A phytogeographical and ecological study of *Prenanthes crepidinea* Michaux (Asteraceae)

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ABSTRACT

A phytogeographical and ecological study of *Prenanthes crepidinea* Michaux (Asteraceae).

Prenanthes crepidinea Michaux is a herbaceous plant that is listed as a species of special concern in eleven states. Since little is known of the natural history of this species, a two-part study was conducted.

The first part was a phytogeographical study involving herbarium loans to determine the current and historic distributions of the species. Ecological data were gathered from the herbarium specimens. A literature search was done for information reported about *Prenanthes crepidinea* to enhance the herbarium study. Micromorphology of selected structures was investigated using scanning electron microscopy.

The second part of the study involved studying three extant sites in depth. This involved developing a characteristic habitat description and a natural history for the species. Soil associations, associated species, and pollinators were studied. Voucher specimens for all associated species were collected and deposited in the Herbarium of Youngstown State University (YUO).

This study was conducted in two field seasons, 1998-1999. The sites were chosen the first year. The sites were visited on a biweekly basis to collect associated species and track the phenology of *Prenanthes crepidinea*. The second season was used to ensure that no associated species were overlooked due to unusual seasonal conditions in the first season and soil samples were taken. At the end of the second season the associated species lists and soil types found for the three sites were compared to determine if the community components were uniform and predictable.

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INTRODUCTION

Athey & Pippen (1987) best stated the need for life history studies, "long-range life history and natural history observations are important for better understanding of ... plants and the ecosystem of which they are a part."

Andreas Michaux was the first to describe *Prenanthes crepidinea* in 1803 in his *Flora Boreali-Americana*. The holotype (Fig. 1) is deposited at the Paris Museum herbarium (P).

Milstead (1964) noted that many species of *Prenanthes* show a high degree of vegetative polymorphism accounting for some rather extensive lists of synonymy; *Prenanthes crepidinea* is no exception. The synonyms found for *Prenanthes crepidinea* Michx. Fl. Bor. Am. 2:84. 1803. (holotype Paris Museum, Fig. 1) were:

Prenanthes opicrinea Raf. Cinn. Lit. Gaz. 2:10. 1824. (PH !)

Harpalyce crepidinea D. Don l.c. Edinb. New Phil. Jour. 308. 1829. Not Moc. & Sesse 1825.

Prenanthes miamiensis Riddell. Synopsis of the Flora of the Western States. West. J. Med. & Phys. Sci. 8:490. 1835. (PH !)

Nabalus crepidineus (Michx.) DC. Prodr. 7:242 1838.

Prenanthes gigantea Raf. In herb. DC., mentioned in Torrey & Gray 1838-43 edition.

Hieracium crepidineum Froel. Mss., mentioned in Torrey & Gray 1838-43 edition.

Prenanthes crepidinea Michaux is a large, usually simple stemmed herb in the family Asteraceae (tribe Lactuceae) of special concern in eleven states. Many descriptions of *P. crepidinea* Michaux have been published since Michaux first described the plant. They all agree on most aspects of the plants morphology. The plant grows up to 2.5 m tall, and is glandular puberulent in the inflorescence. The alternate leaves are glabrous, with a winged petiole, and are generally short hirsute on the midrib and main veins. The leaves are generally broadly deltoid to hastate varying from coarsely toothed to deeply lobed or rarely entire tending to gradually reduce upwards. The leaves exude a milky juice when broken. The inflorescence is corymbose-paniculate with 20-35 perfect creamy yellow ligulate florets, nodding campanulate heads and about twelve glandular pubescent involucral bracts. (Fisher 1988, Gleason & Cronquist 1991, Milstead 1964)

The objective of this study was to determine the current and historic distributions of *Prenanthes crepidinea* and to determine a characteristic habitat description and describe the natural history for this species.

MATERIALS AND METHODS

Phytogeographical study

Herbarium specimens were borrowed from major North American herbaria and from smaller herbaria in the known range of *Prenanthes crepidinea*. Specimens were examined, confirmed to be *P. crepidinea*, annotated and returned to their home institutions. Data from specimens confirmed to be *P. crepidinea* were gathered and entered into a database. Locations and ecological data available for all specimens borrowed were recorded and used to construct a distribution map in conjunction with literature references. The localities from the specimens were mapped and distribution maps generated. Maps were generated, based on date, to discern historic localities from recent sites. Specimens collected in 1950 or earlier were mapped on the historical range map for the species (Fig. 2). Specimens collected after 1950 were mapped on the recent range map for the species (Fig. 3).

Ecological Field Studies

Three sites were chosen for in depth study of *Prenanthes crepidinea*. The three sites chosen were State Game Lands 178 in Lawrence County, Pennsylvania on Big Neshannock Creek; Poland Municipal Forest, in Mahoning County, Ohio on Yellow Creek; and Moraine State Park, Slippery Rock Natural Area in Butler County, Pennsylvania on Slippery Rock Creek (Figs. 4-6). The sites are found on three different watercourses found within a 25-km radius. The farthest apart sites are Poland Municipal Forest and Slippery Rock Natural Area at 43 km. All of the sites are at approximately the same latitude.

Data were collected during the growing seasons of 1998 and 1999. Visits to each site were made biweekly in 1998 and intermittently in 1999. Six $1m^2$ plots were selected for analysis at each of the three sites. The plots were selected "based on a wide range of densities" (Winn & Pitelka 1981) of the study species, *Prenanthes crepidinea.* Winn and Pitelka (1981) suggest that "density affects plant size and plant size influences flowering." Densities were determined by a count of all individuals within each marked plot. Three of the plots at each site were chosen and established early in the season when the plants were just emerging. The other three plots for each site were to be chosen and established later in the season when reproductive individuals could be identified. Plot size was chosen based on Oosting (1956) who suggested $1m^2$ plot size for herbaceous vegetation because "there is further saving of effort in that the total area sampled by small plots may usually be less than that sampled by large plots and yet give comparably valuable information." Phillips (1959) also suggested 1 m^2 plots for medium sized vegetation. All plants of the target species within each of the plots were to be censused and measured at two-week intervals from time of emergence until senescence. This proved to be difficult due to preferential browsing of the *P. crepidinea* by white-tailed deer. (Vegetation broken by walking up to the selected plots seemed to act as open dinner invitations for the deer.) The plots were thus abandoned early in the first year and random observations made. All herbarium specimens and sporadic wild plants were inspected for signs of natural enemies (Tessene 1969) e.g. herbivory, disease or parasitism.

In addition, ecological data available from herbarium specimens was gathered. Life cycles based on herbarium sheets were correlated with field observations

(Wehrmeister & Stuckey 1992). Seasonal growth forms were described, vegetative and sexual cycles from studies of plants in the field, and herbaria were developed, and the environmental parameters of the plant were assessed.

Voucher specimens at various stages in the plant's life cycle were collected. "Multiple herbarium sheets collected from the same population at different times as well as from different populations are a necessity ... to present the total biology and natural history of a species" (Utech et al. 1984). Voucher specimens were made using standard botanical collecting procedures described by Savile (1962) and Foreman & Bridson (1989) and deposited in the herbarium at Youngstown State University (YUO).

During blooming periods, plants were monitored weekly in both growing seasons for any visitors to the florets. Insects found visiting the florets of *Prenanthes crepidinea* were captured for identification, killed in cyanide killing jars and mounted on standard entomological pins. Labeled insect specimens were identified by Dr. John Rawlins of Carnegie Museum of Natural History and deposited in the entomological collection at Carnegie Museum of Natural History.

A characteristic habitat description was developed using information found on herbarium specimens and in the field.

Soils

Soil samples were taken from each of the three study sites. Samples were taken to a depth of 15 cm with a garden trowel from three areas at each of the sites that had *Prenanthes crepidinea* in the immediate vicinity. The soils from the three holes at each site were combined into one composite sample as recommended by the Pennsylvania State University Agricultural Analytical Services Laboratory. These samples were then

dried using a forced air herbarium specimen drier. A representative sample from each site was then mailed to the Pennsylvania State University Agricultural Analytical Services Laboratory for analysis. The soil samples were checked from the three different study sites to see if there might be any soil affinities (Horn 1997). Soil surveys were consulted for soil descriptions. (Figs. 10-12)

Associated species

Plants found growing in the vicinity of *Prenanthes crepidinea* were collected throughout the growing season using standard herbarium techniques (Foreman & Bridson 1989, Savile 1962). These specimens were identified, and lists generated for each site. Voucher specimens were deposited in the Herbarium of Youngstown State University (YUO). All nomenclature follows that of Gleason & Cronquist (1991). The lists were then compared to see if any species are always found growing with *P. crepidinea.* The species collected in association with *P. crepidinea* were checked for nativity.

Micromorphology

Permission was asked for and received from the curators of Carnegie Museum of Natural History (CM) and Youngstown State University (YUO) herbaria to perform limited destructive analysis on specimens of *Prenanthes crepidinea.* Standard herbarium acronyms follow Holmgren et al. (1981). Due to the low number of specimens of this species (only 1 at YUO, 6 at CM) in the herbaria at the onset of this micromophological study, it was determined to take as little as possible from any one herbarium specimen and minimum from all the specimens combined. Using a dissecting microscope, forceps, and razor blade, samples were cut from the herbarium sheets for comparison of the

following structures: seed coat and coma; bract from floral head; stigma; anther with pollen; and petiole.

Each sample was placed in a 2 inch X 2 inch ziplock bag with data recorded on the bag, until the sample was mounted on an aluminum SEM stub using double sided tape. The stem of each stub was then marked, with a fine point Sharpie permanent marker, with a distinguishing code which was also marked on each bag so that the stubs could be cross referenced to the sample bags. All samples were coated with gold using a BioRad SC510 Sputter Coater. Samples were observed with a Hitachi S450 Scanning Electron Microscope at 25 KV. Micrographs were obtained using a Polaroid camera attached to the SEM using type 55 Polaroid 4 X 5 land film.

An achene was extracted from a specimen with forceps while viewing under a stereo dissecting microscope. Care was taken not to crush the achene due to its very dry state. The achene with the coma attached was mounted to a SEM viewing stubs with double-sided sticky tape and sputter coated with 10 nm of gold. The seed coat and coma in Asteraceae very often has characteristic structural components that are often species specific and could prove very interesting at high magnification (Fig. 14A-14C).

Involucral bracts proved to be extremely difficult to recover due to the extremely fragile nature of the structure. These were recovered using a razor blade under the stereo dissecting scope. An involucral bract was mounted on a SEM viewing stub using double-sided sticky tape and sputtercoated with 10 nm of gold (Fig. 14D).

The stigma, which protrudes from the florets in *Prenanthes*, did not prove to be difficult to harvest at all. Forceps were used under the dissecting microscope where the

pistil was broken to harvest the stigma. The stigma was mounted on a SEM viewing stub using double-sided sticky tape and sputtercoated with 10 nm of gold (Figs. 14E-14F).

Harvesting the anther was accomplished by using forceps under a stereo dissecting scope. The anther proved to be very fragile and great care had to be taken not to lose the pollen during harvesting. The anthers of *Prenanthes* are very small and so not much pollen is in any one anther. Due to the limited source for *Prenanthes crepidinea,* only one floret was permitted to be harvested so the choice of how to prepare the pollen was a critical one. Hanks and Fairbrothers (1970) undertook a study where they performed different preparation procedures on pollen of selected species. They discovered that each of the techniques proved to be the best procedure for some species and not for others and the only way to decide which procedure was best for any one species was by trial and error. Their techniques involved untreated acetolyzed pollen, KOH treated acetolyzed pollen and air-dried pollen. They noted that the "KOH treatment enlarges the grains of the species studied" and so accurate measurements of the pollen would not be possible. They also expressed that the acetolyzed pollen tended to reveal the diagnostic characteristics of the pollen most clearly. However, they noted they were not sure of the effects on the pollen of the various steps of the acetolysis procedure. They also found that the "acetolyzed grains tend to collapse under the SEM vacuum system more readily than KOH or fresh material." Due to these complications and the extremely limited supply of pollen for the species being studied, it was decided to mount air dried pollen. If this mount proved unsatisfactory then another procedure would be tried. This decision was backed up by the study of Ridgway and Skvarla (1969) who compared the differences in pollen of *Zea* (Poaceae) and *Iva* (Asteraceae). Ridgway and Skvarla found

that the "composite pollen, because of its robust exine, is substantially more resistant than *Zea* to distortion during evaporation and in the electron beam." They also noted "the present study emphasizes the necessity for preparing pollen by different methods in order to gain maximum information." Because the plant in the present study (*Prenanthes*) is a composite (a member of the Asteraceae family), it was hoped that it also would have a robust exine and be able to withstand the pressures of the SEM vacuum. The collected pollen was mounted with double sided sticky tape, found to be the best by Ridgway and Skvarla (1969), and sputter coated with 10 nm of gold. Chuang et al. (1978) remark that the most notable characteristics to look for in pollen grains are the shape, number and distribution of apertures, and the surface sculpturing. These would be the characteristics looked for in the present investigation of pollen in *P. crepidinea* (Figs. 14E-14H).

The petiole was harvested using a razor blade (Banerjee, 1976) and a stereo dissecting microscope. This proved to be a very fragile region of the plant and extreme care had to be taken not to destroy the sample. The petiole sample was mounted on a SEM viewing stub with double-sided sticky tape and sputter coated with 10 nm of gold (Fig. 14I).

Harvesting structures fresh may prove to provide better material for micrographs than herbarium harvested specimens. However, since fresh materials are not always available, techniques for working with dried specimens should not be ignored.

Literature Review

Major botanical journals and references were searched for references to *Prenanthes crepindinea,* information found in the literature was compiled and a bibliography for the species was generated.

RESULTS

Phytogeographical Study

Eleven states were found to have had historic collections of *Prenanthes crepidinea*: Arkansas, Illinois, Indiana, Kentucky, Minnesota, Missouri, New York, Ohio, Pennsylvania, Tennessee, and Wisconsin. Nine states were found to have had collections made in them since 1950. These were Illinois, Indiana, Kentucky, Missouri, Ohio, Pennsylvania, Tennessee, West Virginia, and Wisconsin. Two additional states, Arkansas and New York, were found to have literature references for the species since 1950 (Eaton & Schrot 1987; and Smith, Hyatt & Golden. 1992). The agencies in the states of New York and West Virginia that are responsible for tracking species of special concern in their respective states, currently list this species as historic. Minnesota lists this species as "of special concern". The states of Ohio, Tennessee and Wisconsin list this species as Endangered, the highest rank given to a protected species. Pennsylvania currently also lists this species as Endangered, although it has been proposed to have the rank lowered to Threatened at the 1999 Pennsylvania Rare Plant Forum (Isaac personal communication). Kentucky also considers *P. crepidinea* Threatened. Arkansas and Indiana have the plant listed as Rare. Only Illinois and Missouri do not give this species special protection.

