniata River @ Warriors Path State Park, Pavillion #2	18	34	4.821	0.9166	2.649	0.9394
Upstream	Raystown Branch Juniata @ Warriors Path State Park picnic area	14	23	4.146	0.9339	2.465	0.9407

S = Species (or taxa) richness, N = number of individuals collected, d = Margalef's richness index, J' = Pielou's evenness index, H'(loge) = Shannon Diversity, 1-Lambda' = Simpson index). Each column is scaled green – red (high to low) to highlight range of values across sites.

Mussels

A total of 511 individual mollusks representing 5 taxa were collected 28-29 August 2018 (Table 3-5). Six individuals of Yellow Lampmussel (*Lampsilis cariosa*), one of the two targeted mussel species, was found in the Raystown Lake Project area, while the other target species, the Brook Floater (*Alasmidonta varicosa*) was not detected. All of the Yellow Lampmussel specimens were collected downstream of Raystown Lake, and five were collected live. Overall, the majority of the mussels collected were found in the Raystown Branch of the Juniata River downstream of Raystown Lake. Although only three species of native Unionidae taxa were encountered during this survey, one novel taxon, the Rainbow Mussel (*Villosa iris*) was documented from Raystown Branch for the first time. To our knowledge, this species has only been collected within the Juniata Basin in the Juniata River proper and Tuscarora Creek (Welte 2018). The Eastern Elliptio (*Elliptio complanata*) (Figures 3-17 and 3-18) was highly abundant within the watershed and found at all but one sampled station (Table 3-5). In most cases, it was represented by live and/or fresh dead specimens. The non-native Asian Clam (*Corbicula fluminea*) was documented at all sampled stations (Figure 3-17). Aquatic snails (Pleuroceridae) were noted at one station (Table 3-5). Evans and Ray (2008) and Johnson et al. (2013) list three pleurocerid taxa (Sharp Hornsnail (*Pleurocera acuta*), Silty Hornsnail (*P. canaliculata*), and Piedmont Elimia (*Elimia virginica*) for Pennsylvania. However, Dillon et al. (2013) do not include the *Pleurocera* taxa in Atlantic coastal drainages and the specimens likely represent the Piedmont Elimia *P. virginica* (= *Elimia virginica*). All mussels detected during sampling events are presented in Appendix VI.

Table 3-5. Mollusk taxa collected during survey of the Raystown Branch of the Juniata River upstream and downstream of Raystown Lake, PA.

SITE NUMBER Mussel Condition	***Elliptio complanata***	***Lampsilis cariosa***	***Villosa iris***	***Pleuroceridae***	***Corbicula fluminea***	**Total**
US-1					**2**	**2**
Live						
Fresh Dead						
Weathered					2	2
Relict						
US-2	**11**				**12**	**23**
Live	3					3
Fresh Dead	2				1	3
Weathered					4	4
Relict	6				7	13
US-3	**5**				**13**	**18**
Live	1					1
Fresh Dead					3	3
Weathered	4				10	14
Relict						
US-4	**8**				**30**	**38**
Live	5				6	11
Fresh Dead					13	13
Weathered	3				2	5
Relict					9	9
US-5	**15**				**16**	**31**
Live	3				1	4
Fresh Dead	5				5	10
Weathered						
Relict	7				10	17

DS-6	**2**	**3**		**2**	**57**	**64**
Live		3		1	13	17
Fresh Dead				1	25	26
Weathered	1				6	7
Relict	1				13	14
DS-7	**26**	**1**	**1**		**21**	**49**
Live	26	1	1		10	38
Fresh Dead					5	5
Weathered					6	6
Relict						
DS-8	**71**				**10**	**81**
Live	46				2	48
Fresh Dead	5				3	8
Weathered	1				5	6
Relict	19					19
DS-9	**33**				**22**	**55**
Live	14				8	22
Fresh Dead	2					2
Weathered	12				14	26
Relict	5					5
DS-10	**3**				**21**	**24**
Live	2				8	10
Fresh Dead					9	9
Weathered						
Relict	1				4	5
DS-11	**35**				**21**	**56**
Live	17				8	25
Fresh Dead	1				3	4
Weathered					5	5
Relict	17				5	22
DS-12	**12**	**1**			**14**	**27**
Live	6				5	11
Fresh Dead	2				2	4
Weathered		1			7	8
Relict	4					4
DS-13	**28**	**1**			**14**	**43**
Live	26	1			11	38
Fresh Dead						
Weathered	2					2
Relict					3	3
Total	**249**	**6**	**1**	**2**	**253**	**511**

US = Upstream of Raystown Lake; DS = Downstream of Raystown Lake.
See Figure X for site numbers and locations.

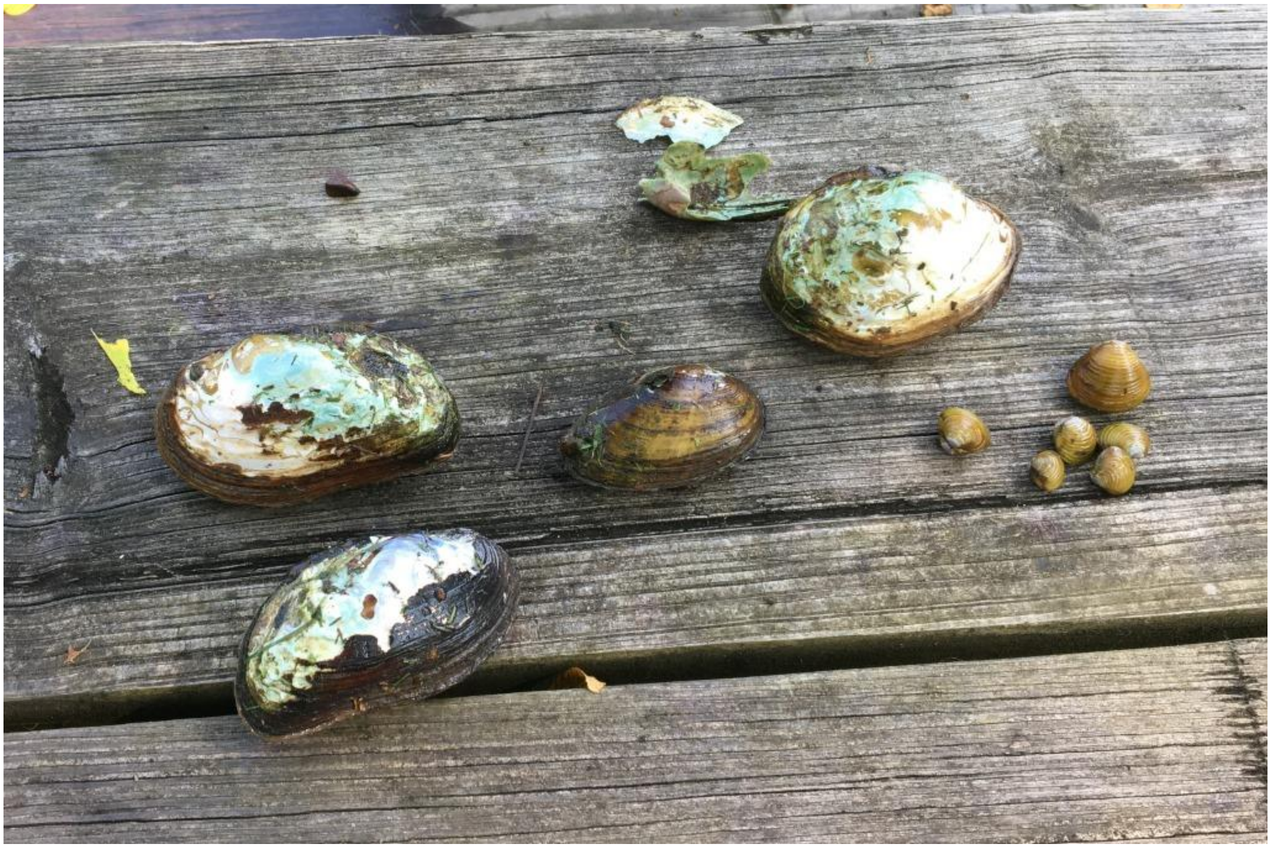

Figure 3-17. Examples of Eastern Elliptio (left), Rainbow Mussel (center), Yellow Lampmussel (top right) and Asian Clam (bottom right) documented at Corbin Island (DS-7), Raystown Lake, PA.

Figure 3-18. Series of live Eastern Elliptio documented at station DS-8, Raystown Lake, PA. Note extensive shell erosion on dorsal half of most specimens.

Summary

Overall, EPT diversity was very high across all sites sampled, indicating stable conditions and good water quality (Barbour et al. 1999). In general, higher diversity was measured in samples collected upstream of Raystown Lake, as well as tributary streams, however this could be related to stream conditions at the time of sampling, which limited access to many of the downstream sites. Although neither of the targeted Odonata species were collected during this sampling effort, other notable taxa were, including other river-breeding dragonflies and damselflies. Additionally, several novel taxa, including stoneflies and mayflies were reported for Pennsylvania.

Mussel diversity was low both upstream and downstream of Raystown Lake in the Raystown Branch of the Juniata River. Compared to rivers in other geographical provinces, however, this region has comparatively low diversity overall (Haag 2012). Within the Juniata River Basin, there are only 10-11 known mussel taxa, and within the Raystown Branch, only 6 taxa have been reported previously (Welte 2018). By comparison, the 20 rivers within North

America with the most diverse mussel assemblages occur in the southeastern United States with richness ranging from 104 taxa in the Tennessee River to 43 in the Meramec (Missouri) and Kaskaskia rivers (Illinois) (Haag 2012). The number of mussels reported per state varies greatly with Alabama (177), Tennessee (132), Kentucky (103), Georgia (98) and Mississippi (87) comprising the top five (Williams et al. 1993; Lydeard et al. 1999; Jones et al. 2005) while the fewest number of freshwater mussels (1-6 per state) occur in states west of the Great Plains (LaRoe et al. 1995; Haag 2012). Pennsylvania ranks 13th for total mussel diversity with 67 native species occurring in six major drainages: Delaware (14), Genesee (3), Lake Erie (23), Ohio (54), Potomac (9) and Susquehanna (12) (LaRoe et al. 1995; Welte 2018). Raystown Lake and the associated watershed (Raystown Branch Juniata River) is located within the Juniata River watershed which is included within the Susquehanna drainage. Diversity within the drainage ranges 1-11 species per watershed with a mean of 2.89 species per watershed (Welte 2018, Appendix M, N, O and P).

In order to protect the existing biotic integrity of the Raystown Branch of the Juniata River, it is our recommendation to maintain habitat stability by mimicking to the extent possible the natural flow regime, as well as reducing any activities that could lead to decline of water quality or clarity through nutrient or sediment pollution.

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4 Noctuid Moth Surveys on Shale Barren Habitats, USACE Raystown Lake, Pennsylvania

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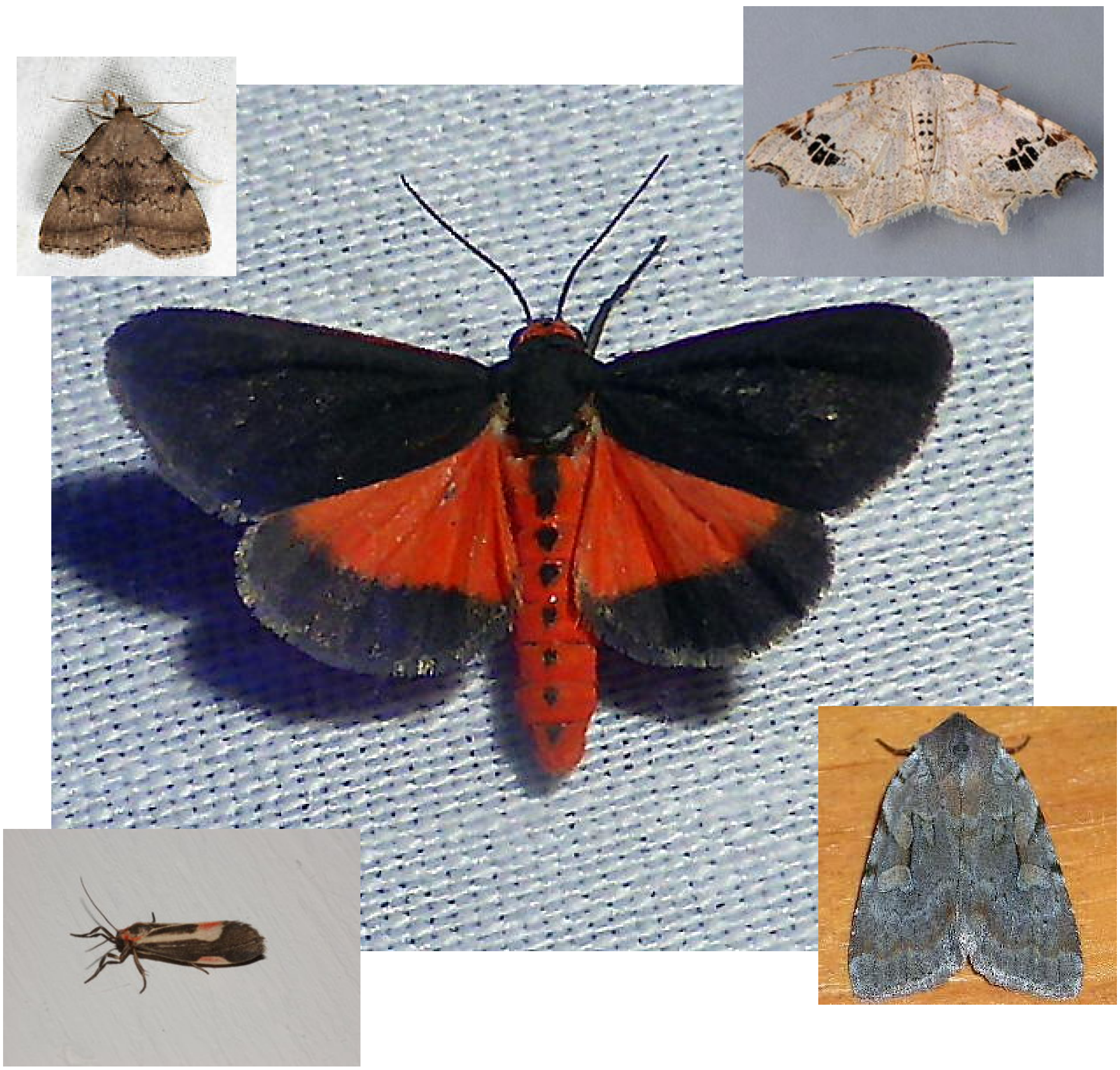

Introduction

This study was conducted at the request of the United States Army Core of Engineers (USACE) to inform updates to Master Plan of the Raystown Lake Reservoir and Recreation Area. My survey efforts focused primarily on the Lepidoptera inhabiting the area's shale barrens, as well as other habitats or plant communities deemed most likely to harbor rare, endangered or threatened species.

Lepidoptera, as a group, are widely variable in their ecologies and flight periods throughout the year. Habitat specialists are often tightly bound to a single plant species or genus, and many moth species fly for no more than a few weeks each growing season. Given these inherent difficulties in their detection, as well as the targeted nature of my study, this survey should not be considered a comprehensive inventory of all Lepidoptera present in Raystown Lake.

Methods

An initial site survey was conducted by Steve Johnson on May 20, 2018 (40°23'56" -78°02'39") (Figure 4-1), using a 200W Mercury Vapor light. Mr. Johnson monitored the light over the course of one night, and recorded the species of any Lepidoptera that were attracted.

Six trapping sites were selected for systematic sampling during the first site visit in July 2018. Sites were selected based on the presence of plant species or communities deemed likely to host rare or threatened Lepidoptera. Initial site surveying and discussion with the project botanist focused on locating New Jersey tea (*Ceanothus americanus* L.) and roundleaf ragwort (*Pakera obovata* (Muhl. ex Willd.) W.A. Weber & Á. Löve), both of which prefer to grow in well-drained habitats and host several of the rarest Lepidoptera found in Shale barrens. During my visits to Raystown, I did not locate either plant. With input from Raystown Lake personnel, two sites were selected on Upper Corners peninsula (Sites 1 and 2), one on Valley Camp peninsula (Site 3), and three on Hawns peninsula (Sites 4-6). During the first collection visit, one trap was also placed at the Ridenor Overlook (40°25'47" -78 01'10"); this site was abandoned due to concerns that heavy foot traffic in the area created a risk of equipment tampering (Figure 4-1).

