

Conservation Assessment
for the
Heartleaf Plantain
(Plantago cordata Lam.)



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Plantago cordata Lam., from Steve Olson @ USDA-NRCS PLANTS Database / USDA SCS. 1989. **Midwest wetland flora: Field office illustrated guide to plant species.** Midwest National Technical Center, Lincoln, NE.

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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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, if 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

This Conservation Assessment is a review of the taxonomy, distribution, habitat, ecology, and status of the Heartleaf Plantain, *Plantago cordata* Lam., throughout the United States and Canada, and in the U.S.D.A. Forest Service lands, Eastern Region (Region 9), in particular. This document also serves to update knowledge about the potential threats, and conservation efforts regarding the Heartleaf Plantain to date. Heartleaf Plantain is a perennial herb with a rosette of stalked leaves that grows in very specific habitats of clear-running streams in gravelly soils. It demonstrates an unusual and fragile life cycle, and its habitat is extremely vulnerable. The species is widespread in the eastern United States and a small area of adjacent Canada and it is known historically from twenty states including the District of Columbia, from New York and Ontario, Canada, south to Florida (perhaps), and west to Arkansas and Iowa. It has declined severely and is known today from only 13 states and one Canadian province. It is an obligate wetland species. Globally, its ranking is G4 (apparently secure world-wide); its National status in the United States is N4 (with similar meaning) and it is critically endangered in Canada (N1). Heartleaf Plantain is listed as Endangered in six states, as Threatened in three states, and as Presumed Extirpated in six states including the District of Columbia. In Forest Service Region 9, the Heartleaf Plantain is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest where it has not been found. It is at risk at the margins of its range.

In addition to species listed as endangered or threatened under the Endangered Species Act (ESA), or species of Concern by U.S. Fish and Wildlife Service, the Forest Service lists species that are Sensitive within each region (RFSS). The National Forest Management Act and U.S. Forest Service policy require that National Forest System land be managed to maintain viable populations of all native plant and animal species. A viable population is one that has the estimated numbers and distribution of reproductive individuals to ensure the continued existence of the entity throughout its range within a given planning area.

The objectives of this document are to:

- Provide an overview of the current scientific knowledge on the species.
- Provide a summary of the distribution and status on the species range-wide and within the Eastern Region of the Forest Service, in particular.
- Provide the available background information needed to prepare a subsequent Conservation Approach.

NOMENCLATURE AND TAXONOMY

Scientific Name:	<i>Plantago cordata</i> Lam. [1792]
Common Names:	Heartleaf Plantain; Heart-leaf Plantain; Heart-leaved Plantain; King-root; Water Plantain.
Synonymy:	<i>Plantago kentukensis</i> Michx.; <i>Plantago canadensis</i> Hort.
Class:	Magnoliopsida (Dicots)
Family:	Plantaginaceae (The Plantain Family)
Plants Code:	PLCO2 (USDA NRCS plant database, W-1) http://plants.usda.gov/

The herbaceous genus *Plantago* contains as many as 250 - 275 species throughout the world, depending on one's concept of the genus. The family Plantaginaceae, as generally circumscribed, is a cosmopolitan family of 3 related genera, *i.e.*, *Bougueria* Decne., *Littorella* P. Bergius, and *Plantago* L., and they are distributed in diverse habitats throughout the world (Cronquist 1981, Heywood 1993, Mabberley 1997). However, a few botanists, such as Rahn (1996) consider all of the species to belong to the single genus *Plantago*. Summaries on the genus and many of its species have been presented by Shehata and Loutfy (2006) and Rahn (1978, 1996). Most of the species of *Plantago* are found in the temperate regions of the world, though a few can be found at high elevations in the mountains in the tropics; 35 species are found in Europe and about 31 species are found in North America, 25 of which are native (Kartesz and Meacham 1999). In North America, the species can be found in very diverse habitats, including highly disturbed areas, prairies, barrens, meadows, canyons, mountains, and chaparral to name a few. There are several distinct subgenera and sections within the genus *Plantago*, including (assuming that the family is monogeneric) the subgenera *Bougueria*, *Coronopus*, *Littorella*, *Plantago*, and *Psyllium* (Rahn 1978, 1996). *Plantago cordata* belongs to the typical subgenus, *Plantago* subgenus *Plantago*. Other familiar species in this group are the broad leaved and weedy species *Plantago major* L., *Plantago rugelii* Decne., and *Plantago virginica* L., as well as the tropical American *Plantago australis* Lam. and the East Asian *Plantago asiatica* L. The name *Plantago* was derived from a Latin word meaning 'sole of the foot' or even 'footprint' apparently because species of this genus always seemed to be present along disturbed footpaths. The epithet '*cordata*' means 'heart-shaped' because of the shape of the leaves. The members of this genus have been used since pre-historic times by humans for their medicinal qualities, including, but not limited to, the seeds that have been used as laxatives and as anti-dysentery agents, and the leaves that have been used as wound dressings and as food. Steyermark (1963) noted that *Plantago cordata* is edible and one of the best tasting species of the genus.

The common name 'Heartleaf Plantain', or its minor variants, is generally used and accepted as the common name for this plant. The common name 'Kingroot' (or 'King-root') is rarely used.

The common name ‘Water Plantain’ is quite confusing, because it is more often used for *Alisma plantago-aquatica*, an unrelated but much more common wetland plant not at all related to plantains.

DESCRIPTION OF THE SPECIES

Plantago cordata, the Heartleaf Plantain, is a somewhat soft-fleshy perennial glabrous herb from a stout, corky, often partially hollow caudex, with several long fleshy **roots** 0.5 – 1.3 cm thick; the fleshy, long-petioled, summer **leaves** are in a basal rosette, the stalks are often purplish at their bases and the stalks and blades are about equal in length; the blades are cordate-ovate in shape, (10-) 12-25 (-30) cm long x (6-) 8-20 cm wide basally, entire-margined, and obtuse at the apex; the main lateral veins are not parallel to the margin and they tend to arise from the lower part of the midveins of the blade; leaves on the plants at other seasons are generally much smaller than the summer leaves and they are often narrower and more lanceolate; the usually several **flowering stems** are up to about 50 cm tall, the scapes (peduncles) are 10 –30 (-40) cm long, stout and hollow (at least at the time of fruit ripening); the **flower spikes** are interrupted (with the axis exposed) and 8 – 20 (-30) cm long. The single **bract** and 4 **sepals** of each flower are about equal in size and shape (or the sepals are slightly longer), 2-2.5 mm long, broadly round-ovate, nearly flat, with very narrow keels, herbaceous sides, and narrow scarious margins, and they are obtuse to rounded at the tip; the 4 **petals** are scarious, fused, and long persistent on the top of the fruit, and the lobes are reflexed; the long, feathery **stigmas** have two parallel rows of hairs extending the total length of the stigma; the **fruits** are capsules, circumscissile near the middle, ovoid, equaling or slightly longer than the calyx, and (4-) 5-6 (-10) mm long; the 2 (-4) **seeds** are 3-4 mm long, dark brown, slenderly ellipsoid, with a pit on the inner face, smooth, and mucilaginous. The **chromosome number** is $2n = 24$. (Adapted from Gleason and Cronquist 1991; Godfrey and Wooten 1981).

The Heartleaf Plantain is one of the largest-leaved plantains in eastern North America and it is normally restricted to wetlands. It is sometimes confused with the similar and weedy *Plantago major*, but it can usually be separated by its distinct habitat and its leaf venation, in which the two leaf veins nearest the midrib do not diverge from it until about 3 cm or more from the base of the blade; the veins in *P. major* are equally spaced. *Plantago cordata* normally has only 2 seeds per capsule, while *P. major* and the similar *P. rugelii* have 4-30 seeds per capsule. *Plantago cordata* also has a thick, sometimes partly hollow, horizontal rootstock and it flowers only briefly and very early compared to *Plantago major*, which flowers for most of its growing season and which has an erect, solid rootstock. The mature peduncles of the fruiting stalk are hollow in *Plantago cordata*, but solid in *P. major*. At its full development, it is quite a bit larger than *Plantago major*. The two species can usually be distinguished readily by this series of vegetative, habitat, and phenological features.

HABITAT AND ECOLOGY

The Heartleaf Plantain has been given a national wetland indicator status of OBL, indicating that the species occurs almost always (estimated probability 99 %) in wetlands under natural conditions. In Wetland Region 3, including both Illinois and Indiana, *Plantago cordata* is also designated as an OBL species (Reed 1988; W-1; W-2). Overall, this semi-aquatic plant has a very narrow habitat preference, and these habitats include the margins and beds of clear, clean water running streams in forested areas, generally on silt-free gravelly or rocky bars in these stream beds, as well as on their muddy floodplains (W-3). It is only very rarely found growing in full sun (W-4). It appears to prefer temperate, moderate climates without hot or cold temperature extremes, and so it is relatively rare in the far northern portions of its range, the far southern parts of its range, as well as in portions of the Midwest that have a continental climate with the greatest temperature extremes. It appears to be most common in the moderate and mesic climates of the more topographically diverse Ozarks, in the moderate climates near the Great Lakes, and in the Hudson Valley of New York.