Four other states at some time have had *Prenanthes crepidinea* reported for them. They are Iowa, Kansas, North Carolina and Virginia. *P. crepidinea* is attributed to Iowa by Milstead (1964) and Anonymous (1996). Milstead, however, does not cite any specimen for Iowa and no specimens have been found to represent the state. Iowa does not list *P. crepidinea* in its species of special concern listings. Although, no specimens

were found for Iowa, the state cannot be discounted from the distribution for the species. Specimens have been collected from four surrounding states in counties adjacent to Iowa. Rydberg (1932) listed Kansas in the range of *P. crepidinea*; other authors have also listed Kansas (Britton & Brown 1913, Gates 1940). Kansas, like Iowa, is not far from the known range of *P. crepidinea* and thus cannot be totally ruled out of range. The third state with reports for *P. crepidinea* is North Carolina. No specimens are known from North Carolina, however, specimens that had previously been identified as *P. crepidinea* from North Carolina were obtained on loan and determined to be *P. roanensis* (Chickering) Chickering. *P. roanensis* is a species of "moderate to high elevations in the mountains of eastern Tennessee, western North Carolina, and southwestern Virginia" (Milstead 1964). This species is like a diminutive *P. crepidinea* also having glandular hairy involucral bracts, an uncommon trait for the genus. Michaux (1803) mentions North Carolina in his original description of *P. crepidinea* "in regione Illinoensi et in excelsis montibus Carolinae"[in Illinois and on the high mountains of Carolina]. It is presumed that Michaux believed *P. roanensis* to be at least a form of *P. crepidinea*. *P. roanensis* was not described as a separate species until Chickering described it in 1880. Two of the specimens received on loan, one from the Field Museum (F) and one from Missouri Botanical Gardens (MO), were specimens collected by Chickering on Roan Mountain in 1877, three years before he described *P. roanensis* as a good species. The final state that has been suggested as in the range of *P. crepidinea* is Virginia. A sheet received on loan from the New York Botanical Gardens (NY) was previously determined to be *P. crepidinea*. This study found that determination to be in error. The sheet in question compared favorably to *P. serpentaria* Pursh. Whether this sheet is the sole

reason that Virginia has been listed by BONAP (1999) as unconfirmed presence or false report is undetermined. Virginia also may possibly have been credited to this species due to a synonym of *P. serpentaria*, which unfortunately is *P. crepidinea* Elliott. Voss (1996) notes that *P. crepidinea* may some day turn up in Michigan. This is not an unreasonable assumption since *P. crepidinea* has been found in counties adjacent to Michigan. Eaton (1833) suggests that it may have already been found in Michigan 30-40 miles from Detroit.

Exsiccatae

A brief synopsis of specimens examined by state and decade follows. Number of collections by state: Arkansas 1, Illinois 89, Indiana 18, Kentucky 27, Minnesota 1, Missouri 65, New York 3, Ohio 35, Pennsylvania 33, Tennessee 5, West Virginia 3 and Wisconsin 4. Collections by decade: 1830's – 9, 1840's – 2, 1850's – 1, 1860's – 12, 1870's – 23, 1880's – 30, 1890's – 22, 1900's – 21, 1910's – 6, 1920's – 5, 1930's – 22, 1940's – 7, 1950's – 23, 1960's – 4, 1970's – 9, 1980's – 12, 1990's – 33 and 2000's – 5. Table 1 lists the specimens examined by year of collection. Counties of collection are summarized in Table 2.

ARKANSAS. **Drew Co.:** P.O. Monticello, A. & M. College Farm, woods, 12 Oct 1936, *D. Demaree 13925* (F).

ILLINOIS. **Alexander Co.:** Shawnee National Forest, Jonesboro Ranger District, Compartment J-103, W side of Sandy Creek, mesic NE-facing slope; T14S, R2W, SW1/4, Sec. 28, 14 Apr 1994, *L.R. Phillippe 23687* (ILLS). **Brown Co.:** NE of Cooperstown, roadside ditch, 8 Oct 1970, *R.A. Evers 104384* (ILLS). **Champaign Co.:**

Urbana, 1880, *M.S. Snyder s.n.* (ILL); no further locality, Aug 1880, *E.S. Stub s.n.* (MU); Urbana, woods, 2 Oct 1888, *A.B. Seymour 16653* (ILL); Urbana, woods, 1 Oct 1895, *G.P.C. 11967* (ILL); near Urbana, Brownfield Woods, 18 May 1941, *G.N. Jones 13659* (ILL); near St. Joseph, edge of woods, 5 Sep 1948, *G.N. Jones 18830* (ILL); "Lake of the Woods", 1 mi NE of Mahomet, edge of woodland, 18 Sep 1949, *H.E. Ahles & G.N. Jones 1710* (ILL); Brownfield Woods, in shade, 5 Jun 1956, *M.S. Bergseng. s.n.* (ILL); Brownfield Woods (Univ. Woods) Urbana, 22 Jun 1956, *M. Bergseng s.n.* (ILL); Brownfield Woods, NE of Urbana, in openings in dense stands of sugar maple and pawpaw saplings, deep shade, 11 Sep 1956, *M. Bergseng. s.n.* (ILL); no further locality, 22 Jun 1957, *M.S. Bergseng. s.n.* (ILL); Brownfield Woods, near Urbana, near South Gate, 14 May 1959, *G.N. Jones 24173* (ILL); Brownfield Woods, 5 mi NE of Urbana, woodland edge, 16 Sep 1974, *A.G. Jones; T.E. Lockwood & J.N. Brunken 3038* (ILL, ILLS). **Christian Co.:** Taylorville, 21 Sep 1895, *William E. Andrews Herbarium s.n.* (ILL). **Clay Co.:** Southern Flora!, [no date], *Chapman Herbarium s.n.* (NY). **Douglas/Moutrie Co.:** Arthur, [no date], *E. Hall s.n.* (MSC). **Fulton Co.:** near Lewiston, wood border, Sep 1890, *H.S. Pepoon s.n.* (F, ILL); Canton, [no date], *H.C. Hovey 10103* (NY); Canton, [no date], *J. Wolfe s.n.* (F, GH). **Henderson Co.:** near Sagetown, in rich woods, 12 Sep 1874, *H.N. Patterson s.n.* (F). **Henry Co.:** grounds of Indian Creek School, ca 5 mi S of Kewanee, in moist woodlands, 3 Sep 1946, *R.J. Dobbs s.n.* (ILLS). **Jackson Co.:** Shawnee National Forest, Oakwood Bottoms, Murphysboro Ranger Dist., Compartment 16, forb dominated area in bottomland beneath high power line r-o-w; Gorham Quad., 23 Sep 1993, *L.R. Phillipe 23191* (ILLS). **Johnson Co.:** Vienna, low open woods, 27 Sep 1919, *E.J. Palmer 16605* (MO); Bell Pond Natural

Area, T. 13S, R4E, NW ¼ Sect. 13, along edge of swamp in mesic woods, 22 May 1990, *L.R. Phillippe, E. Ulaszek 13976* (ILLS). **Macoupin Co.:** Carlinville, 7 Sep 1889, *William E. Andrews Herbarium s.n.* (ILL). **McLean Co.:** Bloomington, Aug 1869, *J.S. Congdon s.n.* (NY); Bloomington, 6 Sep 1879, *A.B. Seymour s.n.* (ILL); Bloomington, Sep 1886, *B.L. Robinson s.n.* (GH); Bloomington, Sep 1886, *E.C. Smith. s.n.* (MO); Bloomington, in rich soil and open places, 31 Aug 1904, *B.L. Robinson s.n.* (GH, MIN); Bloomington, common in rich soil, sunny places, [no date], *B.L. Robinson s.n.* (CM); B-16 Funk's Grove, 19 May 1951, *R.T. Calef s.n.* (ILLS); Funks Forest Natural Area, 1.5 mi N of McLean, 19 May 1951, *R.T. Calef. 247* (ILL). **Menard Co.:** Athens, bottoms, Sep 1868, *E. Hall s.n.* (F); Athens, Oct 1868, *E. Hall s.n.* (US); pr. Athena, in vallibus pinguioribus, Oct [no year], *E. Hall 46 & 47* (GH); pr. Athenas, in vallibus pinguioribus, [no date], *L. Canby 197* (GH). **Peoria Co.:** no further locality,1870, *J.T. Stewart s.n.* (F); at the mouth of "Rocky Glen", Peoria, rich woods, Aug 1891, *F.E. McDonald, s.n.* (F); N of Princeville, rich woods, 17 Sep 1900, *V.H. Chase 831* (F, ILL, NY, PH); near Peoria, near boy scouts camp, rich soil, open ravine in woods, 28 Aug 1921, *V.H. Chase 3665* (ILL); N of Detweiler Park, woods, 27 Sep 1964, *V.H. Chase 18209* (ILL, ILLS); through Funks Grove, roadside, 19 Oct 1975, *H.H. Iltis 27960* (WIS); Peoria, [no date], *Frederick Brendel Herbarium s.n.* (ILL). **Richland Co.:** 3.5 mi N of Olney, wet bottom land, 15 Sep 1947, *V.L. Scherer 552* (ILL). **Schuyler Co.:** W side of US 67, at S side of East Fork; T1N, R1W, SW/4, SW/4, NE/4 Sect. 16 floodplain woodland, near hayfield, 12 Sep 1995, *S.R. Hill 27495* (ILLS). **St. Clair Co.:** A. Centerville Station, bluffs, 25 Sep 1877, *H. Eggert s.n.* (F); vicinity Southern RR, edge of woods, 1 Sep 1957, *J.O. Neill 8557* (ILLS); vicinity Southern RR., edge of woods, 29 Sep 1957, *J.O. Neill 8649*

(ILLS); vicinity Southern RR, woods, 19 Oct 1957, *J.O. Neill 8727a* (ILLS); vicinity Southern RR, low ground, shaded, 2 Oct 1960, *J.O. Neill 15503* (ILLS); vic. Union Hill, creek valley, 5 Sep 1965, *J.O. Neill 16718* (ILLS). **Stark Co.:** 4 mi NW of Wady Petra, rich wooded hillside, 10 Sep 1900, *V.H. Chase A 791* (ILL). **Union Co.:** near McCann School, 2.5 mi NE of Aldridge, 7 Oct 1939, *E. Anderson & W. Bauer s.n.* (MO). **Vermilion Co.:** Vermilion River Observatory Area, ca 4.5 mi SE of Danville, W of old radio tower site and NE of bldg, open area on wooded ridge, in woods near ridgetop, NE-facing dry mesic woods, 6 Jun 1997, *L.R. Phillippe; D.M. Ketzner & J. Jawad 28862* (ILLS); Horseshoe Bottom Nature Pres., ca 2.6 mi directly E of Collison, E side Middle Fork of Vermillion R, mesic upland woods at base of slope; UTM Zone 16, 4453300mN, 436050mE, 14 May 1998, *L.R. Phillipe; R. Larimore; & M.A. Feist 29609* (ILLS). **Wabash Co.:** Bonpas Bottoms, 1 Sep 1895, *H. Shearer s.n.* (ILL); grown in collectors garden, 8 Sep 1927, *H. Shearer s.n.* (ILL). **Will Co.:** Joliet, shady bank, 27 Aug 1900, *J. Shaddick, H.C. Skeels. s.n.* (MSC). **Williamson Co.:** Crab Orchard National Wildlife Refuge, Devil's Kitchen Dam Research Area, rich mesic upland forest, 21 Apr 1985, *E.F. Ulaszek 1078* (ILLS). **Woodford Co.:** Upper Ferry Road, Aug 1888, *F.E. McDonald s.n.* (MSC); along road from Upper Ferry to Little Detroit Mill, Aug 1889, *F.E. McDonald (1)* (GH); no further locality, Aug 1889, *F.E. McDonald (2)* (GH); along the Upper Ferry Road, Sep 1889, *F.E. McDonald s.n.* (ILL). **[no county]:** Rills in the bluffs, damp woods, 25 Sep 1877, *H. Eggert s.n.* (CM, MIN, ND, NY, US, WIS); Cantonville, ditches, [no date], *Eggert s.n.* (F); Mead, [no date], *H.P. Sartwell Herbarium s.n.* (GH); no further locality, [no date], *E. Hall s.n.* (ILL); Hall, [no date], *H.F. Munroe s.n.* (F).

INDIANA. Allen Co.: St. Mary's River, just S of Ft. Wayne, alluvial bank, 16 Sep 1906, *C.C. Deam 1705* (ILL, MIN, MICH, US). **Clark Co.:** Mayberry Woods, 4 mi N of Jeffersonville, grown in garden from plant collected in Mayberry Woods, 9 Sep 1948, *C.C. Deam 65285* (OU). **Delaware Co.:** near Muncie, 7 Sep 1888, *A.W. Brady 1617* (GH). **Floyd Co.:** New Albany,1834, *A. Clapp 10102* (NY); near New Albany, 12 Sep 1837, *A. Clapp s.n.* (F). **Fountain Co.:** 2 mi NE of Riverside, slightly wooded creek terrace, 20 Sep 1953, *F.B. Buser 3210* (ILL). **Howard Co.:** N of Albright's Cemetery, 4 mi SE of Kokomo, low open woods, 6 Sep 1935, *C.W. Ek s.n.* (NY). **Jefferson Co.:** Hanover, 29 Aug 1874, *J.M. Coulter 10101* (NY). **La Porte Co.:** Kankakee, [no date], *J.M. Coulter 10068* (NY). **Putnam Co.:** S of Russellville, along Raccoon Creek, rich low ground, 4 Sep 1910, *E.J. Grimes 346* (NY); 1 mi N of Russellville, in rich woods, 2 Oct 1910, *E.J. Grimes 2135* (NY). **Spencer Co.:** Rockport, edge of woods on hilltop, soil rich, 5 Sep 1899, *C. Kennedy 23* (MU). **[no county]:** no further locality, 12 Sep 1837, *Clapp s.n.* (NY); no further locality, [no date], *Clapp s.n.* (NY).

KENTUCKY. Fayette Co.: Lexington, thicket, Sep 1833, *R. Peter 659* (MICH); near Lexington, thicket, Aug 1835, *R. Peter s.n.* (PH); Lexington,1837, *C.W. Short s.n.* (US); around Lex[ington]n, in fencerows of cultivated ground, Aug-Oct [no year], *C.W. Short 4* (US); Lexington, [no date], *C.W. Short s.n.* (KY); Lex[ington], 19 Sep 1894, *J.S. Terrill s.n.* (KY); Raven Run, by trail W of waterfall on Collinsia Creek, 26 Apr 1989, *J. Campbell s.n.* (KY); Raven Run, cultivated in Lexington, full sun, 2 Jun 1991, *J. Campbell s.n.* (KY). **Graves Co.:** 0.7 mi on Mill Road from KY 131, Kaler, W fork of Clarks River, edge of wet woods, 1 Sep 1974, *R. Athey 2932* (VDB). **Jefferson Co.:**

Louisville, [no date], *Short 11181* (MO). **Leslie Co.:** mouth of Cawood, hollow on shady roadside, 1992; cultivated in Fayette Co., 27 Sep 1993 & 7 Nov 1993, *J. Campbell s.n.* (KY). **Rockcastle Co.:** Bowling Green, 31 Aug 1897, *S.F. Price s.n.* (MO); Lower Horselick Creek, edge of lower slope, woods by dirt road, 11 May 1990, *J. Campbell s.n.* (KY). **[no county]:** "in many parts of KY, near Hendersonville, Hardensburg, Louisville, Lexington, Stanford, Harrodsburg Bowling Green, &c.", [no date], *Hembel Herbarium s.n.* [type of *Prenanthes opicrinia*] (PH); no further locality [no date], *J. Hale s.n.* (NY), *C.W. Short s.n.* (GH, NY, PH), [no collector given] *s.n.* (NY), 1858, *C.W. Short s.n.* (F), 1860, *C.W. Short s.n.* (MO, NY, PH).

MINNESOTA. Houston Co.: Jefferson, 29 Aug 1900, *H.L. Lyon 755* (MIN).