Sites 1 (40°22'25", -78°04'53"), 2 (40°22'34", -78°06'37"), and 3 (40°22'33", -78°06'35") were located along the upper boundaries of steep, south-facing shale barren habitats, in areas dominated by mature oaks and hard pines, with an understory of lowbush blueberry (*Vaccinium angustifolium* Aiton). Site 4 (40°24'52", -78°00'45") was located in a ~0.5-ha grassland, surrounded by an upland hardwood forest. Site 5 (40°25'00", -78°00'51") was centered in a dense Virginia pine (*Pinus virginiana* Mill.) thicket. Site 6 (40°25'01", -78°00'55") was located in a dry oak woodland, adjacent to a small clearing (Figure 4-2).

Sampling was conducted at roughly 14-day intervals from July 9 to October 1, 2018. Each sample was conducted on a single night, using one 15W black light bucket trap, run with a photo sensor and a 12V deep cycle battery, at each site. Traps were armed with either Ethyl acetate or Acetone to kill captured insects. The complete catch from each trap was collected the next morning and frozen for storage and subsequent identification.

Sample collection was conducted by Neil Schoppmann, or by Raystown Lake seasonal staff members, Mr. Aiden Nagle and Mr. Hunter Maas. Moth identifications were conducted by Neil Schoppmann, and rare or difficult species were determined with assistance from Dr. David Wagner (University of Connecticut) and Dale Schweitzer. Individuals from the following families were identified to the finest possible taxonomic classification: Apatelodidae, Drepanidae, Erebidae, Geometridae, Lasiocampidae, Limacodidae, Noctuidae, Nolidae, Notodontidae, Saturniidae, Sesiidae, Sphingidae, Thyatiridae, Uraniidae, and Yponomeutidae. Mr. Johnson also included the families Crambidae, Depressariidae, Gelechiidae, Pyralidae, and Tortricidae in his sample. All other Lepidoptera, as well as all other Arthropods collected, were refrozen and returned to the USACE for further sorting.

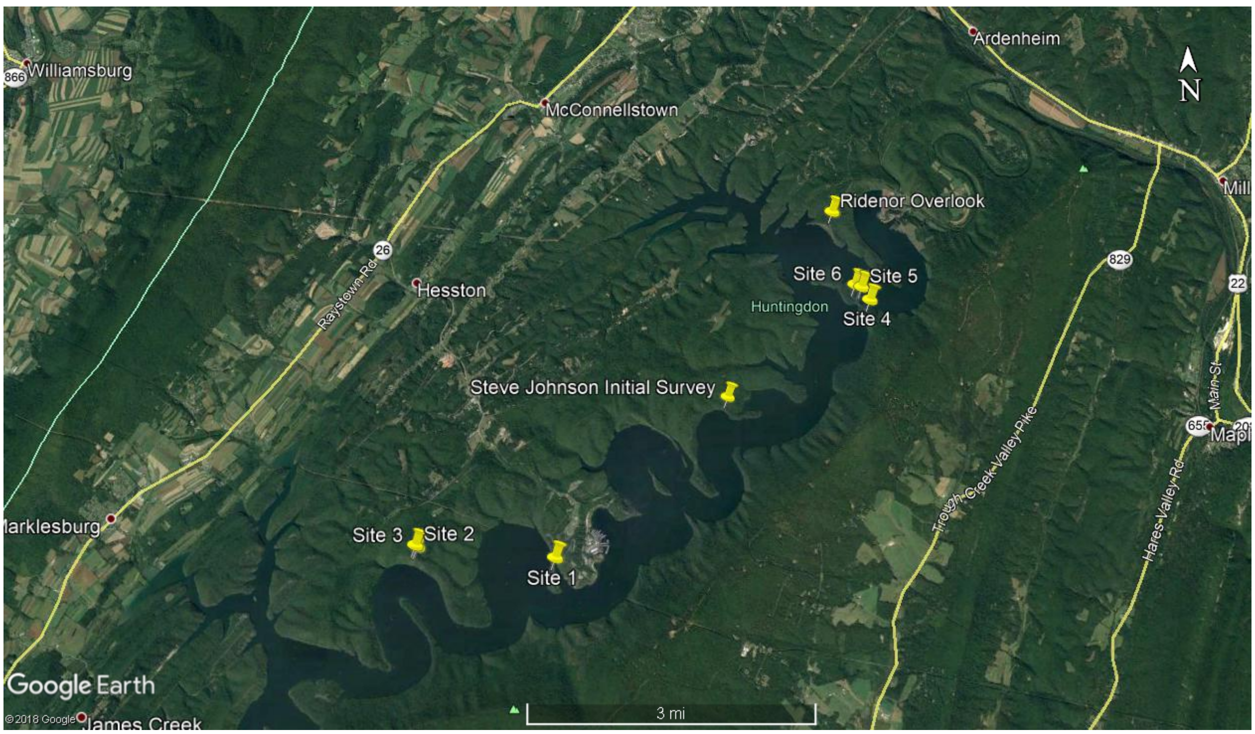

Figure 4-1. Locations of the eight sites around Raystown Lake, PA, where Lepidoptera were collected during the 2018 field season.

Figure 4-2. Photography of each site selected for repeated surveying at Raystown Lake, PA, in 2018.

Results

Over the remainder of the 2018 season we conducted 44 sampling events and collected 11,397 specimens from the Taxonomic families under consideration. From these, 300 species were positively identified (Appendix VII). During his initial site visit, Mr. Johnson recorded the presence of 79 species (Appendix VIII). In total, 347 unique species were recorded across both sampling efforts; total species captured at each sampling site are presented in Appendix IX.

Discussion

Six species were recorded over the course of the survey which are listed by the Pennsylvania Natural Heritage Program as rare, threatened or endangered in the state:

- *Xestia elimata* (Guenée) (G4, S2/S3) is found in well-drained pine woodlands and barrens across the eastern United States, and feeds exclusively on hard pines (Wagner et al. 2011).
- *Zanclognatha dentata* Wagner & McCabe (G3/G4, SNR) feeds on leaf litter and has been reared successfully or collected from a number of different plants. They are found sporadically across the eastern United States (Wagner et al. 2011).
- *Virbia laeta* (Guérin-Méneville) (G4, S1/S2) feeds on forbs and has a range extending from Nova Scotia to Kentucky (Covell 1984)
- *Megalopyge crispata* (Packard) (G5, S1) is a woody plant generalist. Its range extends across the southeastern United States, as well as into more northern states, primarily in coastal areas (Wagner 2005)
- *Macaria promiscuata* (Ferguson) (G4, S1) Feeds on maple and locust and is found in the east central and southeastern United States (Covell 1984).
- *Cisthene packardii* (Grote) (G5, S1/S3) is a lichen feeder, and has a range encompassing much of the eastern United States (Wagner 2005).

Of the six listed species that were recorded, *X. elimata* and *Z. dentata* are both commonly associated with barrens habitats across their ranges, and specifically in areas dominated by hard pines and other mature, woody plants. *X. elimata* is almost exclusively associated with Pine Barrens and similar habitats, while *Z. dentata* is most loosely associated, but almost always collected in the vicinity of either barrens or bogs (NatureServe 2018). Given the prevalence of mature hard pines and oaks found along the ridgeline throughout the Raystown Lake properties, I expect that both species are able to maintain stable populations in the area. Consideration should be given in the long term to management practices that maintain oak-pine woodlands in well-drained soils, and prevent succession to more shade-tolerant species such as maples and hemlocks.

The remaining four listed species that were recorded are all, to some degree, habitat generalists south of Pennsylvania. They range primarily south of PA and in coastal areas farther north, which explains in part their rarity in collections in the state. Mr. Johnson reports increasing collections of *M. crispata* in recent years, which suggests an ongoing range shift to the north (Personal communication, November 2018). This pattern fits with the observations of many regional Lepidopterists in recent decades.

Recommendations

Because my survey efforts started in July, much of the latent Lepidoptera community remains undocumented. This is doubly true when considering the difficulties inherent in collecting nocturnal insects, in general; one-season surveys can document a species turnover of up to 30% if continued into a second field season. Given these circumstances, completing the remainder of my systematic survey in early-May-early-July in a future field season is advisable, and a fully comprehensive survey of the Nocturnal Lepidoptera at Raystown Lake will likely require a second year of sampling.

Many of the rarest Lepidoptera to inhabit shale barrens are diurnal (e.g. *Pyrgus wyandot* Edwards, the Appalachian grizzled skipper, and *Calephelis borealis* Grote and Robinson, the northern metalmark), and would not have been collected using my survey methods. They are also active as adults in the spring to early summer, before I began my work. As these species represent many potentially high-priority conservation targets, any future work should take care to conduct a comprehensive daytime survey for diurnal species, during their peak activity as adults.

My work lacks thorough historical context for species that were once present in the Raystown Lake area of Pennsylvania. This information can be obtained fairly easily, with visits to regional insect collections (ex. the Frost Entomological Museum at Pennsylvania State University). Historical data collection, in addition to a contemporary survey, will create a truly comprehensive picture of the past and current insect populations, and allow the Raystown lake staff to make better informed decisions about their conservation priorities and large scale management practices.

The Lepidoptera community, as currently documented, will require management practices that minimize or eliminate the presence of invasive plant species to remain stable in the long term. Some attention should also be given to maintaining the presence of hard pines around the lake, particularly Virginia pine, and creating areas of exposed, sclerified soil to allow recolonization by early-successional plants such as roundleaf ragwort and New jersey tea. Doing so will improve the condition of the available shale barren habitats and may allow for recolonization by many habitat specialist Lepidoptera which do not appear to be currently present.

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Appendix I: State Rank Codes and Definitions

S1 **Critically Imperiled -** Critically imperiled in the nation or state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.

S2 **Imperiled -** Imperiled in the nation or state because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state.

S3 **Vulnerable -** Vulnerable in the nation or state due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

S4 **Apparently Secure** - Uncommon but not rare; some cause for long-term concern due to declines or other factors.

S5 **Secure** - Common, widespread, and abundant in the nation or state.

S#S# **Range Rank** - A numeric range rank (e.g., S2S3 or S1S3) is used to indicate any range of uncertainty about the status of the species or ecosystem.

SNR **Not Ranked** - State conservation status not yet assessed.

SU **Unknown** - Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.

SX **Presumed Extinct** -Species or community is believed to be extirpated from the nation or state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

SH **Possibly Extinct (Historical)** -Species or community occurred historically in the nation or state/province, and there is some possibility that it may be rediscovered. Its presence may not have been verified in the past 20-40 years. A species or community could become NH or SH without such a 20-40 year delay if the only known occurrences in a nation or state were destroyed or if it had been extensively and unsuccessfully looked for. The NH or SH rank is reserved for species or communities for which some effort has been made to relocate occurrences, rather than simply using this status for all elements not known from verified extant occurrences.

SNA **Not Applicable** - A conservation status rank is not applicable because the species is not a suitable target for conservation activities.

Appendix II: Plot Datasheets

North-Central Appalachian Acidic Shale Woodland

Site Name/Project: Raystown Lake Shale-barren Survey		**Date:** 9/22/2018
City/County: Huntingdon County	**State:** Pennsylvania	**Plot #:** RLB23_PIVI
Investigators: Kevin Philley, Nathan Beane		
Latitude/Longitude: N 40.39807 W 78.04332		**Datum:** NAD83
Plot Size/Shape: Rectangular, 12.5mx8m		
% Slope: 30	**Landform:** hillslope	**Aspect:** Southwest

Cowardin	**Hydrologic Modifiers**		
_X_Upland	___Semipermanently Flooded	___Intermittently Flooded	Salinity/Halinity
___Estuarine	___Seasonally Flooded	___Permanently Flooded	___Saltwater
___Riverine	___Saturated	___Permanently Flooded tidal	___Brackish
___Palustrine	___Temporarily Flooded	___Tidally Flooded	___Freshwater
___Lacustrine			

Surface Geology: | **Soil Taxon:**

Soil Texture

___sand ___loamy sand ___sandy loam _X_loam ___silt loam ___silt
___clay loam ___silty clay ___clay ___peat ___muck

Soil Drainage

_X_Rapidly drained ___Well drained ___Moderately well drained
___Somewhat poorly drained ___Poorly drained ___Very poorly drained

Unvegetated Surface - % by cover class (see table)

_02_Bedrock _07_Small rocks (2 mm - 10 cm) ___Wood (>1cm)
_02_Large rocks (> 10 cm) ___Sand (0.1 - 2mm) _03_Litter
___Bare soil ___Other:

Leaf Phenology of dominant stratum		**Leaf Type of dominant stratum**	
Trees and shrubs	*Herbs*	___Broad-leaved	___Graminoid
_X_Evergreen	___Annual	_X_Needle-leaved	___Forb
___Cold-deciduous	___Perennial	___Microphyllous	___Pteridophyte
___Drought-deciduous			

Physiognomic Class

___Forest _X_Woodland ___Shrubland ___Dwarf shrubland
___Herbaceous ___Nonvascular ___Sparsely vegetated

Strata	**Height Class**	**Cover Class**	**Diagnostic Species** (*if known*)
T1 Emergent			
T2 Canopy			
T3 Sub-canopy			
S1 Tall shrub			
S2 Short shrub			
S3 Dwarf shrub			
H Herbaceous			
Grass			
Forb			
Fern			
N Nonvascular			
V Vine/liana			
E Epiphyte			

Site Name/Project: Raystown Lake Shale-barren Survey		Plot #: RLB23_PIVI
Stratum	**Species name**	**% Cover**
T2	*Pinus virginiana*	40
T2	*Quercus montana*	12
T1	*Pinus virginiana*	10
T1	*Juniperus virginiana*	5
S2	*Pinus strobus*	2
S2	*Quercus rubra*	2
S2	*Quercus velutina*	1
S2	*Pinus virginiana*	1
S2	*Quercus montana*	2
S2	*Junuiperus virginiana*	2
H	*Pinus virginiana*	1
H	*Avenella flexuosa*	2.5
H	*Verbascum thapsus*	1
H	*Trichostema dichotomum*	0.5
H	*Symphyotrichum patens*	0.5
H	*Ambrosia artemisiifolia*	1
H	*Solidago nemoralis*	0.25
H	*Penstemon canescens*	2
H	*Arabis lyrata*	1
H	*Paronychia fastigiata*	1
N	*Cladonia spp.*	5
N	*Polytrichum spp.*	5

Site Name/Project: Raystown Lake Shale-barren Survey			**Date:** 9/22/2018
City/County: Huntingdon County		**State:** Pennsylvania	**Plot #:** RLB23_JUVI
Investigators: Kevin Philley, Nathan Beane			
Latitude/Longitude: N 40.39859 W 78.04409			**Datum:** NAD83
Plot Size/Shape: Rectangular, 12.5mx8m			
% Slope: 35	**Landform:** hillslope	**Aspect:** South	

Cowardin	**Hydrologic Modifiers**		
_X_Upland	___Semipermanently Flooded	___Intermittently Flooded	Salinity/Halinity
___Estuarine	___Seasonally Flooded	___Permanently Flooded	___Saltwater
___Riverine	___Saturated	___Permanently Flooded tidal	___Brackish
___Palustrine	___Temporarily Flooded	___Tidally Flooded	___Freshwater
___Lacustrine			

Surface Geology: | **Soil Taxon:**

Soil Texture

___sand	___loamy sand	___sandy loam	_X_loam	___silt loam	___silt
___clay loam	___silty clay	___clay	___peat	___muck	

Soil Drainage

_X_Rapidly drained	___Well drained	___Moderately well drained
___Somewhat poorly drained	___Poorly drained	___Very poorly drained

Unvegetated Surface - % by cover class (see table)

_02_Bedrock	_04_Small rocks (2 mm - 10 cm)	_01_Wood (>1cm)
_01_Large rocks (> 10 cm)	___Sand (0.1 - 2mm)	_02_Litter
___Bare soil	___Other:	

Leaf Phenology of dominant stratum		**Leaf Type of dominant stratum**	
Trees and shrubs	*Herbs*	___Broad-leaved	___Graminoid
_X_Evergreen	___Annual	_X_Needle-leaved	___Forb
___Cold-deciduous	___Perennial	___Microphyllous	___Pteridophyte
___Drought-deciduous			