A review of the literature demonstrates that this herb has a variety of plant associates and slightly diverse habitats throughout its range. *Plantago cordata* grows mainly in level, wet, clear-running stream beds especially in areas of dolomitic limestone, running through heavily wooded areas. Floras generally list the habitat of *Plantago cordata* as “In and along streams and in swampy woods” (Fernald 1950), “Semiaquatic; in marshes and along streams, especially on calcareous substrate” (Gleason and Cronquist 1991), “Margins of streams, marshes” in New York (Magee and Ahles 1999), “marshes and streams” in the Blue Ridge physiographic province (Virginia only; Wofford 1989), “Slate bottom streams, very local” in North and South Carolina (Radford *et al.* 1968), and “Fresh-water marshes, small woodland streams and adjacent wet woodlands, ditches” in the Southeastern states (Godfrey and Wooten 1981). Tessene (1969) described communities and listed associates for sites that he studied and Alverson (1981) listed typical associates in Wisconsin.

The soils where the Heartleaf Plantain grows are normally wet and alkaline (calcareous) to circumneutral and they are associated with basic rock or pebble substrates (W-3). In Ohio, the plants grow in and around small streams, and they are rooted in the cracks of dolomite substrate with a muddy bottom and on gravel bars (W-3, W-4, Jones and Filbert 1981). While at many sites the Heartleaf Plantain grows in clear, cool waters issuing from springs, in New York, plants grow around tidal flats of the Hudson River and the waters can have a significant salt content (W-3, W-5). The ability of *Plantago cordata* to persist in the silt-laden water of the tidal flats as well as in clean spring-fed creeks raises questions about the water chemistry requirements of the plants. In Missouri, the creek beds are filled with cherty dolomite gravel or sandstone rubble; in Alabama and North Carolina, plants are rooted in gravel bars or in cracks of the shale or slate

stream beds; in Georgia, the plants are found in gravel or rooted in the cracks of a limestone stream bed (Godfrey 1961); and in Wisconsin, the stream bed is limestone cobbles buried under silt (Kunowski 1983). At its northern range limit in Ontario, Canada, plants occur in depressions in a deciduous forest, and they are thought to be partially immersed in the spring. The soil is a clay-loam with a pH of 7.2 (Allen and Oldham 1985). Essentially all of the habitats do have a calcareous, and basic, component.

In the northeastern United States, in New York, Heartleaf Plantain plants are often firmly rooted in gravel at the mouth of creeks that enter the Hudson River (W-3, W-5). They are located at the upper level of the intertidal zone and are subject to a 3-4 foot tide range daily. The water at the sites contains 20 ppm salt with a pH of 6-8. The plants usually grow along a woodland edge in half sun. Major tributaries enter the Hudson River near several *Plantago* sites and the influx of clean water may flush impurities away from the plantains (W-3). The plant communities, or habitats, generally associated with this plant in New York are the Freshwater intertidal mudflats, Freshwater tidal marsh, Freshwater intertidal shore, Freshwater tidal creek, Marsh headwater stream, and the Red maple hardwood swamp. Common associates with this species in New York include the **trees** *Acer rubrum*, *Acer saccharinum*, and *Celtis occidentalis*, the **shrubs** *Amorpha fruticosa* and *Physocarpus opulifolius*, the **vines** *Amphicarpaea bracteata* and *Vitis riparia*, the **herbs** *Alisma subcordatum*, *Amaranthus cannabinus*, *Ambrosia trifida*, *Bidens bidentoides*, *Bidens cernua*, *Cardamine pensylvanica*, *Eleocharis* spp., *Elodea canadensis*, *Eupatorium maculatum*, *Gratiola neglecta*, *Helenium autumnale*, *Impatiens capensis*, *Iris pseudacorus*, *Lindernia dubia*, *Lobelia cardinalis*, *Ludwigia palustris*, *Lysimachia ciliata*, *Lythrum salicaria*, *Orontium aquaticum*, *Peltandra virginica*, *Pilea fontana*, *Pilea pumila*, *Polygonum hydropiperoides*, *Pontederia cordata*, *Rudbeckia hirta*, *Sagittaria graminea*, *Sagittaria latifolia*, *Typha latifolia*, and *Trapa natans*, the **sedges** *Schoenoplectus americanus* and *Schoenoplectus tabernaemontani*, and the **grasses** *Panicum virgatum* and *Zizania aquatica* (W-5).

In Michigan, the Heartleaf Plantain grows in what are locally called southern swamps and southern floodplain forests, and it has been reported to associate with the **trees** *Acer negundo*, *Acer nigrum*, *Acer rubrum*, *Acer saccharinum*, *Aesculus glabra*, *Celtis occidentalis*, *Cercis canadensis*, *Fraxinus nigra*, *Fraxinus pennsylvanica*, *Gymnocladus dioica*, *Juglans nigra*, *Morus rubra*, *Platanus occidentalis*, *Populus deltoides*, *Quercus bicolor*, and *Salix nigra*, the **shrubs** *Asimina triloba*, *Euonymus atropurpurea*, and *Lindera benzoin*, the **vines** *Menispermum canadense* and *Toxicodendron radicans*, and the **herbs** *Asarum canadense*, *Collinsia verna*, *Cryptotaenia canadensis*, *Galium aparine*, *Lysimachia nummularia*, *Mertensia virginica*, *Podophyllum peltatum*, *Proserpinaca pectinata*, *Ranunculus abortivus*, *Solidago canadensis*, *Symplocarpus foetidus*, *Trillium erectum*, *Trillium recurvatum*, and *Urtica dioica* (W-6).

In Illinois, the Heartleaf Plantain grows “Along streams in woods” in widely scattered parts of the state (Mohlenbrock 1986, 2002). Herbarium labels on specimens in the Illinois Natural

History Survey herbarium (ILLS) included the habitats ‘intermittent stream’, ‘Gravel creekbed in dry-mesic upland forest’ and ‘barrens’, the latter being near a creek. It is generally reported that the Heartleaf Plantain usually occurs in sand or gravel bars of shallow, clear-water streams under a forest canopy (Herkert and Ebinger 2002, Shawnee National Forest 2005). The stream beds at sites in Illinois are composed of neutral to basic gravelly outwash, sandstone rubble, or they are sandy-bottomed (W-3; Kurz and Bowles 1981). Kurz and Bowles (1981) as well as Mohlenbrock (1959) list the typical plant associates for the species in southern Illinois. These associates include the **trees** *Acer negundo*, *Acer saccharinum*, *Alnus serrulata*, *Betula nigra*, *Platanus occidentalis*, *Populus deltoides*, and *Salix nigra*, the **shrubs** *Cornus stolonifera*, *Forestiera acuminata*, *Salix interior*, and, occasionally, *Staphylea trifolia*, the **forbs** *Astragalus canadensis*, *Bidens cernua*, *Bidens comosa*, *Bidens connata*, *Commelina virginica*, *Hypericum mutilum*, *Lobelia cardinalis*, *Lobelia siphilitica*, *Rhexia virginica*, and *Scutellaria lateriflora*, the **sedges** *Carex torta*, *Carex vulpinoidea*, *Cyperus pseudovegetus*, and *Lipocarpa micrantha*, and the **grasses** *Cinna arundinacea*, *Eragrostis hypnoides*, *Glyceria striata*, and *Leptochloa filiformis*.

In Arkansas, the plants are rooted in cherty gravel pockets that were scoured into the dolomite creek beds. Its habitat has been described as within the *Fraxinus pennsylvanica* – *Ulmus americana* – *Celtis laevigata* / *C. occidentalis* Temporarily Flooded Forest Alliance. Orzell (W-3) has found *Alnus serrulata*, *Carex torta*, *Oxypolis rigidior*, *Rhynchospora capillacea*, and *Rudbeckia fulgida* growing near *Plantago cordata* in Arkansas.