MISSOURI. Adair Co.: Kirksville, 24 Sep 1887, *C.S. Sheldon s.n.* (NYS); **Boone Co.:** along Perche Creek, 1.5 mi S of Hwy 40, shady woods, 21 Sep 1933, *A.A. Jeffrey & F. Drouet 1184* (TENN). **Cape Girardeau Co.:** 2.5 mi SW of Whitewater, rich woods with slight ridges alternating with depressions filled with Saururus, 31 Aug 1954, *J.A. Steyermark 77040* (MO). **Gentry Co.:** along E side of West Fork of Grand River, 2.25 mi N of Alanthus Grove, wooded ravines and slopes tributary to and wooded slopes, 28 Sep 1951, *J.A. Steyermark 72921* (F). **Greene Co.:** no further locality, 7 Sep 1893, *J.W. Blankinship s.n.* (MU). **Knox Co.:** Bridge Creek, on S side of creek, 7.5 mi NW of Knox City, alluvial ground, wet meadows and swales in valley, 19 Sep 1950, *J.A. Steyermark 70685* (F). **Laclede Co.:** Highway #5 Bridge, 24 Aug 1937, *G. Moore s.n.* (F). **Maries Co.:** along Camp Ground Creek, 6 mi NW of Tavern, N and NE facing limestone

wooded small bluffs, 19 May 1950, *J.A. Steyermark 69705* (F). **Ozark Co.:** along Little North Fork of White River between Burse Ford and Nave Ford, 1 mi SW of Pontiac on E side of river, lower part of slopes, 26 Sep 1949, *J.A. Steyermark 69372* (F). **Pettis Co.:** along Muddy Creek, 2 mi E and NE of Lookout, base of wooded limestone slopes, 4 Oct 1938, *J.A. Steyermark 21496* (F). **Pike Co.:** Louisiana, [no date], *Pech* s.n. (CLM); Louisiana, [no date], [no collector given] *s.n.* (NY). **Ralls Co.:** along Salt River near "Blue Bank" and Brashear Ford, 2 mi S of Spalding, in thickets on low slopes, 4 Sep 1937, *J.A. Steyermark 25789* (F, MO, MUHW, NY, TENN, WIS). **Randolph Co.:** along tributary of Walnut Creek, 3.75-4 mi NW of Cairo, wooded limestone slopes, 27 Aug 1950, *J.A. Steyermark 70379* (F). **St. Charles Co:** along Callaway Fork and tributary to it, 4-5 mi SE of New Melle, 3.5-4 mi NE of Schluersburg, N-facing limestone wooded slopes, steep narrow ravines, 26 Jul 1956, *J.A. Steyermark 82064* (MO). **Saline Co.:** Davis Creek Bottom near Emma, Ju [?] thickets, 23 Aug 1894, *C.H. Demetrio s.n.* (GH). **St. Louis Co.:** Allenton, Sep 1874, *G.W. Letterman s.n.* (MO); St. Louis,1877, *H. Eggert s.n.* (MO); St. Louis, meadows, 25 Sep 1877, *H. Eggert s.n.* (GH); Waldern, 25 Sep 1877, *H. Eggert s.n.* (MO); Allentown, Jul 1879, *Letterman s.n.* (PH); Allenton, Sep 1879, *G.W. Letterman 5092* (MSC); Allenton, Oct 1879, *G.W. Letterman s.n.* (GH, US); Allenton, Sep 1881, *G.W. Letterman s.n.* (US); Allenton, 16 Jul 1884, *J.H. Kellogg s.n.* (MO); in Valley Park, woods, 7 Sep 1886, *H. Eggert s.n.* (MO); Allenton, 10 Aug 1887, *G.W. Letterman 253* (F, MICH); no further locality, 10 Aug 1887, *G.W. Letterman s.n.* (MO); near Valley Park, 6 Oct 1887, *H. Eggert s.n.* (MO); Allenton, 30 Aug 1894, *G.W. Letterman s.n.* (NY); Allenton, 31 Aug 1894, *G.W. Letterman s.n.* (US); near St. Louis, 11 Sep 1894, N.M. *Glatfelter s.n.* (MICH); Allenton, 30 Aug 1894, *G.W. Letterman s.n.*

(MO); Vigo, Creve Coeur Lake, 11 Sep 1894, *N.M. Glatfelter Herbarium 301* (MO); Creve Coeur, 27 Sep 1914, *J.R. Drushel s.n.* (MO); Creve Coeur Lake, rich upland woods, 24 Sep 1928, *J.A. Steyermark 9085* (MO); Creve Coeur Lake Park, 26 Sep 1939, *O. Petersen s.n.* (MO); Lower Coldwater Creek, floodplain forest, 19 Jun 1979, *S.L. Orzell 132* (MO). **Stone Co.:** 2 mi SW of Jamesville, Silver Lake, wet margins, 11 Sep 1976, *Summers, B. 285* (MO). **Taney Co.:** Swan, rich woods, 22 Sep 1905, *B.F. Bush 3344* (MO, NY, US). **Texas Co.:** near junction of N and S forks of Jacks Fork, S of Arroll, Sep 1939, *B. Bauer 1136* (F). **Warren Co.:** along tributary of Dry Fork of Charrette Creek, 4 mi NW of Hopewell, 7 mi SW of Warrenton, 8 Jun 1952, *J.A. Steyermark 73329* (F); Toque Creek, 6-6.5 mi NE of Marthasville, sandstone and limestone slopes and bluffs, valley woods, 22 Aug 1956, *J.A. Steyermark 82485* (MO). **Washington Co.:** Old Mines, rich soil, banks, etc., 17 Aug 1929, *J.H. Kellogg s.n.* (MO); junction HWY 21 & 47, in wet area, 16 Sep 1982, *A. Christ s.n.* (MO). **Wayne Co.:** Williamsville, thickets, 10 Aug 1898, *C. Russell s.n.* (MO). **[no county]:** : no further locality, in civitate Missouri, Unio itiner.,1837, *B. Frank s.n.* (MO, NY); no further locality,1860?, *F. Pech* s.n. (NY); F[orest?] Park, 20 Sep 1891, *[no collector given] 279* (MO).

NEW YORK. Chautauqua Co.: Chautauqua, [no date], *B.H. Patterson s.n.* (CM). **Erie Co.:** Buffalo,1844, *Prestele s.n.* (GH). **Livingston Co.:** near Golah, on Genesee River Flats, thicket bordering fields, 20 Sep 1930, *W.A. Matthews 3452* (BRIT).

OHIO. Butler Co.: Oxford Twp., Bishop Circle woods, E of Upham Hall, Miami University Campus, Oxford, 19 Aug 1987, *M.A. Vincent 2600* (MU); Oxford, Bishop Circle, on campus of Miami University, disturbed oak-hickory woods, 8 Sep 1989, *T.G. Lammers 7108* (ILL, MU). **Champaign Co.:** Rosewood,1916, *T. Draper A144* (US). **Cuyahoga Co.:** Rocky River, Lakewood, bottoms, 14 Sep 1902, *L.D. Stair s.n.* (CLM); Rocky River Reservation: along W side of Rocky River, SW corner of Middleburg Heights, open thickets and open woods, floodplain, throughout open thickets and young woods, 19 Sep 1981, *J.K. Bissell 81:161* (CLM); Olmsted Falls, Rocky River, Cleveland Metropark: Bike Path ca 100 ft S of Willow Bend picnic area, 10 Sep 1984, *D. Lad s.n.* (CLM); Olmsted Falls, Rocky River Cleveland Metropark: Exercise path, S of Baldwin Lake, scattered on both sides of path at this site, 10 May 1986, *D. Lad s.n.* (CLM); Olmsted Falls, Rocky River Cleveland Metropark: South Quarry, Exercise Trail S of Baldwin Lake both sides of path at this site, 22 Aug 1986, *D. Lad s.n.* (CLM). **Erie Co.:** German Settlement woods, Perkins, 31 Aug 1896, *E.L. Moseley s.n.* (US). **Fairfield Co.:** Lancaster, Aug 1878, *W.A. Kellermann s.n.* (F). **Franklin Co.:** Worthington, [no date], *J.L. Riddell s.n.* (NY). **Hamilton Co.:** Luddham[?] meadow just below the house, 21 Sep 1842, *T.G. Lea Herbarium s.n.* (PH); Cincinnati, Mt. Echo,1882, [no collector given] *s.n.* (CINC); no further locality, 8 Sep 1904, *E.L. Braun s.n.* (US); Fernbank - ad ripas fluminis Ohio, prope "North Bend", [no date], *C.W. Short s.n.* (GH, MO). **Jackson Co.:** Leo, [no date], [no collector given] *s.n.* (NY). **Lake Co.:** near Painesville, 14 Sep 1885, *W.C. Werner s.n.* (CLM); near Painesville, 4 Sep 1887, *W.C. Werner 3585* (MIN); near Painesville, 4 Sep 1887, *W.C. Werner 5097* (NY); near Painesville, 4 Sep 1887, *W.C. Werner s.n.* (CLM, MSC); near Painesville, Sep 1887, *W. Werner s.n.* (MIN); Painesville,

[no date], *W.C. Werner s.n.* (MSC); Willoughby Twp., Willoughby, 4 Sep 1932, *B.D. Hawgood s.n.* (CLM). **Mahoning Co.:** 1.1 km SW of Poland, along Yellow Creek, Poland Municipal Forest, floodplain woods, 310 m, 41°00'50"N, 80°37'03"W, 9 Oct 1997, *B.L. Isaac & J.A. Isaac 10174* (YUO). **Montgomery Co.:** Dayton,1834, *J.L. Riddell s.n.* [type of *Prenanthes miamiensis*] (PH); Dayton, Sep [no year], *J.W. Nau s.n.* (CINC). **Pickaway Co.:** 1 mi E of Thatcher, 26 Oct 1972, *F. Bartley s.n.* (OU). **Richland Co.:** Cass Twp., 50 yds E of Bowman Street Rd and 75 yds S of Black Fork River, Shiloh Quad, NE¼, Sec. 27, river floodplain, 14 Oct 1991, *S.M. McKee 88* (CLM); Cass Twp., 50 yds E of Bowman Street Rd and 75 yds S of Black Fork River, Shiloh Quad, NE¼, Sec .27 Elm-Ash river floodplain, 16 Sep 1992, *S.M. McKee 144* (CLM). **Ross Co.:** along Scioto River E of Ross County Infirmary, on bluff, 2 Oct 1951, *F. Bartley s.n.* (OU). **Sandusky/Seneca Co.'s:** Green Spring, Jul 1889, *H.C. Beardslee Herbarium s.n.* (NYS); Green Spring, Sep 1889, *H.C. Beardslee Herbarium s.n.* (F); Green Spring, Sep 1890, *H.C. Beardslee Herbarium s.n.* (MIN). **Trumbull Co.:** Mecca Twp., S of West Mecca between Hoagland-Blackstub Rd and Mosquito Lake, in humus of average to dry moisture, open exposure, 7 Jul 1981, *P. Hovance s.n.* (YUO); Howland Twp., N of North River Road on W side of Mosquito Creek, in deciduous floodplain woods, 11 May 1999, *C.F. Chuey* 26803A (YUO).

PENNSYLVANIA. Allegheny Co.: along Chartiers Creek below Mayview, in rocky woodlands, thickets; 2 Sep 1932, *J. Bright 7465, 7691* (CM); near Mayview, in woodlands, 2 Sep 1932, *J. Bright 7617* (PH); at Mayview, in thickets, 10 Sep 1933, *J. Bright 8743* (PAM). *8746* (PH); Mayview, in thickets, 12 Sep 1933, *J. Bright 8712*

(MIN); Woodsville, above Chartiers Creek near Mayview Sanitorium, rich wooded slope, 10 Sep 1939, *J.A. Churchill s.n.* (MSC). **Beaver Co.:** Bocktown, junction of PA 151 and Raccoon Creek; 40-32N, 80-18W, forested floodplain, 5 Nov 1994, *J.A. Isaac 7009* (CM); 1.8 km SW of Cannelton, along North Fork Little Beaver Creek; 40-47-26N, 80-29-37W floodplain woods, 19 May 1998, *B.L. Isaac & J.A. Isaac 10488* (CM). **Butler Co.:** Moores Corners, 41-02N, 80-06W, floodplain and swamp, 8 Sep 1994, *J.A. Isaac 6360* (CM); 2 mi W of Slippery Rock, Wolf Creek Narrows, 41-03N, 80-05W, wooded floodplain, 10 Sep 1994, *J.A. Isaac 6390* (CM); 0.7 km SE of Moores Corners, along Slippery Rock Creek, floodplain woods, 335 m, 41°02-08"N, 80°06'19"W, 25 May 1998, *B.L. Isaac & J.A. Isaac 10537a* (YUO). **Indiana Co.:** along Yellow Creek at Rt. 259, 3 Sep 1952, *L.K. Henry & F.H. Beer s.n.* (CM). **Lawrence Co.:** 2.6 km NE of Hillsville, along Mahoning River; 41-01-44N, 80-30-30W, floodplain woods, 19 May 1998, *B.L. Isaac & J.A. Isaac 10490* (CM); 4.8 km SE of New Wilmington, along Neshannock Creek; 41-05-01N, 80-18-30W; alt. 285 m, floodplain woods 24 May 1998, *B.L. Isaac, J.A. Isaac & H.R. Isaac 10534* (CM), 3 Oct 1998, *B.L. Isaac & J.A. Isaac 11625* (CM); 3.5 km NW of Eastbrook, along Neshannock Creek, State Game Lands 178, floodplain woods, 275 m, 41°03'17"N, 80°18'52"W, 11 Apr 1998, *B.L. Isaac & J.A. Isaac 10251* (YUO), 8 Sep 1998, *B.L. Isaac & J.A. Isaac 11584* (CM, YUO), 18 Oct 1998, *B.L. Isaac & J.A. Isaac 11738* (CM), 13 Jun 1999, *B.L. Isaac & J.A. Isaac 12026* (YUO); Old Enon, floodplain of North Fork of Little Beaver Creek; 40-51-57 N, 80-27-51 W; alt. 985 ft, floodplain woods 29 April 2000, *J.A. Isaac & H.R. Isaac 12116* (CM, YUO). **McKean Co.:** 2.4 km S of Eldred, along Allegheny River, 41-56-08N, 78-22-51W, alt. 1350 ft, 6 May 2000, *B.L. Isaac & J.A. Isaac 12120* (CM). **Mercer Co.:** [West] Middlesex, 15 Sep

1869, *A.P. Garber s.n.* (BRIT, GH, PH, US); Greenville, Sep 1869, *A.P. Garber s.n.* (NY); no further locality, [no date], *T.C. Porter s.n.* (US). **Somerset Co.:** Jake Zimmerman's meadow, by creek, 27 Aug 1877, *B.H. Patterson s.n.* (CM). **Venango Co.:** 3.6 mi N of Kennerdell, along Allegheny River; 41-19N, 79-51W, roadside thicket on floodplain, 5 Oct 1997, *B.L. Isaac & J.A. Isaac 10172* (CM); ca 3.3 km SE of Pecan, along Allegheny River; 41-19-16N, 79-51-01W; alt. 285 m, floodplain woods, 21 May 1998, *B.L. Isaac & J.A. Isaac 10491* (CM); ca 3.3 km SE of Pecan, mouth of Little Sandy Creek; 41-19-33N, 79-50-51W; alt. 290 m, floodplain woods, 21 May 1998, *B.L. Isaac & J.A. Isaac 10493* (CM). **Washington Co.:** 6.5 km WSW of Florence, along Aunt Clara Fork, 40°26'47"N, 80°30'32"W, lower slope in mixed deciduous woods, 19 May 1998, *B.L. Isaac & J.A. Isaac* 10486 (CM); 1.4 km NW of Dunsfort, along Buffalo Creek, 40-11-50N, 80-30-51W, alt. 830 ft , 30 April 2000, *B.L. Isaac, J.A. Isaac & H.R. Isaac 12118* (CM, YUO).

