APPENDIX G

NATURAL HISTORY AND TAXONOMIC REFERENCES FOR PRICE'S POTATO-BEAN

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Natural History and Taxonomic References for Price's potato-bean (*Apios priceana*)

Kral, R. 1983. A report on some rare, threatened or endangered forest related vascular plants of the south. Atlanta, GA: U.S. Forest Service. p.718. USFS technical publication R8-TP2, . Vol. 1.

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Text & map by:
Robert Kral

FABACEAE

Apios priceana B. L. Robinson. Price's groundnut
Glycine priceana (Robinson) Britton

Technical Description

Herbaceous perennial, sometimes rampant, vine from a stoutish, thickened tuber.
Stems.--TWining, also somewhat twisted, terete and also low-ridged, yellow-green or tan, smooth or with a scattering of stiff hairs, forming a large vine.
Leaves.--Alternate, the stipules linear with a round attachment scar, odd-pinnately compound, mostly 2-3 dm long, spreading on slender but stiff, sparingly pubescent petioles one-third to one-half the length of the leaf; leaflets on stalks 3-5 mm long, spreading, 5-9, mostly 7, broadly to narrowly ovate, the lowest pair usually the largest, acuminate, entire, the bases rounded, the upper surface at maturity smooth, dark yellow-green, reticulate, the lower surface paler, puberulent, reticulate-veiny.
Inflorescence.--All but the lower leaves bearing rather compact panicles or racemes 5-9 cm long on stout, hairy stalks 3-4 cm long. Flowers one or more in axils of pale green, ovate, hairy, acuminate bracts, on pedicels 3-5 mm long, in total length ca. 2 cm.
Flowers.--Calyx a thin, pale green, villous cup ca. 3-4 cm high, this bearing at its lower edge a very narrow projecting lobe ca. 3 mm long. Corolla as in pea or bean, brownish-green with maroon tints, when viewed from the side strongly curved outwardly below, concave on the keeled greenish-yellow or pink standard blade above, this blade folded over most of the rest of the corolla and longest, its tip fleshier than the rest, beak-like, its base short-auricled; wings oblong linear, short-clawed, each bearing a short auricle basally; keel petals rather fleshy, strongly curved upward and linear, blunt, short clawed.
Fruit.--Pods 13-20 cm long, linear, somewhat turgid, the base cuneate, the apex abruptly attenuated into a prominent slender beak, the surface smooth, the valves firm with somewhat thickened margins. Beans oblong, smooth, dark brown, 7-8 mm long.

Distribution and Flowering Season

Rocky wooded slopes and floodplain edges, middle Kentucky southward through middle Tennessee into northern Alabama and Mississippi. Flowering from late June into August; fruit maturing in August.

Special Identifying Features

This plant is distinguished from A. americana Medic as follows:

1. The leaves are larger, the leaflets usually with one pair more.
2. The standard petal (uppermost petal) is larger, pink or with yellow-green tints rather than purple-maroon (as in A. americana), bearing at its tip a thickened, mucro-like appendage. In A. americana

the standard tip is blunt, even emarginate.
3. The fruits are longer, with the shorter ones about equal to the longest ones produced by A. americana.

Habitat and Management Implications

A. priceana is usually found under mixed hardwoods or in clearings therein, usually where ravine slopes or banks break into creek or river bottoms. It is on well-drained loams either on old alluvium or over calcareous boulders.

This is such a rare plant that little is yet known for sure of its response to disturbance, grazing, etc. It has been collected in secondary growth hardwood forest, thus is known to survive in the wake of logging. I have observed it in an area of recent burning and it may be conceded that it may react well to fire disturbance as do many other leguminous plants that have large tuberous rootstocks (Gleason, 1952, measured some rootstocks to be 18 cm wide!) However, the very rarity of the plants is an indication that this species has a narrow ecological amplitude.

References

Gleason, H. A. 1952. Illustrated flora, ed. 3, Vol. 11: 448-449. New York.

Small, J.K. 1933. Manual of the southeastern flora, p. 723. Chapel Hill, N.C.

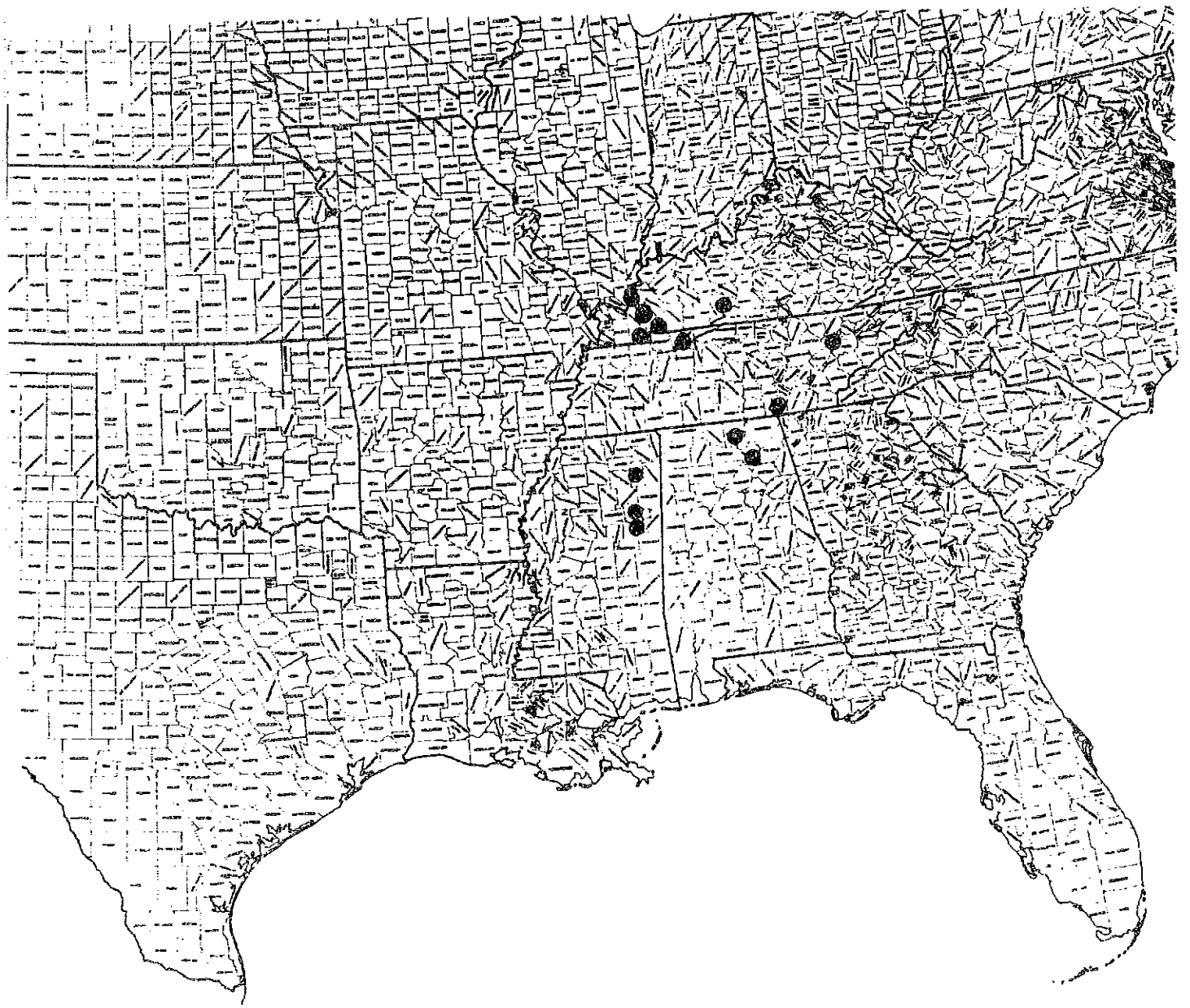
SPECIES Apios priceana B.L. Robinson

Expected* Effect on the Species	Management Practices							
	Prescribe Burn	Bulldoze or Root Rake	Bed	Chop	Thin over-story	Cut over-story	Establish Plantation	Graze
Destroy		X	NA	NA				
Damage					X	X		?
No Lasting Effect								
Beneficial if Done Properly	X							

Other Comments:

*Expected effect on the species is an estimate made by Dr. Robert Kral based on his knowledge of the habitat and on knowledge gained from personal field observations. Estimates are "rough" in many instances. Results of practices may be modified depending upon the degree of application, intensity of treatment, nearness to plant communities, etc. A management practice for which no entry is made indicates a lack of sufficient information from which to predict expected results. As observations are made in the field by users of the data, the expected effect will be refined.

Apios priceana B. L. Robinson



NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer.

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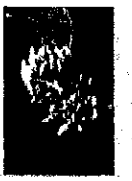
Apios priceana - B.L. Robins.
Price's Potato-bean
Unique Identifier: ELEMENT_GLOBAL.2.138209
Element Code: PDFAB0D020
Informal Taxonomy: Plants, Vascular - Flowering Plants - Pea Family



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Kingdom	Phylum	Class	Order	Family	Genus
Plantae	Anthophyta	Dicotyledoneae	Fabales	Fabaceae	Apios

Check this box to expand all report sections: ☑

Concept Reference

Concept Reference: Kartesz, J.T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. 2nd edition. 2 vols. Timber Press, Portland, OR.
Concept Reference Code: B94KAR01HQUS
Name Used in Concept Reference: *Apios priceana*
Taxonomic Comments: One of the two U.S. species in this small genus.

Conservation Status

NatureServe Status

Global Status: G2
Global Status Last Reviewed: 09Jul2004
Global Status Last Changed: 25Jul1983
Rounded Global Status: G2 - Imperiled
Reasons:
Currently known from about 25 widely scattered populations, most with fewer than 50 individuals. *Apios priceana* is apparently dependant on a moderate level of disturbance; however, excessive habitat modification is threatening the existence of the species. Many of these few remaining occurrences are threatened by successional canopy closure, cattle grazing/trampling, right-of-way maintenance and forestry activities.
Nation: United States
National Status: N2

U.S. & Canada State/Province Status	
United States	Alabama (S2), Illinois (SX), Kentucky (S1), Mississippi (S1), Tennessee (S2)

Other Statuses

U.S. Endangered Species Act: LT: Listed threatened (05Jan1990)
U.S. Fish & Wildlife Service Lead Region: R4 - Southeast

Comments on official statuses: Apios priceana was proposed threatened on May 12, 1989 and federally listed as a Threatened species by the U.S. Fish and Wildlife Service on January 5, 1990.

NatureServe Conservation Status Factors

Global Abundance Comments: Individual EO's often have less than 50 plants present.