DISTRIBUTION AND ABUNDANCE

Plantago cordata, the Heartleaf Plantain, is widespread in portions of the temperate eastern United States and, according to most sources, it was known to occur historically in twenty states including the District of Columbia, namely, Alabama, Arkansas, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Michigan, Mississippi, Missouri, New York, North Carolina, Ohio, South Carolina, Tennessee, Virginia, and Wisconsin (W-1, W-3). It has also been found in a small portion of adjacent Ontario, Canada (W-3). Steyermark (1963) included Louisiana and Minnesota within its distributional range, but no records of this plant have been seen from either state. MacRoberts (1989) indicated that a few early reports were known for Louisiana, but that no vouchered records were known to exist for the state. References to its occurrence in Florida are equally obscure; it was not included in the state by Godfrey and Wootton (1981) or by Wunderlin (1998). Likewise, records of *Plantago cordata* in South Carolina appear to be highly questionable and no vouchers are known (J.Nelson, pers. comm.). The current distribution is considerably reduced from its historic distribution. Extant populations are known in only 13 of the 20 states (including the District of Columbia) where it once occurred (Mymudes and Les 1993; Bryson, pers. comm.). As far as is known, *Plantago cordata* has been extirpated (or else never actually occurred) in the District of Columbia, Florida,

Iowa, Kentucky, Maryland, South Carolina, and Virginia. Its historic range assessed on a county basis has also declined in essentially every state. One can generally expect that the decline has occurred in recent decades because of the general loss and degradation of its natural wetland habitats nationally.

Based upon its state rankings (W-3) only, this herb would appear to be most frequent in Missouri (as a S3S4 species), and in Georgia and New York (yet as a vulnerable, S3 species). In Missouri it is most common in the southeastern part of the state in the Upper Ozark Section of the Ozark Natural Division, and it may be more common in that state than in any other. According to Yatskievych (1999), *Plantago cordata* is “a characteristic species of rocky streambeds throughout the eastern half of the Ozarks, and less commonly north of the Missouri River as well, but which has become nearly entirely extirpated from the rest of its broad historical distribution in the eastern half of the United States”. The Heartleaf Plantain is very local even within its range because of its habitat preferences. A combination of records from several sources (see appendices) on the frequency of *Plantago cordata* show that this herb has been found in more than 20 counties in Illinois and Missouri, and in more than 10 counties in Michigan, New York, and Ohio. In the remaining fifteen states (including the District of Columbia) *Plantago cordata* has been found in nine or fewer counties, though its frequency within each county varies. Additional details on the distribution of this herb can be found in Kartesz and Meacham (1999), Bowles et al. (1988), Mymudes and Less (1993), and several Internet sites (e.g., W-1, W-3). Representative voucher specimens of this herb have been listed in Appendix 1. A summary of the distribution of the Heartleaf Plantain has been presented in Appendix 2.

Plantago cordata has been found in all of the Midwestern states (W-3; Steyermark 1963, Mohlenbrock and Ladd 1978, Deam 1940) but it appears to have been extirpated in Iowa and Kentucky. It is currently known from only a single county in Indiana (Homoya, pers. comm.). While it was formerly said to be relatively common around the Great Lakes, this is no longer the case.

Within the U.S. Forest Service Eastern Region (Region 9) *Plantago cordata* is known to be present within the Shawnee National Forest in Illinois and the Mark Twain National Forest in Missouri (W-7) but it has not been found in or near the Hoosier National Forest in Indiana. It is known in Uwharrie National Forest in North Carolina in the Southern Forest Region (Region 8) it likely occurs within the Ouachita, Ozark, St. Francis National Forests in Arkansas, and it may yet be found in other National Forests in that region.

In Illinois, *Plantago cordata* has been listed as Endangered (Illinois Endangered Species Protection Board [IESPB] 2005). The species has been reported historically in 25 counties mostly along Illinois River watershed and in southern Illinois (W-1; Herkert and Ebinger 2002,

Mohlenbrock 1986, 2002; Mohlenbrock and Ladd 1978; Shawnee National Forest 2005; herbarium specimens). Currently, as far as is known, it occurs today in Du Page, Jackson, Johnson, Kendall, Pope, Saline, and Tazewell counties. It is thought to have been extirpated (and therefore known only historically) in Cass, Champaign, Christian, Cook, Grundy, Hancock, Lake, La Salle, Macoupin, Madison, Marshall, Menard, Peoria, Piatt, St. Clair, Sangamon, Wabash, and Will counties. In 2002, nine stations were known in Illinois, including four in the Shawnee National Forest, one in a county forest preserve, another in a state park, and two in state nature preserves (Herkert and Ebinger 2002). This species has declined throughout its range due to alteration of stream habitat by erosion and siltation caused by poor watershed management. Its current distribution in the state appears to have very significantly decreased overall from a maximum of 25 counties to approximately seven counties today. Within and near the Shawnee National Forest it has been found historically at nine sites, namely, Lake Kincaid, Cedar Lake, Cave Hill Research Natural Area, Simpson Township Barrens Ecological Area, north of Flat Rock Hollow (though possibly extirpated at this site), state land at Lake Murphysboro, private land at Flat Lick Branch, Gyp Williams Hollow Ecological Area (also likely extirpated), and Copperous Branch Ecological Area (Shawnee National Forest 2005). Few flowering individuals are ever seen in southern Illinois, and the plants often remain in a juvenile stage likely due to shading (Shawnee National Forest 2005). The current and historic sites are located around the state within at least six Natural Divisions, namely, the Northeastern Morainal Division, Morainal Section and Chicago Lake Plain Section; Grand Prairie Division, Grand Prairie Section and Springfield Section; Upper Mississippi River and Illinois River Bottomlands Division, Illinois River Section; Western Forest – Prairie Division, Galesburg Section and Carlinville Section; Wabash Border Division, Bottomlands Section; Shawnee Hills Division, Greater Shawnee Hills Section and Lesser Shawnee Hills Section of Illinois (Schwegman *et al.* 1973).

In Indiana, *Plantago cordata* is also listed as Endangered, and the state's Heritage Program records only one extant population in Whitley County, in the northern part of the state (Homoya, pers. comm.). It has been reported previously in Boone, Floyd, Knox, Kosciusko, Tippecanoe, Wells, and Whitley counties in the northern and southern thirds of the state (W-1; Deam 1940). The Indiana Natural Heritage Data Center (2001) recorded seven localities, all in northern Indiana. No sites are in or close to the Hoosier National Forest. Only one new location has been found since 1957; at least two of the historical sites are destroyed and one is being used as a hog-wallow.

The populations of this herb in Illinois and most other areas of the Midwest are few and are scattered widely and the populations are isolated from one another. It was more common in the region at the time of European settlement, because records show that it has declined from 25 counties to 9 in recent times in Illinois alone. Its clear-water stream habitats have greatly decreased in Illinois since European settlement, hence the loss of most of the reported populations of the plant.

There is some data available on population sizes for this herb, but herbarium label data rarely include its local frequency or abundance. Despite its very narrow habitat preferences, the plant can sometimes be locally common (W-3). In Deer Run State Forest in Missouri in 1992, for example, about 700 plants were found in localized colonies. In New York, there are nearly 30 known populations and subpopulations scattered along the tidal areas of the Hudson River, and a few disjunct sub-populations are in the western part of the state, but at least three have more than 1,000 plants each (W-5). Most Illinois populations are found in shade and the number of individuals can be small. Historically, population counts in the state have varied from thousands of individuals at a site, to 80, to none, with a great deal of variation in different years at the same site. According to Beth Shimp (pers. comm.) thousands of individuals may germinate and grow at a given site, but because of floods and other hydrological variation only a few individuals may survive to reproduce.

PROTECTION STATUS

The Nature Conservancy ranking for *Plantago cordata* is G4 (apparently secure; W-3), indicating that the species is apparently secure worldwide. In the United States, overall, the species is given the National Heritage rank of N4, for similar reasons. In Canada, the national ranking is N1 (nationally critically imperiled).

In the United States, official protection for this herb outside of Forest Service lands depends upon state and local laws because it is not listed as Federally threatened or endangered. It was previously a candidate for federal listing with the status of 3C (taxa that proved to be more abundant or widespread and therefore not federally listed) but it currently has no federal status.

The state rankings vary somewhat. *Plantago cordata* is listed as Endangered (and ranked as S1) in Illinois, Indiana, Michigan, North Carolina, Tennessee, and Wisconsin. It has been classified as Threatened in Arkansas (S2), New York (S3), and Ohio (S1). This species has also been listed as historic only (SH, presumed extirpated) in the District of Columbia, Florida, Iowa, Kentucky, Maryland, and Virginia. It also has been listed as Critically Imperiled (S1) in Alabama and Mississippi and in Ontario, Canada. It is considered to be Vulnerable (S3) in Georgia and slightly less so in Missouri (S3S4). Heartleaf Plantain was formerly included on the Watch List in Missouri (Missouri Department of Conservation 1991). In South Carolina, the species is still under review, but no records have been found indicating that it has ever been found there (J. Nelson, pers. comm.). It is at risk at the margins of its range.

In Forest Service Region 9, the Heartleaf Plantain is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest, where it has not been found (W-7; Shawnee National Forest 2005). It does occur in the Mark Twain National Forest in Missouri, but it is considered to be too common there to be included on its

Regional Forester Sensitive Species list.

