Conservation Assessment
for
Selected Dragonflies of the Allegheny National Forest

Helocordulia uhleri

Somatochlora elongata

Gomphus adelphus

Gomphus descriptus

Gomphus Fraternus

Gomphus quadricolor

Gomphus viridifrons

Ophiogomphus mainensis

Stylurus scudderi

USDA Forest Service, Eastern Region

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Ryan Evans
Western Pennsylvania Conservancy
209 Fourth Avenue
Pittsburgh, PA 15222

This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, id you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service – Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

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EXECUTIVE SUMMARY

The objective of this document is to provide background information and review the conservation status for several odonate species in the Allegheny National Forest. These species were chosen based upon their rarity in the Allegheny National Forest and the State of Pennsylvania. The following species are the focus of this report: *Helocordulia uhleri* (Uhler's Sundragon), *Somatochlora elongata* (Ski-tailed Emerald), *Gomphus adelphus* (Mustached Clubtail), *G. descriptus* (Harpoon Clubtail), *G. fraternus* (Midland Clubtail), *G. quadricolor* (Rapids Clubtail), *G. viridifrons* (Green-faced Clubtail), *Ophiogomphus mainensis* (Maine Snaketail), and *Stylurus scudderi* (Zebra Clubtail).

These species are found primarily in wetlands, rivers, and streams. Primary threats to these species include degradation of water quality by resource extraction, changes in riparian vegetation due to forest management practices, and sedimentation and pollution of streams from agricultural inputs into watersheds. Management considerations include protecting high quality streams in the Allegheny National Forest from future impacts. These species should continue to be monitored in Allegheny National Forest streams, and survey efforts should be expanded to document the ranges of these species.

ACKNOWLEDGEMENTS

I would like to acknowledge the assistance of individuals who assisted in preparation of this document: Nick Donnelly, Charles Bier, and Clark Shiffer. I would also like to thank Brad Nelson, Brent Pence, and Nancy Berlin of the USFS for their comments and assistance.

CONSERVATION STATUS

The following information summarizes the state and global conservation rankings of the odonate species in this report. Taxonomy follows Paulson and Dunkle (1999).

Global Rank Information (modified from NatureServe Explorer 2002):

G1 = *Critically Imperiled*, typically 5 or fewer occurrences, very few individuals left (<1,000), acres (<2,000), or linear miles (<10)
G2 = *Imperiled*, typically 6 to 20 occurrences, few remaining individuals (1,000-3,000), acres (2,000 to 10,000) or linear miles (10-50).
G3 = *Vulnerable to extirpation or extinction*, 21 to 100 occurrences, between 3,000 to 10,000 individuals believed to remain
G4 = *Apparently Secure*, usually greater than 100 occurrences, more than 10,000 individuals
G5 = *Secure*, far greater than 100 occurrences remaining, far greater than 10,000 individuals remaining

NOMENCLATURE AND TAXONOMY

Cordulidae – Emeralds

Species	Common Name	State Rank	Global Rank
Helocordulia uhleri (Selys, 1871)	Uhler's Skydragon	S3	G5
Somatochlora elongata (Scudder, 1866)	Ski-tailed Emerald	S2	G5

Gomphidae – Clubtails

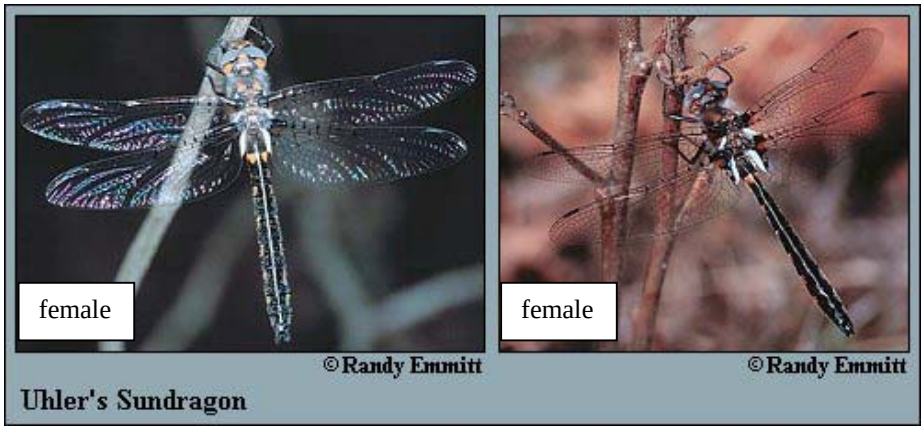
Gomphus adelphus Selys, 1858	Mustached Clubtail	S?	G4
Gomphus descriptus Banks, 1896	Harpoon Clubtail	S1S2	G4
Gomphus fraternus (Say, 1839)	Midland Clubtail	S2S3	G5
Gomphus quadricolor Walsh, 1863	Rapids Clubtail	S1S2	G3G4
Gomphus viridifrons Hine, 1901	Green-faced Clubtail	S1	G3G4
Ophiogomphus mainensis *Packard in Walsh, 1863*	Maine Snaketail	S3	G4
Stylurus scudderi (Selys, 1873)	Zebra Clubtail	S2	G4

DESCRIPTION AND LIFE HISTORY OF SPECIES

Cordulidae – Emeralds

These are very attractive dragonflies. The body color tends to be brown, some with emerald green "jewel-like" eyes, which sometimes have bronze or green iridescence (Dunkle 1989). The eyes touch on top of the head. In females, the ovipositor is normally both bifurcated and flared or absent.

Helocordulia uhleri



This is a medium–sized dragonfly. Adults of this species have a characteristic gold spot near the center of the brown basal spot. The black abdomen is narrowest in sections 1 and 2, and widest in sections 4 to 10. In tenerals and juvenile adults, the eyes and portions of the thorax tend to be light gray. Adult eye color is green-blue. Portions of the thorax are covered with patches of shaggy white hairs at the basal portions of the wings. In the hind wing, there is a gold-yellow spot within the brown

basal spot (Needham and Westfall 1954). Adults are fast fliers, but can be frequently observed hovering and sometimes basking on rocks (Dunkle 2000).

Somatochlora elongata –

As the common name implies (Ski-tailed Emerald), this species can be identified by the black, elongated, curved male superior appendages. The abdomen becomes wider and laterally convex. There is a lateral basal spine on the male superior appendages. The eyes of adults are strikingly iridescent. There are spots present on the side of the thorax, which is a rusty brown color.