Estimated Number of Element Occurrences:21 - 80
Estimated Number of Element Occurrences Comments: Apios priceana has been collected from 21 sites in Alabama, Mississippi, Kentucky, Tennessee and Illinois (Norquist 1990, USFWS 1989, Medley 1980). However, many of these occurrences are no longer extant (Norquist 1990). The greatest concentration of occurrences are from western Kentucky and Tennessee (Medley 1980). The single Illinois site has been destroyed (Medley 1980) and the species is no longer considered extant in the state (Karnes pers. comm.). Apios priceana is considered extant at only 15 sites throughout its range: 4 sites in Kentucky; 4 sites in Tennessee; 4 sites in Mississippi; and 3 sites in Alabama. Several of these sites have multiple EO's, with 58 extant EO's in the central databases (July 2004).

Global Short Term Trend: Declining (decline of 10-30%)

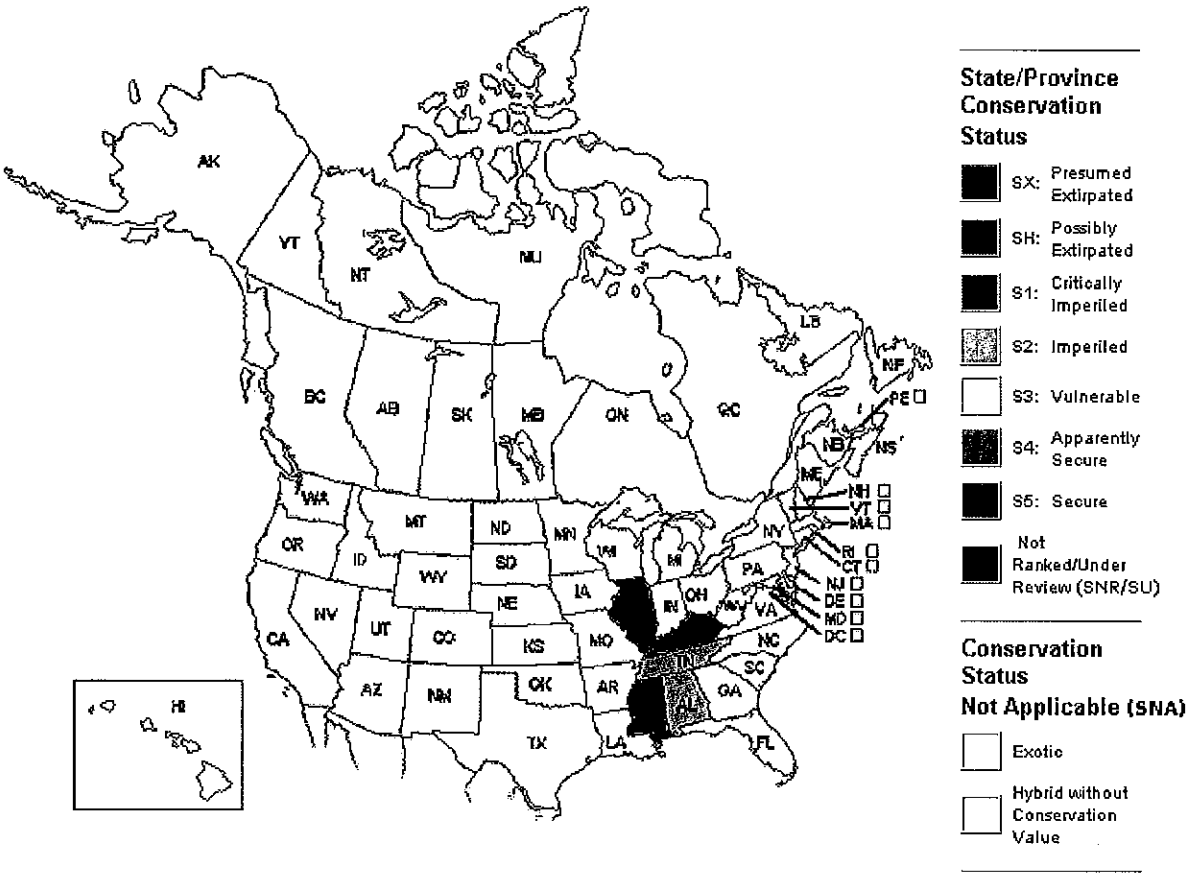
Degree of Threat: Widespread, low-severity threat
Threat Scope: High
Threat Severity: Low
Threat Immediacy: Unknown
Threats: Habitat loss and degradation from heavy or clear-cut logging, highway right-of-way maintenance, trampling and soil compaction by cattle are threats to this early successional species (Bender pers comm., Norquist 1990, USFWS 1989, Medley 1980). Development of lands for housing or other uses is a potential threat to occurrences of this species (Medley 1980). Brush-clearing (bush-hogging) during the growing season, line replacement and upgrading are additional threats to some sites (Bender pers. comm.). Some sites are threatened by non-native invasive species.

Threats at the Trigg County, Kentucky, sites include trampling by hikers, overcrowding by shrubs, canopy closure, mowing, highway maintenance and competition from introduced crown vetch (Coronilla varia) (Chester and Holt 1990). Succession is considered a major threat at some sites (Norquist 1990).

Fragility Comments: Relatively resistant.

Distribution

U.S. States and Canadian Provinces



U.S. & Canada State/Province Distribution	
United States	AL, IL*, KY, MS, TN

Range Map
No map available.

Global Range Comments: Mississippi (Clay, Oktibbeha and Lee counties); Alabama (Madison, Autsuga and Marshall counties); Kentucky (Lyon, Livingston and Trigg counties); Tennessee (Marion, Montgomery and Williamson counties). Historic in Illinois.

U.S. Distribution by County (based on available natural heritage records unless otherwise indicated) ?	
State	**County Name (FIPS Code)**
AL	(01001)+, (01047)+, (01071)+, (01079)+, (01089)+, (01095)+
KY	(21035)+, (21139)+, (21143)+, (21157)+, (21221)+, (21227)+
MS	(28025)+, (28069)+, (28081)+, (28105)+
TN	(47037)+, (47041)+, (47055)+, (47081)+, (47115)+, (47119)+, (47125)+, (47161)+, (47181)+, (47187)+

* Extirpated/possibly extirpated

U.S. Distribution by Watershed (based on available natural heritage records) ?	
Watershed Region ?	**Watershed Name (Watershed Code)**
03	Upper Alabama (03150201)+, Middle Alabama (03150203)+, Town (03160102)+, Tibbee (03160104)+, Noxubee (03160108)+
05	Barren (05110002)+, Caney (05130108)+, Lower Cumberland-Sycamore (05130202)+, Harpeth (05130204)+, Lower Cumberland (05130205)+, Lower Ohio-Bay (05140203)+, Lower Ohio (05140206)+
06	Sequatchie (06020004)+, Guntersville Lake (06030001)+, Wheeler Lake (06030002)+, Lower Elk (06030004)+, Lower Tennessee-Beech (06040001)+, Lower Duck (06040003)+, Buffalo (06040004)+, Kentucky Lake (06040005)+

+ Natural heritage record(s) exist for this watershed
* Extirpated/possibly extirpated

Ecology & Life History

Technical Description: Plant a herbaceous, twining, perennial vine, to 5 m, scrambling over other vegetation, arising from a large, starchy underground tuber. Stems slender, twining, round in cross-section, ridged; green or tan, smooth or with scattered, stiff hairs. Leaves alternate, 0.6-1 foot long, composed of 5-9 (mostly 7) ovate leaflets; the lowest pair of leaflets usually the largest. Leaflets entire-margined, with rounded bases and narrowed points, widest below the middle, the upper surface smooth at maturity, dark yellow-green, net-veined, the lower surface paler, fine-hairy; tiny (but evident) rusty-brown hairs on the short stem at the base of each leaflet. The flowers are swollen, greenish-pink with maroon tints and a beak-like tip. They are arranged in compact racemes, on stout hairy stalks, in the axils of pale green, ovate, hairy, pointed bracts. Fruit an elongated legume, 5-8 inches long, somewhat swollen, abruptly narrowing into a slender beak. The seeds are oblong, smooth, dark brown, and about 0.3 inch long.

Diagnostic Characteristics: This species most closely resembles Apios americana (= A. tuberosa), from which it is distinguished by the following characteristics: (a) larger leaves, usually with 7 rather than 5 leaflets; (b) the uppermost petal (standard) has an elongated tip, is larger, and is pink with green tints rather than maroon; (c) the fruits are longer, the shortest ones similar in length to the longest ones in A. americana. Wisteria is similar, but can have more leaflets (5-11) which are all about the same size and widest in the middle (in contrast to those of Apios); the leaf rachis of Wisteria is hairy, and its flowers are purple and bloom in the early spring.

Reproduction Comments: Flowers of A. priceana bloom from June through August, possibly as late as September (Kral 1983, Mahler 1970). Legumes mature in August to September (Kral 1983). Early reports by the discoverer of the species, Sadie Price, suggested that it does not frequently set fruit (Robinson 1898).

Ecology Comments
Unlike its close relative, Apios americana, which produces numerous tubers, A. priceana produces only one. This fact may serve to severely limit natural dispersal of the species. Since A. priceana has just the single tuber, it is unable to be dispersed effectively along rivers by spring freshets as is A. americana (Seabrook and Dionne 1976).

Apios priceana has a potential value to humans as a food source (USFWS 1989). The large single tubers from which the plant grows are edible and may have been used by Native American Indians and early settlers as food, as was Apios americana. The ability of the species to grow in highly alkaline (pH > 8.0) and acidic (pH < 5.0) (Duke 19) soils could provide genetic resources for the development of Apios hybrids in cultivated lands otherwise marginal for most other crops (USFWS 1989, Walter et al. 1986). Perhaps the most valuable aspect of A. priceana is as a source of germ plasm for breeding with other Apios species (Norquist 1990, Walter et al 1986).

According to a recent study of A. priceana (Walter et al. 1986), the tubers were found to be composed of 61.9% water, 5.0% fiber, 2.6% crude protein, 2.7% ash, 27.1% carbohydrate and 0.7% fat. For a compositional comparison of A. priceana tubers with those of A. americana and A. fortunei, see Walter et al. (1986). As a food crop, A. priceana tubers are naturally low in essential amino acids. Extraction of nonprotein nitrogen by alcohol resulted in tuber protein that could be useful in human nutrition (Walter et al. 1986).

Open forest canopies tend to correlate with increased flowering in the species (Somers pers. comm.). Flowers of A. priceana bloom from June through August, possibly as late as September (Kral 1983, Mahler 1970). Legumes mature in August to September (Kral 1983). Early reports by the discoverer of the species, Sadie Price, suggested that it does not frequently set fruit (Robinson 1898). Potential pollinators include a butterfly (Eudamus tityrus), honey and bumble bees (Robinson 1898). Apparently the bees find the nectaries very difficult to access. Apios priceana can be readily germinated by scarification of the seed coat through chipping (Seabrook 1973) or acid (Walter et al. 1986).