Table 1 lists the official state rank for *Plantago cordata* assigned by each state’s Natural Heritage program according to the Nature Conservancy at their Internet site ([W-3](#)). Appendix 3 explains the meanings of the acronyms used ([W-8](#)).

A summary of the current official protection status for *Plantago cordata* follows:

- U.S. Fish and Wildlife Service: Not listed (None). Formerly a 3C species.
- U.S. Forest Service: Listed as at risk in the Shawnee National Forest only, Region 9
- Global Heritage Status Rank: G4
- U.S. National Heritage Status Rank: N4
- Canada National Heritage Status Rank: N1

Table 1: S-ranks for *Plantago cordata* [Heritage Element Code: PDPLN02090]

State/Province	Heritage S-rank		
UNITED STATES			
Alabama	S1		
Arkansas	S2	[Threatened]	
District of Columbia	SH		
Florida	SH		
Georgia	S3		
Illinois	S1	[Endangered]	
Indiana	S1	[Endangered]	
Iowa	SH		
Kentucky	SH	[Historic]	
Maryland	SH	[Endangered, Extirpated]	
Michigan	S1		[Endangered]
Mississippi	S1		
Missouri	S3S4		
New York	S3		[Threatened]
North Carolina	S1		[Endangered]
Ohio	S1		[Threatened]
South Carolina	SNR		
Tennessee	S1		[Endangered]
Virginia	SH		
Wisconsin	S1		[Endangered]
CANADA			
Ontario	S1		

LIFE HISTORY

Plantago cordata is a short-lived, semi-aquatic perennial fleshy herb with a rosette of large

heart-shaped fleshy leaves and, when reaching full development, several spikes of inconspicuous greenish flowers. The plants grow individually or in loose clusters in the shallow water of clear-running streams and along floodplains (W-3). The large leaves measuring (6-) 8 – 20 cm wide are only conspicuous in the summer months, and at other seasons the leaves are considerably smaller (Tessene 1969). Winter leaves are only 1-3 cm wide and lanceolate to spatulate. Spring leaves are intermediate in size between these and the larger summer leaves, and habitat stress, such as drought and high temperatures, can cause a reversion to smaller leaves.

Day length and temperatures appear to control leaf production and flowering of the plants (Tessene 1969). Heartleaf Plantain is a short-day (cool weather) species, and flowering normally occurs in March and April in the South, and in mid-April to May in the northern populations. One specimen from Missouri was in flower on June 18 (herbarium specimen), and flowering has been reported as late as the second half of July in New York (W-5). The young inflorescences are produced in the fall and they overwinter under the protection of overlapping petiole bases (Tessene 1969). On average, six flower spikes are found on each mature plant. The lowest flowers on the spikes open first; four days after the stigmas have extended, the stamens will protrude. As flowering progresses, the axis continues to extend. Under favorable conditions, the inflorescence grows to a length of 40-60 cm and bears 80-130 flowers (W-3, Tessene 1969). The flowers are wind-pollinated and have long feathery stigmas, and long-exserted stamens release pollen into the air. Plants are self-compatible but the stigmas are receptive before pollen is shed in any given flower, so outcrossing can occur, especially in the lower flowers (W-3, Tessene 1969). In one study in Reynolds County, Missouri, of 700 plants counted in one stream run, approximately 75 % were in flower in 1992 (herbarium specimen data).

The stalks of the flower spikes are firm and fleshy at first, then, as fruits mature the stalks dry and become hollow, and eventually collapse, helping to release the seeds. The fruits mature one to three weeks after flowering. Fruiting occurs generally in May and June in southern populations and in June (rarely to July) in northern populations. In New York, fruits have been reported to occur from August to the second half of September (W-5). Seeds are released in early summer. In most populations, all vestiges of the fruiting spikes are gone by July. Each capsule usually produces two seeds. The mature spikes may fall over into the water or onto the stream bank, causing the capsules to dehisce (W-3, Alverson 1981). The seed falls with its fleshy placenta still attached, which aids in buoyancy. Once a seed hits the water, the seed coat swells into a mucilaginous mass, which breaks the seed free of the placenta. They adhere to each other by the sticky floating placenta, and are dispersed by water (W-4). The mucilaginous coat will cause the seed to adhere to any object it floats against. Stromberg *et al.* (1981) found that the majority of seeds fell and germinated in close proximity to the parents.

The seeds will germinate in six to fourteen days even if they are still floating (Tessene 1969). In contrast to Tessene's observations, Stromberg *et al.* (1981) found that submerged seeds will also germinate. Tessene (1969) cited a critical three-week period within which germination and establishment must take place. Stromberg *et al.* (1981) observed germination and establishment occurring up to five weeks after dehiscence. Seeds kept under cool, moist conditions continue to germinate after one year but at a lower percentage (W-3). They normally break dormancy in a short time, and must germinate and root quickly or they will die (Tessene 1969). Dispersal can be hampered by dense algal growth, and the seeds observed tended to germinate and die while

caught in the algal filaments. Seedlings found on moist exposed clay banks were larger than any others at the site. Even for those that become established, seedling mortality is high. Many seedlings die from herbivory or are swept away in floods (W-3, Stromberg *et al.* 1981, Jones and Filbert 1981). Tessene (1969) noted that once a seedling is established, it will bloom the following year. According to Meagher *et al.* (1978) plants may take two years or more to reach maturity.

The adult plants are said to be very hardy (W-4). They are resistant to flooding (Jones and Filbert 1981), submergence, and occasional drought (Tessene 1969). They have been successfully established in transplanted populations (Meagher *et al.* 1978). The seeds are well adapted for water dispersal. However, it has been shown that *Plantago cordata* has the lowest known reproductive potential of any *Plantago* species (Primack 1976).

Vegetative reproduction has been reported (Tessene 1969, Primack 1978; Stromberg *et al.* 1982). Lateral buds on established rosettes may sporadically give rise to new rosettes. The new rosettes are attached to the parent rosette until the connected stem tissue rots or is severed. Tessene (1969) did not observe the production of inflorescences by the lateral rosettes while they were attached to the parent plants.

It is rather well known that the young individuals growing in shade in forest wetlands remain sterile and short during the late fall and winter. For this reason, the Heartleaf Plantain is often overlooked during floristic inventories because the sterile plants can be confused with immature forms of other genera such as *Rumex*.

POPULATION BIOLOGY AND VIABILITY

Heartleaf Plantain has the lowest reproductive output of all plantain species (Primack 1979). This low reproductive effort may be due to the allocation of resources into the broad leaves and fleshy thick roots that increase the probability for adult survival (Primack 1979). The high seedling mortality rate and great dependence on the same mature individuals to reproduce each year places *Plantago cordata* in a precarious position. Adult plants can withstand stress for short periods or perhaps even one growing season. If the stress conditions (stream draining, increased pollution) persist for several seasons, the adult population may not reproduce and could eventually die from the stress conditions or senescence (Tessene 1969).

Plantago cordata, as mentioned in the last section, has a complicated life history and population dynamics. The species is wind pollinated, and so a lack of insect pollinators does not affect the plant. However, the species grows in rather closed, usually forested habitats, and such areas sometimes have little wind. It appears that one of the strategies of the plant is to have individuals growing rather closely together and in locally large populations in the hundreds. It is possible that small populations of widely scattered plants may not produce many cross-pollinated (genetically variable) seeds and this could also result in population crashes.

It is generally understood that fertility is reduced in inbred populations through the process of autogamy (self-fertilization). Autogamy is useful to the plant when there are small numbers of individuals per area, since the safeguarding of the success of propagation is more important than

the production of new genotypes. In primary habitats, those that are generally poorly vegetated, initial success is very important. However, in subsequent periods of vegetation increase, pioneers are often substituted by other, more competitive species (W-9). In plants such as Heartleaf Plantain, all individuals at a site may be very closely related, and they can even be progeny from a single introduction event, and so they may possess little genetic variability. Fertilization by siblings is the most likely outcome in such cases because there is almost no chance of fertilization by other genotypes unless they are within dispersal range. The populations of this herb in Illinois are isolated from one another by the nature of their habitat and from those in other states. In theory, continued fertilization within a group of closely related individuals can result in severe reproductive problems in these few isolated populations, and successful seed production, as well as the genetic variation that allows competition with other species, may be compromised (W-9).

An example of negative effects thought to have arisen through the isolation of populations can be seen in the case of a monocot, Offer Hollow Reedgrass (*Calamagrostis porteri* ssp. *insperata* (Swallen) C.W.Greene), which has become isolated on rather dry sandstone bluffs throughout its range. This grass almost never produces viable seed anywhere in its range and this reproductive failure may be a reflection of a high genetic load that has occurred as a result of its long isolation (see Hill 2003). High genetic load can be seen in dominant mutations that result in factors lethal to embryos, and this situation appears to be indicated in that grass. That plant survives as a rare relict in the vegetative state only. It is a vulnerable species in the Midwest and elsewhere, though it does appear to be secure in some other areas with suitable habitat remaining. Whether that grass or the Heartleaf Plantain persist or not in the future in areas where they are currently scarce appears to depend on the survival and maintenance of their habitats.