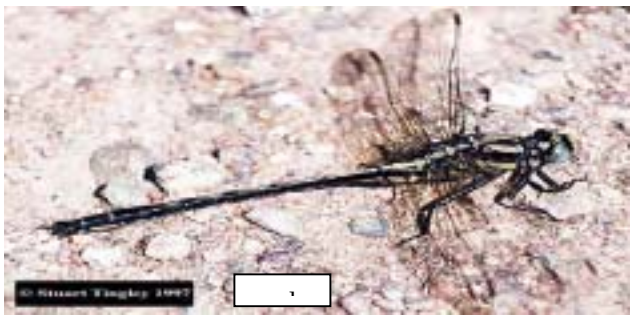
Gomphidae – Clubtails

The abdomen of adult gomphids ends in a club shaped swelling and tends to be slightly larger in males (Dunkle 1989). The larvae are burrowers, and have tarsi adapted specifically for burrowing in loose sediments such as sand, mud, silt, or detritus. However, gomphids have also been reported as occurring in gravel substrates (Bright and O'Brien 1998). Generally, gomphid adults can be found near their natal source (Shiffer 2002).

Gomphus adelphus

This species is distinguished according to Needham and Westfall (1954) by several characteristics: 1) the presence of a facial stripe; 2) middorsal thoracic stripes that are widened to form a triangle; 3) yellow markings on the tibia; and 4) almost entirely black abdominal segments 8 and 9. Beyond segment 4, the male abdomen is almost entirely black, but the female abdomen may be edged in yellow. The synthorax is yellow in young individuals, green-gray in adults, and heavily striped in the front with black markings. Wing details include the presence of nine antenodal crossveins in the hindwing, and the males have a three-celled basal triangle. The face has black cross-stripes that resemble a mustache. This is the sole member of the Gomphidae with greater than 1 facial stripe (Dunkle 2000).

Gomphus descriptus



Adults are dark brown, with some pale yellow pigmentation on the dorsal surface of the abdomen. The thorax has several yellow stripes in young individuals,

becoming green-gray as adults. Because the nymphs of this species spend much of their life burrowed, they are often the color of their surrounding medium, such as silt, mud, etc. (Needham and Westfall 1954). A characteristic of the females in this genus is hind leg spines longer than those of the males (Dunkle 1989). These are perhaps useful in capturing larger prey. Males fly low over riffles and perch on exposed rocks

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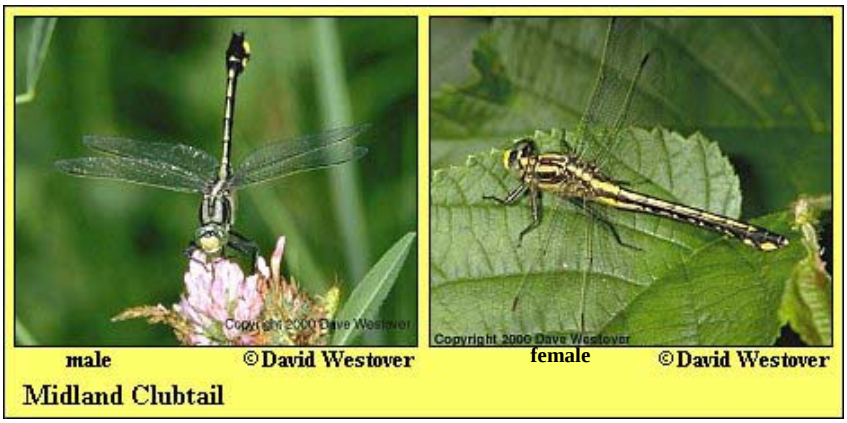
Gomphus fraternus



Appearance of this species is green-yellow with a gray to gray-yellow striped thorax. A visible bright yellow spot is located on the ventral surface of segment nine. The lateral stripe forms triangular yellow spots on the ventral surface of sections seven and eight of the abdomen (around the "club"). Beatty et al. (1969) reported only limited collections of this species in Pennsylvania, and reported collections in May as well as June 23 and June 28. Bier et al. (1994) reported collection of adult *Gomphus fraternus* from Clarion, Forest, Elk, and Jefferson Counties on June 22, with nymphs collected in June, July, September, and October. Collections of images have been reported within the ANF National Forest on June 23, with nymphs collected from late July to late September (Bier et al. 1997).

Gomphus quadricolor

This is one of the shortest of the *Gomphus* species. It is slender bodied, with maximum length of hind wings around 27 mm (Needham and Westfall 1954). The male superior appendage has a distinct swelling just below the medial face.

Gomphus viridifrons –

This species resembles *G. adelphus,* except there are no markings on the face. There are distinctive yellow markings on segments eight and nine. The anteapical tooth of the male superior appendage is relatively triangulate.

Ophiogomphus mainensis

This is a striking species, with a black striped thorax, a black abdomen marked with yellow, and several flat emerald green markings on the labrum and thorax. There are also markings on the dorsal surface of the abdomen that blend from green to a mustard yellow. There are orange-yellow markings on the laterals of segments six to nine (laterals of the club section of the abdomen). Distinctive lateral protrusions of the inferior appendage of males are also present

Donnelly (1987) reported that there are several distinct subspecies of *Ophiogomphus mainensis*. *Ophiogomphus mainensis fastigiatus* is restricted to the Appalachian Plateau section of western and central Pennsylvania. The other subspecies, *O. mainensis mainensis,* is found east of the Appalachian section of the state. Separation of the 2 subspecies is based on phenetic differences, and in West Virginia both subspecies are found in the Appalachian Mountains and the Appalachian Plateau (N. Donnelly 2002). Given consistent differences in morphology between the subspecies, *O. mainensis fastigiatus* could be a valid species and is under current review (C. Shiffer, personal communication, 2002).

Stylurus scudderi

This is a fairly large gomphid. There is yellow to green striping on the body, and distinctive colored bars at the posterior of each abdominal segment. The labrum is a pale yellow to whitish color, and the eyes often have a greenish hue. The anterior hamulus is rod-like unlike other gomphines, who have an elongate hamulus that is generally c-shaped in cross section (Carle 1986). The body and legs are black.

REPRODUCTION

For successful reproduction in the Odonata, Corbet (1999) outlines the following steps:

1) ***Encounter*** – sexually mature males and females (sometimes after males establish mating rights)

2) ***Recognition*** – each gender must be able to identify the conspecific (to achieve reproductive isolation), and males must be able to avoid needless agonisitic interactions

3) ***Sperm transfer*** – The male transfers sperm from the 9th to the 2nd abdominal segment. This occurs prior to or while the mating pair is in the "wheel position". While copulation generally occurs at oviposition sites, some mating pairs will travel away from the oviposition site during copulation to enhance the chances of male reproductive success.

4) ***Oviposition*** – males of some species will hover around the female to reduce the likelihood of sperm removal by other males. Other species will physically grasp the female during oviposition, while other species do not.

In general, *Gomphus* and corduliid females will oviposit eggs into water while flying. Gomphidae and Cordulidae both have relatively brief copulatory periods. Unlike other species, *Gomphus* are able to emerge on flat surfaces (Silsby 2000). Additionally, certain riverine gomphid eggs have devices that help them remain anchored after oviposition.

For the species in this report, species-specific reproduction information is generally lacking in the literature. What little general information that was found is summarized below. I believe that there is a significant amount of research needed to address questions related to these species' reproductive biology.

Helocordulia uhleri

No specific information was located for the reproductive biology for this species.