Physiognomic Class

___Forest	_X_Woodland	___Shrubland	___Dwarf shrubland
___Herbaceous	___Nonvascular	___Sparsely vegetated	

Strata	Height Class	Cover Class	Diagnostic Species (*if known*)
T1 Emergent			
T2 Canopy			
T3 Sub-canopy			
S1 Tall shrub			
S2 Short shrub			
S3 Dwarf shrub			
H Herbaceous			
Grass			
Forb			
Fern			
N Nonvascular			
V Vine/liana			
E Epiphyte			

Site Name/Project: Raystown Lake Shale-barren Survey		**Plot #:** RLB23_PIVI
Stratum	**Species name**	**% Cover**
T2	*Juniperus virginiana*	15
T2	*Pinus virginiana*	5
T2	*Quercus montana*	8
S2	*Quercus montana*	2
S2	*Carya glabra*	1
S2	*Quercus rubra*	2
S2	*Robinia pseudoacacia*	5
S2	*Lonicera maackii*	1
H	*Schizachyrium scoparium*	10
H	*Avenella flexuosa*	8
H	*Pinus virginiana*	1
H	*Paronychia fastigiata*	1
H	*Carex pensylvanica*	12
H	*Ailanthus altissima*	0.5
H	*Solidago nemoralis*	1
H	*Erechtites hieraciifolius*	3
H	*Ebony spleenwort*	1
H	*Quercus velutina*	0.5
H	*Cunila origanoides*	1
H	*Verbascum thapsus*	2
H	*Trichostoma dichotomum*	1
H	*Penstemon sp.*	2
H	*Ambrosia artemisiifolia*	0.5
H	*Polygonatum biflorum*	0.5
H	*Juniperus virginiana*	0.5
H	*Arabis lyrata*	1
H	*Heuchera pubescens*	1.5
H	*Fraxinus americana*	0.5
H	*Ostrya virginiana*	0.5
H	*Parthenocissus quinquefolia*	2

Central Appalachian Xeric Shale Woodland

Site Name/Project: Raystown Lake Shale-barren Survey | **Date:** 9/22/2018

City/County: Huntingdon County | **State:** Pennsylvania | **Plot #:** RLB50QUMO

Investigators: Kevin Philley, Nathan Beane

Latitude/Longitude: N 40.35554 W 78.14371 | **Datum:** NAD83

Plot Size/Shape: Rectangular, 12.5m x 8m

% Slope: 45 | **Landform:** Upper slope | **Aspect:** SE

Cowardin	**Hydrologic Modifiers**		
_X_Upland	___Semipermanently Flooded	___Intermittently Flooded	Salinity/Halinity
___Estuarine	___Seasonally Flooded	___Permanently Flooded	___Saltwater
___Riverine	___Saturated	___Permanently Flooded tidal	___Brackish
___Palustrine	___Temporarily Flooded	___Tidally Flooded	___Freshwater
___Lacustrine			

Surface Geology: | **Soil Taxon:**

Soil Texture

___sand ___loamy sand ___sandy loam _X_loam ___silt loam ___silt
___clay loam ___silty clay ___clay ___peat ___muck

Soil Drainage

_X_Rapidly drained ___Well drained ___Moderately well drained
___Somewhat poorly drained ___Poorly drained ___Very poorly drained

Unvegetated Surface - % by cover class (see table)

_01_Bedrock _09_Small rocks (2 mm - 10 cm) _01_Wood (>1cm)
_01_Large rocks (> 10 cm) ___Sand (0.1 - 2mm) _02_Litter
___Bare soil ___Other:

Leaf Phenology of dominant stratum		**Leaf Type of dominant stratum**	
Trees and shrubs	*Herbs*	_X_Broad-leaved	___Graminoid
___Evergreen	___Annual	___Needle-leaved	___Forb
_X_Cold-deciduous	___Perennial	___Microphyllous	___Pteridophyte
___Drought-deciduous			

Physiognomic Class

___Forest _X_Woodland ___Shrubland ___Dwarf shrubland
___Herbaceous ___Nonvascular ___Sparsely vegetated

Strata	**Height Class**	**Cover Class**	**Diagnostic Species** (*if known*)
T1 Emergent			
T2 Canopy			
T3 Sub-canopy			
S1 Tall shrub			
S2 Short shrub			
S3 Dwarf shrub			
H Herbaceous			
Grass			
Forb			
Fern			
N Nonvascular			
V Vine/liana			
E Epiphyte			

Site Name/Project: Raystown Lake Shale-barren Survey		Plot #: RLB50QUMO
Stratum	**Species name**	**% Cover**
T2	*Quercus montana*	15
T2	*Quercus rubra*	8
T2	*Carya glabra*	5
T2	*Pinus virginiana*	1
S2	*Quercus rubra*	2
S2	*Quercus montana*	5
S2	*Quercus velutina*	1
S2	*Prunus serotina*	1
H	*Erechtites hieraciifolius*	1
H	*Avenella flexuosa*	3
H	*Cunila origanoides*	2
H	*Ailanthus altissima*	0.5
H	*Trichostema dichotomum*	1
H	*Hedeoma pulegioides*	5
H	*Carex pensylvanica*	2
H	*Pinus virginiana*	0.5
N	*Cladonia*	5

Appendix III: Shale Barren Classification Summary of Survey Areas

Survey Area	Classification	Area (acres)
RLB_00	Not surveyed	1.1
RLB_01	Central Appalachian Circumneutral Barrens	6.6
RLB_02	Central Appalachian Circumneutral Barrens	27.5
RLB_03	Central Appalachian Circumneutral Barrens	16.5
RLB_04	Central Appalachian Circumneutral Barrens	7.3
RLB_05	Not surveyed	0.4
RLB_06	Not surveyed	1.1
RLB_07	Central Appalachian Circumneutral Barrens	20.4
RLB_07	Central Appalachian Xeric Shale Woodland	0.8
RLB_08	Central Appalachian Circumneutral Barrens	0.5
RLB_09	North-Central Appalachian Acidic Shale Woodland	2.1
RLB_10	North-Central Appalachian Acidic Shale Woodland	0.3
RLB_11	Central Appalachian Circumneutral Barrens	17.4
RLB_12	Not surveyed	0.4
RLB_13	Not surveyed	0.2
RLB_14	North-Central Appalachian Acidic Shale Woodland	2.3
RLB_15	Not surveyed	0.4
RLB_16	North-Central Appalachian Acidic Shale Woodland	0.3
RLB_17	North-Central Appalachian Acidic Shale Woodland	2.2
RLB_18	Non-barren	0.5
RLB_19	North-Central Appalachian Acidic Shale Woodland	2.5
RLB_20	Non-barren	0.3
RLB_21	Non-barren	1.4
RLB_22	Not surveyed	0.6
RLB_23	Central Appalachian Circumneutral Barrens	3.3
RLB_24	Central Appalachian Circumneutral Barrens	5.3
RLB_25	North-Central Appalachian Acidic Shale Woodland	3.3
RLB_26	North-Central Appalachian Acidic Shale Woodland	1.3
RLB_27	Central Appalachian Circumneutral Barrens	7.4
RLB_28	Not surveyed	1.0
RLB_29	North-Central Appalachian Acidic Shale Woodland	1.8
RLB_30	North-Central Appalachian Acidic Shale Woodland	3.0
RLB_31	North-Central Appalachian Acidic Shale Woodland	4.3
RLB_32	Non-barren	1.1
RLB_33	Non-barren	3.1
RLB_34	Non-barren	4.9
RLB_35	North-Central Appalachian Acidic Shale Woodland	1.4
RLB_36	North-Central Appalachian Acidic Shale Woodland	0.5
RLB_37	North-Central Appalachian Acidic Shale Woodland	1.8
RLB_38	Central Appalachian Xeric Shale Woodland	5.6
RLB_39	Central Appalachian Circumneutral Barrens	13.0
RLB_40	Central Appalachian Circumneutral Barrens	5.6
RLB_41	Central Appalachian Xeric Shale Woodland	2.8
RLB_41	Central Appalachian Circumneutral Barrens	1.8

RLB_42	Central Appalachian Circumneutral Barrens	3.7
RLB_43	Central Appalachian Circumneutral Barrens	2.7
RLB_44	North-Central Appalachian Acidic Shale Woodland	1.8
RLB_45	North-Central Appalachian Acidic Shale Woodland	1.8
RLB_46	Not surveyed	1.8
RLB_47	Not surveyed	13.3
RLB_48	Not surveyed	1.3
RLB_49	Not surveyed	2.1
RLB_50	Non-barren	3.6
RLB_50	Central Appalachian Xeric Shale Woodland	0.4
RLB_51	Non-barren	0.5
RLB_52	Non-barren	1.6
RLB_53	Non-barren	1.0
RLB_54	Non-barren	1.4
RLB_55	Non-barren	1.1
RLB_56	North-Central Appalachian Acidic Shale Woodland	3.1
RLB_57	North-Central Appalachian Acidic Shale Woodland	3.9
RLB_57	Central Appalachian Xeric Shale Woodland	0.7
RLB_58	Non-barren	3.8
RLB_59	North-Central Appalachian Acidic Shale Woodland	0.2
RLB_60	North-Central Appalachian Acidic Shale Woodland	4.6
RLB_61	Non-barren	2.1
RLB_62	Non-barren	1.3
RLB_63	Non-barren	1.7
RLB_64	Non-barren	3.8
RLB_65	North-Central Appalachian Acidic Shale Woodland	2.7
RLB_66	Non-barren	1.3
RLB_67	Non-barren	1.5
RLB_68	Non-barren	1.5
RLB_69	Not surveyed	0.9
RLB_70	Not surveyed	0.4
RLB_71	Not surveyed	0.5
RLB_72	North-Central Appalachian Acidic Shale Woodland	0.7
N/A (observed)	North-Central Appalachian Acidic Shale Woodland	2.5
N/A (observed)	North-Central Appalachian Acidic Shale Woodland	1.5
N/A (observed)	North-Central Appalachian Acidic Shale Woodland	1.2

Appendix IV: Breeding Bird Surveys on Raystown Lake, PA, May 16-21, 2018

Introduction

This report presents initial results from breeding bird surveys conducted from May 16-21, 2018 on lands managed by the USACE Baltimore District on Raystown Lake in central Pennsylvania. This effort was conducted while performing botanical surveys on shale barren habitats on the project lands. Personnel from ERDC-EL, Vicksburg, MS, performed all avian surveys. Results can support the North American Bird Conservation Initiative, which includes Partners in Flight (PIF), and is designed to provide the Baltimore District personnel with a list of breeding bird species, diversity, and relative abundance throughout numerous forest and shale barren sites on Raystown Lake. Data collected provides an index of the relative abundance and species diversity of breeding Neotropical migrants[1], some Nearctic migrants[2], and resident species[3]. The results of this effort should provide a better understanding of the breeding bird community on Raystown Lake and could also provide a basis for future management decisions that seek to identify important areas and habitats for the protection and conservation of native flora and faunal populations.

Objectives

The main objective of this investigation is to inventory seasonal bird communities on forested and shale barren habitats around the Raystown Lake project areas. Specific objectives include:

1) Conduct a preliminary breeding season survey on bird communities in forested and shale barren found on project lands, and
2) Identify and document the presence of species listed by Partners in Flight (PIF) as regional species of concern

Partners In Flight

Partners in Flight (PIF) is a voluntary, international coalition of government agencies, conservation groups, academic institutions, private businesses, and everyday citizens dedicated to “keeping common birds common.” PIF’s goal is to direct resources toward the conservation of birds and their habitats through cooperative efforts in North America and the Neotropics. While PIF’s focus applies mainly to the conservation of landbirds, it is intended to compliment similar efforts for other taxa including the North American Waterfowl Management Plan, United States Shorebird Conservation Plan, and North American Waterbird Conservation Plan (Carter et al. 2000).

The foundation of PIF’s bird conservation strategy is a series of Bird Conservation Plans. These plans identify species and habitats most in need of conservation, and establish objectives for the bird populations and habitats in physiographic areas (Bird Conservation Regions; BCRs)

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[1] Neotropical migrant bird species breed in North America but migrate to wintering areas in Mexico, Central and South America, and the Caribbean Islands.

[2] Nearctic migrant bird species (also called temperate migrants) reside in North America year-round and typically breed in the northern U.S. and Canada and winter in the southern U.S.

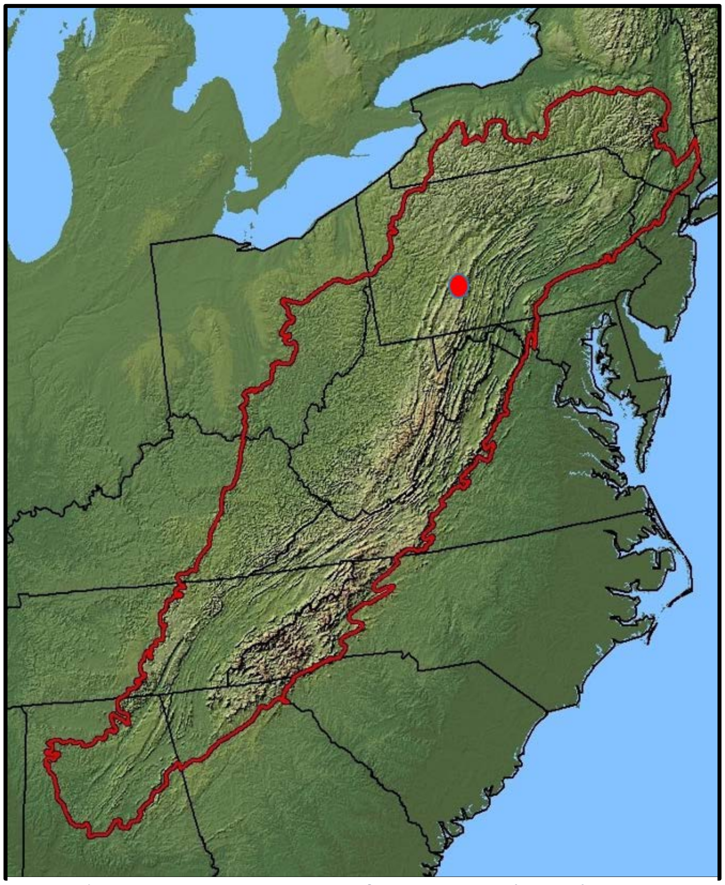
[3] Resident species are typically non-migratory bird species that breed and winter within a general geographic area.

and states. The plans identify the general habitat requirements of priority species at the site-level, and then identify the quantity and quality of habitat required by birds at the landscape scale. These plans are being drafted for each of the BCRs in the contiguous United States. Raystown Lake lies within the Appalachian Mountain Physiographic region (BCR #28), as defined by the North American Bird Conservation Initiative (NABCI) and PIF (http://nabci-us.org/resources/bird-conservation-regions-map/) (PIF 2018).

A PIF Species Prioritization Scheme was developed to determine which species in each region are the most in need of conservation attention (Carter et al. 2000). The scheme ranks each species of North American breeding bird by BCR based upon seven measures of conservation "vulnerability." These factors include; (1) relative abundance (interspecific); (2) size of breeding range; (3) size of non-breeding range; (4) threats to the species on the breeding grounds; (5) threats to the species on the wintering grounds; (6) current known population trends; and (7) relative density (intraspecific) in a given planning unit compared to the maximum reached within its range. While focus is generally on breeding birds, information for all birds, including Neotropical migrants, wintering Nearctic migrants, and resident species are included in the measure of conservation vulnerability. Each species is rated from 1-5 in each category, with 1 indicating the least amount of vulnerability with regard to that parameter, and 5 the most vulnerable. Scores in each category are then summed to produce a composite score ranging from 7-35. Species with relatively high overall scores are considered most in need of conservation attention (although they are often not endangered at present) and need at least to be carefully monitored throughout their ranges. Scores for PIF species are posted on the internet at http://rmbo.org/pifpopestimates/ (Partners in Flight Science Committee 2013).