TENNESSEE. Davidson Co.: banks of Mill Creek, near Nashville, Oct 1877, *A. Gattinger s.n.* (NY). **Montgomery Co.:** Lock B Road, Cumberland River, 1 mi W of Old Lock B site, S of Excell community bottomlands, weedy bank between road and bluffs, 2 Sep 1991, *E.W. Chester 91-105* (TENN, VDB). **Shelby Co.:** along Loosahatchie River, SW side of Hwy 70/79 bridge over the river, ca 500 yards from highway, bottomland hardwood forest, Oct 1986, *V. Bates 10612* (VDB). **Stewart Co.:** Land Between the Lakes, Bear Creek bottom, cultivated in Fayette Co. KY, 9 Sep 1993, *J. Campbell s.n.* (KY).

WEST VIRGINIA. Brooke Co.: 1.2 km ESE of Bethany, along Buffalo Creek, 40-12-12N, 80-32-32W, alt. 820 ft.,30 Apr 2000, *B.L. Isaac, J.A. Isaac & H.R. Isaac 12117* (CM, WVA, YUO); 2.7 km ESE of Louise, along Cross Creek, 40-17-55N, 80-32-03W, alt. 730 ft, 30 Apr 2000, *B.L. Isaac, J.A. Isaac & H.R. Isaac 12119* (CM, WVA). **Randolph Co.:** Elk River, along road before Whittiker Falls, 26 Aug 1971, *W. Tolstead & E.E. Hutton s.n.* (WVA).

WISCONSIN. Crawford Co.: Lynxville, 1 Sep 1915, *R.H. Denniston s.n.* (WIS). **Green Co.:** town of Decatur, along Milw. RR, Sect. 31-32, low prairie, 15 Aug 1956, *H.C. Greene s.n.* (BRIT, WIS). **Sauk Co.:** no further locality, T11N, R5E, Sec. 33, NWSW, SWNW, moist seepage areas in oak-maple forest, 1 Sep 1992, *A. Clark 52* (WIS).

UNKNOWN LOCALITY: in regione Illinoensi et in excelsis Carolinae, [no date], *Michaux s.n.* **holotype** (GH, photograph); no locality, [no date], *B.B. [=Robert Buchanan?] s.n.* (WIS); no locality given, [no date], *J.L. Talbot 3995* (PH).

Herbaria specimens were borrowed (or data obtained) from: BRIT, CINC, CLM, CM, F, GH (HUH), ILL, ILLS, KY, MICH, MIN, MO, MSC, MUHW, ND, NY, NYS, OU, PAM, PH, TENN, UM, US, VDB, WIS, WVA, and YUO. Acronyms are from Holmgren, P. K. et al. (1981).

Ecological Field Studies

Observations of *Prenanthes crepidinea* at the three study sites reveal that the earliest plants emerge in late March to early April while the forest canopy is still quite open. Emergent plants start out as a small basal rosette (Fig. 7). These rosettes grow in

relation to the size of their rhizome. Smaller rhizomes grow smaller plants. These rosettes may be quite close together and in areas dominate the forest floor. Three one-meter square plots that were randomly chosen had densities of 55, 94 and 123 individuals on 14 May 2000. Well after some of the smaller individuals had already senesced. These carpets of *P. crepidinea* are often heavily predated by white-tailed deer. Often after the deer have found the plants, all that remains are stubs of petioles (Fig. 8). There is some evidence that rhizomes of vegetative rosettes may grow new plantlets by budding off the rhizome. This vegetative reproductive possibility needs further investigation. The smaller rosettes begin to senesce as the canopy closes. By late April the individuals that are bolting to bloom for the season are already evident. The denser the canopy becomes, the more rosettes begin to yellow and senesce. By late June, there is no evidence that any vegetative rosettes ever existed. At this point in the season, only the individuals that are bolting to bloom remain. Mention of this early senescence of the young rosettes was not found in any literature references. Very few of the herbarium specimens borrowed were early season basal rosettes. The individuals that are bolting continue to grow taller as the season progresses. By late July flower buds have begun forming. The plant continues to elongate until mid-August when the earliest flowers begin to open. The top center flower is the first to open. By this point in the season, the predation of the species by herbivores has greatly diminished. This is most likely due to the senescence of the young, and thus less *P. crepidinea* to choose from. The surrounding vegetation is also much taller by this point and no doubt acts as a screen for the bolting individuals. By mid-September, the lowest leaves of the stalk begin wilting and senesce; the upper leaves remain green. Individuals that managed to survive the herbivory are at full bloom (Fig. 16). They

continue to bloom until the canopy looses its leaves and heavy frost kills them. Blooming often continues into mid-November. Shown in Fig. 9 is a phenophase diagram for *P. crepidinea.*

In the 1998 season, fourteen blooming individuals at the State Game Lands 178 site made it to the end of the season. These individuals ranged from 77 to 184 cm tall. Only seven of these plants set seed. The viability of those seeds is unknown.

Poland Municipal Forest also had fourteen individuals survive to the end of the 1998 season. These plants were on the average taller than the individuals that bloomed at State Game Lands 178. This could be due to the soils at Poland Municipal Forest being richer. Other possibilities are lower light levels and less competition at the Poland Municipal Forest site. The plants ranged from 114 cm to 220 cm tall at Poland. Only two of these individuals set seed. The seeds from one of these plants fell into Yellow Creek where they floated on the water like a dry fly and were attacked by minnows. The 1999 season was not as successful. Twenty-five individuals attempted to bloom, but only one had set seed by late October.

Twelve plants that bloomed in 1998 at State Game Lands 178 were dug up in the spring of 1999 and the rhizomes inspected. All individuals had rhizomes that were rotting with no evidence of regrowth. Contrary to published descriptions of the plants life cycle as a biennial (Bright 1939) or perennial (USDA, NRCS 1999, and others), *Prenanthes crepidinea* proves to be a monocarpic perennial. The seeds of *P. crepidinea* are wind dispersed, as is the norm for the genus.

Habitats from known sites for *Prenanthes crepidinea* were compared with habitat descriptions found on herbarium specimens to try and identify a characteristic habitat for

the species. Most specimen habitat descriptions agree with visited sites. The majority of sites are moist areas, typically floodplains. The floodplain descriptions vary from thicket areas to relatively open sites. Observations at the study sites would suggest that the species tends to develop faster in areas that are less shady. Several areas that suffered disturbances in the canopy tended to have a higher number of individuals bolt in the years following the disturbances. Julian Campbell (personal communication) also observed this in Kentucky. The canopy at State Game Lands 178 was very dynamic throughout the study period. Areas with beaver activity and bank erosion in the preceeding years had several individuals bolt for blooming during the study. A few individuals at Poland Municipal Forest bloomed in shadier parts of the park, but these were the most diminutive of the blooming individuals.

Habitat characteristics need to be investigated for other portions of the species range. It is possible that the habitat may differ throughout the range of the species. Some species that are known from lower areas in the northern portions of their range tend to climb as they get further south. The full extent of the known range of *Prenanthes crepidinea* would need to be explored for a totally complete habitat description to be written. Specimens from herbaria would suggest that the species has potential to be very versatile. Habitat notes on specimens range from floodplain thickets, low prairies and bottoms to wooded ridges, hilltops and disturbed oak-hickory woods. While the majority of habitat descriptions fit what the author observed, the other habitats mentioned are worth investigating.

Soils

The analyses from the three sites revealed that all of the soils are fairly acidic with pH ranging from 5.5 at Slippery Rock Natural Area to 6.1 at Poland Municipal Forest (Table 3). All sites had some soil nutrient levels below optimum with P_2O_5 being the lowest. Other nutrients at these sites were also measured to be below optimum by the Agricultural Analytical Services Laboratory of The Pennsylvania State University (Tables 4-6).

The major soils at State Game Lands 178 (Fig. 10) where the *Prenanthes crepidinea* occurs are: Ho-Holly silt loams and Sn-Sloan silt loam. Holly silt loams are nearly level, deep poorly drained soils that occur on floodplains. Permeability is moderate and moderately slow with a high available water capacity. These soils are frequently flooded with slow runoff. Sloan silt loam is a nearly level deep very poorly drained soil on floodplains. Permeability is moderate and available water capacity is high. Runoff is slow and flooding is frequent (Smith 1982).

The major soils at Poland Municipal Forest (Fig. 11) that foster *Prenanthes crepidinea* are: Lb-Lobdell loam and Wc-Wayland silt loam. Lobdell loam is a deep moderately well drained nearly level soil. Permeability is moderate with a high available moisture capacity. Flooding is common. Wayland silt loam is a soil that occupies floodplain areas and is prone to flooding. These soils are generally deep, poorly drained and nearly level. Permeability is moderately slow with a high available moisture capacity (Lessig et al. 1971).

The major soils at Slippery Rock Natural Area (Fig. 12) that contain *Prenanthes crepidinea* are: At-Atkins silt loam, Ph-Philo loam, Po-Pope loam and RdC-Riverhead

sandy loam. Atkins silt loam, a nearly level, very deep and poorly drained soil that occurs on floodplains. Atkins silt loams have moderate to slow permeability in the subsoil and moderately rapid to moderately slow permeability in the substratum. Atkins silt loams have a high available water capacity with slow runoff and frequent flooding. Philo loam, a nearly level, deep and moderately drained soil that is mainly on floodplains. Philo loam has a moderate to high water capacity with slow runoff. Flooding is frequent on this soil with a seasonal water table at a depth of 18 to 36 inches (Smith 1989). Pope loam, also a near level, very deep well drained soil that is on floodplains of major waterways. Pope loam has a moderately rapid or moderate permeability with a moderate to high available water capacity. Pope loam has a slow runoff and is only occaisionally flooded. Riverhead sandy loam, a strongly sloping, very deep well drained soil. Riverhead sandy loam is usually on outwash plains, kames, eskers and terraces with convex slopes. Riverhead soils have moderately rapid permeability in the subsoils and very rapid permeability in the substratum. The available water capacity is moderate. Runoff is medium or rapid.

All three sites have soils that are nearly level containing silt loam with moderate permeability and frequent flooding.

Associated species

Plants collected at State Game Lands 178 are listed in Table 7. Plants collected at Poland Municipal Forest are listed in Table 8. The plants collected at Moraine State Park, Slippery Rock Natural Area are listed in Table 9.

Introduced species accounted for 11.8% of the species collected at the Moraine State Park, Slippery Rock Natural Area. State Game Lands 178 showed a similar rate

with 14.5% of those species being introduced. Poland Municipal Forest in Ohio had only 7.7% of the species collected being introduced. Rhoads & Klein (1993) show that 37.4% of the total Pennsylvania flora is introduced. With such low incidence of introduction at the sites where *Prenanthes crepidinea* occurs, it could be suggested that *P. crepidinea*, like many other native species, require only that its native habitat be left relatively undisturbed. Fifty-one species are shared between the Lawrence and Mahoning sites. Fifty-six species are shared between the Butler and Lawrence sites. Fifty-three species are shared between the Butler and Mahoning sites. Only 35 species are shared at all three sites. Table 10 lists the species found at all three sites. Of these 35 species, only four are introduced species. Those four species are *Hesperis matronalis* L., *Berberis thunbergii* DC., *Rosa multiflora* Thunb. and *Ranunculus repens* L.. All of these aliens are known to be wide invaders and are troublesome in many native habitats.

Floral visitors

Insects from three Orders were found visiting the florets of *Prenanthes crepidinea* (Table 11). The Order with the most species collected was Hymenoptera. This Order is known to have important pollinators as members. Five families of Hymenopterans were found in the samples, two of which were considered to be incidental (personal communication, J. Rawlins). The two incidental Hymenopterans collected were *Camponotus pennsylvanicus* (DeGeer) of the Formicidae: Formicinae collected once at Poland Municipal Forest; and *Glypta animosa* Cresson of the Ichneumonidae: Banchinae: Glyptini, from State Game Lands 178, also collected only once. The three families of Hymenopterans that were deemed to be possible pollinators included five species. These included *Andrena (Callandrena) simplex* Smith of the Andrenidae; *Bombus*

(Pyrobombus) bimaculatus Cresson and *Bombus (Pyrobombus) vagans vagans* Smith both of the Bombinae; and *Augochlora (Augochlora) pura pura* (Say) and *Augochlorella striata* (Provancher) of the Halictidae: Halictinae: Augochlorini. Of these species only *Augochlorella striata* has previously been reported to pollinate *Prenanthes* (personal communication, J. Rawlins).

The *Andrena (Callandrena) simplex* may be the most interesting species captured. Members of the subgenus *Callandrena* are solitary oligolectic univoltine species that emerge in the fall, when *Prenanthes crepidinea* blooms, and are known to affiliate with members of the Asteraceae. *Andrena (Callandrena) simplex* is an infrequently encountered species (Carnegie Museum had only five specimens in their collection previous to this study) (personal communication, J. Rawlins). This study captured ten specimens of this species from both sites that produced blooming individuals during the study.

The other Order present as a possible pollinator is Diptera. *Epistrophe (Epistrophella) emarginata* (Say) of the Syrphidae: Syrphinae is the only species of Diptera collected. This syrphid is a widespread polylectic Holarctic species known to frequently visit flowers and is more than likely a pollinator for *Prenanthes crepidinea.*

The species collected that were deemed as incidentals were *Psyllobora virgintimaculata* (Say) of the Coccinelidae: Coccinellinae; and *Brachypterus urticae* (Fabricius) of the Nitidulidae: Cateretinae, both members of the Order Coleoptera.

This floral visitor study, although small, shows that the outlook for pollen flow for *Prenanthes crepidinea* is optimistic. *P. crepidinea* is evidently not dependent upon a single insect for a pollinator. Several polylectic autumn flying pollinators were caught

visiting *P. crepidinea*. In addition to these polylectic pollinators, *P. crepidinea* also benefits from a few oligolectic species that specialize in Asteraceae. This is very beneficial to the plant. If the plant should fail to bloom for several seasons, as seems to be the case with *P. crepidinea*, local populations of the pollinators will not go extinct. If the more specialized pollinators happen not to be present at a site, the more generalist pollinators, such as *Bombus*, should be present to pollinate the species.

Few insects were observed visiting the florets of *Prenanthes crepidinea* in the 1998 season, when pollinator numbers where at a low throughout the area (personal communication, D. Vogler), despite several hours of observation. The 1999 season proved better for pollinator numbers, although not outstanding. Time of observations may have proved to be a limiting factor in insect collections, most observation times were late afternoon or evening. Many pollinators tend to fly in morning hours to limit water problems and avoid dehydration (personal communication, J. Rawlins).

Pests and parasites

Observations of *Prenanthes crepidinea* for pests and parasites showed that the white-tailed deer (*Odocoileus virginianus*) is the major predator of the species. White-tailed deer proved to prefer the species as a food plant. *P. crepidinea* was eaten when nearby individuals of species known to be eaten by deer were apparently left alone. Without erecting exclosures around the *P. crepidinea*, individuals of the species could not be tracked. Any broken vegetation near the plants only seemed to aid the deer in finding them. Deer were an obvious problem at all three study sites.