Apios priceana is apparently quite easy to grow from seed, but requires scarification or other natural processes to break physical dormancy (Baskin pers. comm.; Bowden pers. comm.). Following scarification, 18 of 20 seeds planted 1 cm deep in soil grew in a recent test in Kentucky (Baskin pers. comm.). Scarification can be accomplished through a nick with a file, grinding wheel, hot water or sulfuric acid (Bowden pers. comm.). Plants can grow 5-6 feet during the first summer, but do not flower. Flowering is apparently initiated only in plants that have over-wintered (Baskin pers. comm.).

Tubers of A. priceana apparently require vernalization for growth (Bowden pers. comm.). Plants die back to the tuber in the mid-summer.

Additional research has been conducted on A. priceana for horticultural purposes. According to the Missouri Botanical Garden, A. priceana prefers acidic, water retentive soils, requires no soil additives, can withstand winter temperatures below 5 degrees Celsius, shows no intolerance to supplemental feedings, and possesses no apparent pests (Bowden pers. comm.). The species has been successfully propagated.

Habitat Comments: Open, rocky, wooded slopes and floodplain edges. Sites are usually under mixed hardwoods or in associated forest clearings, often where bluffs or ravine slopes meet creek or river bottoms. Soils are well-drained and loamy, formed on alluvium or over calcareous boulders. Several populations extend onto road or powerline rights-of-way.

Price's potato-bean is an inhabitant of open, mixed-oak forests, forest edges and clearings on river bottoms and ravines, being unable to tolerate deep shade (USFWS 1989, Kral 1983). The species occurs on well-drained loams on old alluvium or over calcareous boulders (Kral 1983). Associates typically include Quercus muhlenbergii, Campanula americana, Lindera benzoin, Arundinaria gigantea, Tilia americana, Fraxinus americana, Acer saccharum, Ulmus rubra, Cercis canadensis, Toxicodendron radicans and Parthenocissus quinquefolius (Medly 1980).

Four extant populations of A. priceana are known from Kentucky. The type location near Bowling Green, Warren County, Kentucky, was

characterized as a rocky woods (Robinson 1898); it has been destroyed. A population in Livingston County (estimated at 50-65 plants in 1984) has been severely degraded by cattle since their introduction into the area in 1986 (Norquist 1990). Additional collections in Kentucky have been made in Lyon and Trigg counties (Chester and Holt 1990, Browne and Athey 1976). The Lyon County site consisted of 25-30 individuals, extending onto a right-of-way (Norquist 1990).

The Hematite Lake site in northern Trigg County, Kentucky, was relocated by Woods (1985) and later by Chester and Holt (1990). The population had been considered extirpated (Medley 1980). This site is along a hiking trail at the base of a southeast-facing slope with numerous limestone outcrops (Chester and Holt 1990). The population consisted of 25 plants in 1989, but no plants were observed to set seed in that year. Associates included Arundinaria tecta, Symphoricarpos orbiculatus, Acer saccharum, Celtis laevigata, C. occidentalis, Carya ovata, Ulmus rubra, Quercus muehlenbergii, Ostrya virginiana, Amphicarpa bracteata, Hystrix patula, Solidago rugosa, Matelea gonocarpos, Agrimonia rostellata, Lobelia inflata and a species of Panicum (Chester and Holt 1990). The southern Trigg County, Kentucky, site (previously unseen since 1966) was rediscovered by Chester and Holt (1990). A population of 30-50 plants occurs at the base of a southeast-facing slope with numerous limestone outcrops, in a roadside ditch that is fairly open to light (Chester pers. comm., Chester and Holt 1990). In 1989, at least 15 mature legumes were produced by this population. Associates include Spigelia marilandica, Cimicifuga racemosa, Campanula americana, Geum canadensis, Anemone virginica, Lactuca canadensis, Melilotus officinalis, Rudbeckia triloba, Ptela trifoliata, Fraxinus americana, Morus rubra, Cercis canadensis, Carpinus caroliniana, Ostrya virginiana, Quercus muehlenbergii, Acer saccharum and Ulmus rubra (Chester and Holt 1990).

Tennessee has four extant sites of A. priceana. All occur in soils overlying limestone bedrock in the Highland Rim physiographic region or the Sequatchie Valley, which drains into Alabama (Somers pers. comm.). Associated vegetation varies considerably between sites, but all sites are close to streams or rivers. Western mixed mesophytic forest is present at two of the sites, while a third is present on a bluff. The largest population is in an area recovering from a recent clear-cut operation (Somers pers. comm.). Populations are known from Marion, Montgomery and Williamson counties (Norquist 1990).

Four extant sites occur in three counties in Mississippi: Clay, Oktibbeha and Lee (Norquist 1990). At Kilgore Hills (Clay County), 15-20 plants occur on the banks of a prairie stream. The population occurs on clay alluvial soil over the Demopolis Formation. Soil pH varies between 6.6 and 8.4. The Coonewah Creek (Lee County) and Ray's Woods (Oktibbeha County) sites occur in mixed deciduous forest on a calcareous north-facing slope above the broad expanse of the northeast Prairie Belt. The soil at both sites is a marly clay underlain by a thick bed of a white marine chalk deposit. At both sites the soil pH varies between 7.4 and 8.4 (Medley 1980). For site-specific information pertaining to associated species, see Medley (1980).

Three extant populations are known from Alabama in Madison, Autsuga and Marshall counties (Norquist 1990). Two of the populations are located along the floodplain of the Alabama River (Gunn pers. comm.).

A single population occurred along a swamp border in a federal ecological area in Illinois, but this population has been destroyed. The area has been searched repeatedly with no positive results (Karnes pers. comm.). Ebinger (1981) stated that the habitat of the species in the state was floodplain forests and thickets of the Lower Mississippi River.

Economic Attributes

Economic Comments: Germplasm of agricultural value.

Management Summary

Stewardship Overview: Management techniques to provide long-term survival for the species will need to center around the maintenance of natural openings in the forest canopy brought on by prescribed fire, forest thinning or logging. Monitoring should be done to track population size and stability, fruit production, seed set and recruitment. Changes in these factors with respect to other vegetation and canopy closure are also in need of monitoring.

Restoration Potential: Apios priceana is currently being cultivated at the Missouri Botanical Garden (Pickering 1989). Information gained from the cultivation of Price's groundnut at this and other sites (such as the University of Kentucky) will prove important in the long-term recovery of the species. Early results indicate that seeds from the plant are relatively easy to germinate upon scarification. First-year plants grow rapidly, often reaching 5-6 feet in height during the first year.

Preserve Selection & Design Considerations: Land protection must include land occupied by the primary population as well as adequate buffer to protect the site from outside influences (pesticide drift, etc.). Protection of only the immediate population may lend it susceptible to a number of potential threats.

Management Requirements: Precise management needs are poorly known at this time. Maintenance of natural openings, possibly via artificial cutting or prescribed fire, have been suggested by some authorities. Apios priceana is apparently able to withstand light, selective logging (Kral 1983), but whether this is a suitable management alternative is unknown. It has been suggested that light logging may enhance the species, while heavy clear-cut logging would destroy populations (Kral 1983, Medley 1980). The species may require specific seral stages or seasonal disturbances to arrest succession (Norquist 1990). Determination of precise habitat requirements through research is needed in order to suggest adequate management options.

Protection of the population from excessive grazing and trampling, as well as herbicide application is recommended. Presently, some populations are suffering from the adverse affects of grazing, while potential herbicide application threatens others.

Kral (1983) stated that A. priceana has been observed in secondary forests, suggesting that it is able to survive logging. He also observed that it reacted well to fire disturbance, as do many legumes with tuberous rootstalks. The rarity of the species suggests that it has a narrow ecological amplitude (Kral 1983), so management tolerance levels must be known prior to the undertaking of management options.

Bulldozing or root raking are believed to destroy the plant (Kral 1983). Thinning or cutting of the overstory may possibly damage A. priceana plants if done during the growing season. If undertaken, these methodologies should only be utilized when the plant is dormant.

Monitoring Requirements: Development of adequate monitoring techniques is a need at all sites (Somers pers. comm.). Monitoring should asses the actual number of plants in each extant population over time. Fruit production, seed set and recruitment also should be monitored (Bender pers. comm.). Monitoring should be considered on at least a five-year cycle. Many managers might wish to consider more extensive annual or biennial monitoring programs.

Habitat monitoring is also a major need. Apios priceana is intolerant of excessive canopy shading and competition. Canopy closure should be monitored to determine when canopy thinning or other management activities should be instituted.

Due to the relatively large size of this vine, counts of all individuals would be relatively easy to complete and should be undertaken on a periodical basis. Fruit production, seed set, and recruitment should be documented during the visit. For ease of monitoring, visits should coincide with that of fruit set. Locations of individuals should be mapped on a base map in order to determine life span, recruitment and death rates.

Canopy closure should be monitored on an annual basis using a wide-angle or similar photographic lens. Photographs of the canopy immediately above the population should help determine the extent to which closure is tolerated by the species, as well as the optimal time for appropriate management options.

Management Programs: The two Trigg County, Kentucky, sites occur within the Land Between The Lakes management area of the Tennessee Valley Authority (TVA). The area is designated as a multiple-use facility for recreation, education and conservation activities (Chester and Holt 1990). Contact: Beth Wellbaum, TVA Forester. Telephone No. (502) 924-5602; OR, Dr. Leo Collins, TVA Stewardship Program Botanist, Norris, TN. Telephone No. (615) 494-9800.

After acquisition of the Lyon County site in Kentucky, the State Nature Preserves Commission intends to open the canopy in several areas near the species' present location. Attempts to grow plants from seeds collected at the site, followed by introduction into new openings are also considered. All activities will have the approval of the USFWS prior to implementation. Contact: Joyce Bender, Stewardship Coordinator, Kentucky Heritage Program, KY Nature Preserves Commission, 407 Broadway, Frankfort, KY 40601. Telephone No. (502) 564-2886.

Barnett's Woods Preserve in Tennessee, owned by The Nature Conservancy, protects two element occurrences. At present, no specific management is being conducted for the species. Contact: Geoff Roach, Director of Protection Planning and Stewardship, Tennessee Field Office, The Nature Conservancy, P.O. Box 3017, Nashville, TN 37219. Telephone No. (615) 242-1787.