POTENTIAL THREATS

Globally, Heartleaf Plantain has been judged to be apparently secure, but it is a North American endemic with a limited overall range and the number of populations has been shown to be declining (W-3). It appears to be unable to increase its range.

Threats to this species include habitat destruction from urbanization and development, clear-cutting of the surrounding forest, cattle and horse grazing and trampling, unrestricted recreational use of its habitat, industrial, agricultural and domestic water pollution, and the altering of stream flow by means of ditching, draining, or damming (W-3; Shawnee National Forest 2005). Some have suggested also that excessive shading may adversely affect the plant (Shawnee National Forest 2005). The plant is also known to be used as a food and medicinal plant, and this may further threaten the small populations of the plant. Because of its edibility, it appears that animal foraging by native mammals may also be a serious threat to small populations (Miller *et al.* 1992). Competition from introduced exotic species is thought to be an additional threat to this plant (Shawnee National Forest 2005).

Habitat destruction from urbanization and development can completely eliminate entire populations of plants as well as the habitat on which they depend. This has become a serious problem not only in Heartleaf Plantain populations elsewhere in Illinois, but in other portions of this plant's range. It is a national problem (W-3). Since European settlement, much of the

previously available habitat has been destroyed, converted to cultivated fields, orchards, or commercial forests, or has succumbed to land development (W-3). Many extant populations are in national forests or protected areas, but these have only been found as a result of careful searches at these sites in recent decades; it cannot be determined precisely how many populations were lost at other sites before field botanists began to recognize the decline of this plantain and before searches were initiated.

Clear-cutting of the surrounding forest is a well-known threat to the Heartleaf Plantain. Exposed plants wilt quickly and die. Unlike the more common weedy plantains, this species has large soft fleshy leaves that do not retain water well. Direct sun tends to remove more water from the plants than they can take up by their weak root system, resulting in eventual decline and death of individuals and populations if the forest cover is removed. Furthermore, clear-cutting can change the hydrology of the woodland stream (W-3). Increased runoff can heighten the frequency and intensity of flooding and scouring of the stream bed. The siltation from the runoff, even from upstream activities, can kill adult plants and prevent seedling establishment. The broad leaves are resistant to low water flow, but during a flood, leaves have been shredded and entire plants have been uprooted (Meagher *et al.* 1978). Seedlings are especially vulnerable to uprooting during floods (Jones and Filbert 1981). Complete clearing or cutting of a forest stand could not be enacted where a colony occurs nor within its watershed upstream without such adverse effects (W-3).

Cattle and horse grazing and trampling are another well-known threat to this delicate species (W-3). The unrestricted human recreational use of its habitat poses a similar threat. For example, the development of user-created trails in the Shawnee National Forest are thought to pose a major threat to the few populations of this species because of the resulting trampling of the plants and the damage to its clean-water habitat; compaction, the loss of the thin soils present, as well as the increase in siltation in other parts of a stream can cause colony destruction by human, equestrian, or vehicular traffic (Shawnee National Forest 2005). The added possibility of grazing or browsing of this edible herb could quickly exterminate a small local population. The difficulty in maintaining this species is that active management itself appears to produce destructive effects to its environment. Instead, increased enforcement of exclusionary rules appears to be necessary to keep damage causing activities away from these plants and their unpolluted habitats.

Various types of industrial, agricultural and domestic water pollution have been indicated as the cause of the loss of several populations of Heartleaf Plantain around the country (W-3). The enrichment of streams from agricultural runoff can lead to eutrophication. Algal growth is then stimulated and the resulting algal bloom can trap seeds and kill seedlings (Stromberg *et al.* 1983). Algal blooms have also been blamed for the elimination of fish that prey on snails (*Physa* sp. and *Triodopsis* sp.) that eat *Plantago cordata* seedlings (Stromberg *et al.* 1983). The influx of excrement from horses and other domestic animals can pose the additional threat of polluting the water and causing eutrophication. It can also be assumed that herbicides will easily eliminate this plant from an area. Such commonly used herbicides as Roundup are known to be particularly effective against plantains and other broadleaf herbs, and so herbicides should not be used in the vicinity of these plants.

The altering of stream flow by means of ditching, draining, or damming has also been

responsible for the loss of populations of this plant throughout its range (W-3). Altered stream flow can change the dynamics of the stream beds. Yearly spring flooding causes the gravel bars to change shape or position in the streams. This physical instability of the gravel bars minimizes the potential for competition with the Heartleaf Plantain and, therefore, benefits it. If the gravel bars become too stable (from controlled stream flow), other vegetation generally will become established and crowd out *Plantago cordata* (W-3). The undercutting of banks has led also to many cases of sloughing-off of great volumes of sediment that have covered and smothered as well as carried away populations of this plant.

Excessive shading may adversely affect the plant (Shawnee National Forest 2005). While there is little support for this in the literature, it is often the case that some plants growing in dense shade will not have sufficient light to produce many flowers and fruits. As evidence, it is said that populations in southern Illinois in dense shade often do not flower or achieve full size, but there have been no known studies to support this hypothesis. It is well-known, however, that clear cutting and exposure of the plants to direct sunlight, especially when their leaves are fully developed, can kill the plants (W-3; Hill, pers. obs.).

The fact that *Plantago cordata* can be used as a food and medicinal plant may threaten some smaller populations (W-3). Heartleaf Plantain was once harvested for use as a medicinal herb by local Indians in Ontario; the roots, fresh or dried, can be used in a tea to heal various ailments (Tessene 1969). According to Allen and Oldham (1985), *Plantago cordata* is no longer harvested due to a declining interest in medicinal herbs by the local people. Steyermark (1963) claimed that the Heartleaf Plantain is the most edible and tender of all the plantains when the young fleshy leaves and petioles are cooked as a vegetable. Furthermore, because of its edibility, animal foraging by native vertebrates and invertebrates can also be a serious threat to small populations. Allen and Oldham (1985) report invertebrate herbivory on the Ontario population. Many plants were found with holes in the leaves, or with leaves severed at the petiole. Stromberg *et al.* (1981) commented on the palatability of the plants due to the number of damaged leaves in seedlings and adult plants. It has also been shown that snails (*Physa* sp. and *Triodopsis* sp.) eat *Plantago cordata* seedlings (Stromberg *et al.* 1983). Slugs, also, can consume entire seedlings (Hill, pers. obs.) and these can be a major problem in a nursery setting.

Competition from introduced exotic species is also thought to be a threat to this plant (Shawnee National Forest 2005). The Heartleaf Plantain is not an aggressive or competitive herb. While the species normally inhabits a specialized habitat with little competition, if the stream becomes polluted, especially by means of silt and nutrient-rich runoff, weeds can become established and prevent the establishment of seedlings as well as choke out the adult plantain plants. Some potential pests (depending on location) include *Dioscorea batatas*, *Lonicera japonica*, and *Lythrum salicaria*, the grasses *Microstegium vimineum*, *Phalaris arundinacea*, and *Phragmites australis*, as well as other aggressive exotics (Shawnee National Forest 2005). Additional native *Polygonum* species, as well as several native and introduced grasses, may also pose a threat if excessive light is introduced through selective tree clearing. The elimination of exotic species should not be accomplished by means of herbicides because of the known sensitivity of species of *Plantago* to most commonly used brands. The habitat of the plant is generally not susceptible to fire and so the use of a fire treatment would not eliminate the roots and seeds of the pest species. Therefore, hand elimination may be the only safe means of control of associated

competitive species.

It is generally believed among biologists that habitat fragmentation can have profound effects on the success and persistence of local populations. Over time, as populations become increasingly more isolated, the effects of fragmentation can potentially be observed at the molecular level by reduced genetic frequencies caused by random drift (Barrett and Kohn 1991). When one is considering populations that are already isolated, as in the case of the Illinois populations, random genetic drift may have already occurred and may have caused negative effects to the species.

At the current time, it appears that the populations of *Plantago cordata* in the Shawnee National Forest will persist if they are protected from habitat change and disturbance; without these protections of selective management and increased enforcement of habitat protection, the plant could disappear from the areas where it occurs.

RESEARCH AND MONITORING

As noted above, research has been undertaken in the areas of basic taxonomy, ecology, and the life history of this rare herb and these have produced useful results. There is some additional basic field research and monitoring needed regarding *Plantago cordata* in order to ensure its survival.

