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A SURVEY OF ODONATA OF THE PATOKA RIVER NATIONAL WILDLIFE REFUGE AND MANAGEMENT AREA

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ABSTRACT. The Patoka River National Wildlife Refuge and Management Area (hereafter Patoka River Refuge or the Refuge) represents one of the largest intact bottomland hardwood forests in southern Indiana, with meandering oxbows, marshes, ponds, managed moist-soil units, and constructed wetlands that provide diverse and suitable habitat for wildlife. Refuge personnel strive to protect, restore, and manage this bottomland hardwood ecosystem and associated habitats for a variety of wildlife. The Patoka River National Wildlife Refuge Comprehensive Conservation Plan (CCP) lists many species of management priority (McCoy 2008), but Odonata are not included, even though they are known to occur on the Refuge. The absence of Odonata from the CCP is the result of lack of information about this ecologically important group of organisms. Therefore, we conducted a survey, from May to October 2009, to document their presence, with special attention being paid to rare, threatened, and endangered species. A total of 43 dragonfly and damselfly species were collected and identified. No threatened or endangered species were found on the Refuge, but three species were found that are considered imperiled in Indiana based on Nature Serve Ranks (Stein 2002). Additionally, 19 new odonate records were documented for Pike County, Indiana. The results of this survey will be used by Refuge personnel to assist in management decisions and to help establish priorities for the Patoka River Refuge activities and land acquisition goals.

Keywords: Odonata, dragonflies, damselflies, management, wetlands

Odonata play vital roles as predators and prey, contribute significantly to ecosystem biomass, are important bioindicators of ecosystem health, and are of conservation concern in wetland and aquatic habitats. Odonate nymphs and adults have been extensively examined for their roles in predator-prey and trophic relations (Kennedy 1950, Sih 1987, Corbett 1999, Peyman 2000, Silsby 2001). Both damselfly and dragonfly nymphs feed on small aquatic organisms, fish, and tadpoles (Corbet 1999, Colburn 2004), while adults feed on mosquitoes, butterflies, and other winged insects associated with vegetation of aquatic habitats. Odonata nymphs and adults also fall prey to other organisms, especially fish and birds (Kennedy 1950, Orians & Horn 1969, King & Wrubleski 1998).

Odonates associated with the vegetation of lakes, ponds, and streams contribute a significant amount of biomass to aquatic and terrestrial habitats (Bried 2005). Odonates are also dominant or co-dominant organisms with respect to biomass in permanently flooded wetlands (Batzer & Wissinger 1996), beaver impoundments (Benke et al. 1999), constructed or restored wetlands (Fairchild et al. 1999), and many other wetland types.

The presence of odonates in aquatic and terrestrial habitats has been linked to ecosystem health. Odonata are used as indicators of ecosystem health because they respond readily to changes in hydrology, are sensitive to degradation of water quality, and are directly linked to the composition and structure of vegetation (Burton et al. 1999, Chovanec & Rabb 1997, Chovanec & Waringer 2001). Clark & Samways (1996) noted that Odonata are highly rated (top 20%) for their suitability as indicators of ecosystem health because they occupy a wide spectrum of aquatic habitats. Recently, odonates, in conjunction with plants, have been evaluated for use as possible 'umbrella' species for bioassessment purposes (Bried et al. 2007). The umbrella species concept focuses on a few core species that can

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be used as proxies for protecting and managing a much larger community of species.

A number of Odonata are beginning to appear on lists of rare, threatened, or endangered organisms as a result of declines in odonate populations caused by environmental stresses such as habitat loss, introduction of exotic invasive species, or grazing activities (Foote & Hornung 2005, Stewart & Samways 1998). Clausnitzer et al. (2009) examined the current status of a subset (1,500 species) of the 5,680 known species of Odonata using the International Union for Conservation of Nature (IUCN) Red List criteria. Their analysis revealed that 10% of the world's Odonata species are threatened. However, because 35% of the 1,500 species they examined are poorly known biologically, the number of threatened species may actually be higher.