Monitoring Programs: The Kentucky State Nature Preserves Commission is currently pursuing the purchase of 140 acres in Lyon County to protect the species (Bender pers. comm.). The stem count of the population will be conducted in the summer of 1990 if the site has not been purchased by the time of flowering. Contact: Joyce Bender, Stewardship Coordinator, Kentucky Heritage Program, KY Nature Preserves Commission, 407 Broadway, Frankfort, KY 40601. Telephone No. (502) 564-2886.

The Tennessee Field Office of The Nature Conservancy will hire an independent contractor for the collection of ecological and biological information pertaining to A. priceana at one of its preserves. Duties will include: (1) identification of the community associated with A. priceana, (2) mapping, inventory and monitoring of A. priceana populations, and (3) generation of two reports. Monitoring will include the assessment of growth rates, flowering period, flower number, inflorescence number, seed set, fruit/seed ratio, average rainfall, soil moisture, relative humidity and competition. Contact: Geoff Roach, Land Steward, The Nature Conservancy of Tennessee, P.O. Box 3017, 174 Second Avenue N., Nashville, TN 37219. Telephone No. (615) 242-1787.

The Mississippi Natural Heritage Program does not have an active monitoring program for the species, but does determine if the habitat and the species are still present (Gordon pers. comm.). They continue to maintain contact with the private landowners who possess populations. Contact: Ken Gordon, Coordinator/Botanist, Mississippi Natural Heritage Program, Museum of Natural Science, 111 N. Jefferson St., Jackson, MS 39201-2897. Telephone No. (601) 354-7303.

Management Research Programs: Geoff Roach, Tennessee Field Office of The Nature Conservancy, and Drs. Carol Baskin, Jerry Baskin and Ed Chester are considering doing some life-history research on Apios priceana. Contact: Geoff Roach, Director of Protection Planning and Stewardship, Tennessee Field Office, The Nature Conservancy, P.O. Box 3017, Nashville, TN 37219. Telephone No. (615) 242-1787.

Carol Baskin is currently growing 18 plants in a greenhouse, some of which will be planted at TVA's Land Between the Lakes visitor center. Seed germination has been studied, but insufficient amounts of seed are available for adequate studies regarding flowering requirements and germination phenology. It is hoped that seed produced from the plants at the Land Between the Lakes visitor center will help facilitate these future studies. Contact: Dr. Carol Baskin, University of Kentucky, Lexington, KY. Telephone No. (606) 257-3996.

The Tennessee Ecological Services Division has received Section 6 money from the USFWS to search for additional populations this summer (1990). Contact: Paul Somers, ESD, Tennessee Department of Conservation, 701 Broadway, Nashville, TN 37219-5237. Telephone No. (615) 742-6549.

The Missouri Botanical Garden is currently propagating the species, but no active research is being conducted or is planned for the species. At present, plants are growing on a wall in the Scented Garden as well as six plants in the nursery. Additional plants in the Woodland Garden have died, and research will need to be conducted to determine the reason for death. Plants in the nursery may be used to replace those that died in the Woodland Garden. Contact: Robert Bowden, Director of Horticulture, Missouri Botanical Garden, P.O. Box 299, St. Louis, MO 63166. Telephone No. (314) 577-5189.

Biological Research Needs:

Population/Occurrence Delineation

Alternate Separation Procedure: **Use the Habitat-based Plant Element Occurrence Delimitation Guidance (2004).**
Date: 01Oct2004

Population/Occurrence Viability

Excellent Viability: An A-rated occurrence of *Apios priceana* is a population that contains 150 or more plants in a mature, relatively undisturbed forest. Ideally the occurrence should be well insulated from potential anthropogenic disturbance where the habitat is characterized by a partially shaded forest with no or minimal influence (< 10 %) by exotic and/or native invasive species.

Good Viability: A B-rated occurrence of *Apios priceana* is a population that contains 50 to 149 plants in a mature, relatively undisturbed forest. Ideally the occurrence should be well insulated from potential anthropogenic disturbance where the habitat is characterized by a partially shaded forest with no or minimal influence (< 10 %) by exotic and/or native invasive species. B-rated specifications also apply to larger occurrences having a greater affluence (to 30 %) of invasive species, logging, and/or development. Easily restored to A-rated conditions.

Fair Viability: A C-rated occurrence of *Apios priceana* is a population that contains 10 to 49 plants in a mature, relatively undisturbed forest. Ideally the occurrence should be well insulated from potential anthropogenic disturbance where the habitat is characterized by a partially shaded forest with no or minimal influence (< 10 %) by exotic and/or native invasive species. C-rated specifications also apply to larger occurrences having a moderate to high affluence (to 75 %) of invasive species, timber harvesting, and/or development. Restoration potential to A- and B-rated specifications is good.

Poor Viability: A D-rated occurrence of *Apios priceana* is a population that contains less than 10 plants in a mature, relatively undisturbed forest. D-rated specifications also apply to larger occurrences in highly modified habitat with minimal or no restoration potential.

Justification: Specifications are based on Element Occurrence Records, academic publications (namely USFWS), personal observations, and expert opinions. Currently limited research is being conducted on this species but no information outlining population dynamics and viability has been published. As new information becomes available, EO specs should be reassessed and updated.
Date: 04Jan2005
Author: Schotz, Alfred

U.S. Invasive Species Impact Rank (I-Rank) **Not yet assessed**

Authors/Contributors

NatureServe Conservation Status Factors Edition Date: 10Jul1990
NatureServe Conservation Status Factors Author: Ostlie, Wayne MRO; rev. Pyne/Maybury, 1996.
Management Information Edition Date: 30Jun1990
Management Information Edition Author: WAYNE OSTLIE

Botanical data developed by NatureServe and its network of natural heritage programs (see **Local Programs**), The North Carolina Botanical Garden, and other contributors and cooperators (see **Sources**).

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Citation for Bird Range Maps of North America:
Ridgely, R.S., T.F. Allnutt, T. Brooks, D.K. McNicol, D.W. Mehlman, B.E. Young, and J.R. Zook. 2003. Digital Distribution Maps of the Birds of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA.

Acknowledgement Statement for Bird Range Maps of North America:
"Data provided by NatureServe in collaboration with Robert Ridgely, James Zook, The Nature Conservancy - Migratory Bird Program, Conservation International - CABS, World Wildlife Fund - US, and Environment Canada - WILDSPACE."

Citation for Mammal Range Maps of North America:
Patterson, B.D., G. Ceballos, W. Sechrest, M.F. Tognelli, T. Brooks, L. Luna, P. Ortega, I. Salazar, and B.E. Young. 2003. Digital Distribution Maps of the Mammals of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA.

Acknowledgement Statement for Mammal Range Maps of North America:
"Data provided by NatureServe in collaboration with Bruce Patterson, Wes Sechrest, Marcelo Tognelli,

Gerardo Ceballos, The Nature Conservancy-Migratory Bird Program, Conservation International-CABS, World Wildlife Fund-US, and Environment Canada-WILDSPACE."

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Woods, Michael. 2005. A Revision of the North American Species of Apios (Fabaceae). Castanea 70(2): 85-100.

CASTANEA 70(2): 85–100. JUNE 2005

A Revision of the North American Species of *Apios* (Fabaceae)

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ABSTRACT

The revision of *Apios* in North America is based on morphological analysis of herbarium specimens as well as field and greenhouse observations. The genus is herein recognized as consisting of two distinct species in North America. *Apios priceana* was described by Robinson in 1898. Currently it is listed as threatened by the United States Fish and Wildlife Service and is known from 47 populations in 22 counties in Alabama, Kentucky, Mississippi and Tennessee. The other species, *A. americana*, widely distributed in eastern North America, was first described by Cornut in 1633 and has been regarded as consisting of six infraspecific taxa, which are not recognized in the present treatment. Demarcation is based primarily on reproductive features as vegetative characteristics, both within and between species, exhibits a significant amount of variation. In addition to the taxonomic descriptions, dichotomous keys, illustrations and distribution maps are presented for each species.

INTRODUCTION

Apios Fabricius (Fabaceae) occurs in Asia and North America. The Asian species are represented by three specific and two infraspecific taxa. Prior to this treatment, *Apios* was represented in North American by two specific and six infraspecific taxa (Woods 1988).

Taxonomic History of Apios

The genus *Apios* was named by Cornut (1633) when he described *A. americana*. Linnaeus (1753) brought *A. americana* into the modern era of botanical nomenclature when he listed it as a synonym for *Glycine apios*. The first revision of *Apios* after Linnaeus was by Fabricius (1759), who recognized *A. americana*, crediting Cornut as the authority. *Glycine apios* was listed as a synonym. Medikus (1787) recognized *A. americana* and listed *G. apios* as a synonym. Of the original eight species Linnaeus (1753) included in the genus *Glycine*, *G. apios* (*A. americana*) was the only one that Medikus accepted. He noted that the flower alone was so distinctive that it was clearly different from the other seven species in Linnaeus' genus *Glycine*.

In 1794, Moench named *A. tuberosa* and described it as having tuberous roots, unevenly pinnate leaflets, and purple flowers in lateral racemes. He listed *G. apios* as a synonym. For the next 80 years the names *G. apios* and *A. tuberosa* were used about equally in major publications.

Rafinesque (1824) created the binomial *Gonancylis thyrsoidea* to replace *A. americana*. It was not until Rafinesque (1836) discussed the use of equivocal names that are pronounced nearly alike, that an explanation for this nomenclatural change was given. According to Rafinesque, the generic names *Apis*, *Apus*, *Apios*, *Apium*, and *Apion* were poor names because they sound too much alike when pronounced. There was no explanation as to why the specific epiphet was changed from *americana* to *thyrsoidea*.

In an attempt to gain acceptance for the use of duplicate binomials, MacMillan (1892) proposed the tautonym *A. apios*. The source of this combination was from the generic name of *A. tuberosa* and from the specific epiphet of *G. apios*. This combination was occasionally used;

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however, it is an illegitimate name according to article 23 of the Botanical Code (Voss 1983) which states "The specific epiphet may not exactly repeat the generic name with or without the addition of a transcribed symbol (tautonym)."

In the first edition of the Botanical Code (Briquet 1906), *A. americana* Medikus (1787) was chosen as the nomenclatural type in the conservation of *Apios* against *Glycine* (Linnaeus 1753, 1754) (*partim quoad spec 1*). Had the congress, who were evidently unaware, known *A. americana* Fabricius (1759) had been published prior to Medikus' publication, it would likely have been chosen as the nomenclatural type.

Although *A. americana* was chosen as the nomenclatural type (Briquet 1906), Rehder (1934) pointed out that *A. tuberosa* was usually cited as the correct name. The reason for this was two fold: firstly, the rarity of the periodical in which Medikus (1787) published *A. americana* (as Rehder noted, it cannot be found in any American library); secondly, Taubert (1894) treated *A. americana* and *A. tuberosa* as representing different species.