Galls were found on stems of *Prenanthes crepidinea* at the State Game Lands 178 site in Lawrence County, Pennsylvania on 28 August 1998. The galls were located on

the stem, usually just above the roots, but sometimes several decimeters above the ground. The galls resemble small knotty masses (Fig. 13). The plants with galls were mapped on 12 September 1998 so that the galls could be recovered early in 1999. Other members of the Asteraceae were also searched for galls. Genera at the site that were searched are *Verbesina*, *Vernonia*, *Rudbeckia*, *Solidago*, *Lactuca*, *Ambrosia* and *Aster*. No galls were found on any other Asteraceae. The gall-bearing plants were left in the field to overwinter. One gall-bearing plant was brought into the lab for dissection and collection of larvae. On 18 March 1999 gall-bearing plants were relocated in the field. These plants were gathered on 19 March 1999 and placed in a clear plastic shoebox for observation. On 2 May 1999 a few tiny insects appeared in the enclosure. The galls were then moved to glass pint jars with pieces of nylon stocking over the mouth of the jar. The culture jars were handed over to Dr. John E. Rawlins at the Carnegie Museum of Natural History, Pittsburgh, PA. Dr. Rawlins carefully examined the two culture jars daily and removed any insects that had eclosed since the previous day and placed them in 80% ethanol. Each day's eclosions were placed in a separate vial and carefully labeled. Close inspection by Dr. Rawlins revealed that the gall forming insect was a hymnopteran in the Cynipoidea: Cynipidae: *Aulacidea* sp. One species of *Aulacidea*, *A. nabali*, was reported to be restricted to *Prenanthes* (Felt 1917). Brodie originally described *Aulacidea nabali (Brodie)* from a gall at the base of the stem of *P. altissima (Nabalus altissimus)* from Toronto, Canada as *Aulax nabali* (Brodie 1892). Beutenmüller (1910) notes the species as occurring in Canada (Toronto); Massachusetts; New York; and New Jersey. Three herbarium sheets of *P. crepidinea* were found to have galls on them. The three sheets were: M. Bergseng, 11 September 1956, Champaign Co., Illinois (ILL); C.C.

Deam, 16 September 1906, Allen Co., Indiana (US); and P. Hovance, 7 July 1981, Trumbull Co., Ohio (YUO). Since most herbarium sheets were "top snatches" and did not contain the entire plant, it is hard to speculate whether more of them were gall bearing.

The galls also contained hemiparasites which eclosed with or shortly after the gall-forming wasp. The hemiparasites also noted by Brodie (1892), tended to eclose after the gall producer. The Cynipids and their hemiparasites that eclosed have been sent to Dr. Shiwei Liu of the Field Museum of Natural History for identification.

Felt (1917) notes a small purplish leaf gall caused by a gall-midge in the Itonididae, *Cystiphora canadensis* Felt, which also uses *Prenanthes* as a host. This gall-producer may also occur on *P. crepidinea* even though no evidence for this has been found.

Micromorphological findings

Table 12 shows which herbarium specimen the morphological structures were taken from, the collector, state of collection origin and the herbarium that houses the specimen. Micrographs obtained from herbarium specimen samples show that the pollen of *Prenanthes crepidinea* is not unlike other members of the genus. Milstead (1964) studied pollen using light microscopy in an effort to determine if pollen structure would be useful in determining species relationships in his revision of the genus *Prenanthes*. Sayers (1989), in her study of six species of *Prenanthes*, used scanning electron microscopy to determine if greater magnification would reveal differences among pollen grains that light microscopy did not reveal. Milstead and Sayers both concluded that pollen morphology is very uniform throughout the genus. They described *Prenanthes*

pollen, using terminology of Blackmore (1982), as spherical, triporate, with equatorial ridges of sharp conical spines of the echinolophate condition, and large hexagonal polar thickenings with a fine granular texture. They have three germinal pore lacunae, six paraporal lacunae, and six open abporal lacunae. This study found that *P. crepidinea* pollen fits that description. Milstead (1964) found *P. crepidinea* pollen ranged from 24.0 to 32.0 microns with an average of 29.55 microns. *P. crepidinea* pollen micrographs obtained from this study show the pollen used for this study falls in this range.

Seed coat and coma micrographs (Figs. 14A-14B) show microstructures that could prove useful in revisionary work for the genus. Other species in the genus would need to be examined to find out. The involucral bract in Fig. 14D shows that the hairs on the bract have glands on the ends. This is a character that is not common in the genus in the range of *Prenanthes crepidinea.*

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DISCUSSION

Prenanthes crepidinea proves to be an interesting species. New knowledge revealed by this study is that the species is monocarpic, i.e. blooms once and dies. The best time to locate new populations is in the spring when the full extent of the population is evident before the juveniles senesce. This information has already proven useful to state natural heritage programs in Pennsylvania, Ohio and Kentucky.

The major finding of comparing the data was that the significant factor that ties all the studies sites together was the relatively undisturbed high quality floodplain. Several of the species found in association with the study species are indicators of high quality floodplains, i.e. *Arisaema dracontium*. Kawano et al. (1983) states it best. "All the evidence available at present clearly indicate that life history characteristics of any species under consideration are reflections of a direct adaptation to the current physical environments where it lives as well as to the biotic communities with which it is associated, and also of their past evolutionary histories."

The future of this species is bright. Although it is currently listed as Endangered or Threatened in several states, I believe this will change. For a relatively large plant, *Prenanthes crepidinea* is easily overlooked. With knowledge of its life history revealed in this study, more populations will be found. Pennsylvania, Ohio and Kentucky have already contacted me for information on this species so that they could do more effective surveying. The information that juvenile plants are only emergent for a limited time allows botanists to look for the plant early in the spring when surrounding vegetation is lower and populations of *P. crepidinea* are most evident. Once populations are located, revisits can occur later in the season in search of blooming individuals. Even with

knowledge of population locales, the plant is still difficult to find. Floodplains are often a difficult place to be in mid-summer and early fall. Between vicious mosquitoes, stinging nettle, poison ivy and other itchy and biting things, plants of interest can be quite difficult to locate, even if you know where they are. (Fig. 15)

In Pennsylvania, where active exploration has taken place, the number of known sites has grown substantially and the species will more than likely be delisted in just a few more years. Knowledge of this species has come a long way since Deam (1940) stated that there was never more than one at a site. As long as good habitat is protected this *Prenanthes* should be quite secure.

Future studies

Several studies in the future could prove to be quite interesting. The wasp that formed the gall on this plant could turn out to be a new species. Dr. Shiwei Liu, the world expert in Cynipidae, did not recognize the species. He intends to compare the specimens to types for the genus. Whether it turns out to be a new species or not, it is of entomological interest. *Prenanthes crepidinea* has not been reported in the literature as a host for any of these gall wasps. Very little is known of this group of insects. Life history studies of the wasp are possible and of interest to entomologists. Collaborative studies with Dr. John Rawlins of the Carnegie Museum of Natural History and Dr. Shiwei Liu of the Field Museum are ongoing.

Hedge and Ellstrand (1999) conducted a study comparing life history traits of common species with life history traits of rarer species. Their study involved plants from California and the British Isles. A similar study in the eastern United States would be

interesting to see if the patterns they found hold for other regions. One danger in this study though, could be relying on information found in literature. This study showed that is not always a good idea. If only species that were studied in depth were included, the possibilities of bogus data could better be avoided.

Pollination biology studies would be another interesting avenue to investigate. Efforts to determine whether *Prenanthes crepidinea* was self-compatible or not were unsuccessful during this study. Exclosure studies were inconclusive. Collaboration with a pollination biologist to expand this effort would be a worthwhile future effort. This could be followed up with seed germination studies. Parameters that *P. crepidinea* seeds need to germinate could be determined. An expanded pollinator study could be another interesting research route. This effort could expand the knowledge of the plant as well as increase knowledge of the pollinators, as this study did with *Andrena simplex*. The small successes with this limited pollinator study are intriguing and compel one to expand the study.

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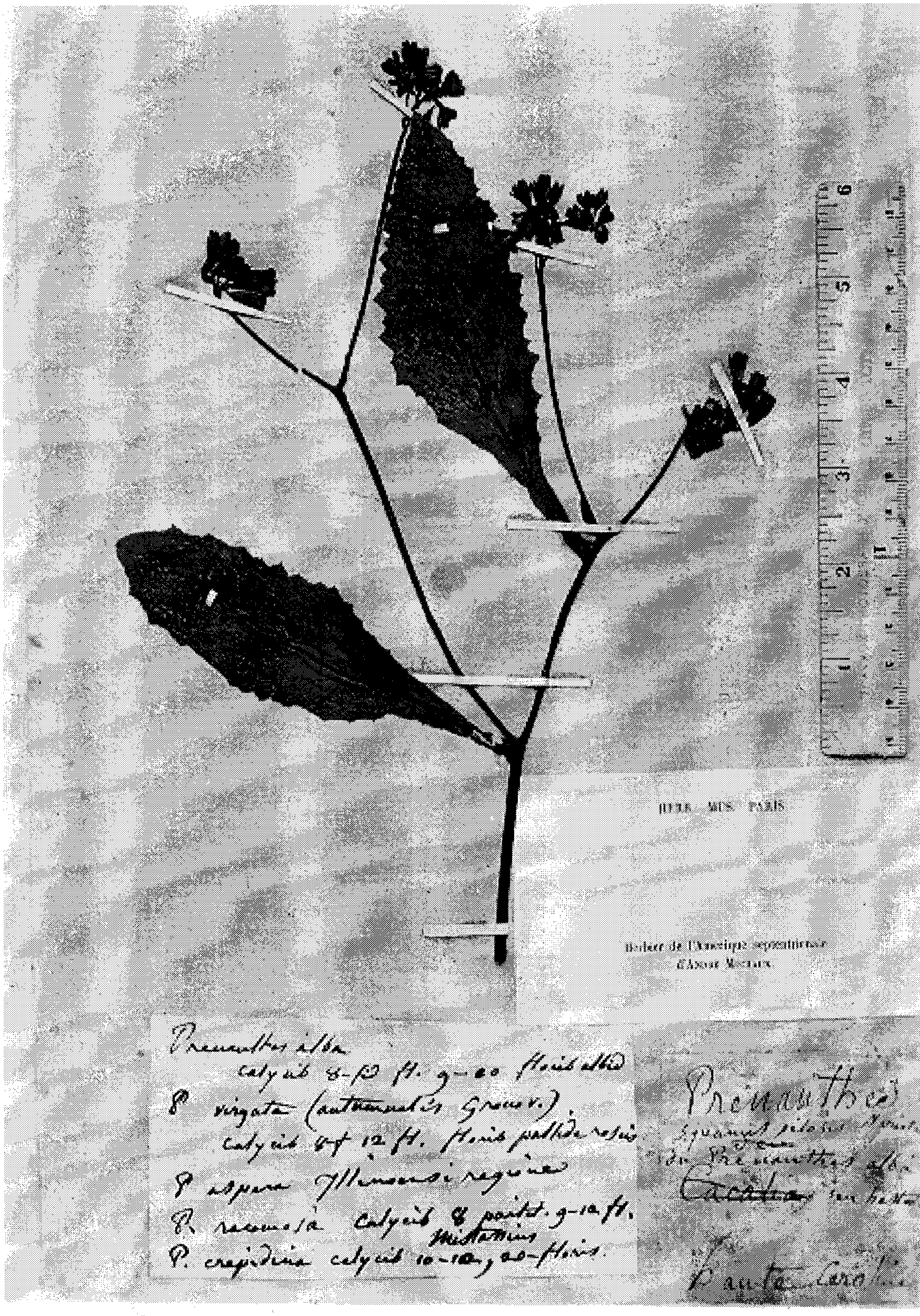
FIGURES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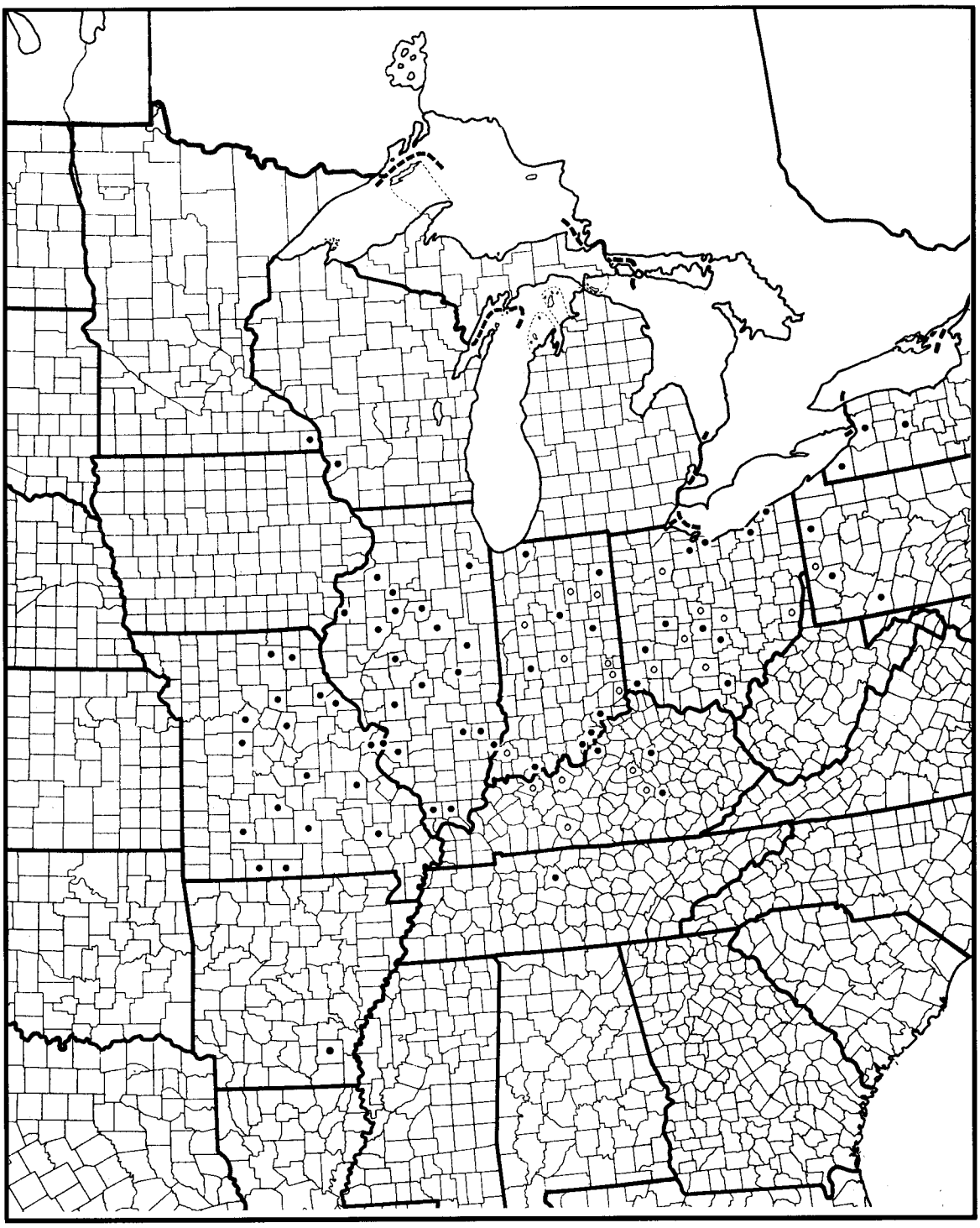
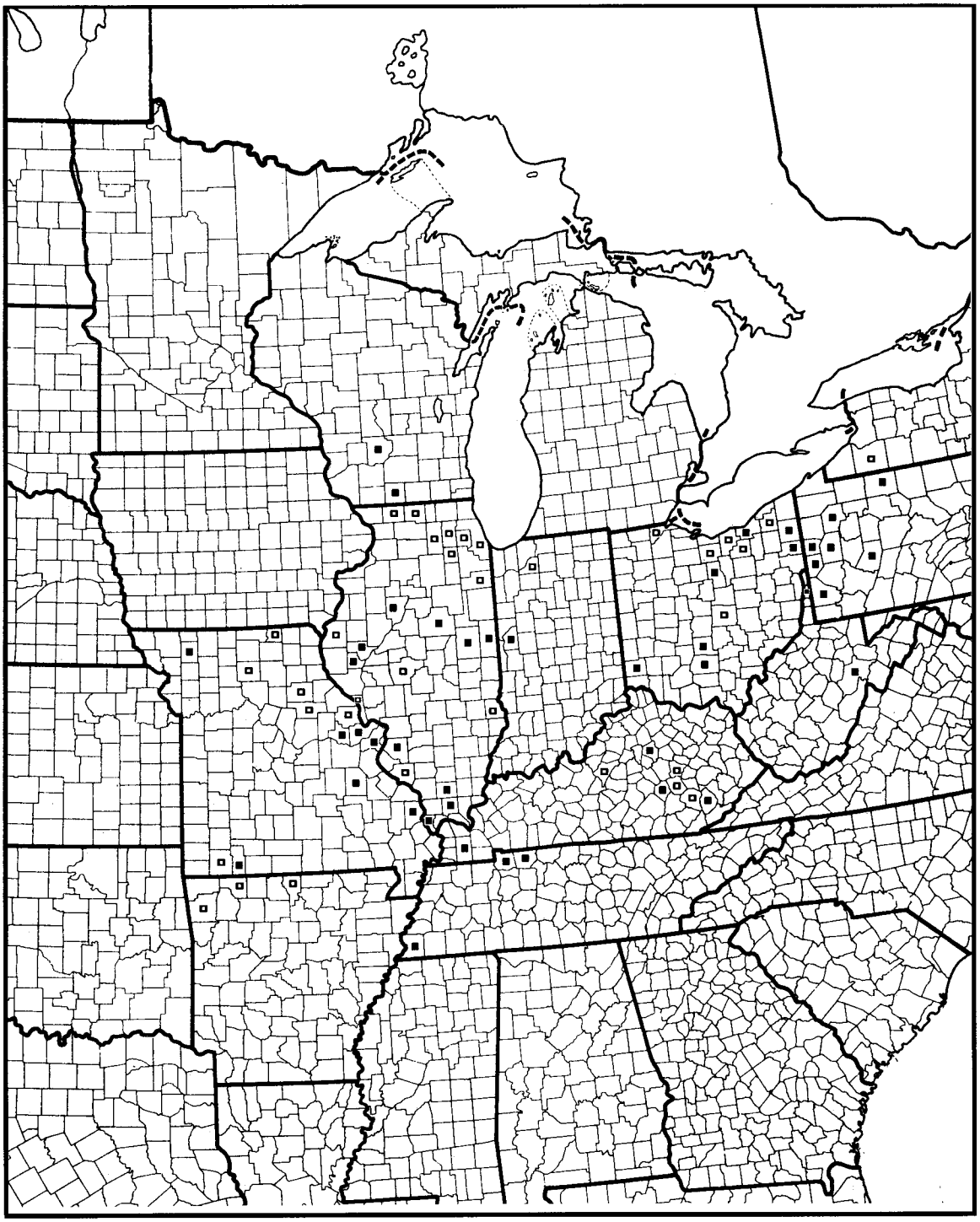
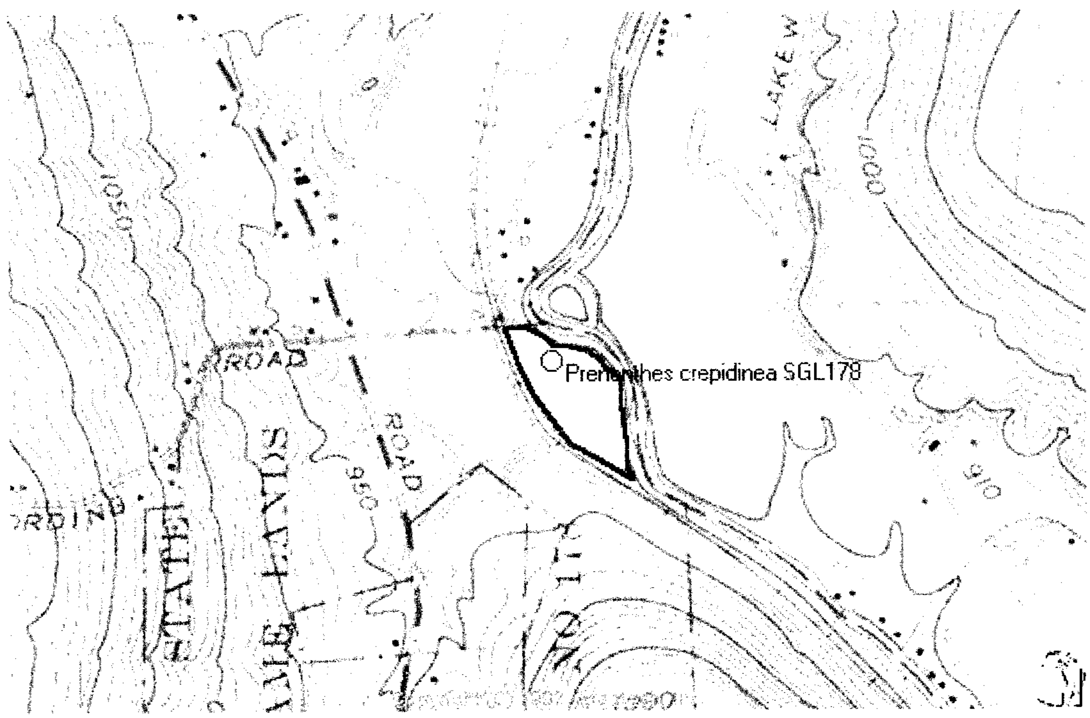
Herbier de l'Amérique septentrionale d'André Michaux
Prenanthes