Odonata are important in ecosystem structure and function, as indicators of ecosystem health, and increasing as organisms of conservation concern. Therefore, odonates warrant study in an area, such as the Patoka River National Wildlife Refuge and Management Area (hereafter Patoka River Refuge or the Refuge), where they are poorly understood. The Patoka River Refuge Comprehensive Conservation Plan (CCP) (McCoy 2008) outlines a vision and states goals that will direct future activities at the Refuge. An overall goal of Refuge personnel is to restore, protect, and manage the bottomland hardwood ecosystem and associated habitats for migratory birds, threatened and endangered species, and indigenous fish and wildlife, while striving to develop citizen understanding and support for the protection of natural resources by providing wildlife-related education and recreation opportunities (McCoy 2008). With this management goal in mind, our objectives were to: (1) Conduct a survey to document what species of odonates are present on the refuge, (2) examine species-habitat associations, with an emphasis on locating rare, threatened, and endangered species, and, (3) provide a voucher collection (and other materials) as tools to educate the public about the habitats odonates occupy and the role they play in the ecological processes on the Refuge.

METHODS

Study area.—The Patoka River Refuge was established in 1994. The federal government authorized acquisition of approximately 23,000 acres along a 20-mile stretch of the lower Patoka River in Pike and Gibson Counties in southwest Indiana. The Patoka River Refuge is one of the last remaining intact bottomland hardwood forests in southern Indiana, providing a variety of habitats for a number of wildlife species and other organisms, including odonates.

We sampled forested wetlands, scrub-shrub wetlands, emergent marshes, moist-soil units, constructed wetlands, other aquatic habitats (e.g., ponds, streams, and river), and grasslands. We also sampled similar habitats on the nearby White River Wildlife Management Area (WMA) and Cane Ridge WMA, both managed by Refuge personnel.

Terrestrial (or aerial) sampling.—Adult dragonflies and damselflies were captured at various lentic and lotic habitats on the Refuge with an insect net (diameter 15 inches). Odonates were captured from behind with a swinging motion and ending with a twist to secure the individual in the net. Captured individuals were identified in the field and released, or if new to our collection placed in a Ziploc® bag, put on ice to retard movement, and returned to the laboratory for identification to species. We used the nomenclature of Curry (2001) for adult dragonflies and either DuBois (2005) or Westfall & May (2006) for adult damselflies. Data recorded included date of capture, collector, location on the Refuge, GPS location, and type of habitat, as well as specific distinguishing features to aid in identification. After identification, adult odonates new to our collection were scanned (both top and side view) at 300 dpi using a Hewlett-Packard flatbed scanner (Fig. 1). Once scanned, specimens were placed in acetone to remove excess fats and air dried. Dried specimens were stored individually in 3 5/16 inch by 5 1/8 inch clear, plastic envelopes (www.cistamps.com) along with unlined index cards containing pertinent collection data. A voucher collection for adults, housed at the University of Evansville, was prepared and will be maintained for educational and research purposes.

Aquatic sampling.—Nymphs of dragonflies and damselflies were sampled from lentic and lotic habitats within the Refuge with a standard D-frame dipnet (0.5 mm mesh). We sampled each habitat qualitatively by dragging the

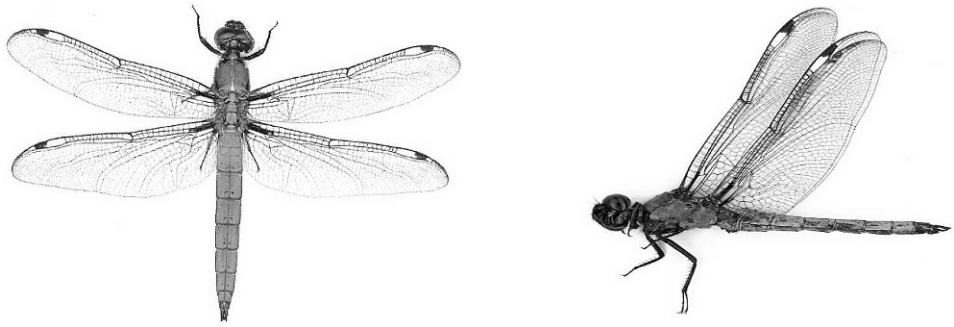

Figure 1.—Top and side view scans of a Spangled Skimmer (*Libellula cyanea*).

dipnet through vegetation and searched for nymphs. Nymphs were collected with forceps, placed in vials with 70% ethyl alcohol, and returned to the laboratory for sorting and identification. Nymphs were identified to species following the nomenclature of Needham and Westfall (1954), Merritt & Cummins (1996), and Westfall & May (2006). Data recorded included date of capture, collector, location on the Refuge, GPS location, and type of habitat. Voucher specimens were stored in vials with 70% ethyl alcohol for educational and research purposes, and will be housed at the University of Evansville.