Robinson (1898) described *A. priceana* and named it in honor of Sadie F. Price, its discoverer. The type location of *A. priceana* in Warren County, Kentucky, has never been relocated and likely has been destroyed by development. Britton transferred *A. priceana* to *G. priceana* (Britton and Brown 1913). This transfer was unjustified as *Apios* had already been conserved against *Glycine* (Briquet 1906). When Robinson (1898) described *A. priceana* he divided the genus into two subgenera. He placed *A. priceana* in subgenus *Tylosemium* and *A. americana* into the subgenus *Euapios* along with the three described Asian species of *Apios*. Subgenus *Tylosemium* was characterized as having a standard with a thick, spongy, knot-like prolongation (stylobus) at its apex and a single, irregularly spheroidal tuber. Subgenus *Euapios* was characterized as having a standard rounded or retuse at the unthickened sumit and the below ground portions, as far as known, fibrous or moniliform-tuberous.

Reproduction

No detailed studies have been conducted on the reproductive and pollination biology of *Apios priceanea* Robinson. The long tailed skipper (*Urbanus proteus* L.), honey bees (*Apis mellifera* L.) and bumble bees (Subfamily *Aspinae*, Tribe *Bombini*) are common visitors and, therefore, possible pollinators (United States Fish and Wildlife Service 1993). However, Connolly et al. (1998) reported that uniformity of banding patterns using electrophoretic analysis suggests that *A. priceanea* may be self-pollinating. Bruneau and Anderson (1988, 1994) reported the reproductive biology of *A. americana* Medikus. In the northern one-half of its range, *Megachile* species (leaf cutter bees) are the only visitors reported to trip the flowers and, therefore, are the only likely pollinators. In the southern part of its range, *Megachile* species are the only insects observed tripping the flowers. Two additional types of bees, honeybees (*Apidae*), and members of the *Halictidae* are frequent visitors but have not been observed tripping the flowers. Based on pollination studies conducted on alfalfa by Free (1970) honeybees tripped 18% of the flowers they visited. Since the number of alfalfa flowers tripped increased from north to south, Bruneau and Anderson (1988) suggested that honeybees may be more effective at tripping flowers of *A. americana* in the southern part of the range and, therefore, would be legitimate pollinators as well.

Crossing experiments and field observations have shown that triploid individuals are sterile and no fruits are produced. Triploid populations consist entirely of clonal individuals that propagate asexually through the production of tubers. Diploid individuals also propagate asexually through tubers but they also produce fruits and viable seeds (Bruneau and Anderson 1988).

Phylogeny, cytology, ethnobotany, conservation biology, and infraspecific taxa are all reasons why a revision of the North American species of *Apios* was needed.

Phylogeny

Apios (Papilionoideae: Phaseoleae) is not phylogenetically related to any other genera in the subtribe Erythrininae, where it has historically been placed. Based on analyses of plastid

rbcL (Kajita et al. 2001) and matK gene sequences (Wojciechowski et al., in press) *Apios* is nested in one of two main subclades, the one containing the majority of members of Phaseoleae, that comprise the clade informally know as the Millettioid/Phaseoloid clade (Kajita et al. 2001) or the Millettioids (Wojciechowski et al., in press). Phaseoleae consists of approximately 80 genera and only about 50% of the genetic diversity of the tribe has been sampled. Therefore, the relationships of all of the constituent genera are still uncertain (M.F. Wojciechowski, Arizona State University, pers. comm.).

Cytology

Chromosome counts have been reported for both North American species of *Apios*. Seabrook and Dionne (1976) described diploid ($2n = 2x = 22$) for *A. priceana* Robinson and also for *A. americana* Medikus, in the southern part of its range. However, most *A. americana* populations in the northern part of its range are described as triploid ($3n = 3x = 33$) (Seabrook and Dionne 1976, Bruneau and Anderson 1988). Diploid and triploid individuals are nearly identical morphologically (Bruneau and Anderson 1988).

Ethnobotany

Apios americana Medikus has been considered as a potential commercial root crop (Blackmon 1986) primarily because of its 16.5% dry weight protein content (Walter et al. 1986). Nutritional analyses of *A. priceana* Robinson indicate that its tubers are far less beneficial for human consumption (Connolly et al. 1998). Thus far, cultivation has been unsuccessful (Reynolds et al. 1990). However, recent data shows both *A. priceana* and *A. fortunei* Maximowicz have alleles not present in either diploid or triploid populations of *A. americana*. This indicates that they may have unique characters that could increase the feasibility of developing *A. americana* as a new root crop (Connolly et al. 1998). In addition, the recent isolation of the anticarcinogenic compound genistein from the tubers of *A. americana* should greatly enhance its desirability as a new root crop (Krishnan 1998).

Conservation Biology

Apios priceana Robinson received a global rank of G2 in 1983, meaning it was imperiled globally with only 6–20 known occurrences (United States Fish and Wildlife Service 1990). Woods (1988) recommended that the United States Fish and Wildlife Service list *A. priceana* as endangered throughout its range. At that time, only 10 extant populations were known and 60% of those were in threat of destruction. *Apios priceana* was listed as threatened throughout its entire range in 1990 due to the small number of populations and threats to its habitat (United States Fish and Wildlife Service 1990). When the recovery plan was published in 1993 there were only 24 known populations. The three strategies recommended for recovery of the species are: research on population biology (habitat requirements, vegetative reproduction, pollinations biology, seed dispersal and germination requirements, demography, and the genetic make-up of the populations); search for new populations; and, maintain seeds and plants under artificial conditions so that material will be available for transplanting if natural populations decline or disappear (United States Fish and Wildlife Service 1993).

Infraspecific Taxa

At the time of the last revision of the genus (de Candolle 1825), *Apios americana* Medikus was the only described North American species and none of its six infraspecific taxa had been described. Daniels (1911) described forma *boulderensis* based on a specimen he collected from Boulder, Colorado. Fernald (1934) described forma *cleistogama* as having greenish, minute expanding corollas which scarcely protrude from the calyx while variety *turrigera* (Fernald 1939) is described as having lax, lanceolate or ovoid-attenuate racemes that are prolonged at the apex (Figure 1, number 2). *Apios americana* forma *pilosa* was described by Steyermark (1938) as having spreading hairs on the stems and leaflets. Two color forms of *A. americana*, form *keihneri* and form *mcculloughi*, were described by Oswald (1961a, 1961b). Both of these formas are distinguished, based on *Color Standard and Color Nomenclature* (Ridgway 1912). Oswald

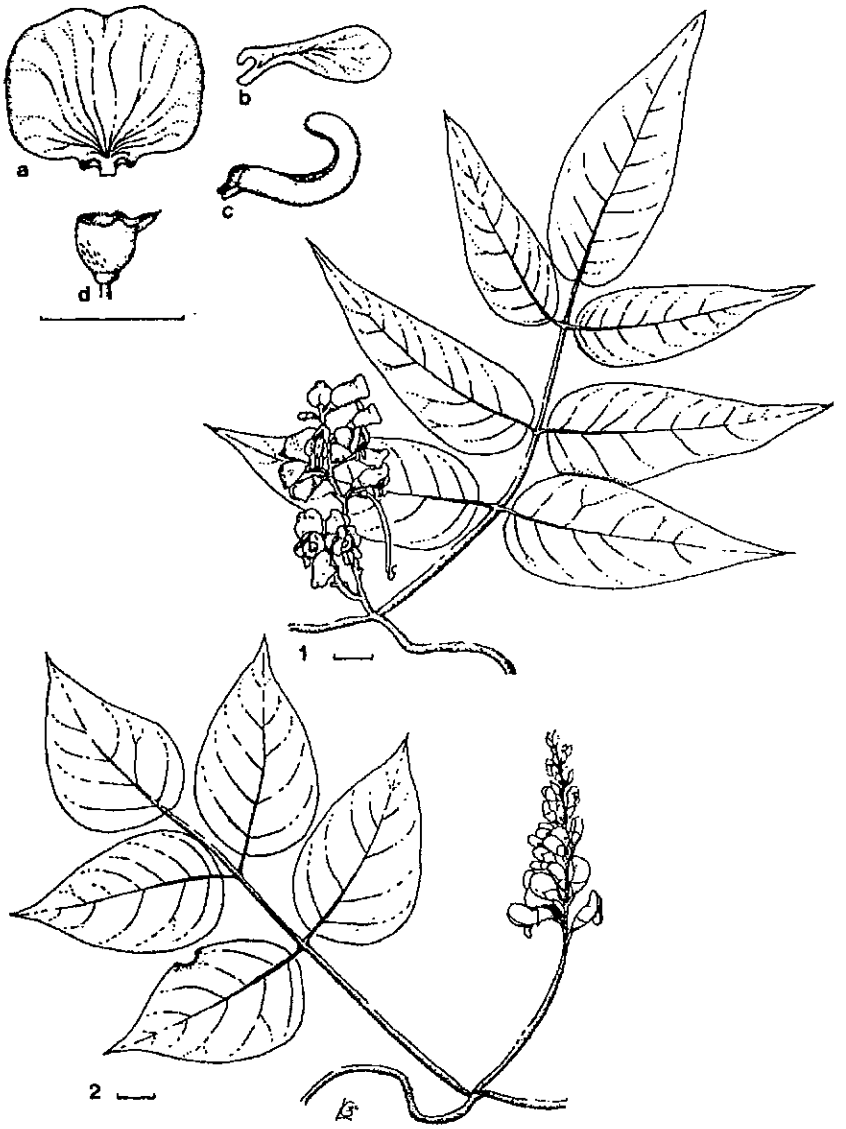

Figure 1. Illustration of *Apios americana*–Number 1: typical raceme habit; a. standard petal; b. wing petal; c. keel petal; d. calyx. Number 2: variation in raceme habit. All scales equal 1.0 cm. *From*: Woods (1988). Illustrated by Linda Gucciardo.

described the corolla color of *A. americana* form *keihneri* as Indian Purple to Dark Corinthian Purple inside and out, except for a small white area in the throat. For *A. americana* form *mcculloughi*, the external color of the standard blends from Pale Vinaceous to Vinaceous, the tip White to Dull Green-yellow. The internal color of the standard is Garnet-brown. Both surfaces of the wings are Oxblood Red to Dark Perilla Purple, while the keel blends from Dark Vinaceous to Pale Dull Green-yellow or White.

METHODS

This revisionary treatment was based on an analysis of reproductive and vegetative organs. The morphological, anatomical, and geographical data were compiled from over 2,100 herbarium specimens, including the types of both *Apios americana* Medikus and *A. priceana* Robinson. Four of the six types of the infraspecific taxa of *A. americana* were also examined.