Study Area

Raystown Lake is a USACE reservoir project located in west-central Huntingdon County, PA, and was completed in 1973. This reservoir receives inflows from Juniata Creek and was created for flood control and recreation purposes. In addition to the open water area of approximately 8,300 acres (3,359 ha), the managed lands around the lake are approximately 29,700 acres (12,019.2 ha). The lake is situated in the Ridge and Valley Providence, a region of alternating ridges underlain by rock strata that have experienced uplift and are resistant to weathering, and valleys underlain by softer sediments, shale and limestone that have weathered to a moderately level surface. Bird surveys documented in this report were performed while conducting rare plant surveys on exposed shale barren habitats around the lake perimeter. Shale barren habitats occur on small rocky south-east to west facing exposures, typically on steep slopes surrounded by mature oak-hickory forests. Woody trees and shrubs found on these barrens typically exhibit stunted or reduced growth patterns compared to forested surroundings. The barrens also lack an organic surface and a soil horizon, which can act as a growth limiting factor for various woody plant species. Tree species found growing in the barrens of consist of eastern red cedar (*Juniperus virginiana*), Virginia pine (*Pinus virginiana*), chestnut oak (*Quercus montana*), northern red oak (*Quercus rubra*), table-mountain pine (*Pinus pungens*), and pignut hickory (*Carya glabra*). Shrubs may include dwarf hackberry (*Celtis tenuifolia*), bear oak (*Quercus ilicifolia*), blueridge blueberry (*Vaccinium pallidum*), black huckleberry (*Gaylussacia baccata*), and winged sumac (*Rhus copallinum*). Mature forests surrounding or adjacent to most of the shale barren areas are mature oak-hickory forests, occasionally intersperse with patches of Virginia pine.



Appendix IV; Figure 1. Location of Raystown Lake in the Appalachian Mountain Bird Conservation Region (BCR #28) in southcentral Pennsylvania.

The Appalachian Mountain BCR #28 is extends from central New York south to northeastern Alabama and northern Georgia (Appendix IV; Figure 1). This region supports a wide-ranging diversity of forests types, including oak-hickory forests, northern hardwoods, high elevation spruce-fir forests and pine forests. Interspersed in this region are mountain grasslands, riparian and wetland communities, glades, cave and carst communities (Appalachian Mountains Joint Venture (AMJV) 2018). Many sensitive and rare bird species are experiencing significant declines including the Bewick's Wren (*Colinus virginianus*), Blue-winged Warbler (*Vermivora cyanoptera*), Cerulean Warbler (*Setophaga cerula*), Golden-winged Warbler (*Vermivora chrysoptera*), and Wood Thrush (*Hylocichla mustelina*), and are found in this region (AMJV 2018).

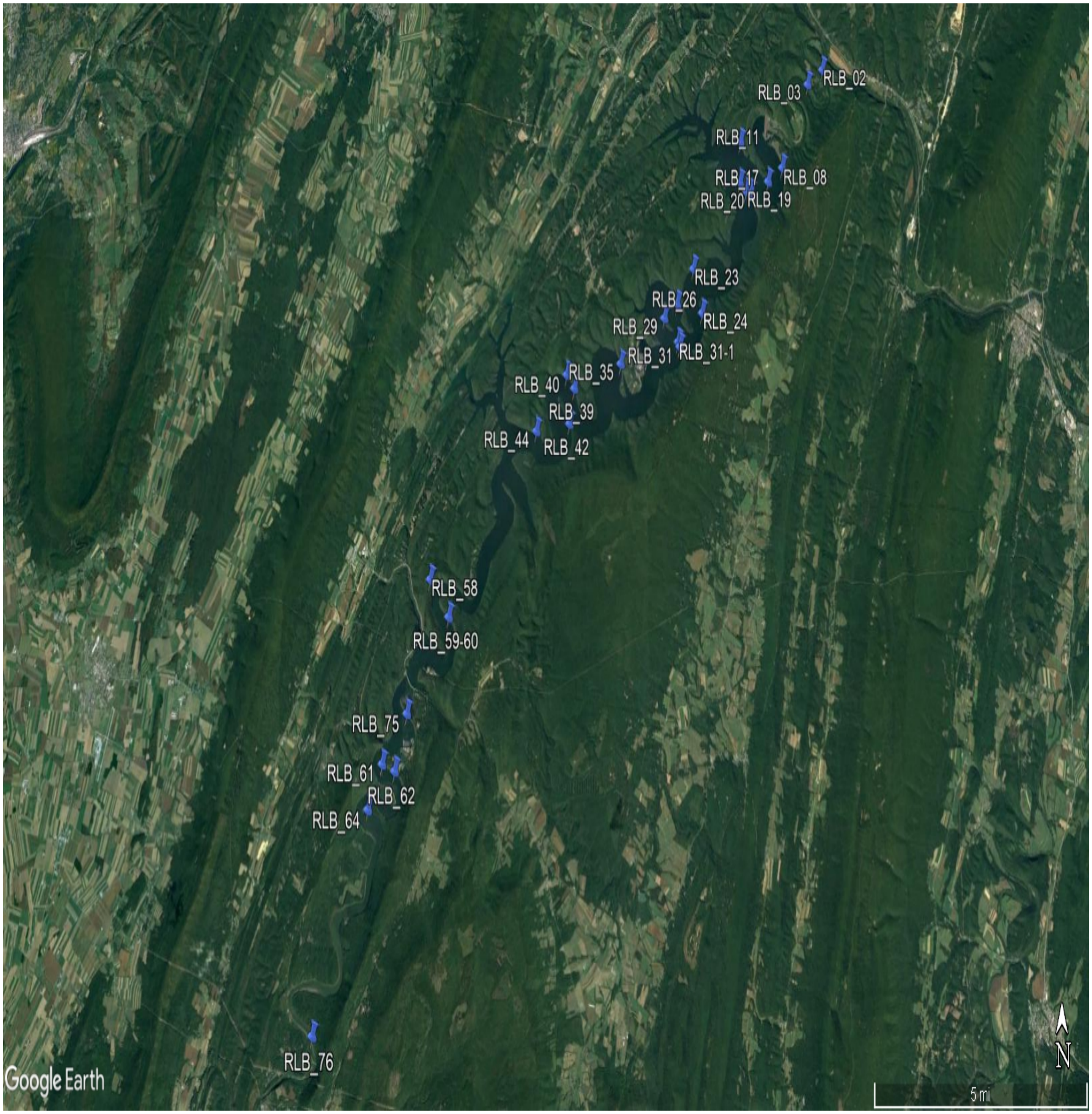
Avian Community Sampling

Establishment of Sampling Points

To provide a preliminary sample of the bird communities on Raystown Lake, areas managed by the USACE were located and point-count stations were established according to Hamel et al. (1986). In May 2018, 26 point-count stations were established in managed areas that represent most shale barren habitats and adjacent forested areas around the reservoir project lands (Figure 2). Sampling stations were occasionally established along roadsides and "off-road" areas within habitat stands. To reduce chances of double-counting individual birds, sampling stations were separated approximately at least 250 m (984 ft.) within habitat types (Hamel et al. 1996).

GPS Data

During May 2018, all established avian point-count stations were located and the positions of each station (Latitude/Longitude; NAD83) were documented using a hand-held global positioning (GPS) unit (Garmin ®E-trex). These data are now available to upload into a geographic information system (GIS) software (e.g., ARCGIS 10.1) for the purposes of graphical presentation, future relocation, and installation planning purposes (Appendix IV; Table 1). Data on the position of each sampling station will allow points to be relocated for any potential future monitoring efforts.



Appendix IV; Figure 2. Location of 26 point-count stations established and surveyed on Raystown Lake, Pennsylvania, May 16-21, 2018.

Appendix IV; Table 1. Established point-count number and coordinates for summer breeding bird surveys on Raystown Lake, PA, May 16-21, 2018.		
Hords Creek Lake		
Point Count ID	Latitude	Longitude
RLB 02	N 40.44667	W 77.97604
RLB 03	N 40.44313	W 77.98380
RLB 08	N 40.42260	W 77.99865
RLB 09	N 40.41934	W 78.00601
RLB 11	N 40.42860	W 78.01942
RLB 17	N 40.41914	W 78.02015
RLB 19	N 40.41701	W 78.01715
RLB 20	N 40.41670	W 78.01474
RLB 23	N 40.39875	W 78.04468
RLB 24	N 40.38855	W 78.04089
RLB 26	N 40.39057	W 78.05309
RLB 29	N 40.38744	W 78.05948
RLB 31	N 40.38095	W 78.05225
RLB 31-1	N 40.38204	W 78.05306
RLB 35	N 40.37703	W 78.08127
RLB 39	N 40.37152	W 78.10402
RLB 40	N 40.37452	W 78.10772
RLB 42	N 40.36368	W 78.10645
RLB 44	N 40.36196	W 78.12244
RLB 58	N 40.32978	W 78.17245
RLB 59/60	N 40.32206	W 78.16356
RLB 61	N 40.29196	W 78.19324
RLB 62	N 40.29057	W 78.18740
RLB 64	N 40.28290	W 78.19929
RLB 75	N 40.30215	W 78.18233
RLB 76	N 40.23954	W 78.22127

Point-count Surveys

Point-sampling methodology followed Hamel et al. (1996) and consisted of 5-min counts during the 2018 May breeding season. All birds detected by sight or vocalizations were noted on a field data form. Birds detected during the surveys were denoted in 2 time categories (3-min, and 3-5-min intervals) (Hamel et al. 1996). Birds were also denoted into 5-m distance intervals, up to ≥100 m; flyovers were noted separately. These distance category designations permit an estimation of detectability that can be used to estimate density and to verify the quality of the count data (Guilfoyle and Fischer 2007). Bird surveys were conducted once during the 2018 breeding season, May 16-21. Bird surveys were conducted while performing shale barren mapping and botanical surveys; therefore, surveys were not constrained during the morning hours as recommended by Hamel et al. (1986). While efforts were done to limit surveys in light rain or windy conditions, some surveys were conducted in non-optimal conditions due to time constraints and other logistic factors required for completion of shale barren survey and mapping efforts. Future bird survey work on Raystown Lake should focus solely on the bird communities. All survey data were entered into the MS Excel program, and all records were checked for accuracy. Data were summed by species groups (Neotropical migrants, Nearctic migrants and resident species, and total species) using Statistical Analysis Software (SAS), version 9.3 (SAS Institute, Inc., Cary, North Carolina 2010).

Results

May Breeding Season

During the May 16-21, breeding season, we detected 403 birds of 63 species at Raystown Lake (Appendix III; Table 2). Thirty-two species were year-round residents, 29 were Neotropical migrants, 2 were Nearctic migrants, and 16 were identified as PIF regional species of concern (RBJV 2013) (Appendix III; Table 2&3).

Common resident species on Raystown Lake include the Tufted Titmouse (*Baeolophus bicolor*) (26), American Crow (*Corvus brachyrhynchos*) (20), Chipping Sparrow (*Spizella passerina*) (19), Northern Cardinal (*Cardinalis cardinalis*) (19), Pileated Woodpecker (*Dryocopus pileatus*) (12) and Carolina Wren (*Thryothorus ludovicianus*) (12)(Appendix III; Table 2). Common Neotropical migrants detected include the Red-eyed Vireo (*Vireo olivaceus*) (45), Indigo Bunting (*Passerina cyanea*)(29), Great-crested Flycatcher (*Myiarchus crinitus*)(12), Yellow-throated Vireo (*Vireo flavifrons*)(12) and Blue-gray Gnatcatcher (*Polioptila caerula*) (10) (Appendix III; Table 2). Although surveys were conducted during the breeding season (e.g., mid-May) several Nearctic species were still present in the area including the Eastern Phoebe (*Sayornis phoebe*)(1) and Yellow-rumped Warbler (*Setophaga coronata*)(1). Relatively common PIF Priority Species were detected that have been identified as regional species of concern within the Appalachian Mountain BCR include the Indigo Bunting (29), Yellow-throated Vireo (12), Eastern Towhee (*Pipilo eryhrophthalmus*)(9), Scarlet Tanager (*Piranga olivacea*)(7), Wood Thrush (*Hylocichla mustelina*)(7) and Eastern Wood-pewee (*Contopus virens*)(5) (Appendix IV; Table 3). Several Neotropical migrants detected breed north of Raystown Lake and were likely late spring migrants on passage to more northern breeding areas including the Black-poll Warbler (*Setophaga striata*)(3), and Tennessee Warbler (*Oreaothlypis peregrina*)(2)(Appendix

IV; Table 2). Several PIF Priority species of Highest Priority were detect during the surveys, including the Cerulean Warbler (*Setophaga cerulea*), Wood Thrush and Worm-eating Warbler (*Helmitheros vermivorum*) (Appendix IV; Tables 3 and 4). All birds detected at each point are presented in Appendix IV; Table 4.

Appendix IV; Table 2. Number of detections by species and number of points at which each species was detected during point-count surveys, Raystown Lake, PA, May 16-21, 2018.

Spring 2018					
Species	# Detected	# Points	Species	# Detected	# Points
Red-eyed Vireo	45	26	Hairy Woodpecker	2	2
Indigo Bunting§	29	15	Song Sparrow	2	2
Tufted Titmouse	26	16	*Tennessee Warbler*	2	2
American Crow	20	12	*Yellow-billed Cuckoo*	2	1
Chipping Sparrow	19	14	Brown Thrasher§	1	1
Northern Cardinal	19	16	Cedar Waxwing	1	1
Pileated Woodpecker	15	14	*Chimney Swift*§	1	1
Carolina Wren	12	9	Common Loon	1	1
Great-crested Flycatcher	12	11	*Common Yellowthroat*	1	1
Yellow-throated Vireo§	12	9	*Chestnut-sided Warbler*	1	1
American Goldfinch	10	8	Eastern Bluebird	1	1
Blue-gray Gnatcatcher	10	8	Eastern Phoebe	1	1
Eastern Towhee§	9	5	House Wren	1	1
Ovenbird	8	7	*Louisiana Waterthrush*§	1	1
Red-winged Blackbird	8	4	*Magnolia Warbler*	1	1
Cliff Swallow	7	2	*Ruby-throated Hummingbird*	1	1
Red-bellied Woodpecker	7	5	Turkey Vulture	1	1
Scarlet Tanager§	7	7	Yellow-rumped Warbler	1	1
Wood Thrush§	7	6			
Baltimore Oriole	6	5			
Mallard	6	1	**Total**	403	
Mourning Dove	6	5			
American Redstart	5	4			
American Robin	5	5			
Eastern Wood-pewee§	5	5			
Pine Warbler	5	4			
Black-and-white Warbler§	4	4			
Brown-headed Cowbird	4	4			
Canada Goose	4	2			
Common Grackle	4	3			
Northern Flicker§	4	4			
Northern Parula§	4	4			
Black-capped Chickadee§	3	3			
Belted Kingfisher	3	3			
Blue Jay	3	2			
Blackpoll Warbler§	3	2			
Cerulean Warbler§	3	2			
Common Raven	3	2			
Osprey	3	3			
White-breasted Nuthatch	3	3			
Worm-eating Warbler§	3	3			
Yellow Warbler	3	3			
Barn Swallow	2	1			
Eastern Kingbird	2	2			
Gray Catbird	2	2			

[1]Neotropical migrants are denoted in *italics*; Short-distance migrants are underlined.

§ Appalachian Mountain BCR Priority Species

Appendix IV; Table 3. Partner's in Flight "Priority" Species detected during summer breeding season point-count surveys, Raystown Lake, PA, May 16 – 21, 2018, as scored in the Appalachian Mountain Bird Conservation Region (#28) (Panjabi et al. 2012).