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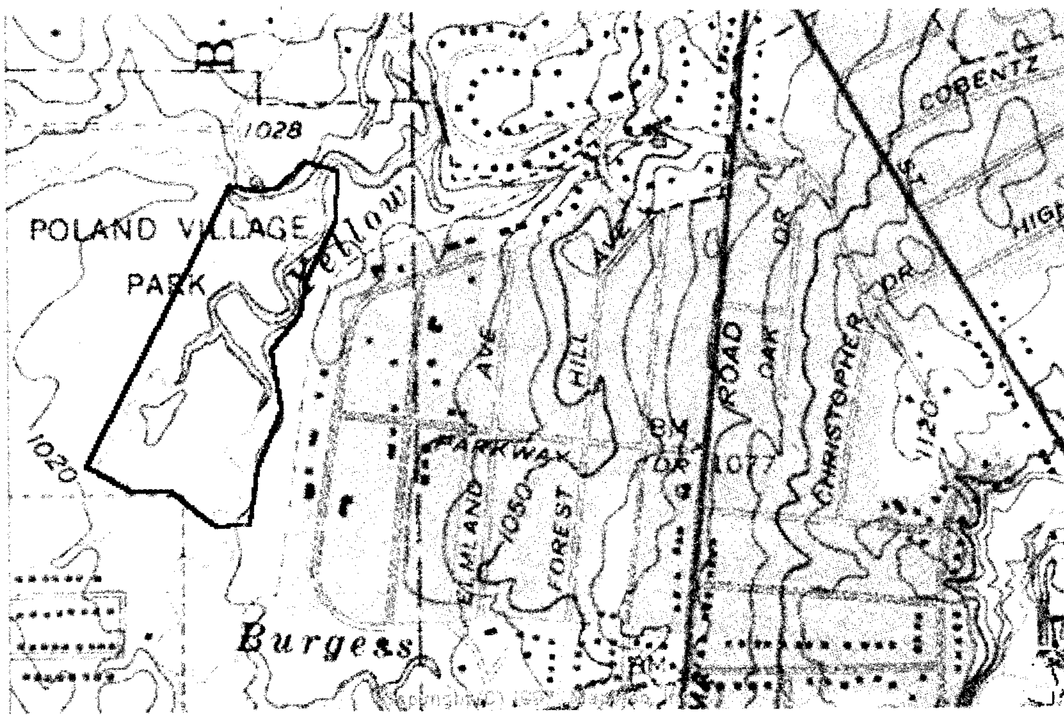
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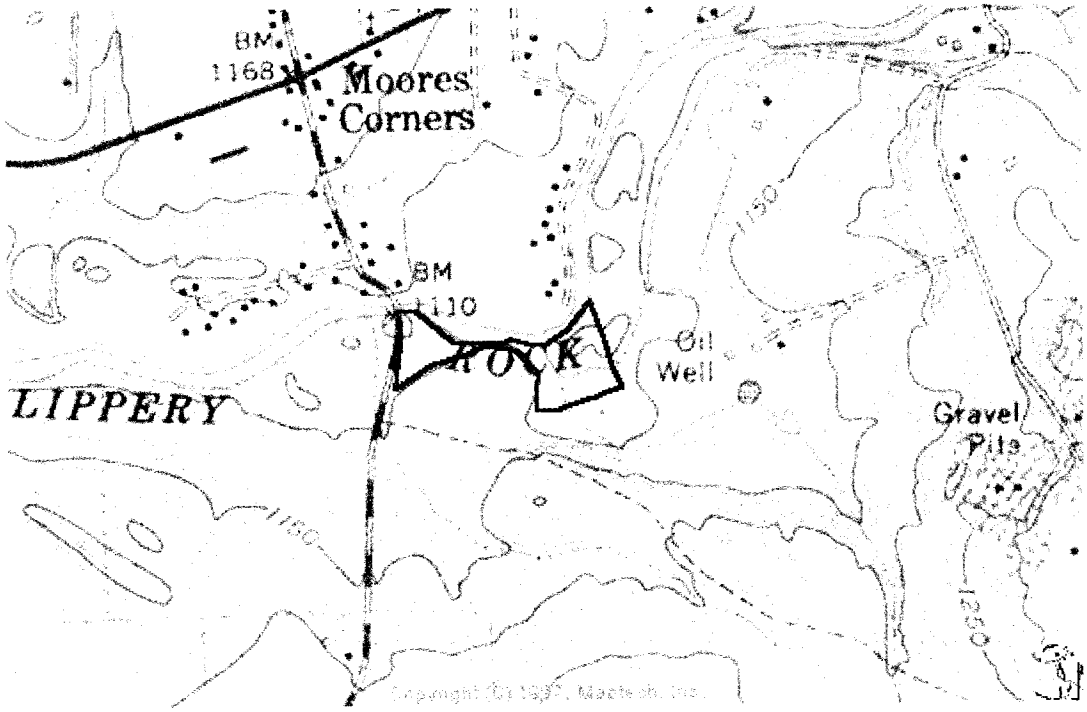
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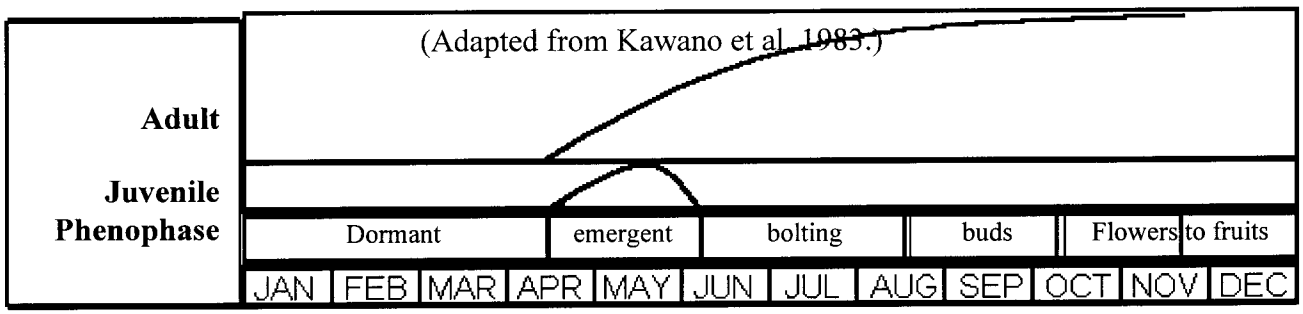

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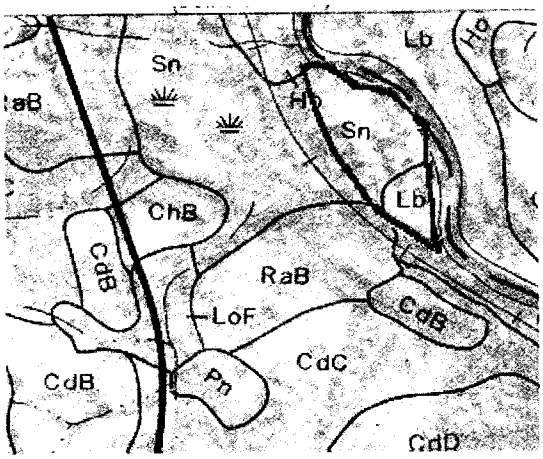
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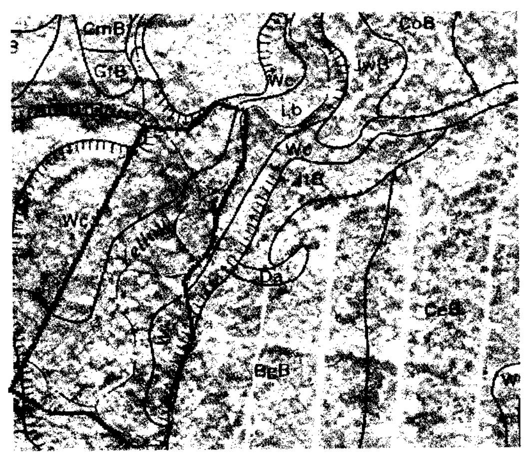
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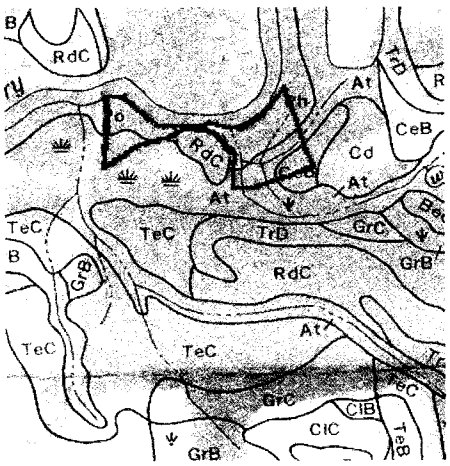
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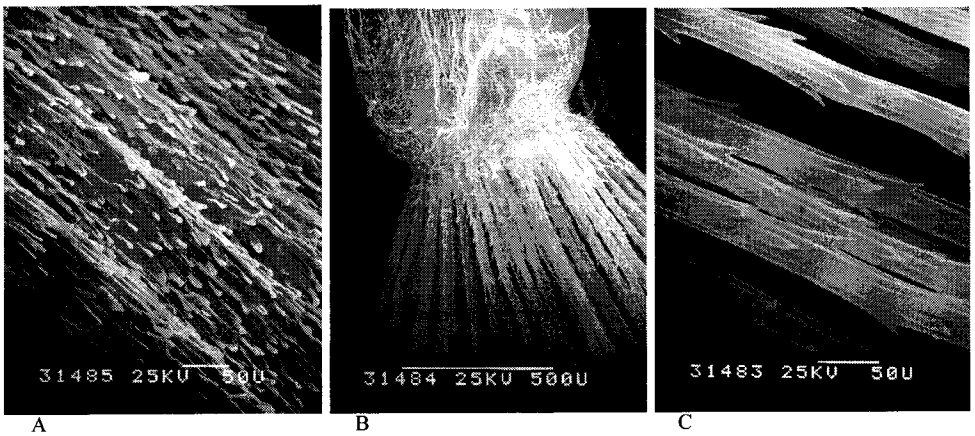
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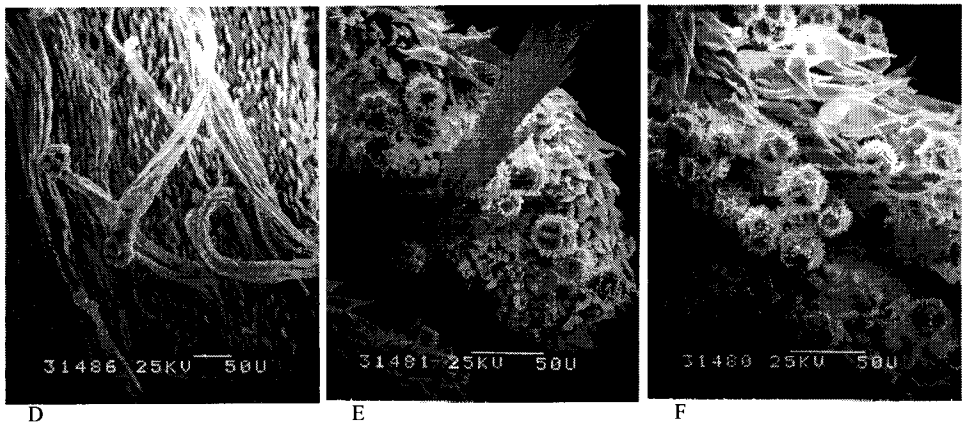
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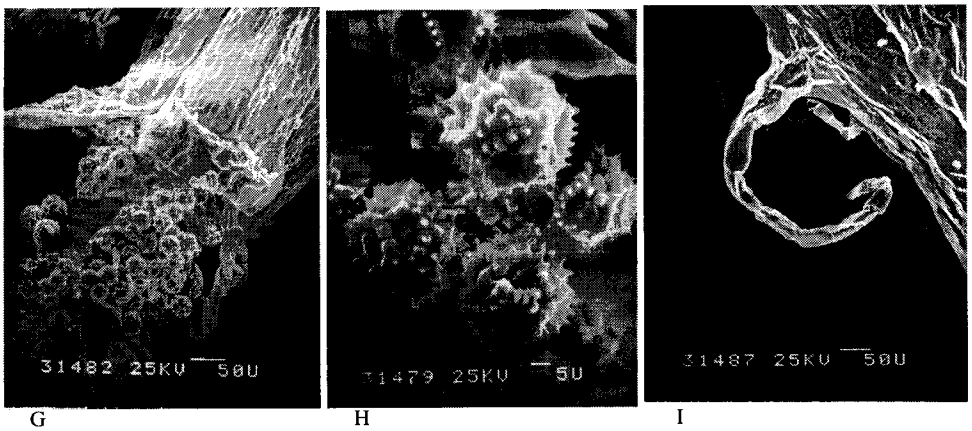
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G H I