Herbarium specimens were obtained on loan from the following herbaria: A, APSC, AUA, B, CAL, CHI, E, F, FWM, GH, ILL, ILLS, K, LE, LSUM, MISS, MO, NTSC, NY, P, PE, PH, SIU, SMU, TAI, TENN, TEX, TROY, TTC, UNA, UPS, US, and WNLM. Field studies were conducted throughout most of the geographical range of both species. In addition, seeds and/or tubers from various populations were planted in the greenhouse on the campus of Southern Illinois University at Carbondale and the resultant plants were studied.

Herbarium specimens were initially divided into groups based on overall morphological similarity. Each group was then critically examined and a tentative decision of species was established. Morphological measurements were then made from selective specimens of each group. Specimens were measured using a Bausch & Lomb 0.7X-3.0X stereoscope, a plastic 15 cm ruler graduated in 1.0 mm divisions, and a dial caliper graduated in 0.1 mm divisions. A surfactant and water were used to pre-soak the flowers for dissection and measurements. The terminology used for descriptive analysis followed Radford et al. (1974), Benson (1959) and Stearn (1983).

RESULTS

The genus *Apios* is recognized as consisting of two North American species, both of which are native. Both species, *A. americana* Medikus and *A. priceana* Robinson are distinct based on both floral and vegetative characteristics. Of the sixty structures measured, twenty-eight are useful in delimiting taxa (Table 1). Additionally, none of the six described infraspecific taxa of *A. americana* merit recognition.

Taxonomic Treatments

Apios Fabricius, Enum., Meth. Pl. 176. 1759. *nom. con.*
Glycine Linnaeus, Sp. Pl., ed. 1. 2: 753. 1753.
Apios Boehmer, Ludwig. Def. Gen. Pl. 268. 1760.
Bradlea Adanson, Fam. Pl. 2: 324. 1763.
Apios Cornut *ex* Medikus, Vorles. Chrupfalz. Phys.-ocon. Ges. 2: 354: 1787.
Apios Moench, Meth. 165. 1794.
Gonancylis Rafinesque, First Cat. Bot. Gard. Transylv. Univ. 14. 1824.
Cyrtotropis Wallich, Pl. As. Rar. 49. t.62. 1830.

Perennial, some producing latex, rhizome with or without tubers, if present single or moniliform; roots adventitious, scattered or fibrous-like along the rhizome. Stems herbaceous, occasionally woody at the base, twining, striate, occasionally terete, glabrous to densely tomentose. Leaves alternate, pinnately compound, (3–) 5–7 (–9) foliolate; rachis striate, occasionally terete, glabrous to velutinous; petiole striate, occasionally terete, glabrous to densely tomentose; pulvinus glabrous to densely tomentose to velutinous; stipules 2, persistent or deciduous, linear to narrowly triangular, glabrous to sericeous; leaflets narrowly elliptic to widely ovate, apex acuminate to acute, apiculate to mucronulate, base acuminate to rounded, often asymmetrical, entire, margins glabrous or ciliate, green above, paler beneath, both surfaces glabrous to tomentose, veins anastomosing before reaching the margin; petiolule reduced to a secondary pulvinus, glabrous to sericeous-tomentose; stipels deciduous or persistent, terminal leaflet 2 and lateral leaflets 1 each, lanceolate to narrowly triangular, entire, glabrous to sericeous. Inflorescence a nodose pseudoraceme or flowers paired at the tip of peduncles in the leaf axil, mostly single, occasionally in twos to fours, simple to branched, lax to densely flowered, with 2–70 flowers per inflorescence; bracts 2, early deciduous, lanceolate to ovate, entire, ciliate, glabrous to pubescent. Flowers occasionally single, or in clusters of twos to fours, on tubercles, occasionally paired at the tip of peduncles, yellow-green to deep maroon; pedicels glabrous to velutinous; bracteoles 2, early deciduous, linear to ovate-lanceolate; bractlets 2, early deciduous, lanceolate to linear-acuminate; calyx hemispherical to campanulate, bilobed, glabrous to puberulous, 4-toothed; petals subequal to unequal, keel incurved, narrowly elliptic, petals of the keel united at their apices (slit at their apices, in some species, after tripping), slit at their bases, two-clawed, narrowly linear to oblong, auricle lacking or

Table 1. The twenty-seven characters used to delimit taxa. Range category represents the lowest and highest measurement taken for each character. The top measurement for each character is for *Apios americana* and the lower measurement is for *A. priceana*. All measurements are in mm

Character	Range
Petiole length	20.00–58.00
	70.00–75.00
Pulvinus length	4.70–7.00
	3.00–4.00
Stipule length	4.00–6.50
	7.00–8.60
Pedicel length	2.00–3.00
	4.00–5.00
Calyx height	2.80–3.40
	4.80–5.20
Posterior tooth	0.20–0.30
	0.75–1.00
Lateral teeth	0.20–0.40
	0.90–1.10
Anterior tooth	1.25–1.75
	3.00–4.00
Keel length	12.00–14.00
	18.00–19.00
Keel width	2.00–4.00
	8.00–9.00
Claw length	1.40–1.80
	2.25–2.50
Claw width	0.40–0.60
	0.75–0.85
Wing length	9.50–10.50
	19.00–21.00
Wing width	4.25–4.75
	2.25–2.75
Claw length	1.00–1.40
	1.60–2.00
Claw width	0.40–0.60
	0.75–1.00
Auricle length	0.30–0.60
	1.00–1.40
Auricle width	0.20–0.30
	1.25–1.50
Standard length	10.50–12.50
	23.00–26.00
Auricle length	1.30–1.70
	0.40–0.50
Auricle width	0.75–1.00
	0.40–0.50
Stylobus length	1.50–2.00
	5.80–7.80
Ovary length	5.50–7.00
	13.00–15.00
Fruit length	60.00–120.00
	120.00–180.00
Style length	6.00–7.50

Table 1. Continued

Character	Range
	8.00–11.00
Seed length	5.00–6.00
	7.20–11.00
Hilum length	0.75–1.25
	3.75–4.25
Hilum width	0.30–0.40
	1.00–1.50

reduced to a rounded lobe to broadly rounded; wing petals narrowly elliptic to obovate, falcate, one-clawed, narrowly linear to oblong, auricle almost obsolete or oblong to square; standard elliptic to circular, apex fused into a stylobos, one-clawed, narrowly oblong to square, auricle obovate; stamens 10, diadelphous; anthers filantherous; pistil stipitate with a disk, surrounding and free from the stipe; ovary, glabrous to tomentose, 7–16 ovules, style coiled, glabrous to bearded; stigma capitate with a stigmatic membrane. Fruit a legume, linear to linear-oblong, apex short-aristate to acuminate, glabrous to tomentose when young, glabrous to appressed strigose at maturity, silvery to off-white endocarp. Seeds elliptic to circular-oblate, green when fresh, brown to black when dry, glaucous, glabrous.

KEY TO THE NORTH AMERICAN SPECIES OF *APIOS*

1. Standard oblate, <17 mm long, stylobos <4 mm long; wing petals <15 mm long; keel petal <16 mm long; style glabrous; fruit <12 cm long; seed <6.5 mm long; hilum <2.25 mm long; flower deep maroon to pale maroon and white; 4–12 monoliform tubers in a chain, 2–10 cm in diameter; petiole <65 mm long . . . . . 1. *A. americana*
1. Standard widely elliptic, >17 mm long, stylobus >4 mm long; wing petals >15 mm long; keel petal >16 mm long; style bearded; fruit >12 cm long; seed >6.5 mm long; hilum >2.2 mmlong; flower pale green and rose purple; single tuber, 15–20 cm in diameter; petiole >65 mm long. . . 2. *A. priceana*

1. *Apios americana* Medikus, Vorles. Churpfalz. Phys.-ocon. Ges. 2: 354. 1787. *nom. con.* Lectotype: *P. Kalm s.n. s.d.* America. (LINN), photograph at (F!). [Figure 1]

Glycine apios Linnaeus, Sp. Pl. 2: 753. 1753. Type: *P. Kalm s.n. s.d.* America. (LINN), photograph at (F!).

Apios tuberosa Moench, Meth. Pl. 165. 1794.

Gonancylis thyrsoidea Rafinesque, First Cat. Bot. Gard. Trans. Univ. 14. 1824.

Apios apios (Linnaeus) MacMillan, Bull. Torr. Bot. Club 19: 15. 1892.

Apios apios (Linnaeus) MacMillan var. *boulderensis* Daniels, Fl. Boulder Col. 161. 1911. Type: *F. Daniels 799.* 18 August 1906. Boulder, Colorado. (MO!).

Apios americana Medikus forma *cleistogama* Fernald, Rhodora 36: 195. 1934. Holotype: *M.L. Fernald* and *B. Long 17002.* 16 August 1918. Herring River, West Harwich, Barnstable County, Massachusetts. (GH!).

Apios americana Medikus forma *pilosa* Steyermark, Rhodora 40: 179. 1938. Holotype: *J. Steyermark 11390.* 7 July 1936. Two miles northwest of Rombauer, Butler County, Missouri. (MO!).

Apios americana Medikus var. *turrigera* Fernald, Rhodora t.575, fig. 1,2. 41: 547. 1939. Holotype: *M.L. Fernald* and *B. Long 9079.* 23 August 1938. Below Sunken Meadow Beach, Surry County, Virginia. (GH!), Isotype: (GH!, MO!, NY!, PH!).

Apios americana Medikus forma *keihneri* Oswald, Phytologia 8: 47. 1961. Holotype: *F.W. Oswald s.n.* 20 August 1960. Porter, Oxford County, Maine. (H. N. Moldenke).

Apios americana Medikus forma *mcculloughi* Oswald, Phytologia 8: 61. 1961. Holotype: *F.W. Oswald s.n.* 22 August 1961. Ten Mile River Scout Camp, Sullivan County, New York. (H. N. Moldenke).