Somatochlora elongata

Mating in this species usually occurs away from water, sometimes on local relief features. Mating pairs will hang from bushes or trees. After fertilization, females lay eggs in seeps and moss-covered banks (Dunkle 2000). Females will dip the ovipositor into wet moss and then deposit eggs into the nearby water source (Shiffer 1985). Eggs are deposited in small batches in these areas. They will hatch the next spring, and the larvae will develop for several seasons until transformation and emergence. Adults will initially leave the area then return within 1 to 2 weeks to mate (Shiffer 1985).

Gomphus adelphus

No specific information could be located for the reproductive biology of this species.

Gomphus descriptus

Females have been observed during oviposition perching on stones with the abdomen curved upward (Dunkle 2000).

Gomphus fraternus

No specific information could be found for the reproductive biology of this species.

Gomphus quadricolor

No specific information was found for the reproductive biology of this species.

Gomphus viridifrons

No specific information was found for the reproductive biology of this species.

Ophiogomphus mainensis

Females lay their eggs exophytically, ovipositing by dipping eggs into the water along the stream margins in areas of current or rapids (NatureServe Explorer 2002).

Stylurus scudderi

Nymphs of this species will spend several seasons developing before entering the adult sexual stage. Emergence takes place in the morning, with peak times during the day (Shiffer 1985).

ECOLOGY

The natal sites of odonates are critical to protect. After emergence, some species will briefly depart the natal site and then return upon reaching sexual maturity (Corbet 1980). After returning, there is only localized flight activity and movement to nocturnal roosting areas. In general, for non-aestivating or hibernating adults, the life span for Anisoptera (Dragonflies) is approximately 8 weeks and Zygoptera (Damselflies) is 7-9 weeks (Corbet 1980). Thermal stability is important to these and many other odonate species, as a linear relationship has been shown between temperature and metabolic requirements (Panadian et al. 1979). Odonates exhibit fairly high vagility (NatureServe Explorer 2002), suggesting that the species in this report may be present in many Allegheny National Forest streams.

Feeding and flight behavior is characterized by 2 lifestyles (after Corbet 1980):

1) **Fliers**, which spend a great deal of time in flight or hovering. Due to this continual activity, it can be difficult to adequately assess if odonate activity is due to foraging behavior or sexual activity. Some species will feed even during mate selection. Corduliids are generally "fliers". Fliers can regulate their body temperature by flight, and this may allow them to spend more time foraging in shaded areas (Corbet 1999). Male corduliids have been known to continuously patrol in mating areas (Corbet 1980).

2) **Perchers**, which make only brief flights and then return to a perch site. The flight activity periods are somewhat more discernible with this group. The gomphids tend to be "perchers". Perchers cannot generally regulate their internal temperature by flight (due to limited activity) and tend to be more dependent on ambient temperature and solar radiation for thermal regulation (Corbet 1999)

Helocordulia uhleri

McMahan and Gray (1957) reported that during 2 seasons of observation in North Carolina, this species arrived and departed during the season on exactly the same day. This suggests a strong photoperiod cue in explaining the phenology of the species. This species is in flight in Pennsylvania from early May to the middle of July. Nymphs have been reported in May (exuviae only) and June and as late as October in Pennsylvania (Bier et al. 1994). Adults have been collected in June in the Allegheny National Forest. In the early summer, the species can be found foraging in clearings, along roads, and stream outlets (Robert 1953). Adults are known to utilize adjacent clearings as feeding areas. Males of this species will patrol the area near shorelines in sunny or shady spots up to dusk (Dunkle 2000).

Somatochlora elongata

Phenology for adult *S. elongata* has been reported by Beatty et al. (1969) from early July through late September, with similar flight times. This species tends to feed high in the air in sunny conditions but has also been observed feeding in shade. Males will patrol shorelines of larger streams or shaded expanses of backwater areas of streams, often hovering and pausing to perch briefly on grass or debris (Shiffer 1985; Dunkle 2000). As reviewed by Corbet (1999), patrolling males of *Somatochlora* have been observed to abandon linear flight paths to search shaded or hidden areas in search of perching or ovipositing females. Also, males within *Somatochlora* have also been observed in flight to maintain an elevated abdomen presumably as a courtship display (Corbet 1999).

Gomphus adelphus

Brunelle (2001) reported flight times in Maine from early June to early August. In Pennsylvania adults have been reported from early May to late June (Beatty and Beatty 1969; Bier et al. 1997). One perched adult taken on July 8 was within 10 m of shoreline (Bier et al. 1997). Peak flight time is at dusk. The species spend much of its time

perched (Needham et al. 2000) on exposed stones and rocks in streams, shoreline, and tree limbs and leaves. Larvae will burrow in shallow silt or sand, typically below riffles (Needham et al. 2000). Emergence is near water's edge on solid vegetative substrate. Males of this species can be observed hovering steadily over the head of stream riffles with an arched abdomen and extended lower hindlegs (Dunkle 2000).

Gomphus descriptus

The phenology for adults of this species in Pennsylvania has been reported as mid-May through late July, with peak activity in June (Beatty et al. 1969; Bier et al. 1997).

Gomphus fraternus

Flight period is from late April to early August in Ohio, with peak abundance in June (Ohio Odonata Survey 1999).

Gomphus quadricolor

Adult and nymph phenology is predominantly reported from late May to mid June (Beatty et al. 1969; Bier et al. 1994) but has been collected in PA as late as July 8. Adults are found in streams generally flying low over the water or perching near shorelines, and also flying far from shorelines as well. The species has been observed perching on the ground or on low graminoid vegetation (Rosche 2002). Males are typically perch on exposed rocks or stones in or near rapids areas (Dunkle 2000).

Gomphus viridifrons

Seasonal phenology of adults and nymphs has been reported by Beatty et al. (1969) from early May to late June. More recently, Bier et al. (1997) reported collection of nymphs from late May into late September, with no collections made in August. Adults were reported from late May to late July. Nymphs were collected from 3 to 25 cm in depth in slow moving to swift flow in sand/detritus/gravel substrates, while adults were collected flying 1 to 3 m above the water surface, about 3-10 m from shoreline, or perched. Male adults are most active in late afternoon and during cloudy conditions or shade. In addition, males can be observed hovering steadily near the head of riffles and rapids. They will perch on exposed rocks and stones and streamside brush (Dunkle 2000).

Ophiogomphus mainensis

Larvae are associated with the interstices of cobble substrates. Adult phenology is reported from mid-May to mid-July (Walker 1958; Beatty et al. 1969; Bier et al. 1997). Males have been observed to perch on reeds and grasses over clear streams (Fisher 1940).

Stylurus scudderi

Phenology of adults in Pennsylvania has been reported by Beatty et al. (1969) from mid-July to early October, with peak abundance between mid-July and mid-September. Males will perch on shorelines, brush, or woody debris and make brief flights near or

over riffles (Dunkle 2000). Peak activity period is late afternoon to dusk. Adults do not travel far from their natal stream source (Shiffer 1985).