RESULTS

Odonate species.—We identified 43 species of dragonflies and damselflies on Patoka River Refuge. These 43 species are distributed among 19 genera in 9 families.

Dragonflies: Thirty species of dragonflies were collected and identified (Table 1). The dominate dragonfly family was Libellulidae, which accounted for 18 of the 30 total species, followed by Aeshnidae (4 spp.), Gomphidae (4 spp.), Corduliidae (3 spp.), and Cordulegastridae (1 sp.). Libellulidae accounted for 57% of total species richness for dragonflies. No Macromiidae (cruisers) were collected in this survey. Adults and nymphs were collected for 13 species, adults only were collected for another 13 species, and nymphs only were collected for 4 species (Table 1).

Damselflies: A total of 13 species of damselflies were collected during the survey (Table 2). These 13 species were distributed among 5 genera in 3 families. The dominate damselfly family was Coenagrionidae (9 spp.), followed by Lestidae (3 spp.), and Calopterygidae (1 sp.). Coenagrionidae accounted for 69% of

Table 1.—Dragonfly species of the Patoka River National Wildlife Refuge and Management Area. Families, species, and life history stage are listed.

Family/Species	Adult	Nymph
AESHNIDAE		
Anax junius	x	x
Basiaeschna janata		x
Epiaeschna heros	x	x
Nasciaeschna pentacantha		x
GOMPHIDAE		
Arigomphus villosipes		x
Dromogomphus spinosus	x	
Hagenius brevistylus	x	
Stylurus plagiatus	x	
CORDULEGASTRIDAE		
Cordulegaster obliqua		x
CORDULIIDAE		
Epitheca cynosura	x	
Epitheca princeps	x	x
Somatochlora linearis	x	x
LIBELLULIDAE		
Celithemis elisa	x	x
Celithemis eponina	x	
Celithemis fasciata	x	x
Erythemis simplicicollis	x	x
Libellula cyanea	x	
Libellula incesta		
Libellula luctuosa	x	x
Libellula lydia	x	x
Libellula pulchella	x	x
Libellula vibrans	x	
Pachydiplax longipennis	x	x
Pantala flavescens	x	
Perithemis tenera	x	x
Sympetrum ambiguum	x	
Sympetrum corruptum	x	
Sympetrum vicinum	x	
Tramea carolina	x	x
Tramea lacerata	x	

Table 2.—Damselfly species of the Patoka River National Wildlife Refuge and Management Area. Families, species, and life history stage are listed.

Family/Species	Adult	Nymph
CALOPTERYGIDAE		
Calopteryx maculata	x	
LESTIDAE		
Lestes rectangularis	x	x
Lestes unguiculatus		x
Lestes disjunctus	x	x
COENAGRIONIDAE		
Argia apicalis	x	
Argia tibialis	x	
Argia sedula	x	x
Enallagma signatum	x	x
Enallagma civile	x	x
Enallagma basidens	x	x
Ischnura posita	x	x
Ischnura hastata	x	x
Ischnura verticalis	x	

Table 3.—Species richness for different wetland and aquatic habitats on Patoka River National Wildlife Refuge and Management Area.

Habitat type	Species richness
NATURAL WETLANDS	
Marsh	16
Oxbow	16
Bottomland Hardwoods	8
MANAGED & CONSTRUCTED WETLANDS	
Moist-Soil Units	22
Seasonal Wetlands	17
Permanent Wetlands	8
AQUATIC HABITATS	
Ponds and Lakes	24
Rivers and Creeks	17

total species richness for damselflies. Adults and nymphs were collected for 8 species, adults only were collected for 4 species, and nymphs only were collected for 1 species (Table 2).

Species-habitat associations.—We sampled adults and nymphs from a number of natural (marshes, bottomland forest, oxbows, and sloughs), managed (moist-soil units), and constructed (seasonal and permanent) wetlands, as well as from aquatic habitats (rivers, lakes and ponds) on the Refuge. The odonates that were most widely distributed, occurring in every habitat, include Eastern Pondhawk (*Erythemis simplicicollis*), Blue Dasher (*Pachydiplax longipennis*), Widow Skimmer (*Libellula luctuosa*), Common Whitetail (*Libellula lydia*), and Fragile Forktail (*Ischnura posita*). Other very common odonates observed at most sites include Common Green Darner (*Anax junius*), Eastern Amberwing (*Perithemis tenera*), Halloween Pennant (*Celithemis eponina*), Familiar Bluet (*Enallagma civile*), and Citrine Forktail (*Ischnura hastata*).