Plantago cordata has been the subject of several studies in recent decades because of its scarcity within so much of its range. While it was recognized to be both scarce and unusual as far back as the 1940s (Harper 1944, 1945) interest in it increased in the 1960s (Godfrey 1961, Tessene 1969) and even more so in the 1970s (Meagher *et al.* 1978, Primack 1978, 1979). Several significant studies on the Heartleaf Plantain appeared subsequently in the 1980s, including those of Allen and Oldham (1985) in Canada, Jones and Filbert (1981) in Ohio, Kurz and Bowles (1981) and Bowles and Apfelbaum (1987, 1989) in Illinois, Morgan (1980) in Missouri, and Alverson (1981), and Stromberg and Stearns (1989) in Wisconsin. Interest in this plant has continued into the 1990s with such studies as that by Mymudes and Less (1993). A great deal of information about this herb was accumulated during the course of these studies (W-3).

Among the conclusions and practices resulting from these studies are specific recommendations regarding the monitoring and management of the remaining populations of the Heartleaf Plantain (W-3). Management objectives for *Plantago cordata* should include maintaining the population in a secured location, maintaining high water quality, and insuring unimpeded stream flow. Biological monitoring should be used to track these management objectives.

A top stewardship priority is the protection and maintenance of the watershed. Downstream migration should be monitored. If the entire watershed has not been secured, the population could conceivably migrate into unprotected or unsuitable areas resulting in the loss of the population (W-3). Monitoring water quality and stream flow together with population censusing may provide some useful correlations on the quality of the habitat and the stability of the population. Seedling recruitment, especially, should be monitored if the population begins to decline. Research into seedling establishment and transplanting may broaden the management

options.

Because of the unstable environment presented by the shifting gravel bars of its typical habitat, population size appears to fluctuate drastically (Meagher *et al.* 1978). Workers should be aware of the local instability of small sub-populations (W-3). Caution is needed in field research to avoid harming the colonies because some states have very few populations of this herb and many of the populations are small.

The most common monitoring procedure is a yearly census of the total population; as part of the basic research on current populations of this species, data such as the counts of numbers of individuals present, the determination of the amount of yearly flowering and seed production, and an assessment of recruitment rates, are all needed in order to monitor population dynamics and to assess the viability of the individual populations found. Individual plants should be monitored over time at each site to determine flowering and fruiting patterns as well as the longevity of individuals. Counts (or reasonable approximations) should be made of individual rosettes, if possible, as well as the area covered by the populations; surveys should be conducted during the flowering and fruiting periods. Long-term monitoring of known populations should be conducted every year to track their status under current management activities (W-3).

It is generally recommended that the habitat quality where this plant grows should be monitored on a regular basis and an assessment of the specific threats to all populations should be made (W-3). When monitoring water quality, one should look for increased nutrient loading, algal blooms, turbidity, and levels of dissolved oxygen. Because of contradictory information, some limited research on prescribed fire or selective thinning of the canopy could be conducted in order to determine the effects of increased light levels to the habitat and populations for the purpose of better management.

Some populations of *Plantago cordata* are being monitored currently by botanists working on behalf of the state Natural Heritage programs and other organizations in the areas where it is listed as endangered or threatened (W-3). In Illinois, John Schwegman, now retired, has been mapping and marking individuals with the bi-coordinate system. To determine reproductive vigor, he has measured maximum leaf width and number of inflorescences on each plant (W-3). Marlin Bowles, of the Morton Arboretum in Lisle, has conducted a monitoring program in Wisconsin that was initiated by Alverson in 1979 and expanded by Stromberg *et al.* from 1981-1983 (W-3). In North Carolina, Rob Sutter has monitored populations previously studied by Antonovics, Meagher, and Primack (Meagher *et al.* 1978). In New York, Steve Clemants has had volunteers checking the status of populations (W-3). In Ohio, the Ohio Field Office of The Nature Conservancy has erected a fence to keep cows from grazing and watering among the protected plantains in that state (W-3).

The obvious should be noted - *Plantago cordata* is so rare and declining so quickly in Illinois, Indiana, and elsewhere that a primary emphasis should be to locate and vigorously protect all remaining populations. Similar habitat should be explored for the plant. There is a small to moderate area of additional suitable habitat in southern Illinois where *Plantago cordata* could also exist, and continued searches for the species should be conducted at the best times of year. A list of associates and indicator species in its preferred habitat has been compiled as a result of

field studies in Illinois and other states (see habitat section above). These indicator plants should be very useful in facilitating the discovery of additional populations of this herb. The herb may have a few more populations than the records indicate, and it could be overlooked because of its similarity to other *Plantago* species; searches for it during seasons when the leaves are not fully developed may result in false negatives for its occurrence at specific sites. Flowering or fruiting material with mature leaves is normally needed for positive identification of this herb, but this is not always possible, but over-collection should be avoided. Specimens can be gathered and verified according to techniques presented by Hill (1995) or in similar works.

Botanical surveys conducted by scientists from the Illinois Natural History Survey have shown repeatedly that with sufficient time and funding, and an experienced eye, many plants thought to be extirpated or else threatened or endangered can be found at additional locations (Hill 2002). These sorts of investigations have been important in that they have led not only to the de-listing of species once thought to be rare, but they have also resulted in the discovery of species previously unknown in the state. The U.S. Forest Service and other related agencies have done a fine job in the effort to preserve rare species with the resources that they have available. Much of the locating and monitoring of known populations of rare species in southern Illinois has been conducted by Forest Service biologists in cooperation with Illinois Department of Natural Resources personnel. However, a continuing problem is that there is neither sufficient funding nor are there enough botanists available to survey the immense area that needs to be covered in the monitoring of the large numbers of sensitive plants, including this one. It appears that a high priority should be given to the training and hiring of additional qualified field botanists to achieve these goals.

RESTORATION

The recovery potential for the Heartleaf Plantain appears to be good to fair (W-4). The adult plants are very hardy. They are resistant to flooding (Jones and Filbert 1981), submergence, and occasional drought (Tessene 1969). They have been successfully established in transplanted populations (Meagher *et al.* 1978). The seeds are well adapted for water dispersal. However, as previously mentioned, *Plantago cordata* has the lowest known reproductive potential of any *Plantago* species (Primack 1976). Establishing new populations may be difficult.

Due to the aquatic and/or amphibious habitat of the Heartleaf Plantain as discussed in the previous section, the most crucial restoration and management need is to control those factors that would adversely affect the water quality and water level fluctuations (W-3). It is well-known that some annual flooding and scouring is important to this plant as it exposes areas along stream banks making them suitable for seedling establishment, and this process must be available for any restored population. The unstable gravel bars shift with each change in water velocity, ensuring the plantains minimal competition for available space. In addition, moving water is essential for its long-distance seed dispersal.

A carefully maintained watershed is needed in restoration efforts for the Heartleaf Plantain, and this is crucial to any selection and design of a preserve for this plant. The Nature Conservancy recommends that if it is not feasible to secure the entire downstream watershed then one should obtain an area extending at least one quarter mile downstream from the present population (W-

3). Securing a section of the downstream watershed will ensure maintenance of favorable habitat for potential seedling establishment. Ideally, the entire watershed should be protected. One should obtain a large buffer of woodland on either side of the stream and prevent clear-cutting, to provide shade (W-3) and to protect against the potential hazard of siltation from increased runoff. The buildup of silt at one site enabled *Phalaris arundinacea* and *Carex* spp. to stabilize a bar upstream from a population of *Plantago cordata* in Wisconsin. The increasingly stable bar is expanding towards the plantains and the *Phalaris* may eventually choke them out. However, the presence of the bar is also prolonging the existence of the herb by trapping the silt upstream from the plants. Alverson (1981) has suggested building silt traps or settling ponds upstream from the plantains to help in the restoration efforts. Algae should be removed from the stream to prevent seed death from entanglement.

Because of the specific habitat requirements of clean water and a silt-free gravelly or rocky creek bed, recovery of a highly degraded site may not be possible. Restoring a depleted site may be feasible. Transplanting experiments by Stromberg *et al.* (1981) showed that the larger plants had a better chance for survival than smaller plants or seedlings. Meagher *et al.* (1978) found that transplanted adults would flower and fruit, but no seedlings were subsequently observed. Several people have transplanted this herb into a controlled habitat (native wildflower garden), and have found seedlings (W-3, Hill, pers. obs.). However, long term success is difficult without continued maintenance or a suitable habitat.

Results from transplanting greenhouse-grown *Plantago cordata* into sites with no previous populations showed a first-year survival rate that ranged from 25% to 100% (Kunowski 1983). Follow-up on the majority of the transplant sites has been casual since 1983 (W-3) therefore, no information is available on long-term survival or reproductive success (seedling establishment). In one transplant attempt, twenty-eight plants have survived for four years. The plants flowered and set seed the first season after transplanting into a spring-fed, calcareous, gravel-bottomed stream. The plants have grown in size, but no seedlings have been found (W-3).