Latex-producing perennial with rhizomes and 4–12 moniliform, fleshy, oblong, oval, or globose tubers. Stems herbaceous, twining, terete, slightly striate, green to brownish green or brown, glabrous to tomentose. Leaves alternate, pinnately compound (3–) 5–7 (–9) foliolate, 10–22 cm long; rachis terete, 10–32 mm between lateral leaflets and terminal leaflet, 16–37 mm long between lateral leaflets, glabrous to slightly velutinous; petiole 20–58 mm long, glabrous to slightly velutinous; pulvinus 4.5–7.0 mm long, glabrous to velutinous; stipules 2, often deciduous, linear-triangular, 4.0–6.5 mm long, 0.25–0.55 mm at the base; leaflets ovate to ovate-lanceolate, apex acuminate to acute, apiculate, base rounded, often asymmetrical, entire, 47–70 (–90) mm long, 21–42 mm wide, leaflets of rameal branches often smaller, 30–45 mm long, 12–20 mm wide, abaxial surface subglabrous to tomentose, usually denser on the major veins, adaxial surface glabrous to puberulous, usually denser on the major veins; petiolule reduced to a secondary pulvinus, (1.50–) 2.75–4.00 mm long, slightly pubescent to velutinous; stipels often deciduous, terminal leaflet 2 and lateral leaflets 1 each, linear triangular, entire, 0.5–1.0 mm long, 0.1–0.3 mm wide at the base, scattered trichomes to sericeous. Inflorescence a nodose pseudoraceme in the leaf axil, mostly single, occasionally in twos or threes, densely flowered, with 40–60 flowers per inflorescence, 3.0–14.0 cm long; bracts 2, often deciduous, lanceolate, 2.00–2.75 mm long. Flowers in clusters of twos or threes on inflated tubercles, deep maroon to pale maroon and white; pedicels 2–3 mm long, glabrous to velutinous; bracteoles 2, early deciduous, ovate-lanceolate, 2–3 mm long, 0.25–0.50 mm wide at the base; bractlets 2, early deciduous, lanceolate-acute, 1.5–2.0 mm long, 0.2–0.3 mm wide at the base; calyx (Figure 1d) hemispherical to campanulate, 2.8–3.4 mm high, green, red and green, or pink-red, glabrous to puberulous, apparently 4-toothed, the posterior tooth almost obsolete to broadly rounded with an acute, triangular apex, 0.2–0.3 mm long, 0.1–0.2 mm wide at the base; the lateral teeth triangular to shallowly triangular, 0.2–0.4 mm long, 0.7–0.9 mm wide at the base; the anterior tooth lanceolate to narrowly triangular, 1.25–1.75 mm long, 0.4–0.6 mm wide at the base; petals subequal, keel (Figure 1c) strongly incurved, narrowly elliptic, petals of the keel united at their apices (slit at their apices after tripping for 2.0–3.5 mm), slit at their bases for 2–3 mm, 12–14 mm long, 2–4 mm wide, two-clawed, narrowly oblong, acuminate, 1.1–1.8 mm long; 0.4–0.6 mm wide; wing petals (Figure 1b) obovate, falcate, 9.5–10.5 mm long, 4.25–4.75 mm wide, one-clawed, the auricle oblong, 0.3–0.6 mm long, 0.30–0.35 mm wide; standard (Figure 1a) oblate, 10.5–12.5 mm long, 14–16 mm wide, apex fused 1.5–2.0 mm into a stylobos; stamens 10, diadelphous, 1 free, 15.5–17.0 mm long, the fused portion of the filaments 0.7–0.9 mm wide, the outer 2 filaments free the upper 1.5–3.0 mm, the remaining 7 filaments free, 0.5–1.5 mm, increasing in length from the inside toward the outside; anthers filantherous, 0.5–0.6 mm long, 0.20–0.25 mm wide; pistil stipitate with a disk, 0.9–1.2 mm long, surrounding and free from the stipe; ovary 5.5–7.0 mm long, 0.4–0.6 mm wide, glabrous to slightly pubescent along the sutures, 6–11 ovules, the style coiled, 6.0–7.5 mm long, glabrous; stigma capitate with a stigmatic membrane, 0.4–0.5 mm long and wide. Fruit a legume, linear-oblong, apex aristate to acuminate, base acute, 6–10 (–12) cm long, 6–7 mm wide, olive green to tannish brown, glabrous, white endocarp surrounding the seeds. Seeds 6–11 per legume, elliptic to widely oblong, 5–6 mm long, 3.5–4.5 mm wide, olive green when fresh, brown to reddish brown when dry, glabrous; hilum 0.75–2.00 mm long, 0.3–0.4 mm wide.

Habitat and distribution: primarily in wet soil along creeks, rivers and lakes, often in dense colonies; eastern North America from southern Florida to Nova Scotia west through southern Canada to southeastern Manitoba, southwest to eastern Colorado and south to southern Texas (Figure 2).

Specimens examined. CANADA. NEW BRUNSWICK: Sunbury County: *Scoggan 12866*, 14 August 1955 (WNLM). NOVA SCOTIA: Queens County: *Graves, Long & Linder 21735*, 16 August 1920 (A). ONTARIO: Carleton County: *Calder, Frankton & Gillett 1606*, 20 August 1947 (MO). QUEBEC: Brome County: *Marie-Victorin, Rolland-Germain, Raymond & Rousseau 56225*, 9 August 1942 (E). UNITED STATES. ALABAMA: Baldwin County: *Wofford 10526*, 7 August 1970 (TENN). ARKANSAS: Clark County: *Demaree 62247*, 22 June 1970 (SMU). COLORADO: Boulder County: *Weber 4211*, 1 July 1948 (TEX). CONNECTICUT: New London County: *Hill 9356*, 13 August 1980 (A, NY). DELAWARE: Kent County: *Proctor 1100*, 1 August

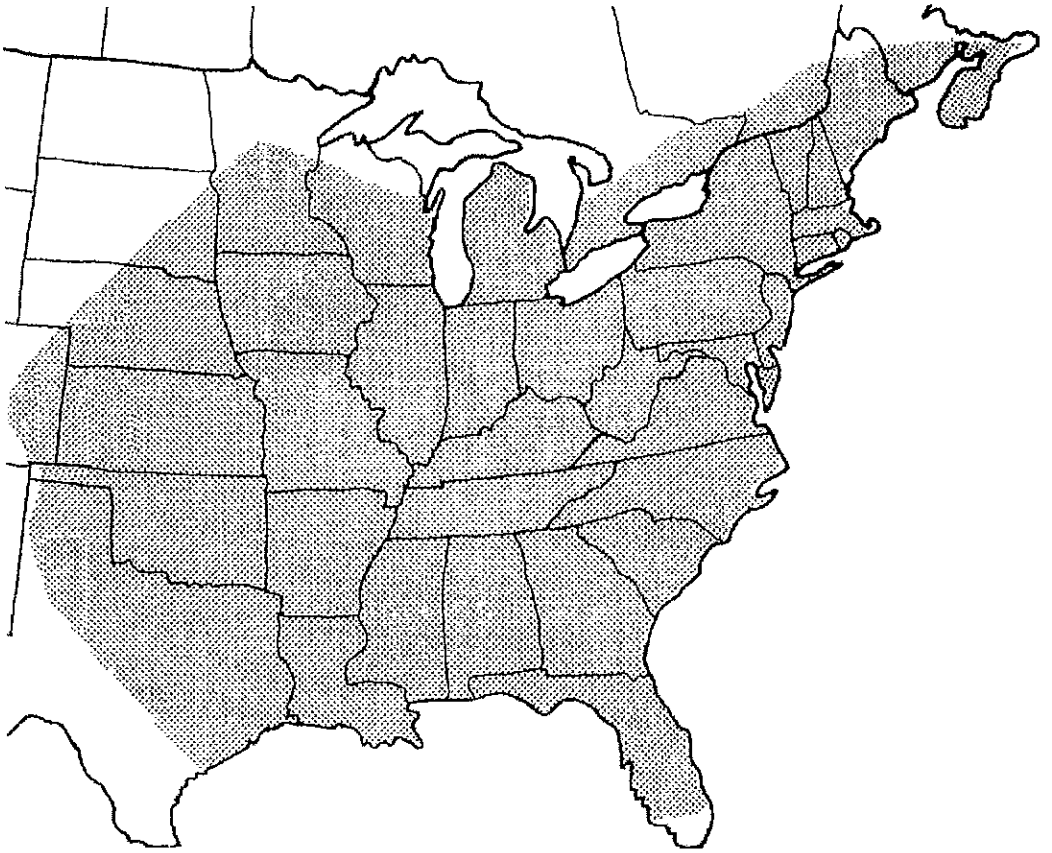

Figure 2. Map showing distribution of *Apios americana*. *From*: Woods (1988).

1944 (SMU). DISTRICT OF COLUMBIA: *Freeman 9252*, 22 August 1934 (US). FLORIDA: Dixie County: *Godfrey 56032*, 5 September 1957 (A). GEORGIA: White County: *Rodgers & Mullens 74458*, 3 September 1974 (MO). INDIANA: Elkhart County: *Demaree 40414*, 19 August 1958 (SMU). ILLINOIS: Jackson County: *Heineke 1169*, 15 August 1976 (SIU). IOWA: Winneshiek County: *Hayden 387*, 31 August 1933 (MO, NY). KANSAS: Meade County: *Horr & McGregor 4037*, 3 September 1951 (NY, US). KENTUCKY: Bell County: *Hinkle 49410*, 8 July 1974 (TENN). LOUISIANA: East Baton Rouge Parish: *Pias & Leibforth 4592*, 16 September 1979 (LSUM). MAINE: York County: *Moldenke & Moldenke 6312*, 28 August 1931 (G, NY). MICHIGAN: Kalamazoo County: *Gillis 12664*, 27 July 1975 (GH). MISSISSIPPI: Desoto County: *Pullen 70863*, 7 August 1970 (MISS). MISSOURI: Camden County: *Steyermark 7194*, 22 September 1938 (F). NEBRASKA: Cuming County: *Stephens 36401*, 4 September 1969 (NY). NEW HAMPSHIRE: Merrimack County: *Rousseau 1887*, 17 August 1972 (MO). NEW JERSEY: Cape May County: *Gershoy 389*, 30 August 1917 (GH). NEW YORK: Oneida County: *House 23090*, 29 August 1935 (MO). NORTH CAROLINA: Nash County: *Godfrey 5170*, 18 July 1938 (GH). OHIO: Delaware County: *Crane 3107*, 29 August 1928 (NY). OKLAHOMA: Marshall County: *Burgess 86*, 28 June 1965 (FWM). PENNSYLVANIA: Indiana County: *Wahl 2868A*, 19 August 1947 (A). RHODE ISLAND: Newport County: *Fernald, Long & Torrey 9761*, 13 September 1913 (A). SOUTH CAROLINA: Colleton County: *Bell 4552*, 4 September 1956 (TEX). TENNESSEE: Benton County: *Shanks & Sharp 5984*, 10 August 1947 (TENN). Bledsoe County: *Wofford & Collins 8396*, 19 August 1983 (TENN). TEXAS: Bowie County: *Correll 33371*, 13 August 1966 (NY, TEX). VIRGINIA: Alexandria County: *Chase 2672*, 21 September 1904 (F, SIU). VERNONT: Franklin County: *Blake 3198*, 28 August 1911 (TEX). WEST VIRGINIA: Jefferson County: *Core 3823*, 20 August 1931 (NY). WISCONSIN: Lincoln County: *Seymour & Schilising 15825*, 14 July 1954 (SMU).