DISPERSAL/MIGRATION

Migration is known to occur in the Odonata but is generally poorly documented. *Anax junius*, a commonly encountered species, has been observed by many to migrate (Soltesz et al. 1995; Russell et al. 1998) and has generally has the best understood pattern of any odonate species. Russell et al. (1998) observed large swarms of dragonflies migrating in Illinois, New Jersey, and Florida. Their research indicated that most large migratory movements were associated with cold fronts associated with NW, N, or NE wind patterns. Weather patterns are likely very important in explaining the migratory behavior of North American dragonflies.

Other dragonflies outside of North America tend to have different migratory patterns. In particular *Libellula quadrimaculata* does not migrate annually and migrates at a different time than many North American species (Russell et al. 1998). Migrations tend to show heavy mortality due to predation and exhausted energy reserves.

As a group, the Gomphidae and Cordulidae are non-migratory (Shiffer 2002). Additionally, Gomphidae tend to have high natal site fidelity. All species in this report move longitudinally and laterally along stream corridors in search of prey.

OBLIGATE ASSOCIATIONS

Odonata are entirely aquatic in larval stages. The species in this report require very high quality streams, with a stable thermal regimes and water chemistry parameters (Shiffer 2002). Experimental temperature shifts have been demonstrated to affect interspecific development rates (Krishnaraj and Pritchard 1995). Increased stream temperature has also been shown to increase metabolic requirements in the gomphid *Mesogomphus lineatus* (Panadian et al. 1979).

Adequate vegetation is required by larvae to avoid and regulate predation pressure in stream systems containing fish. In addition, burrowing larvae such as the gomphids will search for particular particle sizes in selecting burying areas, perhaps to reduce the intake of sediment during respiration (Corbet 1980). Larvae of these respective species will key in on certain prey sizes that are locally available. It appears that small insect larvae (Diptera) and larger zooplankton may be important to the gomphid larvae, while locally available macroinvertebrates are significant to corduliids (Corbet 1999).

HABITAT

Most of these species have similar habitat requirements. The gomphids tend to require well-forested watersheds with intact headwaters and fairly stable hydrological cycles. *Somatochlora elongata* can utilize more standing water habitats. In my opinion, it is

most important to recognize the broad habitat indicators in the absence of quantitative habitat information.

National Forests

Helocordulia uhleri

This species can be found in clean rivers and streams with abundant forest cover and a circumneutral pH (Dunkle 2000). Adults can be found in clearings, perching on brush and weeds, and sometimes on the ground. Larvae can be found along shallow stream margins in organic matter depositions (Needham 1901).

Somatochlora elongata

Ski-tailed Emeralds can be found in slow to moderate flow streams (Dunkle 2000). The species has also been located in low gradient streams bounded by wetlands or bogs, lake inlets/outlets, and marshy beaver ponds.

Gomphus adelphus

This species is typically found in small clear, swift forested streams and rivers and lakes with exposed shorelines (Dunkle 2000; Shiffer 2002). The habitat of larvae reported by Bier et al. (1997) was typical of *Gomphus* (slow moving to standing lotic waters in sand/mud/silt substrates).

Gomphus descriptus

The Harpoon Clubtail can be found in clear, small forested streams and rivers with lightly silted pools, but could be encountered in sandy streams (Dunkle 2000).

Gomphus fraternus

Midland Clubtails can be encountered in moderate to rapidly flowing streams to larger rivers. Substrates preferred by the species are often clay to sandy. The species can also be encountered in ponds to larger lakes with adequate emergent vegetation (Dunkle 2000; Rosche 2002).

Gomphus quadricolor

Gomphus quadricolor is typically encountered in clean, rocky streams and rivers larger than the other gomphids in this report (Shiffer 2002). Substrate for this species typically consists of gravel. Riffle areas are where the species is normally encountered. Streams are typically well forested.

Gomphus viridifrons

This species is found in clean small, rocky forest streams with gravel-sand and lightly silted rocks. It utilizes slightly larger streams than *Gomphus adelphus* (Dunkle 2000).

Ophiogomphus mainensis

Maine Snaketails are found in clear, forested rapid streams with exposed rocks often in headwater areas (Shiffer 2002).

Stylurus scudderi

This species is typically found in clear, forested streams and rivers of alternating current velocity but containing adequate riffle areas (Dunkle 2000). Substrates preferred by the species are gravel with finer organic matter and sand. As with many of the Gomphidae, larvae will burrow fairly deep into sand/silt substrates in pools (Carle 1994).

RANGE-WIDE DISTRIBUTION

The Wisconsin Glaciation of the Pleistocene epoch is critical in explaining much about the distribution of Pennsylvania odonates (Beatty and Beatty 1968). This has led, along with various geological processes, to the wide diversity of aquatic habitats in Pennsylvania. Several species found only in the Appalachian Mountain section of eastern North America, such as *Gomphus fraternus*, *Helocordulia uhleri*, *Ophiogomphus mainensis*, and *Stylurus scudderi* tend to have much more specific habitat requirements and more limited distributional ability versus species that may be have colonized from formerly glaciated areas (Beatty and Beatty 1968).

Unless otherwise noted, all distributional data below is from Beatty and Beatty (1969, 1971), Kondratieff (2000), Needham et al. (2000), NatureServe Explorer (2002), and PNDI (2002). Maps have been modified from Kondratieff (2000).

***Note**: These maps are updated as of 2000, and in this assessment are intended only to provide a general spatial reference. They do not necessarily depict complete distributional information. The maps represent United States distributions only.*

Helocordulia uhleri

Globally: Widespread across the eastern Appalachians. It is known from all northeastern US states, all Mid-Atlantic states (except Delaware), and all southeastern states except Mississippi and Florida. *H. uhleri* is also known from Arkansas and Missouri. In Canada, it can be found from Nova Scotia west to Ontario.

Somatochlora elongata

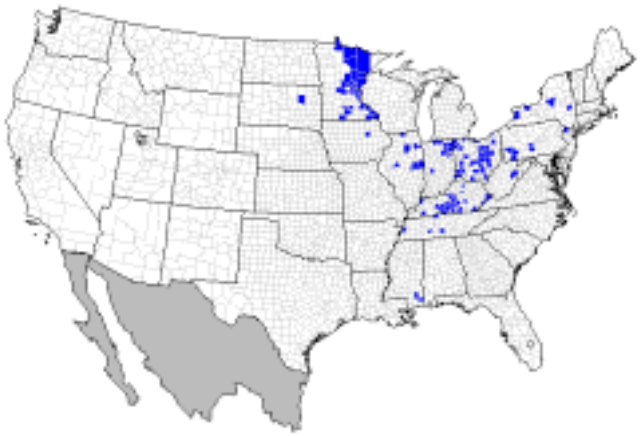
Globally: Found across the middle and northern Appalachians from Maine to Virginia, and can be found in Georgia. It may also occur in portions of Tennessee and the Carolinas based upon its disjunct distribution. Canadian distributions are from Prince Edward Island to Ontario.