Species	PIF Concern Rank	Number of Detections
Cerulean Warbler	Highest	3
Wood Thrush	Highest	7
Worm-eating Warbler	Highest	3
Chimney Swift	High	1
Louisiana Waterthrush	High	1
Black-and-white Warbler	Moderate	4
Black-capped Chickadee	Moderate	3
Brown Thrasher	Moderate	1
Eastern Towhee	Moderate	9
Eastern Wood-pewee	Moderate	5
Indigo Bunting	Moderate	29
Northern Flicker	Moderate	4
Northern Parula	Moderate	4
Scarlet Tanager	Moderate	7
Yellow-throated Vireo	Moderate	12
Blackpoll Warbler	Low	3

Appendix IV; Table 4. Species and total counts of all birds detected at each point-count station during point-count surveys, Raystown Lake, PA, May 16-28, 2018. Partners in Flight Priority Species detected at each point are in **Bold.**

RLB 02		RLB 03		RLB 08		RLB 09	
Species	Count	Species	Count	Species	Count	Species	Count
American Crow	6	American Crow	1	Brown-headed Cowbird	1	American Redstart	2
American Goldfinch	1	American Goldfinch	1	Carolina Wren	1	**Blackpoll Warbler**	1
Black-and-White Warbler	1	**Black-and-White Warbler**	1	Chipping Sparrow	1	Chipping Sparrow	1
Blue Jay	1	Blue-gray Gnatcatcher	1	Common Loon	1	Common Raven	1
Brown Thrasher	1	Brown-headed Cowbird	1	**Eastern Towhee**	1	**Indigo Bunting**	3
Carolina Wren	2	Carolina Wren	1	Mourning Dove	1	Northern Cardinal	2
Common Grackle	1	Chipping Sparrow	1	Northern Cardinal	1	Pileated Woodpecker	1
Eastern Towhee	2	**Eastern Wood-pewee**	1	Pileated Woodpecker	1	Red-bellied Woodpecker	3
Eastern Wood-pewee	1	Great-crested Flycatcher	1	Red-eyed Vireo	2	Red-eyed Vireo	1
Great-crested Flycatcher	1	**Indigo Bunting**	2	**Wood Thrush**	1	**Scarlet Tanager**	1
Indigo Bunting	3	**Northern Parula**	1				
Northern Cardinal	1	Pileated Woodpecker	1				
Ovenbird	1	Red-eyed Vireo	2				
Pileated Woodpecker	2	**Scarlet Tanager**	1				
Red-eyed Vireo	1	Song Sparrow	1				
Yellow-throated Vireo	1	**Wood Thrush**	1				
		Yellow-throated Vireo	1				

RLB 11		RLB 17		RLB 19		RLB 20	
Species	Count	Species	Count	Species	Count	Species	Count
American Goldfinch	1	American Crow	2	American Robin	1	American Goldfinch	2
Blue-gray Gnatcatcher	2	American Goldfinch	1	Blue-gray Gnatcatcher	1	American Redstart	1
Brown-headed Cowbird	1	Carolina Wren	1	Hairy Woodpecker	1	Blue-gray Gnatcatcher	1
Carolina Wren	2	Tufted Titmouse	1	Northern Cardinal	1	Carolina Wren	1
Cerulean Warbler	2	Great-crested Flycatcher	1	**Northern Parula**	1	Common Yellowthroat	1
Chipping Sparrow	2	Red-bellied Woodpecker	1	Pine Warbler	1	**Eastern Towhee**	3
Cliff Swallow	1	Red-eyed Vireo	1	Pileated Woodpecker	1	Tufted Titmouse	1
Common Raven	2			Red-eyed Vireo	1	Hairy Woodpecker	1
Eastern Kingbird	1					**Indigo Bunting**	2
Tufted Titmouse	1					**Norther Parula**	1
Great-crested Flycatcher	2					Ovenbird	1
House Wren	1					Pine Warbler	1
Indigo Bunting	3					Red-eyed Vireo	3
Northern Cardinal	2						

Osprey	1						
Ovenbird	1						
Pileated Woodpecker	1						
Red-eyed Vireo	3						
Red-tailed Hawk	1						
Turkey Vulture	1						
Yellow-billed Cuckoo	2						
RLB 23		RLB 24		RLB 26		RLB 29	
Species	Count	Species	Count	Species	Count	Species	Count
American Robin	1	Baltimore Oriole	1	Blue-gray Gnatcatcher	1	American Robin	1
Black-capped Chickadee	1	Northern Cardinal	1	Eastern Phoebe	1	Baltimore Oriole	1
Chipping Sparrow	2	**Northern Flicker**	1	Magnolia Warbler	1	Blue-gray Gnatcatcher	1
Common Grackle	2	Ovenbird	1	Mourning Dove	1	**Blackpoll Warbler**	2
Tufted Titmouse	2	Red-eyed Vireo	2	Northern Cardinal	1	Chipping Sparrow	1
Mourning Dove	2	**Wood Thrush**	1	**Northern Flicker**	1	Tufted Titmouse	1
Northern Flicker	1	**Yellow-throated Vireo**	1	Red-eyed Vireo	3	**Indigo Bunting**	1
Pine Warbler	2			**Scarlet Tanager**	1	Northern Cardinal	1
Red-bellied Woodpecker	1			Yellow-rumped Warbler	1	Red-eyed Vireo	2
Red-eyed Vireo	3					Red-winged Blackbird	1
Yellow-throated Vireo	1					Song Sparrow	1
						Yellow Warbler	1
RLB 31		RLB 31-1		RLB 35		RLB 29	
Species	Count	Species	Count	Species	Count	Species	Count
American Crow	1	American Crow	1	Baltimore Oriole	1	American Crow	1
Belted Kingfisher	1	**Black-capped Chickadee**	1	Chipping Sparrow	2	**Black-capped Chickadee**	1
Cedar Waxwing	1	Carolina Wren	1	Cliff Swallow	6	Blue Jay	2
Tufted Titmouse	1	Common Grackle	1	Tufted Titmouse	1	Chipping Sparrow	1
Great-crested Flycatcher	1	Chestnut-sided Warbler	1	Mourning Dove	1	Eastern Bluebird	1
Indigo Bunting	1	Tufted Titmouse	3	Red-eyed Vireo	1	Tufted Titmouse	1
Red-eyed Vireo	1	Gray Catbird	1	Red-winged Blackbird	1	Great-crested Flycatcher	1
Yellow-throated Vireo	1	Northern Cardinal	2	**Wood Thrush**	1	**Indigo Bunting**	2
		Ovenbird	1	Yellow Warbler	1	Northern Cardinal	1
		Pileated Woodpecker	1			Pileated Woodpecker	1
		Red-bellied Woodpecker	1			Red-eyed Vireo	2
		Red-eyed Vireo	2				
		Red-winged Blackbird	4				
		Scarlet Tanager	1				

		Tennessee Warbler	1				
		Wood Thrush	2				
RLB 40		RLB 42		RLB 44		RLB 58	
Species	Count	Species	Count	Species	Count	Species	Count
American Crow	1	Carolina Wren	1	**Indigo Bunting**	1	**Cerulean Warbler**	1
Chipping Sparrow	1	Chipping Sparrow	1	Red-eyed Vireo	2	**Eastern Towhee**	2
Tufted Titmouse	1	Great-crested Flycatcher	1			**Indigo Bunting**	1
Indigo Bunting	2	**Indigo Bunting**	1			Northern Cardinal	1
Ovenbird	1	Northern Cardinal	1			Red-eyed Vireo	1
Pileated Woodpecker	1	Pileated Woodpecker	1				
Red-eyed Vireo	1	Red-eyed Vireo	1				
Worm-eating Warbler	1						
RLB 58/60		RLB 61		RLB 62		RLB 64	
Species	Count	Species	Count	Species	Count	Species	Count
American Crow	1	American Crow	1	American Crow	1	American Crow	3
American Redstart	1	American Goldfinch	1	American Goldfinch	1	Baltimore Oriole	1
American Robin	1	Brown-headed Cowbird	1	Tufted Titmouse	1	**Black-and-White Warbler**	1
Eastern Wood-pewee	1	Chipping Sparrow	1	Great-crested Flycatcher	1	Belted Kingfisher	1
Tufted Titmouse	2	Tufted Titmouse	3	Northern Cardinal	1	Blue-gray Gnatcatcher	2
Great-crested Flycatcher	1	**Indigo Bunting**	1	Pileated Woodpecker	1	Canada Goose	3
Northern Cardinal	1	Mallard	6	Red-eyed Vireo	1	Carolina Wren	2
Ovenbird	2	Northern Cardinal	1	**Scarlet Tanager**	1	**Chimney Swift**	1
Pine Warbler	1	Red-eyed Vireo	1	White-breasted Nuthatch	1	**Eastern Wood-pewee**	1
Pileated Woodpecker	1					Tufted Titmouse	2
Red-eyed Vireo	2					**Indigo Bunting**	4
Scarlet Tanager	1					**Northern Flicker**	1
Yellow-throated Vireo	1					Osprey	1
						Pileated Woodpecker	1
						Red-bellied Woodpecker	1
						Red-eyed Vireo	2
						Ruby-throated Hummingbird	1
						Tennessee Warbler	1
						White Breasted Nuthatch	1
						Yellow-throated Vireo	4
RLB 65		RLB 75		RLB 76			
Species	Count	Species	Count	Species	Count		
Belted Kingfisher	1	American Crow	1	American Goldfinch	2		

Chipping Sparrow	1	**Black-and-White Warbler**	1	American Redstart	1	
		Chipping Sparrow	1	American Robin	1	
		Eastern Towhee	1	Baltimore Oriole	2	
		Eastern Wood-pewee	1	Barn Swallow	2	
		Tufted Titmouse	2	Blue-gray Gnatcatcher	1	
		Great-crested Flycatcher	1	Canada Goose	1	
		Red-eyed Vireo	1	Chipping Sparrow	3	
		Scarlet Tanager	1	Eastern Kingbird	1	
		White-breasted Nuthatch	1	Tufted Titmouse	2	
		Worm-eating Warbler	1	Great-crested Flycatcher	1	
		Yellow-throated Vireo	1	Gray Catbird	1	
				Indigo Bunting	2	
				Louisiana Waterthrush	1	
				Mourning Dove	1	
				Northern Cardinal	1	
				Northern Parula	1	
				Osprey	1	
				Pileated Woodpecker	1	
				Red-eyed Vireo	3	
				Red-winged Blackbird	2	
				Worm-eating Warbler	1	
				Wood Thrush	1	
				Yellow Warbler	1	

Discussion

The bird surveys summarized in this report represent an initial effort to document the breeding bird communities utilizing mature oak-hickory forests and shale barren habitat on Raystown Lake project lands. This effort is not an exhaustive effort and there are additional habitat types and likely several other PIF Priority species on the project lands that were missed. For example, several species of PIF Priority species of Highest rank, including the Blue-winged Warbler (*Virmivora cyanoptera*) and the Golden-winged Warbler (*Virmivora chrysoptera*), typically use open shrub and edge habitats. PIF Priority species that typically occupy open grass and shrub habitats, including the Prairie Warbler (*Setophaga discolor*), Field Sparrow (*Spizella pusilla*), Loggerhead Shrike (*Lanius ludovicianus*) and Yellow-breasted Chat (*Icteria virens*), were also missed during these surveys. These habitats, and many other habitats types present on Raystown Lake were not included in this effort because of our emphasis on exposed shale barrens. Moreover, our survey approach did not include nocturnal surveys that may possibly detect other PIF Priority species such as the Whip-poor-will (*Antrostomus vociferus*), Chuck-will's-widow (*Antrostomus carolinensis*), and Northern Saw-whet Owl (*Aegolius acadicus*). Large forested areas, plus river systems and associated riparian habitats are often critical for fall and spring migrants (Gauthreaux and Belser 2005). Long distance migration is a key feature of many North American birds, and suitable stopover habitat is an essential feature required for the conservation of these species (Moore 2000). In addition, large hawk migration events are frequently documented at Hawk Mountain, PA, which is relatively close to Raystown Lake (approximately 174 km (108 mi) east). With the relative close proximity of Hawk Mountain, it is possible that the Raystown Lake area also experiences high abundance of raptors during fall migration. It is recommended that future efforts initiate at least a 3-season (breeding, spring/fall migration seasons), comprehensive (e.g., nocturnal and diurnal) effort to assess the relative abundance and distribution of seasonal bird communities in and around Raystown Lake. These data could inform Baltimore District personnel on the specific habitat types and locations of areas important to seasonal bird communities. Such data could inform management decisions on specific areas to protect and manage for target species as needed. A proactive approach that utilizes a scientifically sound monitoring effort (e.g., Bart et al. 2012; Guilfoyle and Fischer 2007), while incorporating sound management to identify, protect and enhance important bird habitat, may yield benefits to the USACE by providing habitat for rare and sensitive species, reducing likelihood that such species may be listed in the future, and by establishing a foundation for sound conservation management that permits compliance with all state and federal laws, and organizational regulations to protect and conserve seasonal and migratory bird populations.

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Appendix V: Macroinvertebrate taxa captured downstream, upstream, and within Tributaries of Raystown Lake Project Area, Pennsylvania

STATION	CLASS	ORDER	TAXON	COUNT
DOWNSTREAM				
	Crustacea			
		Amphipoda		
			Gammaridae	9
			Hyallelidae	2
		Isopoda		
			Asellidae	4
	Insecta			
		Coleoptera		
			Curculionidae	1
			Psephenus	14
			Stenelmis	3
		Diptera		
			Atherix	1
			Chironomidae	6
			Stratiomys	1
			Tipula	5
		Ephemeroptera		
			Cinygmula	1
			Ephemera	3
			Ephemerella	22
			Eurylophella	8
			Isonychia	3
			Leucrocuta	3
			Maccaffertium	10
			Penelomax septentrionalis	1
			Stenonema_maccaffertium	23
			Teloganopsis deficiens	1
		Megaloptera		
			Corydalus	2
			Sialis	1
		Odonata		
			Argia	3
			Boyeria vinosa	3
			Calopteryx dimidiata	1
			Enallagma	4
		Plecoptera		
			Acroneuria abnormis	1
			Acroneuria internata	5
			Amphinemura	1

			Isoperla	1
			Neoperla choctaw	1
			Paragnetina media	1
			Perlesta decipiens	4
			Perlesta ephelida	4
		Trichoptera		
			Cheumatopsyche	1
			Chimarra	5
			Helicopsyche	7
			Hydropsyche	5
			Pycnopsyche	6
			Rhyacophila	4
	Mollusca			
		Bivalvia		
			Bivalvia undet.	1
TRIBUTARIES AND NEARBY STREAMS				
	Crustacea			
		Amphipoda		
			Gammaridae	3
	Insecta			
		Coleoptera		
			Coleoptera (terrestrial).	19
			Elmidae	1
			Narpus	1
			Staphylinidae	1
		Collembola		
			Salina	1
		Diptera		
			Chironomidae	10
			Euparyphus	1
			Simuliidae	3
			Terrestrial Diptera Larva	2
			Tipula	5
		Ephemeroptera		
			Amaletus	1
			Baetis	2
			Drunella	2
			Epeorus	2
			Ephemera	1
			Ephemerella	25
			Isonychia	6
			Leucrocuta	1
			Maccaffertium	10
			Paraleptophlebia	2
			Penelomax septentrionalis	8

			Siphlonurus	6
			Stenonema	4
		Hemiptera		
			Aquarius	2
			Microvelia	2
		Megaloptera		
			Corydalus	1
			Nigronia	2
			Sialis	1
		Neuroptera		
			Coniopterygidae	1
		Odonata		
			Boyeria grafiana	3
			Calopteryx dimidiata	1
			Calopteryx maculata/dimidiata	3
			Cordulegaster erronea	1
			Stylogomphus albistylus	2
		Plecoptera		
			Acroneuria	1
			Acroneuria abnormis	1
			Acroneuria carolinensis	2
			Acroneuria internata	1
			Agnetina	1
			Alloperla usa	2
			Amphinemura	51
			Isoperla	30
			Paragnetina media	2
			Paraleuctra sara	1
			Peltoperla	4
			Perlesta	5
			Perlesta decipiens	1
			Pteronarcys biloba	2
			Pteronarcys proteus	4
			Remenus bilobatus	2
		Trichoptera		
			Chimarra	2
			Diplectrona modesta	11
			Dolophilodes distincta	1
			Hydropsyche	3
			Neophylax	2
			Philopotamidae	1
			Plectrocnemia	1
			Polycentropus	1
			Pycnopsyche	17

			Rhyacophila	4
UPSTREAM				
	Crustacea			
		Amphipoda		
			Amphipoda	1
			Gammaridae	3
			Hyallelidae	1
		Isopoda		
			Asellidae	1
	Insecta			
		Coleoptera		
			Chrysomelidae (terrestrial)	2
			Dineutus	5
			Peltodytes	3
			Psephenus	4
			Tenebrionidae (terrestrial)	1
		Diptera		
			Chironomidae	8
			Simulium	2
			Tipula	2
		Ephemeroptera		
			Anthopotamus myops	4
			Baetis	2
			Caenis	1
			Drunella	1
			Eurylophella	13
			Isonychia sayi	3
			Leptophlebia	9
			Serratella	1
			Siphlonurus	3
		Hemiptera		
			Corixidae	1
			Ranatra	1
			Trichocorixia	2
		Mecoptera		
			Panorpa insolens (terrestrial)	1
		Megaloptera		
			Nigronia	1
			Sialis	1
		Odonata		
			Calopteryx dimidiata	3
			Dromogomphus	4
			Dromogomphus spinosus	3
			Enallagma	26

			Macromia taeniolata	1
			Ophiogomphus	1
		Plecoptera		
			Acroneuria carolinensis	1
			Acroneuria internata	1
			Clioperla clio	5
			Isoperla	2
			Perlesta decipiens	4
			Perlesta ephelida	21
		Trichoptera		
			Brachycentridae	1
			Hydropsychidae	1
			Pycnopsyche	4
GRAND TOTAL				626

Appendix VI: Site locality, collection, and environmental data for each mussel sampling station, as well as comments noted during field sampling.