Natural wetlands: Emergent marshes (e.g., Snakey Point, Bucks Marsh) and various disconnected oxbows and sloughs (e.g., Miller Bridge) both had an odonate species richness of 16 (Table 3). The dragonfly species richness (9 spp.) and damselfly species richness (7 spp.) was more equitable in marshes than in oxbows and sloughs. Only 2 of the 16 species found in oxbows and sloughs were damselflies. The dragonfly species composition in marshes primarily consisted of Libellulidae (skimmers), while Libellulidae, Aeshnidae (darners), and Gomphidae (clubtails) were common in oxbows and sloughs. Also striking was the low species richness (8 species) found in bottomland hardwood wetlands relative to that in other naturally occurring wetlands on the Refuge.

Managed and constructed wetlands: The managed moist-soil units (e.g., Cane Ridge WMA and Dillin Bottoms) had the greatest species richness among the constructed wetlands on the Refuge, even surpassing the richness of the natural wetland types (Table 3). Seasonal wetlands (e.g., Branum, DuPont), those habitats likely to dry up annually, had species richness similar to naturally occurring marshes. The species composition on moist-soil units and seasonal wetlands was similar except that the moist-soil units had more *Sympetrum* (meadowhawk dragonfly), *Lestes* (spreadwing damselfly), and *Enallagma* (bluet damselfly) species present than did the seasonal wetlands. Permanent wetlands on the Refuge (e.g., Parke) had the lowest species richness among constructed wetlands.

Aquatic habitats: The ponds and lakes on the Refuge had the highest species richness (24 spp.) of odonates of any habitat sampled (Table 3). The species richness was also high in rivers and creeks (17 spp.). A notable difference among aquatic habitats on the Refuge was a greater number of Aeshnidae

Table 4.—The Nature Serve Ranks for Odonata in Indiana (Stein 2002, Faber-Langendoen et al. 2009). The rank, description of rank, and the number of species of odonates of that rank occurring on Patoka River National Wildlife Refuge and Management Area.

Rank	Description of rank	Species
S5	Demonstrably secure in state, and essentially ineradicable under present conditions	15
S4	Apparently secure in state, with many occurrences (greater than 100 occurrences)	15
S3	Presence rare or uncommon in the state, (21 to 100 occurrences)	10
S2	Imperiled in state because of rarity (6–20 occurrences) OR because of some factor making it vulnerable to extirpation	3
S1	Critically imperiled in state because of extreme rarity (5 or fewer occurrences) OR because of some factor making it especially vulnerable to extirpation	0

(darners), Gomphidae (clubtails), Cordulegasteridae (spiketails), and *Argia* (dancers) species present in lakes, ponds, and streams compared to numbers found in wetlands.

Species status.—To evaluate the presence of rare, threatened, and endangered species of odonates on the Refuge, we compared our species list to the Nature Serve Rank for Indiana (Table 4). Nature Serve Ranks (also called Natural Heritage Ranks) is a means of ranking the relative imperilment of species of plants and animals on a global, national and state level (Stein 2002 and Faber-Langendoen et al. 2009). The ranking addresses the conservation status of an organism by using a 1–5 numerical scale from most vulnerable (e.g., S1) to most secure (e.g., S5). Therefore, an imperiled species (e.g., S2) would be one that is rare or is vulnerable to extirpation because of some factor such as habitat loss.

Most of the dragonflies and damselflies (30 spp.) found on the Refuge are considered secure (S5 or S4) because they are common and occur in a variety of habitats (Table 4). Another 10 species are uncommon (S3), but are not considered imperiled because they can be found consistently in appropriate habitats on the Refuge. Only three species are considered to be imperiled (S2) by the ranking system and warrant additional monitoring to assess their status on the Refuge. These species, all of which are dragonflies, include the Mocha Emerald (*Somatochlora linearis*), Arrowhead Spiketail (*Cordulegaster obliqua*), and the Dragonhunter (*Hagenius brevistylus*). No odonates classified as critically imperiled (S1) in the state have been found on the Refuge.