Gomphus adelphus

Globally: Generally known from the eastern Appalachian Mountains, with occurrences in New York, Maine, New Jersey, Pennsylvania, Tennessee, and West Virginia. Records have also been recorded along the upper Mississippi River in Minnesota, and also along the border of Wisconsin and the Upper Peninsula of Michigan near Lake Michigan. Widely distributed throughout the Northeastern US.

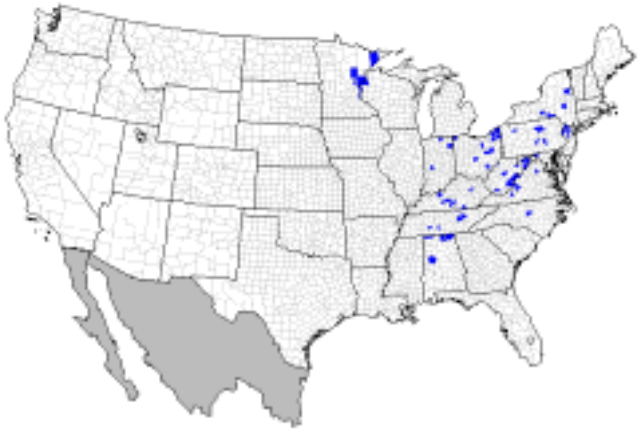
Gomphus descriptus

Globally: This species can be found throughout the northeastern United States (except for Rhode Island), as well as Kentucky, Illinois, Michigan, North Carolina, Virginia, and West Virginia. It is also known from New Brunswick, Nova Scotia, Ontario, and Quebec in Canada. In the northeast, this species is considered widely distributed.



Gomphus fraternus

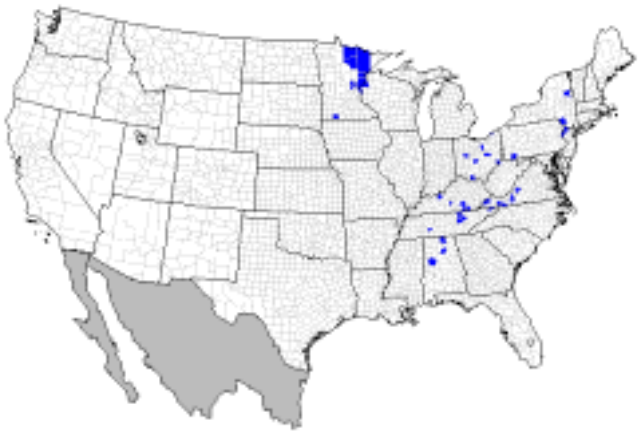
Globally: This species can be found generally across the central and eastern United States, from Tennessee to Missouri, north to Saskatchewan, east to Ontario, and throughout the eastern US from Maine to North Carolina. Records of *Gomphus fraternus* have also been reported in South Dakota. Generally, widely distributed in the northeastern United States.



Gomphus quadricolor

Globally: Broadly distributed in central and eastern North America, found in all states bordering the Mississippi River except for Illinois, Mississippi and Louisiana. It is potentially extirpated in Connecticut. Known from all of eastern US except for Delaware, Florida, Rhode Island, and South Carolina. Historically known from Ontario in Canada, where it may be extirpated. It is generally declining in its eastern US range.

Gomphus viridifrons



Globally: Eastern US distribution. Can be found in all states bordering the Great Lakes (except for Illinois) and Ontario. Found in all southeastern states except Georgia, Florida, Mississippi, and South Carolina, in all Mid-Atlantic States except Delaware, and all northeastern states except Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island.

Ophiogomphus mainensis

Globally: Widespread, occurring from Alabama, the Carolinas, Georgia, Kentucky, Tennessee, all northeastern states, and all Mid-Atlantic states except for Delaware. Widely distributed species in the northeastern United States. It is known in Canada from Nova Scotia west to Ontario.

Stylurus scudderi

Globally: Distributed in Minnesota, Wisconsin to Maine, and south to the Carolinas, Georgia, Kentucky, and Tennessee. This species generally does not occur in Connecticut, Delaware, Ohio, and Illinois. *Stylurus. scudderi* is widely distributed across the northeastern United States. In Canada, *S. scudderi* can be found from Ontario east to Nova Scotia.

STATE AND NATIONAL FOREST DISTRIBUTION

Helocordulia uhleri

Pennsylvania: Found in the Appalachian Plateau and Ridge and Valley Provinces. The species has been documented from Carbon, Centre, Clarion, Clearfield, Clinton, Elk, Fayette, Forest, Franklin, Huntington, Jefferson, Lebanon, Lycoming, Northampton, Potter, Somerset, and Tioga counties.

National Forests:

Allegheny and George Washington National Forests.

Somatochlora elongata

Pennsylvania: Found in the Appalachian Plateau and Ridge and Valley Provinces. Documented from portions of Bradford, Carbon, Centre, Clearfield, Clinton, Cumberland, Elk, Huntington, Jefferson, Forest, McKean, Somerset, Warren, and Union counties.

National Forests:

Allegheny, Chequamegon, George Washington, Jefferson, and Nicolet National Forests.

Gomphus adelphus

Pennsylvania: Found in the Appalachian Plateau and Ridge and Valley Provinces. *Gomphus adelphus* is documented from Cameron, Clarion, Clinton, Dauphin, Elk, Fayette, Forest, Lycoming, Monroe, Pike, Somerset, Sullivan, Tioga, Union, and Westmoreland counties.

National Forests:

Allegheny and George Washington National Forests and Mount Rogers National Recreational Area in Jefferson National Forest.

Gomphus descriptus

Pennsylvania: Found in the Appalachian Plateau and Ridge and Valley Provinces. This species has been documented from Carbon, Centre, Clarion, Clinton, Elk, Fayette, Forest, Huntington, Lycoming, McKean, Pike, Potter, Somerset, Sullivan, Susquehanna, Union, and Warren counties. Eight viable occurrences are currently known from Pennsylvania.

National Forests:

Allegheny and George Washington National Forests.

Gomphus fraternus

Pennsylvania: Found in the Appalachian Plateau and Ridge and Valley Provinces. It has been documented from Allegheny, Clarion, Elk, Fayette, Forest, Huntington, Jefferson, and Westmoreland counties. Eight viable occurrences are known from Pennsylvania. A single nymph has been recently collected in Buffalo Creek, Butler County, PA (C.W. Bier, personal communication, 2002).

National Forests:

Allegheny and Jefferson National Forests.

Gomphus quadricolor

Pennsylvania: Found in the Appalachian Plateau and Ridge and Valley Provinces. The species has been documented from Clarion, Cumberland, Dauphin, Elk, Forest, Juniata, Lebanon, Lehigh, Lycoming, Perry, Philadelphia, and Susquehanna counties.

National Forests:

Allegheny, George Washington, and Jefferson National Forests.

Gomphus viridifrons

Pennsylvania: Restricted to the Appalachian Plateau province. The species is currently only known only from Clarion, Elk, Fayette, and Forest counties in PA.