FIELD NUMBER: Raystown Lake Upstream (US-1)
STATE: Pennsylvania COUNTY: Bedford
WATER BODY: Raystown Branch Juniata River
LOCALE: Junction of Six Mile Rd. and Hwy 265
LATITUDE: 40.16221401 LONGITUDE: -78.255157
DATE: 29 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1205-1223 SEARCH TIME (min): 18
GEAR: Pollywog/hand WIDTH (yd): 40
WATER TEMPERATURE (C°): 21.7 SPECIFIC CONDUCTIVITY (mS/cm): 0.536
pH: 7.91 DISSOLVED OXYGEN (mg/L): 8.47 TURBIDITY (NTU): 7.2
VELOCITY RANGE (cm/s): 36-54 DEPTH RANGE (ft): 0.9-2.4
SUBSTRATE TYPE: Boulder/Cobble
COMMENT: Worked mostly Six Mile Run and downstream area of Raystown Branch along RDB.

FIELD NUMBER: Raystown Lake Upstream (US-2)
STATE: Pennsylvania COUNTY: Bedford
WATER BODY: Raystown Branch Juniata River
LOCALE: Hwy 265 access at Raystown Brethren Church
LATITUDE: 40.19138102 LONGITUDE: -78.25475299
DATE: 29 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1249-1317 SEARCH TIME (min): 28
GEAR: Pollywog/hand WIDTH (yd): 53
WATER TEMPERATURE (C°): 25.4 SPECIFIC CONDUCTIVITY (mS/cm): 0.317
pH: 8.61 DISSOLVED OXYGEN (mg/L): 9.78 TURBIDITY (NTU): 2.6
VELOCITY RANGE (cm/s): 23-56 DEPTH RANGE (ft): 1.8-3.1
SUBSTRATE TYPE: Boulder/Cobble/Sand
COMMENT: RDB just along island with secondary channel; some search time in secondary channel.

FIELD NUMBER: Raystown Lake Upstream (US-3)
STATE: Pennsylvania COUNTY: Bedford
WATER BODY: Raystown Branch Juniata River
LOCALE: Warriors Path State Park, N end of access road
LATITUDE: 40.204004 LONGITUDE: -78.26629998
DATE: 29 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 0951-1016 SEARCH TIME (min): 25
GEAR: Pollywog/hand WIDTH (yd): 48
WATER TEMPERATURE (C°): 24.1 SPECIFIC CONDUCTIVITY (mS/cm): 0.320
pH: 8.27 DISSOLVED OXYGEN (mg/L): 8.21 TURBIDITY (NTU): 2.1
VELOCITY RANGE (cm/s): 0-4 DEPTH RANGE (ft): 1.6-3.0
SUBSTRATE TYPE: Mud/Silt over Rock
COMMENT: Warriors Path State Park Rd., N access at picnic area; RDB slower flow and sediment along near shore; transect halfway across, deep along opposite bank.

FIELD NUMBER: Raystown Lake Upstream 9 (US-4)
STATE: Pennsylvania COUNTY: Bedford
WATER BODY: Raystown Branch Juniata River
LOCALE: Warriors Path State Park, S end of access road
LATITUDE: 40.20220902 LONGITUDE: -78.26215304
DATE: 29 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 0834-0908 SEARCH TIME (min): 34
GEAR: Pollywog/hand WIDTH (yd): 44
WATER TEMPERATURE (C°): 23.6 SPECIFIC CONDUCTIVITY (mS/cm): 0.319
pH: 8.18 DISSOLVED OXYGEN (mg/L): 8.08 TURBIDITY (NTU): 2.6
VELOCITY RANGE (cm/s): 60-101 DEPTH RANGE (ft): 1.0-2.8
SUBSTRATE TYPE: Cobble
COMMENT: RDB on Warriors Path State Park Rd. in Warriors Path State Park; S end of access road, S of picnic area; flow too fast to safely get full transect data; cobble slippery.

FIELD NUMBER: Raystown Lake Upstream (US-5)
STATE: Pennsylvania COUNTY: Bedford
WATER BODY: Raystown Branch Juniata River
LOCALE: Warriors Path State Park, Pavilion No. 2
LATITUDE: 40.19697603 LONGITUDE: -78.25188403
DATE: 29 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1042-1110 SEARCH TIME (min): 28
GEAR: Pollywog/hand WIDTH (yd): 57
WATER TEMPERATURE (C°): 24.7 SPECIFIC CONDUCTIVITY (mS/cm): 0.316
pH: 8.51 DISSOLVED OXYGEN (mg/L): 8.65 TURBIDITY (NTU): 2.0
VELOCITY RANGE (cm/s): 26-52 DEPTH RANGE (ft): 2.4-3.1
SUBSTRATE TYPE: Sand/Silt over Rock/Gravel/Boulder/Cobble
COMMENT: RDB from access point upstream of braided channel (island); good flow near shore area from braided island downstream to access point.

FIELD NUMBER: Raystown Lake Downstream (D-6)
STATE: Pennsylvania COUNTY: Huntingdon
WATER BODY: Raystown Branch Juniata River
LOCALE: 700 ft downstream of hydroelectric station outflow, adjacent to Raystown Lake fishing access
LATITUDE: 40.432865 LONGITUDE: -78.000078
DATE: 28 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 0910-0950 SEARCH TIME (min): 40
GEAR: Pollywog/hand WIDTH (yd): 58
WATER TEMPERATURE (C°): 23.8 SPECIFIC CONDUCTIVITY (mS/cm): 0.198
pH: 7.37 DISSOLVED OXYGEN (mg/L): 4.54 TURBIDITY (NTU): 0.2
VELOCITY RANGE (cm/s): 0-78 DEPTH RANGE (ft): 1-3.2
SUBSTRATE TYPE: Rock/Cobble/Sand

COMMENT: Worked LDB and areas adjacent to mid channel island

FIELD NUMBER: Raystown Lake Downstream (D-7)
STATE: Pennsylvania COUNTY: Huntingdon
WATER BODY: Raystown Branch Juniata River
LOCALE: Corbin Island Campground
LATITUDE: 40.42899599 LONGITUDE: -77.99180598
DATE: 28 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1024-1057 SEARCH TIME (min): 33
GEAR: Pollywog/hand WIDTH (yd): 39
WATER TEMPERATURE (C°): 23.9 SPECIFIC CONDUCTIVITY (mS/cm): 0.188
pH: 7.37 DISSOLVED OXYGEN (mg/L): 6.94 TURBIDITY (NTU): 0.2
VELOCITY RANGE (cm/s): 0-51 DEPTH RANGE (ft): 2.5-2.9
SUBSTRATE TYPE: Big Cobble/Sand
COMMENT: Worked along LDB braided channel and cut between two islands

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FIELD NUMBER: Raystown Lake Downstream (D-8)
STATE: Pennsylvania COUNTY: Huntingdon
WATER BODY: Raystown Branch Juniata River
LOCALE: Access off Point Rd. 0.44 miles NW of junction of Katherine Lane and Point Rd.
LATITUDE: 40.44107004 LONGITUDE: -77.99409801
DATE: 28 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1205-1227 SEARCH TIME (min): 22
GEAR: Pollywog/hand WIDTH (yd): 86
WATER TEMPERATURE (C°): 25.4 SPECIFIC CONDUCTIVITY (mS/cm): 0.185
pH: 7.59 DISSOLVED OXYGEN (mg/L): 7.78 TURBIDITY (NTU): 0.1
VELOCITY RANGE (cm/s): 6-28 DEPTH RANGE (ft): 2.8-4.9
SUBSTRATE TYPE: Cobble/Bedrock
COMMENT: Access along LDB at roadside pull-off

FIELD NUMBER: Raystown Lake Downstream (D-9)
STATE: Pennsylvania COUNTY: Huntingdon
WATER BODY: Raystown Branch Juniata River
LOCALE: Upper access for Riverside Nature Trail, designated parking access off Point Rd.
LATITUDE: 40.43911999 LONGITUDE: -77.98181199
DATE: 28 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1301-1328 SEARCH TIME (min): 27
GEAR: Pollywog/hand WIDTH (yd): 77
WATER TEMPERATURE (C°): 25.4 SPECIFIC CONDUCTIVITY (mS/cm): 0.187
pH: 7.63 DISSOLVED OXYGEN (mg/L): 7.91 TURBIDITY (NTU): 0.3
VELOCITY RANGE (cm/s): 21-46 DEPTH RANGE (ft): 1.9-2.8
SUBSTRATE TYPE: Cobble
COMMENT: Worked along LDB adjacent to and downstream of old boat ramp

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FIELD NUMBER: Raystown Lake Downstream (D-10)
STATE: Pennsylvania COUNTY: Huntingdon
WATER BODY: Raystown Branch Juniata River
LOCALE: Upstream of Campground along Riverside trail
LATITUDE: 40.43972801 LONGITUDE: -77.97367701
DATE: 28 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1354-1412 SEARCH TIME (min): 18
GEAR: Pollywog/hand WIDTH (yd): 58
WATER TEMPERATURE (C°): 26.5 SPECIFIC CONDUCTIVITY (mS/cm): 0.186
pH: 7.72 DISSOLVED OXYGEN (mg/L): 8.22 TURBIDITY (NTU): 0.3
VELOCITY RANGE (cm/s): 34-67 DEPTH RANGE (ft): 2.0-2.8
SUBSTRATE TYPE: Cobble/Boulder/Cobble mixed with Gravel
COMMENT: Worked along LDB 0.05 miles upstream of Raystown Branch Campground

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FIELD NUMBER: Raystown Lake Downstream (D-11)
STATE: Pennsylvania COUNTY: Huntingdon
WATER BODY: Raystown Branch Juniata River
LOCALE: Ripplin Rd. junction with Point Rd.
LATITUDE: 40.45147701 LONGITUDE: -77.98574503
DATE: 28 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1434-1501 SEARCH TIME (min): 27
GEAR: Pollywog/hand WIDTH (yd): 62
WATER TEMPERATURE (C°): 25.9 SPECIFIC CONDUCTIVITY (mS/cm): 0.186
pH: 7.65 DISSOLVED OXYGEN (mg/L): 8.17 TURBIDITY (NTU): 0.3
VELOCITY RANGE (cm/s): 34-67 DEPTH RANGE (ft): 2.0-2.8
SUBSTRATE TYPE: Cobble/Bedrock
COMMENT: Access along LDB at junction of Ripplin Rd. with Point Rd. (River Rd.)

FIELD NUMBER: Raystown Lake Downstream (D-12)
STATE: Pennsylvania COUNTY: Huntingdon
WATER BODY: Raystown Branch Juniata River
LOCALE: Corbin Rd. (T428) crossing, Corbin Bridge No. 2
LATITUDE: 40.45447103 LONGITUDE: -77.98271203
DATE: 28 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1526-1545 SEARCH TIME (min): 19
GEAR: Pollywog/hand WIDTH (yd): 64
WATER TEMPERATURE (C°): 26.4 SPECIFIC CONDUCTIVITY (mS/cm): 0.186
pH: 7.66 DISSOLVED OXYGEN (mg/L): 7.96 TURBIDITY (NTU): 0.1
VELOCITY RANGE (cm/s): 22-40 DEPTH RANGE (ft): 2.1-5.0
SUBSTRATE TYPE: Cobble/Boulder
COMMENT: RDB at Corbin Rd. (T428) crossing Corbin Bridge No. 2

FIELD NUMBER: Raystown Lake Downstream (D-13)
STATE: Pennsylvania COUNTY: Huntingdon
WATER BODY: Raystown Branch Juniata River
LOCALE: Raystown Branch Boat Launch
LATITUDE: 40.45555204 LONGITUDE: -77.97736103
DATE: 28 Aug 2018
MUSSEL COLLECTORS: Todd Slack, Steven George, Bradley Lewis
LOCATION TIME: 1603-1622 SEARCH TIME (min): 19
GEAR: Pollywog/hand WIDTH (yd): 93
WATER TEMPERATURE (C°): 27.2 SPECIFIC CONDUCTIVITY (mS/cm): 0.187
pH: 7.94 DISSOLVED OXYGEN (mg/L): 8.57 TURBIDITY (NTU): 0.2
COMMENT: No transect data (too wide). LDB at Raystown Branch boat launch at junction of Point Rd. and River Rd.; upstream of confluence of Raystown Branch and Juniata River.

Appendix VII: List of all species recorded by N. Schoppmann during the 2018 field season at Raystown Lake, sorted by Family.

Apatelodidae

Apatelodes torrefacta

Bombycidae

Olceclostera angelica

Drepanidae

Drepana arcuata
Oreta rosea

Erebidae

Allotria elonympha
Apantesis vittata
Bleptina caradrinalis
Caenurgina crassiuscula
Caenurgina erechtea
Catocala amica
Catocala antinympha
Catocala epione
Catocala ilia
Catocala lineella
Catocala neogama
Catocala obscura
Catocala retecta
Catocala ultronia
Celiptera frustulum
Chytolita morbidalis
Cisseps fulvicollis
Cisthene packardii
Clemensia albata
Crambidia pallida
Crambidia uniformis
Cycnia oregonensis
Cycnia tenera
Drasteria grandirena
Euparthenos nubilis
Grammia parthenice
Halysidota tessellaris
Haploa clymene
Hypena abalienalis
Hypena baltimoralis
Hypena deceptalis
Hypena edictalis
Hypena humuli
Hypena palparia
Hypena scabra
Hyperstrotia spp.
Hypoprepia fucosa
Hypoprepia miniata
Hypsoropha hormos
Idia aemula/concisa
Idia americalis
Idia dimenuendis
Idia lubricalis
Idia majoralis
Idia rotundalis
Idia scobialis
Isogona tenuis
Lascoria ambigualis
Ledaea perditalis
Macrochilo litophora
Mocis texana
Palthis angulalis
Palthis asopialis
Pangrapta decoralis
Panopoda carneicosta
Panopoda rufimargo
Phalaenophana pyramusalis
Phalaenostola larentioides
Pyrrharctia isabella
Redectis vitrea
Renia adspergillus
Renia discoloralis
Renia factiosalis
Renia flavipunctalis
Scoleocampa liburna
Spargaloma sexpunctata
Spiloloma lunilinea
Spilosoma congrua
Spilosoma virginica
Tetanolita floridana
Virbia ferruginosa
Virbia laeta
Virbia opella

Zale bethunei
Zale horrida
Zale lunata
Zale metatoides
Zanclognatha cruralis
Zanclognatha dentata
Zanclognatha protumnusalis

Eutellidae

Marathyssa inficita
Paectes oculatrix

Geometridae

Aethalura intertexta
Anavitrinella pampinaria
Antepione thisoaria
Besma endopriaria
Besma quercivoraria
Biston betularia
Campaea perlata
Caripeta piniata
Chlorochlamys chloroleucaria
Coryphista meadii
Costaconvexa centrostrigaria
Cyclophora packardi
Cyclophora pendulinaria
Digrammia continuata
Digrammia ocellinata
Dyspteris abortivaria
Epimecis hortaria
Epirrhoe alternata
Eubaphe mendica
Euchlaena amoenaria
Eulithis diversilineata
Euphyia intermediata
Eusarca confusaria
Eutrapela clemataria
Hypagyrtis piniata
Hypagyrtis unipuncta
Idaea demissaria
Idaea dimidiata
Idaea obfusaria
Iridposis larvaria
Iridopsis vellivolata
Macaria aemultaria
Macaria bicolorata
Macaria bisignata
Macaria granitata
Macaria minorata
Macaria notata
Macaria promiscuata
Melilla xanthometata
Nematocampa resistaria
Nemoria bistriaris
Pasiphila rectangulata
Patalene olyzonaria
Pero anceltaria
Plagodis alcoolaria
Plagodis fervidaria
Plagodis phlogosaria
Pleuroprucha insulsaria
Prochoerodes lineola
Protitame virginalis
Protoboarmia porcelaria
Rhumaptera prunivorata
Scopula inductata
Scopula limboundata
Selenia kentaria
Speranza pustularia
Tetracis crocallata
Timandra amaturaria
Trichodezia albovittata
Xanthotype urticaria
Xanthorhoe ferrugata
Glenoides texanaria