Table 5.—New Odonata records for Pike County found in wetlands associated with Patoka River National Wildlife Refuge and Management Area.

Calopteryx maculata	*Celithemis eponina*
Argia sedula	*Libellula luctuosa*
Basiaeschna janata	*Libellula pulchella*
Arigomphus villosipes	*Libellula vibrans*
Dromogomphus spinosus	*Somatochlora linearis*
Hagenius brevistylus	*Sympetrum ambiguum*
Stylurus plagiatus	*Sympetrum vicinum*
Cordulegaster obliqua	*Tramea carolina*
Celithemis elisa	*Tramea lacerata*
Celithemis fasciata	

At the national and global level all of the dragonflies and damselflies occurring on the Refuge are classified as secure. The only federally endangered dragonfly, Hine's Emerald (*Somatochlora hineana*), has not been located on Patoka River Refuge.

New county records.—The Patoka River Refuge covers parts of two Indiana counties: Gibson and Pike. Much of what we know about the presence of odonate species in these two counties comes from Curry (2001) and Abbott (2005). The historical records for Gibson County are more complete than for Pike County. Thus our survey adds no new odonate records for Gibson County, whereas we added 19 new odonate records for Pike County (Table 5). Two of the new records were damselflies and the rest were dragonflies. Most of these new records represent common species except for the Dragonhunter (*Hagenius brevistylus*), Russet-tailed Clubtail (*Stylurus plagiatus*), Arrowhead Spiketail (*Cordulegaster obliqua*), Great Blue Skimmer (*Libellula vibrans*), and Blue-faced Meadowhawk (*Sympetrum ambiguum*).

DISCUSSION

Odonate species.—To gain insights into the Odonata fauna at the Patoka River Refuge we made comparisons to other wildlife refuges with similar habitats and management goals. The Sam D. Hamilton Noxubee National

Wildlife Refuge (hereafter Noxubee Refuge), located in east-central Mississippi, is dominated by bottomland hardwood forests, moist-soil units, greentree reservoirs, flooded ditches, ponds, and streams. Muscatatuck National Wildlife Refuge (hereafter Muscatatuck Refuge), located in southeastern Indiana, is comprised of various wetland and aquatic habitats including bottomland hardwood forests, moist-soil units, marshes, creeks, and springs. In addition to having similar habitats that are suitable for odonates, the Patoka, Noxubee, and Muscatatuck Refuges also share management strategies. All three refuges provide habitat for wildlife, actively restore a mix of habitats to maintain and increase biodiversity, and document use by wildlife of refuge resources, especially species that are considered rare, threatened, or endangered.

Odonata fauna inhabiting the wetland and aquatic habitats of the Patoka River Refuge show a remarkable similarity to that occupying the habitats at the Noxubee Refuge. Bried & Ervin (2005) documented 42 species of odonates at Noxubee Refuge, with 31 dragonfly species and 11 damselfly species. This compares to the 43 Odonata species documented in this study, with 30 dragonfly species and 13 damselfly species. The only species occurring in all wetland types in the Noxubee study were the Eastern Pondhawk (*Erythemis simplicicollis*), Blue Dasher (*Pachydiplax longipennis*), Common Whitetail (*Libellula lydia*), and Fragile Forktail (*Ischnura posita*) (Bried & Ervin 2005). This list is identical to the most widespread species at Patoka River Refuge, except for the addition of the Widow Skimmer in this study. All of these species are among the most commonly observed and widely distributed species in the United States (Donnelly 2004a, b).

Curry (*personal communication*) surveyed only the dragonflies of the Muscatatuck Refuge and identified 33 species. This compares to the 31 species found at the Noxubee Refuge (Bried & Ervin 2005) and 30 species at the Patoka Refuge. A total of 17 dragonfly species (37%) were shared by all three refuges. Libellulidae was the dominant family found at all three refuges; 18 species at the Patoka Refuge, 19 species at the Noxubee Refuge, and 17 species at the Muscatatuck Refuge. Similar distributions were noted for the other dragonfly families at the three refuges, except for Macromiidae. No Macromiidae (cruisers) were found at the Patoka River Refuge, while 2 and 3 cruiser species were found at the Noxubee and Muscatatuck Refuges, respectively.