National Forests:

Allegheny, Chequamegon, and Jefferson National Forests.

Ophiogomphus mainensis

Pennsylvania: Found in the Appalachian Plateau and Ridge and Valley Provinces. This species is documented from Butler, Clarion, Clearfield, Clinton, Centre, Elk, Forest, Huntington, Jefferson, Lycoming, McKean, Monroe, Perry, Pike, Somerset, Sullivan, and Warren counties.

National Forests:

Allegheny, Daniel Boone, and George Washington National Forests.

Stylurus scudderi

Pennsylvania: Restricted to the Appalachian Plateau province. *Stylurus scudderi* is known from Clarion, Clearfield, Clinton, Elk, Forest, Jefferson, McKean, and Warren counties. Currently, 8 viable occurrences are known from PA.

National Forests:

Allegheny, Chequamegon, Daniel Boone, and Nicolet National Forests.

RANGE WIDE STATUS

State Heritage Rank Definitions – modified from NatureServe Explorer (2002)

S1 = *Critically Imperiled* - Critically imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state. Typically 5 or fewer occurrences or very few remaining individuals (<1,000).

S2 = *Imperiled* - Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000).

S3 = *Vulnerable* - Vulnerable in the state either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.

S4 = *Apparently Secure* - Uncommon but not rare, and usually widespread in the state. Possible cause of long-term concern. Usually more than 100 occurrences and more than 10,000 individuals.

S5 = *Secure* - Common, widespread, and abundant in the state. Essentially ineradicable under present conditions. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

S? = *Unranked* - State rank not yet assessed.

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

SH = *Possibly Extirpated (Historical)* - Element occurred historically in the state, and there is some expectation that it may be rediscovered. Its presence may not have been verified in the past 20 years. An element would become SH without such a 20-year delay if the only known occurrences in a state were destroyed or if it had

been extensively and unsuccessfully looked for. Upon verification of an extant occurrence, SH-ranked elements would typically receive an S1 rank. The SH rank should be reserved for elements for which some effort has been made to relocate occurrences, rather than simply using this rank for all elements not known from verified extant occurrences.

SP = *Potential* - Potential that element occurs in the state but no extant or historic occurrences are accepted.

Gomphidae

Species	Common Name	Province/State Rank
Gomphus adelphus	**Mustached Clubtail**	New Brunswick (S?), Nova Scotia (S2), Ontario (S3), Quebec (S?), Connecticut (S2), Kentucky (S?), Maine (S?), Massachusetts (S2S3), Michigan (S?), Minnesota (S?), New Hampshire (S?), New Jersey (S1), New York (S3S4), North Carolina (S1S2), Pennsylvania (S?), Rhode Island (S?), Tennessee (S4?), Vermont (S3), Virginia (S1), West Virginia (S?), Wisconsin (S3S4)

Species	Common Name	State Rank
Gomphus descriptus	**Harpoon Clubtail**	New Brunswick (S?), Nova Scotia (S2), Ontario (S3), Quebec (S?), Connecticut (S2), Kentucky (S?), Maine (S?), Massachusetts (S2S3), Michigan (S?), Minnesota (S?), New Hampshire (S?), New Jersey (S1), New York (S3S4), North Carolina (S1S2), Pennsylvania (S1S2), Rhode Island (S?), Tennessee (S4?), Vermont (S3), Virginia (S1), West Virginia (S?), Wisconsin (S3S4)

Gomphus fraternus	**Midland Clubtail**	Manitoba (S?), Ontario (S3), Quebec (S?), Saskatchewan (S?), Connecticut (S2), Illinois (S3), Indiana (S4), Iowa (S3), Kentucky (S5), Maine (S?), Maryland (S2), Massachusetts (S1), Michigan (S?), Minnesota (S?), Missouri (S?), New Hampshire (S?), New Jersey (S?), New York (S1S3), North Carolina (S1?), Ohio (S5), Pennsylvania (S2S3), South Dakota (S?), Tennessee (S5?), Vermont (S?), Virginia (S1), West Virginia (S?), Wisconsin (S4)

Gomphus quadricolor	**Rapids Clubtail**	Ontario (S1), Alabama (S3S4), Arkansas (S?), Connecticut (S?), Georgia (S?), Illinois (SP), Iowa (S?), Indiana (S2), Kentucky (S2S3), Maine (S?), Maryland (S1), Massachusetts (SX), Michigan (S2S3), Minnesota (S?), Missouri (S?), New Hampshire (S?), New Jersey (S2), New York (S1S2), North Carolina (S1S2), Ohio (S3S4), Pennsylvania (S1S2), Tennessee (S3S4), Vermont (S?), Virginia (S1), West Virginia (S2), Wisconsin (S4)

Species	**Common Name**	**State Rank**
Gomphus viridifrons	**Green-faced Clubtail**	Ontario (S1), Alabama (S3?), Indiana (S1S2), Kentucky (S2S3), Maryland (S1), Michigan (S?), Minnesota (S?), North Carolina (S1S2), New Jersey (S1), New York (S1), Ohio (S3), Pennsylvania (S1), Tennessee (S3?), Vermont (S?), Virginia (S2), West Virginia (S3), Wisconsin (S3)

Ophiogomphus mainensis	**Maine Snaketail**	New Brunswick (S?), Nova Scotia (S1), Ontario (S1), Quebec (S?), Alabama (S?), Connecticut (S3), Georgia (S?), Kentucky (S1), Maine (S?), Maryland (SP), Massachusetts (S?), New Hampshire (S?), New Jersey (S2), New York (S3), North Carolina (S2?), Pennsylvania (S3), Rhode Island (SU), South Carolina (S?), Tennessee (S4?), Vermont (S?), Virginia (S1), West Virginia (S?)
Somatochlora elongata	**Ski-tailed Emerald**	New Brunswick (S?), Nova Scotia (S?), Ontario (S2S4), Prince Edward Island (S1), Quebec (S?), Connecticut (S1S2), Georgia (S?), Maine (S?), Maryland (S?), Massachusetts (S2), Minnesota (S?), New Hampshire (S?), New Jersey (S1), New York (S4), North Carolina (S2S3), Pennsylvania (S2), Vermont (S3), Virginia (S1S2), West Virginia (S?), Wisconsin (S2S3)
Stylurus scudderi	**Zebra Clubtail**	New Brunswick (S?), Nova Scotia (S1), Ontario (S3), Quebec (S?), Connecticut (S2), Georgia (S?), Indiana (S1), Kentucky (SH), Maine (S?), Maryland (SP), Massachusetts (S1), Michigan (S?), Minnesota (S?), New Hampshire (S1?), New Jersey (S1), New York (S3), North Carolina (S3?), Pennsylvania (S1), Rhode Island (S1), South Carolina (S?), Tennessee (S4?), Vermont (S2), Virginia (S1), West Virginia (S?), Wisconsin (S3)