There are several restoration efforts being conducted on *Plantago cordata* within its range, especially in the Great Lakes region and the restoration potential of this species may be good (W-3). Observations and results concerning the restoration potential for *Plantago cordata* in the Midwestern region, especially in the area around the southern Great Lakes, has been presented by Bowles *et al.* (1988). The challenge is to protect an entire watershed from degradation, and this is difficult because it may require the protection of a very large area of land that is not available for these practices. Despite the reduced seed production in this species relative to other species of *Plantago*, seeds are produced in sufficient quantities for increasing the populations, and the seed germination percentage appears to be good. Because seedlings in the wild are very vulnerable to predation and flooding events, the restoration of plants by seeds and seedlings may not be the best method. The success of seed germination off-site, though, eliminates the need for reproduction of the plants by vegetative means, and also helps to eliminate the possibility of creating clonal, genetically identical, colonies. The seedlings can then be raised into stronger, adult plants in a nursery before transplanting into the wild. Once the plants have been introduced to a site, exotic and aggressive species should be completely eliminated from their vicinity as they are found. This would entail physically pulling them out because it is very likely that herbicide application would eliminate this species as well.

The Heartleaf Plantain is sometimes offered by specialty wild plant nurseries. However, restorations of any native plant species are recommended using only propagated material grown from native, local populations to avoid mixing genotypes not adapted to the local conditions and to avoid compromising the local gene pool. If this rule is not followed, the result is generally the loss of plants because they are not competitive under local conditions or the result could be the success of a plant or plants that cannot be considered truly native (considered by some to be a plant community reconstruction rather than a restoration). Local plants should be propagated for planting in such an effort, and they should be raised to maturity outdoors so that they will have a better chance at surviving in the wild. Plantains are normally easily propagated by means of seeds under controlled conditions.

The Holden Arboretum, in Willoughby, Ohio, is the primary custodian for this plant in the Center for Plant Conservation National Collection of Endangered Plants (W-3). The plant is being propagated sparingly at other sites as well.

SUMMARY

Heartleaf Plantain, *Plantago cordata* Lam., is a perennial herb with a rosette of stalked leaves that grows in very specific habitats of clear-running streams in gravelly soils. It demonstrates an unusual and fragile life cycle, and its habitat is extremely vulnerable. The species is widespread in the eastern United States and a small area of adjacent Canada and it is known historically from twenty states including the District of Columbia, from New York and Ontario, Canada, south to Florida (perhaps), and west to Arkansas and Iowa. It is an obligate wetland species. Globally, its ranking is G4 (apparently secure world-wide); its National status in the United States is N4 (with similar meaning) and it is critically endangered in Canada (N1). Heartleaf Plantain is listed as Endangered in six states, as Threatened in three states, and as Presumed Extirpated in six states including the District of Columbia. The species has suffered a major decline, and it is known to occur today in only 13 of the former 20 states from which it has been reported historically. In Forest Service Region 9, the Heartleaf Plantain is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest where it has not been found. It is at risk at the margins of its range.

Suggested research priorities for this rare herb include attempts to locate and protect additional populations, an initiation of studies on the effects of fire or canopy thinning on its survivability and reproduction in southern Illinois, the continued study to learn more about its successful propagation and restoration in the wild, and studies on the techniques on how best to protect its watersheds from disturbance. Management through strict protection of its clear-water habitat, either through enforcement of existing regulations or through the creation of new rules for restricted access to the sites (particularly recreational and equestrian access), appears to be necessary to allow it to persist where it may occur. At this time, with proper management and protection, current populations should persist and they could even increase in size, but the establishment of additional populations will be only through active human efforts.

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APPENDIX 1

Representative specimens of *Plantago cordata* examined or cited in the literature

Herbaria:

ILLS = Illinois Natural History Survey, Champaign. MIL = Milwaukee Public Museum, Milwaukee, WI. MO = Missouri Botanical Garden, St. Louis. MU = Miami University, Oxford, OH. NY = New York Botanical Garden, Bronx. SWSL = Southern Weed Science Laboratory, USDA/ARS, Stoneville, MS. WIS = University of Wisconsin, Madison.

ALABAMA: COLBERT CO., bed of Fox-trap Creek, in SE part of county, 25 Jul 1942, *Harper 3892* (MO); banks of Ligon's Creek about 2 miles W of Littleville, 28 Apr 1943, *Harper 3933* (MO).

DISTRICT OF COLUMBIA: Poplar Point, Jun 1889, *Burgess s.n.* (NY).

GEORGIA: CATOOSA CO., 1.9 mi ENE of Fort Oglethorpe, 31 Mar 1951, *Duncan & McDowell 12236* (MO); **FLOYD CO.**, Rome, s.d., *Chapman s.n.* (MO).

ILLINOIS: COOK CO., Glencoe, 10 May 1891, *Moffatt 1692* (MU); **GRUNDY CO.**, Morris, s.d., *Slosson s.n.* (NY); **HANCOCK CO.**, Augusta, 8 May 1860, *Mead 6681* (MO); **JOHNSON CO.**, Cedar Creek NE of Simpson Township, 25 Jul 1990, *Post & Jeffords s.n.* (ILLS); **MADISON CO.**, Alton at Burlington RR, 25 Apr 1894, *Grover s.n.* (MU); **SALINE CO.**, Three Springs Hollow, Middle Fork River, 2 Apr 1991, *Post & Jeffords s.n.* (ILLS); .

INDIANA: BOONE CO., Lebanon, May 1861, *s.col. s.n.* (NY); **FLOYD CO.**, New Albany, 1838, *Coulter 8354* (NY); **WHITLEY CO.**, about 7 mi E of Columbia City, 13 Jun 1946, *Friesner 20424* (MO, NY).

IOWA: ? CO., s.d., *s.col. s.n.* (NY).

KENTUCKY: ? CO., s.d., *s.col. s.n.* (NY).

MICHIGAN: GENESEE CO., Flint, 30 Nov 1999, *Clarke s.n.* (MO); **IONIA CO.**, west of Bridge on Nickle Plate Road, 23 May 1995, *Case & Case s.n.* (ILLS); **ST. CLAIR CO.**, near Port Huron, 8 May 1895, *Dodge & Beardslee s.n.* (MU); .

MISSISSIPPI: MONROE CO., vicinity of Central Grove, 19 May 1996, *MacDonald 9435* (MO, SWSL); same locality, 15 Apr 1997, *MacDonald 10259 & 10263* (SWSL).

MISSOURI: ADAIR CO., tributary to Chariton River, between Kirksville and Novinger, 4 May 1935, *Steyermark 18857* (MO); branch of Sugar Creek, 2 May 1970, *Conrad 5564* (MO); **CALLAWAY CO.**, ca. 3.5 mi W of Guthrie off Hwy Y, Mark Twain National Forest, 19 Jun 1993, *Summers 5789* (MO); **CRAWFORD CO.**, ca. 1.0 mi WSW of Visitor Center at Meramec State Park, 24 May 1999, *Smith et al. 3450* (MO); **DENT CO.**, north prong of Meramec River,

between Stone Hill and Indian Trail State Park, 4 Aug 1936, *Steyermark 12517* (MO); **HOWARD CO.**, Montineau Creek, 4 mi NE of Bunker Hill, 13 Aug 1952, *Steyermark 74265* (MO); **JEFFERSON CO.**, 6.5 mi W of DeSoto, Mammoth Creek, 4 May 1991, *Raven & Raven 27869* (MO); Cliffdale Hollow SW of Selma, 15 Apr 1934, *Steyermark 8048* (MO); **MADISON CO.**, White Snake Creek 2 mi SW of Cornwall, 15 May 1989, *Summers 2885* (MO); **MILLER CO.**, Saline Valley Wildlife Area, N of Hwy M on Compton Branch, 6 May 1980, *Maupin et al. 355* (MO); **REYNOLDS CO.**, Deer Run State Forest, 9 Apr 1992, *Newman s.n.* (MO); **RIPLEY CO.**, south fork of Buffalo Creek, 5 mi E of Bardley, 14 Jul 1936, *Steyermark 11792* (MO); **SAINT GENEVIEVE CO.**, Bidwell Creek, near Forest Service Road 2199, 12 May 1993, *Brant et al. 2185* (MO); **ST. LOUIS CO.**, Allenton, Flat Rock, 15 Apr 1923, *Greenman 4214* (MO, NY); **SHANNON CO.**, Boardinghouse Hollow Branch, 21 May 1997, *Brant 3712* (MO); **TEXAS CO.**, Grassy Hollow, 2 mi S of Arrill, 23 Aug 1990, *Summers & Ryan 3637* (MO); **WARREN CO.**, Daniel Boone Memorial Forest, near N boundary, Apr 1977, *Robine s.n.* (MO).