Species-habitat associations.—Low species richness in bottomland hardwoods was noted in this survey (Table 3) relative to other naturally occurring wetlands (e.g., marshes and oxbows) and aquatic habitats (e.g., ponds and rivers). Bried & Ervin (2005) made the same observation and attributed the lower species richness to odonate physiology. Adult odonates are ectotherms and require sunny areas; they would not be as active in the shade of a bottomland forest as in more open areas. Additionally, forested habitat may obstruct mobility of adults relative to the more open, herbaceous habitat of marshes, lakes, and ponds.

The moist-soil units at Cane Ridge and Dillin Bottoms had greater species richness than that at other constructed wetlands on the Refuge (Table 3). Bried & Ervin (2005) also found moist-soil units to have greater species richness than other wetland habitats at the Noxubee Refuge. Both vegetative structure and hydrology are major mechanisms determining species richness and composition at these sites. Moist-soil units have a diversity of plant species and structure that likely provide the appropriate perch sites, territory boundary markers, and oviposition substrates for adults and adequate habitat for feeding and protection from predators for nymphs (Buchwald 1992).

Odonata species richness increases with increasing hydroperiod (Corbett 1980, 1999). However, Colburn (2004) noted that vernal pools, which undergo fluctuating water levels, are adequate habitats for a number of odonate species. Moist-soil units, which are managed to simulate fluctuating water levels, are typically drawn down to promote moist-soil plants that are attractive to wildlife (Fredrickson and Taylor 1982). At moist-soil units we observed typical odonate reproductive behaviors such as oviposition attempts, tandem flights, copulation, and protection of females by males. We found nymphs for many of the adults using moist-soil sites, suggesting successful use and perhaps preference of moist-soil units for reproduction.

Species status.—Most of the odonate species documented for the Patoka River Refuge are commonly found in Indiana. Based on the Nature Serve Ranks, 40 of the 43 species found

on the Refuge are either secure or, if they are classified as uncommon, can be consistently found in appropriate habitat (Table 4). The three species considered to be imperiled, are the Arrowhead Spiketail (*Cordulegaster obliqua*), the Dragonhunter (*Hagenius brevistylus*), and the Mocha Emerald (*Somatochlora linearis*). Curry (2001) lists the Arrowhead Spiketail as rare; found in only four counties in Indiana, and not in Gibson or Pike County. It is typically found in small forest streams. The nymph we collected was from Rock Creek, a small, sandy-bottomed stream running through a bottomland hardwood forest on the east side of the Refuge in Pike County. The Mocha Emerald, which Curry (2001) lists as our most common emerald, was collected in adult form from Rock Creek as well. The preferred habitat of the Mocha Emerald is along dark, tree-lined streams (Curry 2001), but until now was not recorded in Pike County.

Curry (2001) describes the Dragonhunter as being locally common in a few counties in Indiana (but not found in either Gibson or Pike County), with its preferred habitat being medium to large forest streams. We collected two specimens along the Patoka River on the east side of the Refuge in Pike County. One was patrolling the Patoka River, and the other was collected on a seasonal wetland site near the Patoka River (i.e., DuPont wetland) in pursuit of another dragonfly. Although most of the odonates identified in this survey are secure in the state and are relatively common, it would be worthwhile to investigate those species that are considered imperiled and to better determine their status on the Refuge.

FUTURE RESEARCH

We would recommend a continuation of the odonate survey on the Refuge to better document the presence (or absence) of dragonflies and damselflies. We suspect that more odonate species may be using the Refuge than were observed in our survey. One reason for this was that high water prevented us from adequately sampling certain aquatic habitats such as bottomland hardwoods, oxbows, and rivers where certain taxa (e.g., Macromiidae) are found. A slightly earlier start to the sampling season may also pick up some of the early emerging odonate species with short flight periods (e.g., Gomphidae (clubtails)).

We would also recommend a more quantitative study on the odonate-habitat associations to better identify what areas of the Refuge are most beneficial for odonates. We have provided preliminary information on where certain species of odonates occur on the Refuge, but we lack sufficient data to determine which species are transient and which are permanent residents. This distinction is important if one is to get a clear idea of how odonates use the resources of the Refuge.

A final recommendation would be to determine if the development of an umbrella index using Odonata would be a benefit for resource professionals at the Refuge. The main advantage of an umbrella index is that it provides managers and conservation planners with limited resources, personnel, and funds with a quick, relatively inexpensive method of assessing ecosystem health and to develop priorities (Bried et al. 2007).

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