Cordulidae

Species	Common Name	State Rank
***Helocordulia uhleri* (Selys 1871)**	**Uhler's Skydragon**	New Brunswick (S?), Nova Scotia (S2), Ontario (S3), Quebec (S?), Connecticut (S2), Kentucky (S?), Maine (S?), Massachusetts (S2S3), Michigan (S?), Minnesota (S?), New Hampshire (S?), New Jersey (S1), New York (S3S4), North Carolina (S1S2), Pennsylvania (S3), Rhode Island (S?), Tennessee (S4?), Vermont (S3), Virginia (S1), West Virginia (S?), Wisconsin (S3S4)
Somatochlora elongata	**Ski-tailed Emerald**	New Brunswick (S?), Nova Scotia (S?), Ontario (S2S4), Prince Edward Island (S1), Quebec (S?), Connecticut (S1S2), Georgia (S?), Maine (S?), Massachusetts (S2), Maryland (S1), Michigan (S?), Minnesota (S?), New Hampshire (S?), New Jersey (S1), New York (S4), North Carolina (S2S3), Pennsylvania (S2), Vermont (S3), Virginia (S1S2), West Virginia (S?), Wisconsin (S2S3)

POPULATION BIOLOGY AND VIABILITY

There has only been one large study for these species in the Allegheny National Forest (ANF) and the goal was to collect species richness data. In addition, sampling was not done as a standard area (plot, quadrant, etc.). Thus, it is difficult to predict population viability based on existing data. If water quality and habitats are maintained, I would expect that the ANF occurrences can be maintained.

POTENTIAL THREATS

These Odonata are broadly susceptible to extreme changes in water chemistry. One of the most significant threats to these species is pollution of stream habitats due to effects of coal mining. In particular, pH is one water quality factor that has been shown to be statistically significant in explaining odonate distributions (Kinvig and Samways 2000). For two species of Gomphidae, *Gomphus lividus* and *Gomphus graslinellus*, Trybula (1998) discovered significant inbreeding coefficients due in part to the isolation effects of acid mine drainage coupled with clinal variations of these species. Other factors I believe should be considered are the negative effects associated with impoundments, channelization, dredging, and flow alterations.

Shiffer (personal communication, 2002) suggested that riparian forest removal to be a serious threat to the ANF odonate populations. This can lead to increased siltation effects and elevated stream temperatures. These factors could also lead to reduction of aquatic vegetation, which has been shown to be an important parameter in explaining odonate habitat preferences (Florence 1995). Shiffer also recommended that hydrological stability of headwater areas be protected to ensure persistence of the species. Thermal enhancement has been implicated in shifts of odonates to more tolerant species (Corbet 1999).

Development of major new roads could be a threat to rare odonate populations. Riffell (1999) reported daily mean mortality rates of 87.69 dragonfly casualties/km in a study in the upper peninsula of Michigan. Most of these were males (60%). This figure may or may not be representative of ANF odonates, but does demonstrate the significant effect that roads could pose to these rare species. Given the short flight period of some of these species, road mortality could be a significant factor in the long-term viability of the populations.

PRESENT OR THREATENED RISKS TO HABITAT

Permitted timbering and oil/gas extraction activities in the ANF are certainly threats to these rare odonates. Corbet (1999) summarized that oil pollution lead to intolerant conditions in Zygoptera larvae in Massachusetts. The lethal effects of chronic acid mine drainage pollution in aquatic insects is well known and should be considered a serious threat to ANF odonate populations.

Chronic damage to streams in the ANF done by oil and gas extraction is likely inhibiting the recolonization of these rare odonates from nearby occupied habitats.

The species in this report are generally considered primitive, and as such are poorly adapted to large shifts in habitats. If timber extraction practices shift the temperatures of streams, this can lead to shifts to more eurythermal taxa.

Disease or Predation

Odonates are known to be important vectors in the life history of trematodes. A literature review by Corbet (1980) suggested that resident odonates might be susceptible to high parasitism loads after mass migration events that lower local numbers of individuals. The odonata are important food items in many trophic webs. Odonates are preyed upon by a variety of organisms, including birds, bats, reptiles, and fish. Potential damaging predation issues of these odonates could potentially arise with fish stocking programs.

Inadequacy of Existing Regulatory Mechanisms

Currently, none of the odonate species in this report are protected under the US Endangered Species Act (ESA). In Pennsylvania, aquatic invertebrates fall under the

jurisdiction of the Pennsylvania Fish and Boat Commission (PAFBC). Currently, the Fish and Boat Commission does not have an official invertebrate advisory committee to help guide management needs and develop adequate management and conservation strategies. The Pennsylvania Biological Survey is currently striving to be recognized as an (unofficial) invertebrate advisory council to the PAFBC. Until these actions happen, it is uncertain whether or not the PAFBC will develop conservation strategies for protecting these and other rare odonate species.

An important recovery activity will be to cap open oil and gas wells that occur from previous extraction activities, many occurring in the area before it was federally owned.

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

A substantial amount of land in Forest and Warren Counties is federally owned, with lesser amounts in McKean, Elk, and Jefferson Counties. For designated timber harvest areas, the ANF requires a filter strip width of 50' in addition to 4' for every 1 degree slope or uses the actual size of the riparian area, whichever is larger. In areas with herbicide applications, a 75-foot buffer applies to perennial streams and intermittent streams that are flowing during application. A 50-foot buffer applies to intermittent streams that are dry during applications, and a 25-foot buffer applies to isolated seep areas. There is also a management measure in place to protect adequate canopy structure along stream to maintain coldwater streams in the ANF. Overall I believe these to be good protection measures.

The Pennsylvania Department of Environmental Protection (DEP) regulates oil and gas wells on ANF property. DEP requires a 100-buffer near streams and water bodies, but this is likely just perennial sources and not specific to intermittent streams.

SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

The ANF has been impacted to various degrees by gas and oil exploration and activities related to timber harvesting. Currently, the ANF has included in its management plan the goal of reforesting many areas. This is accomplished by treating recovering areas with herbicides, fertilization of the areas, fencing areas from deer, and actively planting seedlings. The current 20-year management plan has a goal of reforesting 36,000 acres, with a timber yield of 67,000 acres. Within harvest stands, attempts are made to minimize the impact of herbicide applications. ANF studies on the effects of herbicides on South Branch Tionesta Creek have showed low levels that are not generally harmful to aquatic organisms.

ANF regulates the type of herbicides that are allowable within Forest boundaries.
ANF does not own much of the oil, gas, and mineral rights. Many uncapped wells are still present in the ANF and those close to natal streams can be considered a substantial threat. In 2000, private landowners capped 129 open wells. These sorts of activities are certainly needed in stream protection.

As mentioned previously, sedimentation is a persistent threat to aquatic communities. Currently, the ANF does monitor embeddedness in three streams but does not appear to have a comprehensive sediment management plan. Use of existing roads is encouraged, and less than 60 percent of projected new roads have been constructed due to existing road improvements.