TABLES

Table 1
Synopsis of Exsiccatae by year of Collection

Year	Count of Year	Year	Count of Year	Year	Count of Year
1833	1	1899	1	1954	1
1834	2	1900	8	1956	7
1835	1	1902	1	1957	4
1837	5	1904	4	1959	1
1842	1	1905	3	1960	1
1844	1	1906	5	1964	2
1858	1	1910	2	1965	1
1860	4	1914	1	1970	1
1868	2	1915	1	1971	1
1869	6	1916	1	1972	1
1870	1	1919	1	1974	3
1874	3	1921	2	1975	1
1877	13	1927	1	1976	1
1878	1	1928	1	1979	1
1879	5	1929	1	1981	2
1880	2	1930	1	1982	1
1881	2	1932	3	1984	1
1882	1	1933	4	1985	1
1884	1	1935	1	1986	3
1885	1	1936	1	1987	1
1886	3	1937	7	1989	3
1887	10	1938	1	1990	2
1888	3	1939	4	1991	4
1889	7	1941	1	1992	2
1890	3	1946	1	1993	4
1891	2	1947	1	1994	4
1893	1	1948	2	1995	1
1894	9	1949	2	1997	2
1895	3	1950	3	1998	12
1896	1	1951	4	1999	2
1897	1	1952	2	2000	5
1898	1	1953	1	No date	38

Table 2

Synopsis of Exsiccatae by county of Collection

State	County	Count of County
Arkansas	Drew Co.	1
Illinois	Alexander Co.	1
Illinois	Brown Co.	1
Illinois	Champaign Co.	13
Illinois	Christian Co.	1
Illinois	Fulton Co.	1
Illinois	Henry Co.	1
Illinois	Jackson Co.	1
Illinois	Johnson Co.	2
Illinois	Macoupin Co.	2
Illinois	McLean Co.	3
Illinois	Peoria Co.	11
Illinois	Richland Co.	1
Illinois	Schuyler Co.	1
Illinois	St. Clair Co.	5
Illinois	Stark Co.	1
Illinois	Union Co.	1
Illinois	Vermilion Co.	2
Illinois	Wabash Co.	2
Illinois	Williamson Co	1
Illinois	Woodford Co.	3
Illinois	Wordford Co.	1
Indiana	Allen Co.	5
Indiana	Fountain Co.	1
Indiana	Howard Co.	1
Indiana	Putnam Co.	2
Kentucky	Fayette Co.	2
Kentucky	Graves Co.	1
Kentucky	Leslie Co.	2
Kentucky	Rockcastle Co	1
Minnesota	Houston Co.	1
Missouri	Boone Co.	1
Missouri	Cape Girardea	1
Missouri	Gentry Co.	1
Missouri	Greene Co.	1
Missouri	Knox Co.	1
Missouri	Laclede Co.	1
Missouri	Maries Co.	1
Missouri	Ozark Co.	1
Missouri	Pettis Co.	1
Missouri	Ralls Co.	6
Missouri	Randolph Co.	1
Missouri	St. Charles Co	1

State	County	Count of County
Missouri	St. Louis Co.	15
Missouri	Stone Co.	1
Missouri	Taney Co.	1
Missouri	Texas Co.	1
Missouri	Warren Co.	2
Missouri	Washington Co.	2
Missouri	Wayne Co.	1
New York	Livingston Co.	1
Ohio	Butler Co.	3
Ohio	Champaign Co.	1
Ohio	Cuyahoga Co.	5
Ohio	Erie Co.	1
Ohio	Hamilton Co.	2
Ohio	Lake Co.	2
Ohio	Montgomery Co.	1
Ohio	Pickaway Co.	1
Ohio	Richland Co.	2
Ohio	Ross Co.	1
Ohio	Trumbull Co.	2
Pennsylvania	Allegheny Co.	6
Pennsylvania	Beaver Co.	2
Pennsylvania	Butler Co.	3
Pennsylvania	Indiana Co.	1
Pennsylvania	Lawrence Co.	8
Pennsylvania	McKean Co.	1
Pennsylvania	Mercer Co.	6
Pennsylvania	Somerset Co.	1
Pennsylvania	Venango Co.	3
Pennsylvania	Washington Co.	2
Tennessee	Montgomery Co.	2
Tennessee	Shelby Co.	1
Tennessee	Stewart Co.	1
West Virginia	Randolph Co.	1
West Virginia	Brooke Co.	2
Wisconsin	Crawford Co.	1
Wisconsin	Green Co.	1
Wisconsin	Greene Co.	1
Wisconsin	Sauk Co.	1

Table 3

Soil Sample Results

			Exchangable Cations (meq/100g)					% Saturation of the CEC		
	[1]pH	[2]P lb/A	[3]Acidity	[2]K	[2]Mg	[2]Ca	[4]CEC	K	Mg	Ca
State Game Lands 178	5.8	16	2.7	0.3	0.9	8.9	12.8	2.4	6.9	69.8
Slippery Rock Natural Area	5.5	15	4.1	0.1	1	4.5	9.7	1.4	10.2	46.1
Poland Municipal Forest	6.1	19	2.0	0.2	1.5	8.2	11.8	1.8	12.4	69.0

Test Methods: [1]1:1 soil:water pH, [2]Mehlich 3 Extractant, [3]SMP Buffer pH, [4]Summation of Cations

Table 4

Soil Nutrient Levels for State Game Lands 178, exchangable cations given in Table 3. From Agricultural Analytical Services Laboratory.

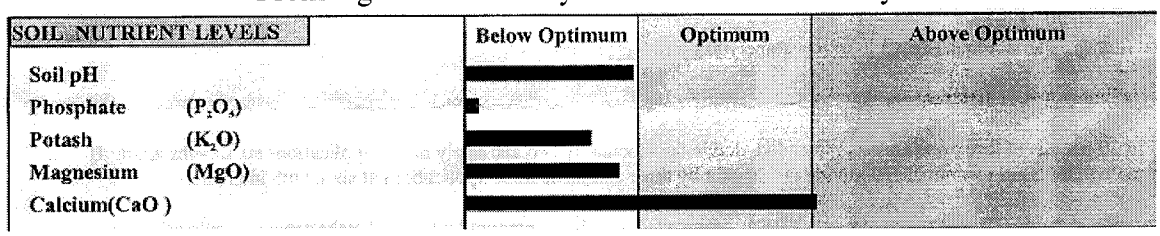

Table 5

Soil Nutrient Levels for Poland Municipal Forest, exchangable cations given in Table 3. From Agricultural Analytical Services Laboratory.

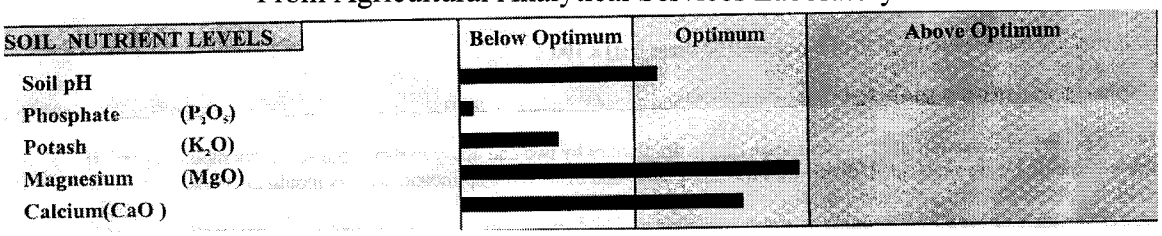

Table 6

Soil Nutrient Levels for Slippery Rock Natural Area, exchangable cations given in Table 3. From Agricultural Analytical Services Laboratory.

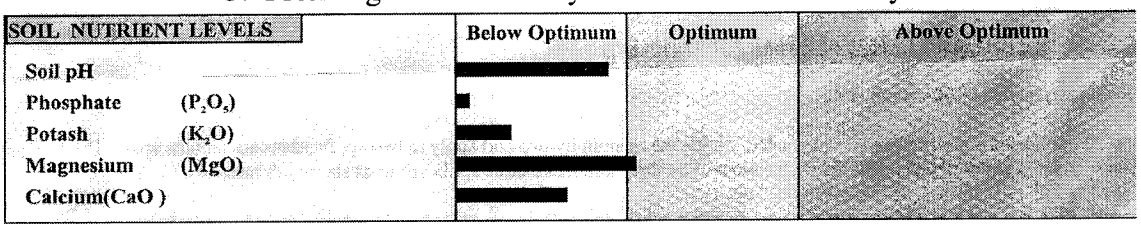

Table 7. Species growing in association with *Prenanthes crepidinea* at State Gamelands 178, Lawrence County.

Family/Species	*Native*
Aceraceae	
Acer negundo L.	y
Acer saccharinum L.	y
Anacardiaceae	
Toxicodendron radicans (L.) Kuntze	y
Apiaceae	
Chaerophyllum procumbens (L.) Crantz	y
Cryptotaenia canadensis (L.) DC.	y
Osmorhiza longistylis (Torr.) DC.	y
Aristolochiaceae	
Asarum canadense L.	y
Asteraceae	
Ambrosia trifida L.	y
Aster lateriflorus (L.) Britton	y
Erigeron annuus (L.) Pers.	y
Eupatorium fistulosum Barratt	y
Eupatorium perfoliatum L.	y
Helianthus decapetalus L.	y
Lactuca biennis (Moench) Fern.	y
Prenanthes crepidinea Michx.	y
Rudbeckia laciniata L.	y
Senecio aureus L.	y
Solidago gigantea Aiton	y
Tussilago farfara L.	n
Verbesina alternifolia (L.) Britton	y
Balsaminaceae	
Impatiens pallida Nutt.	y
Berberidaceae	
Berberis thunbergii DC.	n
Boraginaceae	
Mertensia virginica (L.) Pers.	y
Brassicaceae	
Alliaria petiolata (Bieb.) Cavara & Granden	
Barbarea vulgaris R. Br.	n
Cardamine concatenata (Michx.) Shw..	y
Cardamine diphylla (Michx.) A. Wood	y
Cardamine hirsuta L.	n
Hesperis matronalis L.	n
Rorippa palustris (L.) Besser	y
Campanulaceae	
Campanula americana L.	y
Cannabaceae	
Humulus japonicus Siebold & Zucc.	n
Caprifoliaceae	
Sambucus canadensis L.	y
Caryophyllaceae	
Stellaria aquatica (L.) Scop.	n
Stellaria media (L.) Villars	n
Celastraceae	
Euonymus europaeus L.	n
Convolvulaceae	
Calystegia sepium (L.) R. Br.	y
Cornaceae	
Cornus amomum Miller	y
Cornus racemosa Lam.	y
Cucurbitaceae	
Echinocystis lobata (Michx.) T. & G.	y
Hydrophyllaceae	
Hydrophyllum virginianum L.	y
Juglandaceae	
Carya cordiformis (Wangenh.) K. Koch	y
Juncaceae	
Juncus tenuis Willd.	y
Lamiaceae	
Blephilia hirsuta (Pursh) Benth.	y
Glechoma hederacea L.	n
Lamium purpureum L.	n
Monarda fistulosa L.	y
Scutellaria lateriflora L.	y
Limnanthaceae	
Floerkea proserpinacoides Willd.	y
Onagraceae	
Circaea lutetiana L. ssp. canadensis L	y
Papaveraceae	
Chelidonium majus L.	n
Sanguinaria canadensis L.	y

Family/Species	*Native*
Phytolaccaceae	
Phytolacca americana L.	y
Platanaceae	
Platanus occidentalis L.	y
Polemoniaceae	
Phlox divaricata L.	y
Phlox paniculata L.	y
Polemonium reptans L.	y
Polygonaceae	
Polygonum cespitosum Blume	y
Polygonum scandens L.	y
Polygonum virginianum L.	y
Rumex obtusifolius L.	n
Portulacaceae	
Claytonia virginica L.	y
Primulaceae	
Lysimachia ciliata L.	y
Ranunculaceae	
Clmatis virginiana L.	y
Ranunculus abortivus L.	y
Ranunculus repens L.	n
Thalictrum pubescens Pursh	y
Rosaceae	
Agrimonia striata Michx.	y
Crataegus punctata Jacq.	y
Geum canadense Jacq.	y
Physocarpus opulifolius (L.) Maxim.	y
Prunus serotina Ehrh.	y
Prunus virginiana L.	y
Pyrus coronaria L.	y
Rosa multiflora Thunb.	n
Rubus allegheniensis T.C. Porter	y
Rubiaceae	
Galium aparine L.	y
Salicaceae	
Salix nigra Marshall	y
Salix sericea Marshall	y
Scrophulariaceae	
Chelone glabra L.	y
Scrophularia marilandica L.	y

Family/Species	*Native*
Ulmaceae	
Ulmus americana L.	y
Ulmus rubra Muhl.	y
Urticaceae	
Laportea canadensis (L.) Wedd.	y
Urtica dioica L. ssp. procera (Muhl.) Wedd.	y
Verbenaceae	
Verbena urticifolia L.	y
Violaceae	
Viola cucullata Aiton	y
Viola striata Aiton	y
Vitaceae	
Parthenocissus vitacea (Knerr) A. Hitchc.	y
Vitis riparia Michx.	y
Aspleniaceae	
Dryopteris intermedia (Muhl.) A. Gray	y
Araceae	
Arisaema dracontium (L.) Schott	y
Arisaema triphyllum (L.) Schott var. stewardsonii (Britton) O.A. Stevens	y
Symplocarpus foetidus (L.) Nutt.	y
Cyperaceae	
Carex bromoides Willd.	y
Carex grayi Carey	y
Carex retroflexa Muhl.	y
Carex stipata Muhl.	y
Liliaceae	
Allium canadense L.	y
Camassia scilloides (Raf.) Cory	y
Erythronium americanum Ker Gawler	y
Lilium superbum L.	y
Ornithogalum umbellatum L.	n
Polygonatum biflorum (Walter) Elliott	y
Trillium erectum L.	y
Veratrum viride Aiton	y
Poaceae	
Cinna arundinacea L.	y
Elymus riparius Wieg.	y
Elymus villosus Muhl. ex Willd.	y
Elymus virginicus L.	y
Festuca subverticillata (Pers.) E. Alexeev.	y