Lasiocampidae

Malacosoma americana
Tolype laricis
Tolype velleda

Limacodidae

Adoneta spinuloides
Apoda biguttata
Apoda y-inversum
Euclea delphinii
Isa textula
Lithacodes fasciola
Parasa chloris
Parasa indetermina
Prolimacodes badia

Tortricidia flexuosa

Lymantriidae

Dasichyra basiflava
Lymantria dispar
Orgyia leucostigma

Megalopygidae

Megalopyge crispata

Noctuidae

Abagrotis alternata
Abagrotis anchocelioides
Abagrotis cupida
Acronicta americana
Acronicta connecta
Acronicta dactylina
Acronicta falcula
Acronicta fragilis
Acronicta hasta
Acronicta interrupta
Acronicta lithospila
Acronicta modica
Agnorisma badinodis
Agriopodes fallax
Agrotis gladaria
Agrotis ipsilon
Amphipoea americana
Anathix ralla
Anterastria teratophora
Argyrostrotis anilis
Athetis tarda
Balsa labecula
Callopistria mollisima
Calophasia lunula
Cerma cerintha
Chytonix palliatricula
Cirrhophanus triangulifer
Condica vecors
Condica videns
Cucullia convexipennis
Elaphria alapallida
Elaphria chalcedonia
Elaphria festivoides
Elaphria grata
Elaphria versicolor
Eudryas grata
Euplexia benesimilis
Euxoa bostoniensis
Euxoa redimicula
Eucoa messoria
Feltia herilis
Feltia geniculata
Feltia jaculifera
Feltia subgothica/tricosa
Galgula partita
Helicoverpa zea
Homorthodes lindseyi
Lacinipolia implicata
Lacinipolia renigera
Lacinipolia teligera
Leucania inermis
Leucania phragmatidicola
Leucania pseudargyria
Leucania ursula
Leuconycta diphteroides
Marimatha nigrofimbria
Melanchra adjuncta
Mythimna unipuncta
Nephelodes minians
Noctua pronuba
Ochropleura implecta
Ogdoconta cinereola
Orthodes cynica
Orthodes detracta
Orthodes majuscula
Ozarba aeria
Panthea acronyctoides
Panthea furcilla
Papaipema rutila
Parallelia bistriaris
Peridroma saucia
Phlogophora periculosa
Phosphila turbulenta
Polygrammate hebraeicum
Ponometia erastrioides
Protodeltote muscosula
Protolampra brunneicollis
Proxenus miranda
Pseudeustrotia carneola

Pseudohermonassa bicarnea
Pseudorthodes vecors
Rachiplusia ou
Raphia frater
Rivula propinqualis
Sideridis congermana
Spaelotis clandestina
Spodoptera frugiperda
Spodoptera ornithogalli
Striacosta albicosta
Sunira bicolorago
Tricholita signata
Xestia badicollis
Xestia c-nigrum/dolosa
Xestia elimata
Xestia normanianus
Xestia smithii

Nolidae

Baileya australis
Baileya opthalmica
Nola cilicoides

Notodontidae

Dasylophia anguina
Gluphisia septentrionis
Heterocampa biundata
Heterocampa guttivita
Heterocampa obliqua
Hyperaeschra georgica
Lochmaeus bilineata
Lochmeaus manteo
Macrurocampa marthesia
Nadata gibbosa
Nerice bidentata
Notodonta scitipennis
Oligocentria lignicolor
Peridea angulosa
Phoesia rimosa

Saturniidae

Actias luna
Anisota virginiensis
Anisota senatoria
Antheraea polyphemus
Automeris io
Dryocampa rubicunda
Eacles imperialis

Sesiidae

Synanthedon scitula

Sphingidae

Amorpha juglandis
Ceratomia amyntor
Ceratomia catalpae
Lapara bombycoides
Lapara coniferarum
Darapsa choerilus
Darapsa myron
Hyles lineata
Paonias excaecata
Paratrea plebeja

Thyatiridae

Pseudothyatira cymatophoroides

Uraniidae

Calledapteryx dryopterata

Yponomeutidae

Atteva aurea

Appendix VIII: List of all Lepidoptera collected by Mr. Johnson at Raystown Lake during his preliminary visit in the 2018 field season, sorted by family.

Crambidae
Palpita magniferalis
Depressariidae
Antaeotricha humilis
Antaeotricha leucillana
Semioscopis packardella
Drepanidae
Drepana arcuata
Erebidae
Hypena palparia
Palthis angulalis
Parallelia bistriaris
Phalaenophana paramusalis
Zale horrida
Zale metatoides
Zale minerea
Gelechiidae
Dichomeris georgiella
Geometridae
Anavitrinella pampinaria
Besma quercivoraria
Biston betularia
Caripeta piniata
Coryphista meadii
Epimecis hortaria
Eufidonia notataria
Hydrelia inornata
Iridopsis larvaria
Lambdina pellucidaria
Lomographa vestaliata
Macaria continuata
Macaria minorata
Melanolophia canadaria
Mesoleuca ruficillata
Metarranthis angularia
Metarranthis obfirmaria
Nemoria bistriaria
Pero ancetaria
Pero morrisonaria
Phaeoura quernaria
Plagodis alcoolaria

Plagodis phlogosaria
Tetracis crocallata
Limacodidae
Tortricidia testacea
Noctuidae
Acronicta fallax
Acronicta lobeliae
Acronicta vinnula
Athetis tarda
Charadra deridens
Chytonix palliatricula
Crocigrapha normani
Elaphria alapallida
Elaphria georgei
Elaphria versicolor
Homorthodes lindseyi
Lacinipolia anguina
Morrisonia confusa
Morrisonia latex
Panthea furcilla
Ponometia erastrioides
Raphia frater
Ulolonche culea
Nolidae
Meganola phylla
Notodontidae
Clostera inclusa
Ellida caniplaga
Heterocampa biundata
Pyralidae
Desmia funeralis
Diacme adipaloides
Saturniidae
Actias luna
Dryocampa rubicunda
Sphingidae
Darapsa myron
Lapara coniferarum
Tortricidae
Acleris cervinana
Amorbia humerosana
Argyrotaenia mariana
Argyrotaenia velutinana

Clepsis peritana
Ecdytolopha insiticiana
Phaecasiophora confixana
Proteoteras aesculana
Pseudexentera costomaculana
Retinia virginiana

Uraniidae

Callizzia amorata

Yponomeutidae

Atteva aurea

Appendix IX: Total Number of all Lepidoptera Species Captured at each Sampling Station during the Moth Sampling Period, July 18 – October 1, 2018, Raystown Lake, Pennsylvania, Sorted by Family.

Location	Ridenor	Site 1	Site 2	Site 3	Site 5	Site 6	Site 1	Site 2	Site 4	Site 6	Site 3	Site 5	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Hawns	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Totals by species
Date	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	21-Jul-18	21-Jul-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	21-Aug-18	21-Aug-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	
Apatelodidae																																													
Apatelodes torrefacta	3		1																																										4
Bombycidae																																													
Olceclostera angelica	13		5		2			3			3																																		26
Drepanidae																																													
Drepana arcuata																								1																					1
Oreta rosea		3		1			1			1	1				1			1					1				1		2	1		4					1								19
Erebidae																																													
Allotria elonympha	3			1				1							1	1				5	1			1				1							1						1				17
Apantesis vittata																		1		1																									2
Bleptina caradrinalis	34	14	7	9	1	7	3						16		1	1			24	4	6				2	2	1						4												136
Caenurgina crassiuscula		3																																											3
Caenurgina erechtea	1	2					2		2							1			2	1					1		5																		17
Catocala amica															4																														4
Catocala antinympha																																	3												3
Catocala epione	1														1																														2
Catocala ilia	1			1			1		1				2		2	1			1	1						2		2						1											16
Catocala lineella													1					1																											2
Catocala neogama															1				2	4														2	4				2						15
Catocala obscura																																	1												1
Catocala retecta																																		1											1
Catocala sp.																													2																2
Catocala ultronia	1												1		4		1	5	1	1	1																								15
Celiptera frustulum																			1					2	1						1														5
Chytolita morbidalis		4		1																																									5
Cisseps fulvicollis																											2						1												3
Cisthene packardii																			7	3	4		2	2	4			1		1	2	3													29
Clemensia albata													1		6			2	5	18	19		4	5				1			1														62
Crambidia pallida			2	1			3		11		1		4		15	12	1	12	2	1	2	3	2	1	2	2	1	1				1													80
Crambidia uniformis											1		1		8	2		1		3	2						1	6	3			1													29
Cycnia oregonensis	1												1						1																										3
Cycnia tenera									1						2																														3
Drasteria grandirena			3																																										3
Euparthenos nubilis				1		2					1		1					1		3				1																					10
Grammia parthenice									1										1								1	5	5		2	2													17
Halysidota tessellaris	181	15	60	23	33	122	9	8	24	2	41				6			1			2																								527
Haploa clymene	1						1				1																																		3
Hypena abalienalis						1																																							1
Hypena baltimoralis			2						1																						1														4
Hypena deceptalis				1																																									1
Hypena edictalis			1	1				1										1																											4

Location	Ridenor	Site 1	Site 2	Site 3	Site 5	Site 6	Site 1	Site 2	Site 4	Site 6	Site 3	Site 5	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Hawns	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Totals by species
Date	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	21-Jul-18	21-Jul-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	21-Aug-18	21-Aug-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	
Hypena humuli																	1																												1
Hypena palparia											2				9						2																								13
Hypena scabra		1	1					2										1																						1			1	1	8
Hypena sp.		4		1		1	1			1			2		6					6				2		2		1	1																28
Hyperstrotia spp.	20	1	22	22		3	2	13		4	10		2		##	1		4	3	27	32					1																			372
Hypoprepia fucosa	78	9	65	27	8	31	37	10	*14*	4	29	1	2	1	31	1		4		3	2																								357
Hypoprepia miniata	24		4			1	1	1			1		6		26	1		1						1																					67
Hypsoropha hormos					1	1																																							2
Idia aemula/concisa	198	11	115	46			8	7	3		5				21		1	3	7	3	4			1	1		1	12	4	6	1	3	3	7	4			1	2	6	7				491
Idia americalis	2	4		10	4	7	4	1	5	1	3		4		6			1	15	6	8		4	6	1	3	1	7	7		7	6		5	1	2	1	1	1	3	3		1	1	142
Idia dimenuendis	19	19	2	13	2	6	9	3		1																		5																	79
Idia lubricalis	8	3	1	1	1	5		3	6		6		2		6		2			2			1	1		1		1			1	1													52
Idia majoralis																					1				1			3																	5
Idia rotundalis	61	21	63	23	4	15	34	18	14		33		15		86	3	2	7	7	51	32			1	6		8	26	12	3	1	1													547
Idia scobialis	16		3			4	5				2		1		7			7	6	10	3																								64
Idia sp.		13																	2		7												1												23
Isogona tenius																		2																											2
Lascoria ambigualis						3	2		4		5		1						1												1	1													18
Ledaea perditalis					2																																								2
Macrochilo litophora																3		2																											5
Mocis texana															1																														1
Palthis angulalis	9	17				4	22		4	3	1		17		4		1	6	2		1			3		1	9	1		1	2	6				1									115
Palthis asopialis						1											1	2					1		2	2			1	6	5	4	2					2	1	1	1	1	2	3	38
Pangrapta decoralis		1		2			1			1			2		4		1	3																											15
Panopoda carneicosta	28	6	5	7		2	6		5		2		2		7			2	3	2	5				4	1						1													88
Panopoda rufimargo	23	5	18	9	2	5	5		3	1	1				6				1	1	1		1		1		1					1													85
Phalaenophana pyramusalis		2	1		1				1				1			3			1		1			1	4		4			5	1	1													27
Phalaenostola larentioides	2		26	4			2	1		1			3		1	8		3			2				10			1		1															65
Phalaenostola sp.						1																																							1
Pyrrharctia isabella			1																	1																									2
Redectis vitrea													1						1					1			1	1		1	1														7
Renia adspergillus															13																														13
Renia discoloralis									4		6		1		42	2	3	19	4	24	21			2	2			1																	131
Renia factiosalis							4				6		1																																11
Renia flavipunctalis									1																																				1
Renia spp.	31	5	7	1	4	1	6	5	15	2	1					1			3	3	3	2	3	1	2	9			4	1															110
Scoleocampa liburna	2		5	1	2	4				1	1																																		16
Spargaloma sexpunctata							1						1																																2
Spiloloma lunilinea	4				3					1								3			1			3	1																				16
Spilosoma congrua							1		1	3		2									1			1																					9
Spilosoma virginica	1														1																														2
Tetanolita floridana																			4									1																	5
Virbia ferruginosa																		2																											2

Location	Ridenor	Site 1	Site 2	Site 3	Site 5	Site 6	Site 1	Site 2	Site 4	Site 6	Site 3	Site 5	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Hawns	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Totals by species
Date	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	21-Jul-18	21-Jul-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	21-Aug-18	21-Aug-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	
Virbia laeta	1																																												1
Virbia opella	6		11		2	1		1		1	1				1																														24
Zale bethunei	6		1		3	5	2																																						17
Zale horrida			1	1									1																																3
Zale lunata	14	2	8	1	1			2			2				2									1						1															34
Zale metatoides	1	2			8	2																																							13
Zale sp.															1			2																											3
Zanclognatha cruralis			1		8	13	4		1	2	16		14		13			2	13	10	15	1	1	9	7	4	6	2	8	17	5	4													176
Zanclognatha dentata						4				1																1					1	2													9
Zanclognatha protumnusalis							4	4																																					8
Zanclognatha spp.	29	4	17	16					7	1			1		12			1	3	6											3	2	2				1								105
Eutellidae																																													
Marathyssa inficita		2					2						1																																5
Paectes oculatrix																		1																											1
Geometridae																																													
Aethalura intertexta	2					1												2																											5
Anavitrinella pampinaria	19	3	2		4		12	1	3	2	4		2		16	4	1	15	2	1	1		1	1	1		3					5												1	104
Antepione thisoaria	5	1	1				3	1	3		1																																		15
Besma endopriaria			1				3	3			5				114			1			2																								129
Besma quercivoraria	2		6				4	1	3		6		8		38			2	4	8	2																								84
Biston betularia			1										1		1					3	2			2								1													11
Cabera sp.	2	2			1																																								5
Campaea perlata																					1				1		2	4	7	1	1	2		3	1	1									24
Caripeta piniata																			1							1																			2
Chlorochlamys chloroleucaria	1																																												1
Coryphista meadii					1				1																																				2
Costaconvexa centrostrigaria	2		1	1																									1																5
Cyclophora packardi	8	1	5	2					3						4				2	11	4							3	1				1												45
Cyclophora pendulinaria	2		3						2		1				3										1			1																	13
Digrammia continuata	37	1				1	1																																						40
Digrammia ocellinata	9	3	5	2		3	3		3	3	1		7					1	5	2							1																		48
Dyspteris abortivaria	1																	1	1																										3
Epimecis hortaria	19			2	1	1			1		4							1																											29
Epirrhoe alternata		2																																											2
Eubaphe mendica																														2															2
Euchlaena amoenaria																															1														1
Euchlaena sp.															2				1	1																									4
Eulithis diversilineata	4	2	9	1	2	6	4				2				8			3	1	4	2		3	3	2	1	1				1														59
Euphyia intermediata											1							1																											2