PAST AND CURRENT CONSERVATION ACTIVITIES

ANF actively engages in replanting of timbered areas. In addition, there is annual water quality monitoring, along with the previously mentioned sedimentation studies. ANF does add habitat improvement structures to Allegheny Reservoir, but no such activities needed to improve macroinvertebrate habitat are known for ANF coldwater streams.

ANF has conducted zebra mussel screenings on boats launching into Allegheny Reservoir as well as querying boaters about zebra mussels. These activities were beneficial, although it is unclear how long these activities will continue. As indicated in the ANF 2000 monitoring report, these activities were conducted in 2000 and 2001.

RESEARCH AND MONITORING

Existing Surveys, Monitoring, and Research

The largest and most comprehensive survey conducted in the Allegheny National Forest was conducted by Bier et al. (1997). These included collections in all 10-stream systems of the Allegheny National Forest. Twenty collections were conducted from mid-May through September, and one station had biweekly collections. Additionally, numerous collections were made of *Gomphus* sp. larvae that were not identified to species. This is likely due to the fact that most odonate larvae are not identifiable to species until later to final instars. Bier and Rawlins (1994) surveyed the Odonata of the Clarion River system near the Allegheny National Forest. Some of the species located in that study were also present in Bier et al. (1997).

Other than these studies, there has been very little work in recent years specifically on the Odonata in the Allegheny National Forest. G.H. Beatty conducted several studies of the Pennsylvania Odonata, some of which involved surveys of the north central PA counties. These studies generally do not disclose stream-specific locations of species, and can only be related at the county level.

Most aquatic insect work in the ANF consists of water quality monitoring programs of the PA Department of Environmental Protection or PAFBC. The goal of these studies is primarily to assess water quality through community metrics focusing on larval insect stages. The level of taxonomy in these types of studies is variable, ranging primarily from family level identification to some generic identification. It is quite unlikely adult odonates were collected. Additionally little, if any, species-specific odonate data has been generated out of these studies. However, the potential to gather more species-

specific information could be done through proper identifications of larval samples still retained by the respective agencies.

Survey Protocol

Typically, nymphs of these species are collected using D-frame or kick nets. Samples should be preserved in high-grade ethanol. When collecting adults, aerial netting should take place in the channel, along the banks, and openings near streams. Aerial nets should be sturdy, long handled, dark in color if possible, and lightweight for greater speed in swinging. A shorter poled net is sometimes desirable for certain habitats. Adults should be placed into glassine envelopes and killed in acetone. For most surveys, it is important to collect as many habitats as possible, including open channel substrates, woody debris, undercut banks, and backchannels. Mist netting may be attempted for high-flying species. Additionally, some time at sites should be spent on attempting to locate exuviae. Examining the final instar (penultimate) larvae is the best to attempt species level identifications.

Research Priorities

A top priority for research, as with many poorly understood or cryptic species, is to conduct detailed survey work. This involves systematic collection from a wide range of time periods, gradient, and hydrology at numerous locations. When collecting nymphs of these species, measurements of stream temperature, dissolved oxygen, turbidity, and discharge should be collected when possible. Quantitative characterization of riparian vegetation and canopy cover should also be examined at known sites. Many of the species in this report have very short adult flight periods and could be missed without an adequate sampling strategy. Additionally, mortality studies from automobiles should be carried out on roads that receive heavy daily traffic loads during the spring, especially on those near streams.

The effects that can occur from heavy fish stockings on these species must be considered. The extent of predation pressures may relate to the quality and quantity of aquatic vegetation and available refugia in streams. ANF may need to evaluate woody cover per mile in coldwater streams and evaluate which areas may require cover additions.

Nutrient budgets of ANF streams should be developed to better characterize issues spatially and temporally with water quality. The effects that elevated nutrient profiles may have on these species needs better understanding.

Another area needing research is the specific life-history characteristics of these rare odonate species. Much of this sort of data is entirely lacking form the literature and these data are necessary to better understanding the real threats. Better characterization of proximal cues used by females in selecting oviposition sites is critical to understanding the significance of various management practices (Corbet 1999).

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LIST OF CONTACTS

Charles Bier
Director of Natural Heritage
Western Pennsylvania Conservancy
209 Fourth Avenue
Pittsburgh, PA 15222
cbier@paconserve.org

Clark Shiffer
254 S. Gill Street
State College, PA 16801

Robert Davidson
Section of Invertebrate Zoology
Carnegie Museum of Natural History
4400 Forbes Avenue
Pittsburgh, PA 15213
davidsonb@carnegiemuseums.org

John Rawlins
Section of Invertebrate Zoology
Carnegie Museum of Natural History
4400 Forbes Avenue
Pittsburgh, PA 15213
RawlinsJ@carnegiemuseums.org

APPENDICES

Appendix 1- Glossary of Terms

Anteapical tooth: term referring to tooth like structure anterior to the apex of the abdomen

Antenodal: before the nodus.

Biotope: An area that is uniform in environmental conditions and in its distribution of animal and plant life

Endophytic: inside of a plant; in dragonflies, this refers to the placement of eggs within plant tissue

Exuviae: the cast-off exoskeleton, left behind after a molt

Hamulus: found on males, these are hooks found on the underside of segment 2 used to hold the female during copulation

Hindwing: the lower or 2nd wing

Labrum: upper lip

Nodus: the break of the crossveins found in the middle front edge of the wings

Oviposit: the process by which females deposit eggs using the ovipositor

Phenology: term describing the activity period during the year

Pterostigma: colored spot near the tip of the wings which varies in color

Superior appendage: paired appendage found after body segment 10; used to identify some dragonflies to the generic or species level

Synthorax: term which refers to the combined structure composed of the mesothorax and the metathorax

Tarsus: foot

Thorax: 2nd primary body segment

Triangle: structure formed in the wings just below the 4th medial vein. Attaches the 4th medial vein and the 1st cubital vein

Vagility: degree of mobility

Appendix 2. Threats to odonate populations (modified from Corbet 1999).

Biotopes	Impacts
All lentic and lotic	Lowering of water level by draining, extraction, or diversion Destruction of fauna by earth moving, infilling, construction work, or removal of substrate Increase of sediment load by destruction of vegetation cover in catchment areas Chemical or thermal contamination by runoff or discharge of agricultural, industrial, or urban effluent Eutrophication, especially by seepage of manure or synthetic fertilizer, or urban effluent Unrestricted human access to margins for recreation Progressive isolation of populations as biotopes are destroyed Acidification by afforestation with conifers
Streams, small rivers, ditches, canals	Destruction of heterogeneity of margins and rate of flow by canalization Disruption of vegetation and soil profiles by mechanical clearing Increase of predation on larvae, directly or indirectly, by stocking or propagation of fish, or by introduction of domestic ducks Erosion and physical disturbance of margins by inland water traffic
Lakes	Acidification by airborne industrial emissions Intermittent exposure of littoral zone during draw-down in lakes used for hydroelectric power generation
Bog pools	Destruction of fauna by commercial peat extraction
Phytotelmata and ground litter	Destruction by deforestation

Appendix 3. Allegheny National Forest records

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