NEW YORK: DUTCHESS CO., Ward Manor, May 1933, *Elwert s.n.* (NY); **ULSTER CO.**, Saugerties, Hudson River, 31 Aug 1937, *House 25085* (NY).

NORTH CAROLINA: DAVIDSON CO., Beaverdam Creek on NC Co Rd. 2545, 11 Jun 1979, *Nelson & Matthews 1156* (MO); 2.8 mi NW of Snider, 2 May 1963, *Ahles & Haesloop 57908* (ILLS, NY).

OHIO: ADAMS CO., Plum Run Quarry, 2.6 mile east of Peebles, 29 May 1966, *Tessene & Stuckey 1918* (ILLS); **AUGLAIZE CO.**, St. Mary's, 12 Apr 1897, *Wetzstein s.n.* (MU); **FRANKLIN CO.**, Columbus, 1836, *Short s.n.* (MO); **HARDIN CO.**, Lawrence Woods, Taylor Creek Township, 26 May 1990, *McCormac 2397* (MU); **LORAIN CO.**, South Woods, Oberlin, 21 May 1891, *Cowles s.n.* (MU); .

VIRGINIA: ALEXANDRIA CO., Chesapeake Bay region, at Alexandria Lights, 13 Aug 1902, *Shull 217* (MO, NY); **SMYTH CO.**, Ravine of the Holstein, vicinity of Marion. 8 Jun 1892, *Britton et al. s.n.* (NY).

WISCONSIN: BROWN CO., Bellevue Creek cascade, 15 May 1881, *Schuette s.n.* (NY); **KENOSHA CO.**, Somers, 3 Jun 1899, *Wadmond s.n.* (WIS); **MILWAUKEE CO.**, 6 May 1969, *Kopitzke et al. DK-69-3* (WIS); **OZAUKEE CO.**, Mequon, 28 Apr 1992, *Luebke et al. 831* (MIL); **RACINE CO.**, Racine, 21 May 1980, *Davis s.n.* (WIS).

APPENDIX 2.

**The Historic Distribution of *Plantago cordata* in the United States.
Information from herbarium specimens and the literature.**

STATE	COUNTIES	NOTES
Alabama	Bibb, Cherokee, Colbert, Franklin	W-1, W-3;
Arkansas	Baxter, Carroll, Randolph, Sharp	W-1, W-3; Smith (1978)
District of Columbia	Historic only	W-1, W-3;
Florida	? No specimens known.	W-1, W-3;
Georgia	Catoosa, Floyd, Gordon, Walker	W-1, W-3;
Illinois	25 counties: Cass, Champaign, Christian, Cook, *DuPage, Grundy, Hancock, *Jackson, *Johnson, *Kendall, Lake, La Salle, Macoupin, Madison, Marshall, Menard, Peoria, Piatt, *Pope, St. Clair, Sangamon, *Saline, *Tazewell, Wabash, and Will. * = thought to be extant, all others historic only	W-1, W-3; Herkert and Ebinger (2002); Mohlenbrock and Ladd (1978); Mohlenbrock (1986); includes Shawnee N.F.
Indiana	Boone, Floyd, Knox, Kosciusko, Lake, Porter, Tippecanoe, Wells, *Whitley. * = extant, all others historic only	W-1, W-3; Deam (1940); Homoya, pers. comm.
Iowa	?	W-1, W-3;
Kentucky	?	W-1, W-3
Maryland	Prince Georges	W-1, W-3; M.Smith (unpublished atlas 2006).
Michigan	Clinton, Eaton, Genesee, Gratiot, Hillsdale, Ingham, Ionia, Kent, Macomb, Oakland, St. Clair, Shiawassee, Tuscola, Washtenaw, Wayne	W-1, W-3; W-6
Mississippi	Monroe	W-1, W-3; Charles Bryson (pers. comm.)
Missouri	At least 24 counties, mostly eastern and southeastern	W-1, W-3; Steyermark (1963); Yatskievych (1999) p. 88; including Mark Twain N.F.
New York	Albany, Bronx, Cayuga, Columbia, Dutchess, Erie, Genesee, Greene, Rensselaer, Rockland, Ulster	W-1, W-3; Magee and Ahles (1999)
North Carolina	Davidson, Stanly	W-1, W-3; Radford <i>et al.</i> (1968); herbarium specimens

Ohio	*Adams, Auglaize, Champaign, Clark, Erie, Franklin, Hardin, Logan, Lorain, Lucas, Madison, *Mahoning, Scioto * = extant	W-1, W-3; Mike Vincent (pers. comm.)
South Carolina	? No specimens known.	W-1, W-3; Nelson (pers. comm.)
Tennessee	Franklin, McNairy	W-1, W-3; Chester <i>et al.</i> (1997).
Virginia	Alexandria, Smyth	W-1, W-3;
Wisconsin	Brown, Kanosha, Milwaukee, Outagamie, Ozaukee, Racine	W-1, W-3;

APPENDIX 3.

Natural Diversity Database Element Ranking System

Modified from: <http://www.natureserve.org/explorer/ranking.htm> [W-8]

Global Ranking (G)

G1

Critically imperiled worldwide. Less than 6 viable elements occurrences (populations for species) OR less than 1,000 individuals OR less than 809.4 hectares (ha) (2,000 acres [ac]) known on the planet.

G2

Imperiled worldwide. 6 to 20 element occurrences OR 809.4 to 4,047 ha (2,000 to 10,000 ac) known on the planet.

G3

Vulnerable worldwide. 21 to 100 element occurrences OR 3,000 to 10,000 individuals OR 4,047 to 20,235 ha (10,000 to 50,000 ac) known on the planet.

G4

Apparently secure worldwide. This rank is clearly more secure than **G3** but factors exist to cause some concern (i.e. there is some threat, or somewhat narrow habitat).

G5

Secure globally. Numerous populations exist and there is no danger overall to the security of the element.

GH

All sites are historic. The element has not been seen for at least 20 years, but suitable habitat still exists.

GX

All sites are extirpated. This element is extinct in the wild.

GXC

Extinct in the wild. Exists only in cultivation.

G1Q

Classification uncertain. The element is very rare, but there is a taxonomic question associated with it.

National Heritage Ranking (N)

The rank of an element (species) can be assigned at the national level. The **N-rank** uses the

same suffixes (clarifiers) as the global ranking system above. Rarely the designation **NNR** is used indicating that the species has not been ranked nationally.

Subspecies Level Ranking (T)

Subspecies receive a **T-rank** attached to the G-rank. With the subspecies, the G-rank reflects the condition of the entire species, whereas the T-rank reflects the global situation of just the subspecies or variety.

For example: *Chorizanthe robusta* var. *hartwegii*. This plant is ranked **G2T1**. The G-rank refers to the whole species range (*i.e.*, *Chorizanthe robusta*, whereas the T-rank refers only to the global condition of var. *hartwegii*. Otherwise, the variations in the clarifiers that can be used match those of the G-rank.

State Ranking (S)

S1

Critically imperiled. Less than 6 element occurrences OR less than 1,000 individuals OR less than 809.4 ha (2,000 ac). **S1.1** = very threatened; **S1.2** = threatened; **S1.3** = no current threats known.

S2

Imperiled. 6 to 20 element occurrences OR 3,000 individuals OR 809.4 to 4,047 ha (2,000 to 10,000 ac). **S2.1** = very threatened; **S2.2** = threatened; **S2.3** = no current threats known.

S3

Vulnerable. 21 to 100 element occurrences OR 3,000 to 10,000 individuals OR 4,047 to 20,235 ha (10,000 to 50,000 ac). **S3.1** = very threatened; **S3.2** = threatened; **S3.3** = no current threats known.

S4

Apparently Secure. This rank is clearly lower than S3 but factors exist to cause some concern (*i.e.*, there is some threat, or somewhat narrow habitat).

S5

Secure. Demonstrably secure to ineradicable in the state.

SH

All state sites are historic; the element has not been seen for at least 20 years, but suitable habitat still exists. Possibly extirpated.

SNR, SU

Reported to occur in the state. Otherwise not ranked.

SX

All state sites are extirpated; this element is extinct in the wild. Presumed extirpated.

Notes:

1. Other considerations used when ranking a species or natural community include the pattern of distribution of the element on the landscape, fragmentation of the population/stands, and historical extent as compared to its modern range. It is important to take a bird's eye or aerial view when ranking sensitive elements rather than simply counting element occurrences.
2. Uncertainty about the rank of an element is expressed in two major ways: by expressing the rank as a range of values (*e.g.*, **S2S3** means the rank is somewhere between S2 and S3), and by adding a '?' to the rank (*e.g.* S2?). This represents more certainty than S2S3, but less than S2.