Location	Ridenor	Site 1	Site 2	Site 3	Site 5	Site 6	Site 1	Site 2	Site 4	Site 6	Site 3	Site 5	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Hawns	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Totals by species
Date	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	21-Jul-18	21-Jul-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	21-Aug-18	21-Aug-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	
Eupithecia spp.	14	18		8	10	40									5			1	4				2	3	3			1	1		3	59												1	173
Eusarca confusaria	1	2	2			5																				1		1		5		2	1	1											21
Eutrapela clemataria	2	1		1	2																																								6
Hypagyrtis piniata									2				40		137	7		6																											192
Hypagyrtis sp.						1	16			2									1	34			1	15	2	1																			73
Hypagyrtis unipuncta								1			5		3		6			2													2														19
Idaea demissaria													1																																1
Idaea dimidiata			2																																										2
Idaea obfusaria	4			1	1																																								6
Iridposis larvaria									2		5				28			9																											44
Iridopsis sp.			3				1	1								1																													6
Iridopsis vellivolata	1			1						2					4																														8
Macaria aemultaria		6	16	6	2	7	6	1	6	4	8		3		18			2			7																								92
Macaria bicolorata											1				6			3	2	2	2			1				2			1	1													21
Macaria bisignata															1																														1
Macaria granitata	1										2				7		1	4	1	8	2		2	7		1																			36
Macaria minorata	7	1		6	24	7	3		6	3								1		1												1													60
Macaria notata	2																		3																										5
Macaria promiscuata	4		2	2	2		4		2	4	3				1			3	2	2				1							3														35
Macaria sp.																				19						2	2	3				1													27
Melanolophia sp.	77	17	26	15	51	52	22	3	34	10	25		3		12	3		6	6					12		1		6																	381
Melilla xanthometata					1				2	3								9												4	##	7													31
Nematocampa resistaria																		1																											1
Nemoria bistriaria	6	7	11	5	1		1		3	1	9		1		17																														62
Pasiphila rectangulata						3																																							3
Patalene olyzonaria	3			1			23				1		14		12		1	2	1	1													13	2			1	2	13	1	3		1	2	97
Pero anceltaria	1			1			8	1	14	8	11				6		2	13		2																									67
Plagodis alcoolaria															3																														3
Plagodis fervidaria	92	20	53	38		1	20	8	8		29				15			1		2																									287
Plagodis phlogosaria	28		11	6		4	1	1			12				3																														66
Pleuroprucha insulsaria										2																																			2
Prochoerodes lineola	5		4	2	9				1	1	1				1					1								1		2		3	2	2		4		6			1	1		2	49
Protitame virginalis	4		1				1		3	1	2																																		12
Protoboarmia porcelaria						1				3	2				4	1			2	7											1		1												22
Rhumaptera prunivorata	1			1					3		2							1		1																									9
Scopula inductata	1	2							1							1																													5
Scopula limboundata	4	3	9		5	3			1	1	3		1						1					1		1	1					1													35
Selenia kentaria	2				1		1			1																																			5
Speranza pustularia	3	1	3			5			1																																				13
Tetracis crocallata	1														4	1		1																											7
Timandra amaturaria																											1																		1
Trichodezia albovittata					1																																								1
worm specimens	9	1	25	8	1	2	10	1	4	2	5	1	30		12		6	8	11	102	##		11	6	7	10	2	1	17		6		1	2		5							2		508
Xanthotype urticaria																				3				2																					5
Xanthorhoe ferrugata									4				1													1																			6

Location / Date	Ridenor 10-Jul-18	Site 1 10-Jul-18	Site 2 10-Jul-18	Site 3 10-Jul-18	Site 5 10-Jul-18	Site 6 10-Jul-18	Site 1 20-Jul-18	Site 2 20-Jul-18	Site 4 20-Jul-18	Site 6 20-Jul-18	Site 3 21-Jul-18	Site 5 21-Jul-18	Site 1 5-Aug-18	Site 2 5-Aug-18	Site 3 5-Aug-18	Site 4 5-Aug-18	Site 5 5-Aug-18	Site 6 5-Aug-18	Site 1 16-Aug-18	Site 2 16-Aug-18	Site 3 16-Aug-18	Site 4 16-Aug-18	Site 5 16-Aug-18	Site 6 16-Aug-18	Hawns 21-Aug-18	Site 4 21-Aug-18	Site 1 2-Sep-18	Site 2 2-Sep-18	Site 3 2-Sep-18	Site 4 2-Sep-18	Site 5 2-Sep-18	Site 6 2-Sep-18	Site 1 16-Sep-18	Site 2 16-Sep-18	Site 3 16-Sep-18	Site 4 16-Sep-18	Site 5 16-Sep-18	Site 6 16-Sep-18	Site 1 1-Oct-18	Site 2 1-Oct-18	Site 3 1-Oct-18	Site 4 1-Oct-18	Site 5 1-Oct-18	Site 6 1-Oct-18	Totals by species
Xanthorhoe sp.	5						1	1																																					7
Glenoides texanaria																									1		5	4	4			50					26	32							122
Lasiocampidae																																													
Malacosoma americana			2																																										2
Tolype laricis			1	1																													1	1			9						1		14
Tolype velleda																															1									1					2
Limacodidae																																													
Adoneta spinuloides	2			1	1	1					1																																		6
Apoda biguttata	1		2	1	1												1																												6
Apoda y-inversum	2		1	1				2	1						2			1																											10
Euclea delphinii			1					2																																					3
Isa textula	8			7	1																																								16
Lithacodes fasciola	3	1	1		1	2				1	3								1																										13
Parasa chloris	1	3	3	1						1	1																																		10
Parasa indetermina			1								1																																		2
Prolimacodes badia			1	1			2				1				1																														6
Tortricidia flexuosa			10			1		2			10		1		16	1		1			3																								45
Worn specimens							2																																						2
Lymantriidae																																													
Dasichyra basiflava	4																																												4
Lymantria dispar		1		1				1			1																																		4
Orgyia leucostigma			2															1																								1			4
Orgyia sp.	1			2	1	4			1						2																			1				2	22	3	1		1	1	42
worm specimens		2																															1												3
Megalopygidae																																													
Megalopyge crispata	6	2	3		1	2																																							14
Noctuidae																																													
Abagrotis alternata	5		1	5				1			1				5					2	1							1	1				3	1	2				2	2	3		1		37
Abagrotis anchocelioides			1																																										1
Abagrotis cupida																																		1											1
Acronicta americana	12	8	6	4		1		2		1			2		3			1																											40
Acronicta connecta								1																																					1
Acronicta dactylina							8																																						8
Acronicta falcula															1																														1
Acronicta fragilis																				4																									4
Acronicta hasta	3		2				5				1		1						2	1																									15
Acronicta interrupta	1																																												1
Acronicta lithospila	1												1		1				1																										4
Acronicta modica																				2																									2
Acronicta tristis comple	167	15	98	56	2	8	7	19	9	1	27		3		4		1		2	2																									421

Location	Ridenor	Site 1	Site 2	Site 3	Site 5	Site 6	Site 1	Site 2	Site 4	Site 6	Site 3	Site 5	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Hawns	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Totals by species
Date	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	21-Jul-18	21-Jul-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	21-Aug-18	21-Aug-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	
Acronicta sp.	2		1								1		4		4			2	3	1	1				2																				21
Agnorisma badinodis																																					1		4		1		1		7
Agriopodes fallax																								1		1																			2
Agrotis gladaria																																							5						5
Agrotis ipsilon									2	1			1		1		1	3	18	1			1	4	1	4	5					1	1					1					1	1	48
Agrotis sp.							1																																						1
Amphipoea americana						1					6																																		7
Anathix ralla																				1	1							3	1			1		1				1							9
Anterastria teratophora	37		1				2											1																											41
Apamea sp.									4				1																																5
Argyrostrotis anilis	1	1		1																																									3
Athetis tarda																			14	26				10	9		3	8	3	1															74
Balsa labecula			1																																										1
Balsa sp.	7	1	14	7	2	1																																							32
Callopistria mollisima	2							2			2																																		6
Calophasia lunula		1																																											1
Cerma cerintha	29		5	2		8					1																																		45
Chytonix palliatricula	29	4	9	4	1	6	2	2	3		6		3		5									1																					75
Cirrhophanus triangulifer																											1																		1
Condica vecors		2								1						1							23																						27
Condica videns													1														1																		2
Cucullia convexipennis	1					1					1																																		3
Cucullia sp.																				1																									1
Elaphria alapallida				2											1																														3
Elaphria chalcedonia									9				1					1																											11
Elaphria festivoides								3		2																																			5
Elaphria grata									1		1					2									1		1					1													7
Elaphria versicolor	6		2			4	9			5	4		3							2							1																		36
Eudryas grata	3	6		1		2	7		3	3	2				2	1	1				2																						1		34
Euplexia benesimilis										1	4			1	3			2			1																								12
Euxoa bostoniensis																																												1	1
Euxoa redimicula																			3																										3
Eucoa messoria			1																																										1
Euxoa sp.													2															3								2	1								8
Feltia herilis									1										1						3	1	13		2	10	27	30				1	1	2							92
Feltia geniculata																				1							19	12	14		3	1						1							51
Feltia jaculifera																											1						2												3
Feltia subgothica/tricosa							1												3	1				2	5					5	1	1	3				1	3							26
Galgula partita									1									1	1						1		1	1										1		1					8
Helicoverpa zea																																	1			2			2			1	1		7
Homorthodes lindseyi													4		3	1			6	24	6																								44
Lacinipolia implicata																												1																	1
Lacinipolia renigera		1																	4								1												1						7
Lacinipolia teligera																																	1												1
Leucania inermis															1							1	1	1	2	2				1		1													10

Location	Ridenor	Site 1	Site 2	Site 3	Site 5	Site 6	Site 1	Site 2	Site 4	Site 6	Site 3	Site 5	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Hawns	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Totals by species
Date	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	21-Jul-18	21-Jul-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	21-Aug-18	21-Aug-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	
Leucania phragmatidicola																								1	1	1																			3
Leucania pseudargyria						1																																							1
Leucania sp.																														1	2														3
Leucania ursula																							1	9																					10
Leuconycta diphteroides							1						1														8		4	1	2	4													21
Marimatha nigrofimbria									2				2		2			2	1		1							2				1													13
Melanchra adjuncta																			4	1				1		2																			8
Mythimna unipuncta													7			1		7	9	1			3	2		1	2						1												34
Nephelodes minians																														2					1	2		1							6
Noctua pronuba	3			2		2	1								1			5	4	3				1		1	1	1	2			1													28
Ochropleura implecta																		1						1		1						1													4
Ogdoconta cinereola									1				1														3			1															6
Oligia sp.										1																																			1
Orthodes cynica															1					4	2				1										1										9
Orthodes detracta		1			1																																								2
Orthodes majuscula										1			2		5				3	3	1		1	1	1	1	5			2	1	1													28
Ozarba aeria																								1																					1
Panthea acronyctoides															1																														1
Panthea furcilla							1			1					1			6	2	1			1	3		1		1																	18
Papaipema rutila																																1					1								2
Parallelia bistriaris				1						1	1																																		3
Peridroma saucia																			1							1	1																		3
Phlogophora periculosa																																			1	1									2
Phosphila turbulenta	9			1	10	14																																							34
Polygrammate hebraeicum	30		9	5		6	1	3	1		3		2		8			3		1	1							1																	74
Ponometia erastrioides		1									3																																		4
Protodeltote muscosula													1		24		5	46	4	15	12			19	2																				128
Protolampra brunneicollis																											1											1							2
Proxenus miranda													1											25	6		2	1		1															36
Pseudeustrotia carneola	13	4	1				9		2	1	1		10		2			1	17	2	2			1			6		1	1			1	1					2						78
Pseudohermonassa bicarnea																				2			1	2			1					4													10
Pseudorthodes vecors													7		4			10	18	15	6									3	1														64
Rachiplusia ou																																								1					1
Raphia frater	1			1				1		1					1																														5
Rivula propinqualis	12		3					1	1		1				1			1			1				2		2					2													27
Sideridis congermana	2														1																														3
Spaelotis clandestina	18																																												18
Spodoptera frugiperda																											2																		2
Spodoptera ornithogalli																			1														8		2			5	2		1			1	20
Striacosta albicosta						1																																							1
Sunira bicolorago																														1															1
Tricholita signata																									1																				1

Location	Ridenor	Site 1	Site 2	Site 3	Site 5	Site 6	Site 1	Site 2	Site 4	Site 6	Site 3	Site 5	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Hawns	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Totals by species
Date	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	21-Jul-18	21-Jul-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	21-Aug-18	21-Aug-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	
Worn specimens	35		8			1	8	3	16	1	11		12		15			15	10	8	66	4	8	3	27	18	6		24	2	4	5	3	1	1		1	3	1						320
Xestia badicollis																		1								1		1																	3
Xestia c-nigrum/dolosa																											1				3	2	3			1		2					1		13
Xestia elimata															1				1							1							2	1	1		6	13		5	1		12	8	52
Xestia normanianus																							1						2	1	2	2					1								9
Xestia smithii																			1								1			6	4	7													19
Xestia sp.																																3							5						8
Nolidae																																													
Baileya australis								1																																					1
Baileya opthalmica		8					5				1								3																										17
Baileya sp.			8						1				3		1	1		1		1																			1						17
Meganola sp.											2				3																														5
Nola cilicoides															2	1														1															4
Nola sp.								4			14		2										1																						21
Notodontidae																																													
Datana spp.	25	12	8	3	9	14	3	4	7	2	4													1																					92
Dasylophia anguina									2						4					1				2																					9
Gluphisia septentrionis	1					1									1						1																								4
Heterocampa biundata																		1																											1
Heterocampa guttivita										1																																			1
Heterocampa obliqua	13	7	14	5		2		1	1		3				3																														49
Heterocampa spp.	5	2					4						4		14					13	2				1																				45
Hyperaeschra georgica	1		4	4				1			2				2																														14
Lochmaeus bilineata				1		1					11																																		13
Lochmeaus manteo							1																					1																	2
Macrurocampa marthesia	1			3			4	4			2																																		14
Nadata gibbosa	13	1	22	7	1	2	5	12	4		11		5		24			5	1	8	1		1																						123
Nerice bidentata															2						1																								3
Notodonta scitipennis									4						1																														5
Oligocentria lignicolor																		1																											1
Peridea angulosa			5						3		15		6		19			1	1	27				1	5																				83
Phoesia rimosa													1																																1
Schizura sp.	1	1			1																																								3
Symmerista sp.			1										1																																2
Worn specimens	8	1	14	10	1		5	10	2		8	1	8		22			4	4	10	43		3		4	4	1	1	1			1	1												167

Location	Ridenor	Site 1	Site 2	Site 3	Site 5	Site 6	Site 1	Site 2	Site 4	Site 6	Site 3	Site 5	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Hawns	Site 4	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Totals by species
Date	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	10-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	20-Jul-18	21-Jul-18	21-Jul-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	5-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	16-Aug-18	21-Aug-18	21-Aug-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	2-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	16-Sep-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	1-Oct-18	
Saturniidae																																													
Actias luna	1										1										1																								3
Anisota virginiensis	1	1		1																																									3
Anisota senatoria			2	1																																									3
Antheraea polyphemus		2		2		1	1																																						6
Automeris io											1																																		1
Dryocampa rubicunda	4	3	7	2		1																																							17
Eacles imperialis				1		1			2	1	3		1		3		1																												13
Sesiidae																																													
Synanthedon scitula							1						2		2																														5
Sphingidae																																													
Amorpha juglandis	5		1							1																																			7
Ceratomia amyntor							1																																						1
Ceratomia catalpae											1																																		1
Lapara bombycoides			3						1																																				4
Lapara coniferarum	1	2		4	1	4	1	2		2	2								1				1																						21
Darapsa choerilus		1																																											1
Darapsa myron					1		1																																						2
Hyles lineata													1																																1
Paonias excaecata	2						1	1			2				1																														7
Paratrea plebeja							1																																						1
Thyatiridae																																													
Pseudothyatira cymatophoroides																				1			1									1													3
Worn specimens																					1																								1
Uraniidae																																													
Calledapteryx dryopterata								1	1	4	6		10		16			10	1	2	1		2	3		1																			58
Yponomeutidae																																													
Atteva aurea	4	3		1	1	5	1		1		1		9		1	1		1	18		6		2	3	1	2	1		1	3			3	2		3		1	2			4		2	83
Specimen Totals by Trap	348085	346693	347269	346816	346577	346822	346841	346602	346740	346528	346934	346421	346887	346538	347831	346605	346571	346876	346962	347227	347192	346635	346716	346824	346810	346759	346912	346904	346896	346861	346871	347009	346943	346908	346892	346897	346924	346953	347060	347017	347015	347000	347019	347017	2E+07