Family/Species	*Native*
Leersia virginica Willd.	y
Panicum clandestinum L.	y
Phalaris arundinacea L.	y
Poa pratensis L.	y
Smilacaceae	
Smilax hispida Muhl.	y

Table 8 Species growing in association with *Prenanthes crepidinea* at Poland Municipal Forest, Mahoning County

Family/Species	*Native*
Aceraceae	
Acer saccharum Marshall	y
Annonaceae	
Asimina triloba (L.) Dunal	y
Apiaceae	
Cryptotaenia canadensis (L.) DC.	y
Erigenia bulbosa (Michx.) Nutt.	y
Osmorhiza claytonii (Michx.) C.B. Clarke	y
Osmorhiza longistylis (Torr.) DC.	y
Sanicula gregaria E. Bickn.	y
Araliaceae	
Panax trifolium L.	y
Aristolochiaceae	
Asarum canadense L.	y
Asteraceae	
Aster lateriflorus (L.) Britton	y
Aster prenanthoides Muhl.	y
Prenanthes crepidinea Michx.	y
Rudbeckia laciniata L.	y
Senecio aureus L.	y
Solidago caesia L.	y
Solidago flexicaulis L.	y
Solidago gigantea Aiton	y
Verbesina alternifolia (L.) Britton	y
Balsaminaceae	
Impatiens capensis Meerb.	y
Impatiens pallida Nutt.	y
Berberidaceae	
Berberis thunbergii DC.	n
Caulophyllum thalictroides (L.) Michx.	y
Podophyllum peltatum L.	y
Boraginaceae	
Mertensia virginica (L.) Pers.	y
Brassicaceae	
Cardamine rhomboidea (Pers.) DC.	y
Cardamine x maxima A. Wood	y
Hesperis matronalis L.	n
Caprifoliaceae	
Sambucus racemosa L.	y
Viburnum prunifolium L.	y
Viburnum sieboldii Miq.	n
Caryophyllaceae	
Stellaria media (L.) Villars	n
Crassulaceae	
Sedum ternatum Michx.	y
Fabaceae	
Amphicarpaea bracteata (L.) Fern.	y
Fagaceae	
Fagus grandifolia Ehrh.	y
Fumariaceae	
Dicentra canadensis (Goldie) Walp.	y
Dicentra cucullaria (L.) Bernh.	y
Geraniaceae	
Geranium maculatum L.	y
Grossulariaceae	
Ribes americanum P. Mill.	y
Hydrophyllaceae	
Hydrophyllum canadense L.	y
Hydrophyllum virginianum L.	y
Lamiaceae	
Monarda fistulosa L.	y
Limnanthaceae	
Floerkea proserpinacoides Willd.	y
Magnoliaceae	
Liriodendron tulipifera L.	y
Oleaceae	
Ligustrum vulgare L.	n
Onagraceae	
Circaea lutetiana L. ssp. canadensis L.	y
Orobanchaceae	
Epifagus virginiana (L.) Barton	y
Papaveraceae	
Sanguinaria canadensis L.	y
Platanaceae	
Platanus occidentalis L.	y

Family/Species	*Native*
Polemoniaceae	
Phlox divaricata L.	y
Polygonaceae	
Polygonum virginianum L.	y
Portulacaceae	
Claytonia virginica L.	y
Primulaceae	
Lysimachia ciliata L.	y
Samolus floribundus HBK.	y
Ranunculaceae	
Anemonella thalictroides (L.) Spach	y
Caltha palustris L.	y
Ranunculus abortivus L.	y
Ranunculus hispidus Michx.	y
Ranunculus recurvatus Poiret	y
Ranunculus repens L.	n
Thalictrum pubescens Pursh	y
Rosaceae	
Geum canadense Jacq.	y
Prunus serotina Ehrh.	y
Prunus virginiana L.	y
Rosa multiflora Thunb.	n
Rubiaceae	
Galium aparine L.	y
Saxifragaceae	
Mitella diphylla L.	y
Tiarella cordifolia L.	y
Scrophulariaceae	
Chelone glabra L.	y
Scrophularia marilandica L.	y
Ulmaceae	
Ulmus americana L.	y
Ulmus rubra Muhl.	y
Urticaceae	
Boehmeria cylindrica (L.) Swartz	y
Laportea canadensis (L.) Wedd.	y
Pilea pumila (L.) A. Gray	y
Urtica dioica L. ssp. procera (Muhl.) Wedd.	y
Verbenaceae	
Verbena urticifolia L.	y

Family/Species	*Native*
Violaceae	
Viola cucullata Aiton	y
Viola pubescens Aiton	y
Viola striata Aiton	y
Vitaceae	
Vitis riparia Michx.	y
Araceae	
Arisaema dracontium (L.) Schott	y
Arisaema triphyllum (L.) Schott	y
Symplocarpus foetidus (L.) Nutt.	y
Cyperaceae	
Carex amphibola Steudel.	y
Carex blanda Dewey	y
Carex grayi Carey	y
Carex rosea Schk.	y
Carex sparganioides Muhl.	y
cephaloidea (Dewey) Carey	
Liliaceae	
Allium canadense L.	y
Allium tricoccum Aiton	y
Erythronium americanum Ker Gawler	y
Smilacina racemosa (L.) Desf.	y
Trillium erectum L.	y
Trillium grandiflorum (Michx.) Salisb.	y
Trillium sessile L.	y
Poaceae	
Elymus hystrix L.	y
Festuca subverticillata (Pers.) E. Alexeev.	y
Glyceria striata (Lam.) A. Hitchc.	y
Leersia virginica Willd.	y
Phalaris arundinacea L.	y
Poa alsodes A. Gray	y
Poa sylvestris A. Gray	y
Poa trivialis L.	n
Sphenopholis obtusata (Michx.) Scrib.	y

Table 9 Species growing in association with *Prenanthes crepidinea* at Slippery Rock Natural Area, Butler County

Family/Species	*Native*
Aceraceae	
Acer saccharinum L.	y
Acer saccharum Marshall	y
Anacardiaceae	
Toxicodendron radicans (L.) Kuntze	y
Apiaceae	
Cryptotaenia canadensis (L.) DC.	y
Erigenia bulbosa (Michx.) Nutt.	y
Osmorhiza longistylis (Torr.) DC.	y
Sanicula gregaria E. Bickn.	y
Thaspium barbinode (Michx.) Nutt.	y
Asteraceae	
Ambrosia trifida L.	y
Aster acuminatus Michx.	y
Aster prenanthoides Muhl.	y
Cacalia suaveolens L.	y
Eupatorium fistulosum Barratt	y
Eupatorium rugosum Houttuyn	y
Heliopsis helianthoides (L.) Sweet	y
Prenanthes crepidinea Michx.	y
Verbesina alternifolia (L.) Britton	y
Berberidaceae	
Berberis thunbergii DC.	n
Caulophyllum thalictroides (L.) Michx.	y
Podophyllum peltatum L.	y
Betulaceae	
Alnus serrulata (Aiton) Willd.	y
Carpinus caroliniana Walter	y
Boraginaceae	
Mertensia virginica (L.) Pers.	y
Brassicaceae	
Alliaria petiolata (Bieb.) Cavara & Grande	n
Arabis laevigata (Muhl.) Poiret	y
Barbarea vulgaris R. Br.	n
Cardamine concatenata (Michx.) O. Schwartz	y
Cardamine pensylvanica Muhl.	y
Cardamine rhomboidea (Pers.) DC.	y
Hesperis matronalis L.	n
Caprifoliaceae	
Lonicera morrowii A. Gray	n
Caryophyllaceae	
Stellaria graminea L.	n
Convolvulaceae	
Calystegia sepium (L.) R. Br.	y
Cornaceae	
Cornus amomum Miller	y
Crassulaceae	
Sedum ternatum Michx.	y
Cucurbitaceae	
Echinocystis lobata (Michx.) T. & G.	y
Geraniaceae	
Geranium maculatum L.	y
Hydrangeaceae	
Hydrangea arborescens L.	y
Lamiaceae	
Ajuga reptans L.	n
Glechoma hederacea L.	n
Monarda fistulosa L.	y
Limnanthaceae	
Floerkea proserpinacoides Willd.	y
Monotropaceae	
Monotropa uniflora L.	y
Onagraceae	
Circaea lutetiana L. ssp. canadensis L.	y
Orobanchaceae	
Orobanche uniflora L.	y
Polemoniaceae	
Phlox divaricata L.	y
Polemonium reptans L.	y
Polygonaceae	
Polygonum cespitosum Blume	y
Polygonum virginianum L.	y
Portulacaceae	
Claytonia virginica L.	y
Primulaceae	
Lysimachia ciliata L.	y

Family/Species	*Native*
Ranunculaceae	
Anemone quinquefolia L.	y
Clematis virginiana L.	y
Ranunculus abortivus L.	y
Ranunculus recurvatus Poiret	y
Ranunculus repens L.	n
Thalictrum pubescens Pursh	y
Rosaceae	
Agrimonia gryposepala Wallr.	y
Amelanchier arborea (Michx.f.) Fern.	y
Crataegus flabellata (Bosc) K. Koch	y
Geum canadense Jacq.	y
Physocarpus opulifolius (L.) Maxim.	y
Prunus virginiana L.	y
Rosa multiflora Thunb.	n
Rubiaceae	
Galium aparine L.	y
Galium triflorum Michx.	y
Scrophulariaceae	
Scrophularia marilandica L.	y
Staphyleaceae	
Staphylea trifolia L.	y
Ulmaceae	
Ulmus americana L.	y
Urticaceae	
Boehmeria cylindrica (L.) Swartz	y
Laportea canadensis (L.) Wedd.	y
Verbenaceae	
Verbena urticifolia L.	y
Violaceae	
Viola conspersa Reichb.	y
Viola pubescens Aiton	y
Viola sororia Willd.	y
Viola striata Aiton	y
Aspleniaceae	
Athyrium thelypterioides (Michx.) Desv.	y
Cystopteris protrusa (Weatherby) Blasdell	y
Dryopteris carthusiana (Villars) H.P. Fuchs	y
Dryopteris intermedia (Muhl.) A. Gray	y
Dryopteris marginalis (L.) A. Gray	y
Dryopteris x triploidea Wherry	y
Thelypteris noveboracensis (L.) Nieuwland	y
Onocleaceae	
Onoclea sensibilis L.	y
Ophioglossaceae	
Botrychium dissectum Sprengel.	y
Araceae	
Arisaema dracontium (L.) Schott	y
Arisaema triphyllum (L.) Schott	y
Symplocarpus foetidus (L.) Nutt.	y
Cyperaceae	
Carex amphibola Steud.	y
Carex bromoides Willd.	y
Carex grayi Carey	y
Carex hirtifolia Mackenzie	y
Carex rosea Schk.	y
Carex stipata Muhl.	y
Liliaceae	
Allium canadense L.	y
Allium tricoccum Aiton	y
Erythronium americanum Ker Gawler	y
Lilium superbum L.	y
Polygnatum pubescens (Willd.) Pursh	y
Trillium erectum L.	y
Uvularia sessilifolia L.	y
Veratrum viride Aiton	y
Orchidaceae	
Epipactis helleborine (L.) Crantz	n
Poaceae	
Elymus riparius Wieg.	y
Festuca elatior L.	n
Festuca subverticillata (Pers.) E. Alexeev.	y
Milium effusum L.	y
Phalaris arundinacea L.	y
Poa alsodes A. Gray	y
Poa pratensis L.	n

Table 10 Species found at all three study sites

Family/Species	*Native*
Apiaceae	
Cryptotaenia canadensis	y
Osmorhiza longistylis	y
Asteraceae	
Prenanthes crepidinea	y
Verbesina alternifolia	y
Berberidaceae	
Berberis thunbergii	n
Boraginaceae	
Mertensia virginica	y
Brassicaceae	
Hesperis matronalis	n
Lamiaceae	
Monarda fistulosa	y
Limnanthaceae	
Floerkea proserpinacoides	y
Onagraceae	
Circaea lutetiana canadensis	y
Polemoniaceae	
Phlox divaricata	y
Polygonaceae	
Polygonum virginianum	y
Portulacaceae	
Claytonia virginica	y
Primulaceae	
Lysimachia ciliata	y
Ranunculaceae	
Ranunculus repens	n
Ranunculus abortivus	y
Thalictrum pubescens	y
Rosaceae	
Geum canadense	y
Prunus virginiana	y
Rosa multiflora	n
Rubiaceae	
Galium aparine	y
Scrophulariaceae	
Scrophularia marilandica	y
Ulmaceae	
Ulmus americana	y
Urticaceae	
Laportea canadensis	y
Verbenaceae	
Verbena urticifolia	y
Violaceae	
Viola striata	y
Araceae	
Arisaema triphyllum	y
Arisaema dracontium	y
Symplocarpus foetidus	y
Cyperaceae	
Carex grayi	y
Liliaceae	
Allium canadense	y
Erythronium americanum	y
Trillium erectum	y
Poaceae	
Festuca subverticillata	y
Phalaris arundinacea	y

Table 11

Insects collected while visiting florets of *Prenanthes crepidinea.*

Family	Genus	species	date	site	# specimens
Coleoptera	Brachypterus	urticae	8-Sep-99	Poland	1
Coleoptera	Psyllobora	virgintimaculata	12-Sep-98	SGL 178	1
Diptera	Epistrophe	emarginata	8-Sep-99	SGL 178	1
Hymenoptera	Andrena	simplex	26-Sep-98	SGL 178	1
Hymenoptera	Andrena	simplex	4-Sep-99	SGL 178	1
Hymenoptera	Andrena	simplex	6-Sep-99	Poland	3
Hymenoptera	Andrena	simplex	8-Sep-99	SGL 178	4
Hymenoptera	Andrena	simplex	8-Sep-99	Poland	1
Hymenoptera	Augochlora	pura pura	6-Sep-99	Poland	2
Hymenoptera	Augochlorella	striata	26-Sep-98	SGL 178	1
Hymenoptera	Bombus	bimaculatus	4-Sep-99	SGL 178	1
Hymenoptera	Bombus	vagans vagans	4-Sep-99	SGL 178	2
Hymenoptera	Bombus	bimaculatus	8-Sep-99	SGL 178	1
Hymenoptera	Bombus	vagans vagans	8-Sep-99	Poland	1
Hymenoptera	Bombus	vagans vagans	8-Sep-99	SGL 178	2
Hymenoptera	Bombus	bimaculatus	21-Sep-99	SGL 178	1
Hymenoptera	Bombus	vagans vagans	21-Sep-99	SGL 178	3
Hymenoptera	Campanotus	pennsylvanicus	8-Sep-99	Poland	1
Hymenoptera	Glypta	animosa	4-Sep-99	SGL 178	1

Table 12
Herbarium specimens used for micromorphological structures.

Morphological structure	***Prenanthes crepidinea* sheet used**
achene with coma	Eggert s.n., 1877 ILL (CM)
floral head bract	Bright 7691, PA (CM)
stigma	Bright 7691, PA (CM)
anther with pollen	Bright 7691, PA (CM)
petiole	Isaac s.n., PA (not deposited)