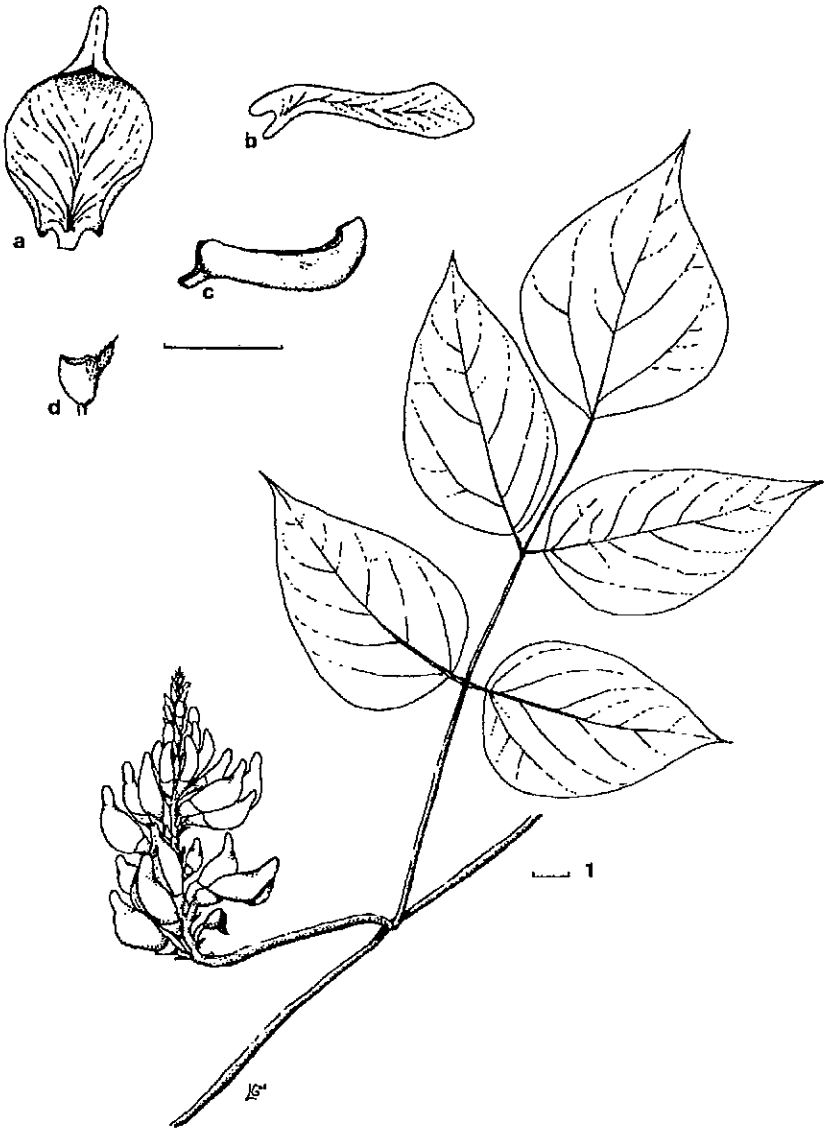

Figure 3. Illustration of *Apios priceana*–a. standard petal; b. wing petal; c. keel petal; d. calyx. All scales equal 1.0 cm. *From*: Woods (1988). Illustrated by Linda Gucciardo.

2. *Apios priceana* Robinson, Bot. Gaz. 25: 450. 1898.

Lectotype: *Sadie F. Price s.n.* July–September 1896. Near Bowling Green, Warren County, Kentucky. (GH!), Isolectotype: three at (GH!), Paratype: *s.n.* 12 July 1896. (GH!), *s.n.* July 1896. drawing at (GH!), *s.n.* 1895, drawing at (GH!), Topotype: *Sadie F. Price s.n.* August 1897. (GH!, NY!). [Figure 3]

Glycine priceana (Robinson) Britton, Il. Fl. edition 2, 2: 418. 1913.

Latex producing perennial with a single oblate spheroidal tuber, 15–20 cm in diameter. Stems herbaceous, twining, terete, slightly striate, brownish green, glabrous to reflexed pubescence. Leaves alternate, pinnately compound, (3–) 5–7 (–9) foliolate, 18–27 cm long; rachis 30–37 mm long between the lateral leaflets and terminal leaflet, 34–52 mm long between the lateral leaflets, glabrous to slightly pubescent; petiole 70–75 mm long, glabrous to slightly pubescent; pulvinus 3–4 mm long, glabrous to scattered pubescence; stipules 2, early deciduous, linear-triangular, 7.0–8.6 mm long, 0.5–0.7 mm wide at the base; leaflets ovate to

ovate-lanceolate, apex caudate, apiculate, base obtuse or rounded, entire, 5.1–10.3 cm long, terminal- 3.1–6.8 cm wide, glabrous to strigose, primarily along the major veins; petiolule reduced to a secondary pulvinus, 3.5–4.0 mm long, slightly pubescent to tomentose; stipels early deciduous, terminal leaflet 2 and lateral leaflets 1 each, narrowly triangular, entire, 0.3–0.4 mm long, 0.1–0.2 mm wide at the base, sericeous. Inflorescence a nodose pseudoraceme in the leaf axil, mostly single, occasionally in twos, densely flowered, with 55–70 flowers per inflorescence, 12–16 cm long; bracts 2, early deciduous, lanceolate, 2.50–3.25 mm long. Flowers in clusters of twos or threes on small tubercles, pale green and rose-purple; pedicel 4–5 mm long, glabrous to sparsely pubescent; bracteoles 2, early deciduous, ovate-lanceolate, 5.0–6.5 mm long, 1.00–1.75 mm wide at the base; bractlets 2, early deciduous, lanceolate-acuminate, 4–6 mm long, 0.75–1.25 mm wide at the base; calyx (Figure 3d) hemispherical, 4.75–5.25 mm high, green, glabrous to sericeous, apparently 4-toothed, the posterior tooth almost obsolete, shallowly triangular, 0.75–1.00 mm long, 1.90–2.25 mm wide at the base; the lateral teeth shallowly triangular, 0.9–1.1 mm long, 2.0–2.25 mm wide at the base; the anterior tooth, lanceolate-acuminate, 3–4 mm long, 1.9–2.1 mm wide at the base; petals subequal, keel (Figure 3c) incurved, narrowly elliptic, petals of the keel united at their apices, slit at their bases for 4.5–5.5 mm, 18–19 mm long, 8–9 mm wide, a triangular pouch present at the mid-point, two-clawed, narrowly oblong, 2.25–2.50 mm long, 0.75–0.85 mm wide; wing petals (Figure 3b) narrowly elliptic, falcate, 19–21 mm long, 2.25–2.75 mm wide at the middle, 4.5–5.0 mm wide at the apex, the auricle square, 1.0–1.4 mm long, 1.25–1.50 mm wide; standard (Figure 3a) widely elliptic, 23–26 mm long, 15–20 mm wide, apex fused 5.8–7.8 mm into a stylobos; stamens 10, diadelphous, 1 free, 20–24 mm long, the fused portion of the filaments 2.75–3.25 mm wide, the outer 2 filaments free the upper 2.5–3.3 mm, the remaining 7 filaments free 1.0–2.3, increasing in length from the inside toward the outside; anthers filantherous, 0.8–1.0 mm long, 0.2–0.4 mm wide; pistil stipitate with a disk, 0.75–1.00 mm long, surrounding and free from the stipe; ovary 13–15 mm long, 0.9–1.1 mm wide, glabrous to slightly pubescent, primarily along the sutures, 8–12 ovules, the style coiled, 8–11 mm long, bearded with simple trichomes, 0.6–1.0 mm long; stigma capitate with a stigmatic membrane, 0.4–0.6 mm long, 0.1–0.2 mm wide. Fruit a legume, linear-oblong, apex acuminate, base attenuate, 12–15 (–18) cm long, 6–10 mm wide, brownish red with tan lines when dry, glabrous, silvery white endocarp surrounding the seeds. Seeds 8–12 per legume, elliptic to oblong, 7.2–11.0 mm long, 4.5–5.5 mm wide, olive green when fresh, brown, glaucous, when dry, glabrous; hilum 3.3–4.5 mm long, 1.4–1.6 mm wide.

Habitat and distribution: in rocky, open woods and forest borders, usually associated with mixed oak woods, limestone and a drainage area; southeastern United States from central Alabama west to western Mississippi and north through central Tennessee and western Kentucky to southwestern Illinois (Figure 4).

Specimens examined. ALABAMA: Autauga County: *Gunn 945*, 15 July 1982 (AUA). Marshall County: *Patrick 1065*, 29 July 1979 (TENN); *Partick & Perkins 1068*, 4 September 1979 (TENN). ILLINOIS: Union County: *Fuller 664*, 8 September 1941 (ILL). KENTUCKY: Livingston County: *Athey 1164*, 2 August 1970 (A, NY). Lyon County: *Athey 771*, 11 July 1969 (A); *Athey s.n.*, 19 September 1969 (SIU); *Schwegman 1334*, 30 July 1967 (ILLS). Trigg County: *Ellis 772*, 5 August 1965 (APSC); *Ellis 2383*, 16 August 1966 (APSC). Warren County: *Price s.n.*, July–September (A); *Price s.n.*, July–September 1896 (A); *Price s.n.* 1895 (A); *Price s.n.*, July 1896 (A); *Price s.n.*, 12 July 1896 (A); *Price s.n.*, August 1897 (A, NY); *Price s.n., s.d.* (MO, NY). MISSISSIPPI: Clay County: *Thomas 1797*, 9 September 1968 (UNA). Oktibbeha County: *Ray 6728*, 9 July 1956 (A). Davidson County: *Svenson 7325*, 24 July 1935 (TENN). TENNESSEE: Marion County: *Patrick 1529*, 9 November 1980 (TENN); *Simmers s.n.*, 28 July 1978 (TENN). Montgomery County: *Chester 4130*, 21 July 1979 (APSC, TENN); *F.H.N. et al. 16303*, 19 August 1951 (TENN); *Silva & Clebsch 510*, 15 July 1949 (APSC).

Excluded Names

Apios frutescens Pursh, Fl. Am. Sept. 474. 1814.

=*Wisteria frutescens* (Linnaeus) Poiret in Lamarck, Tabl. Encycl. Meth. Bot. 3: 674. 1823. Basionym: *Glycine frutescens* L.

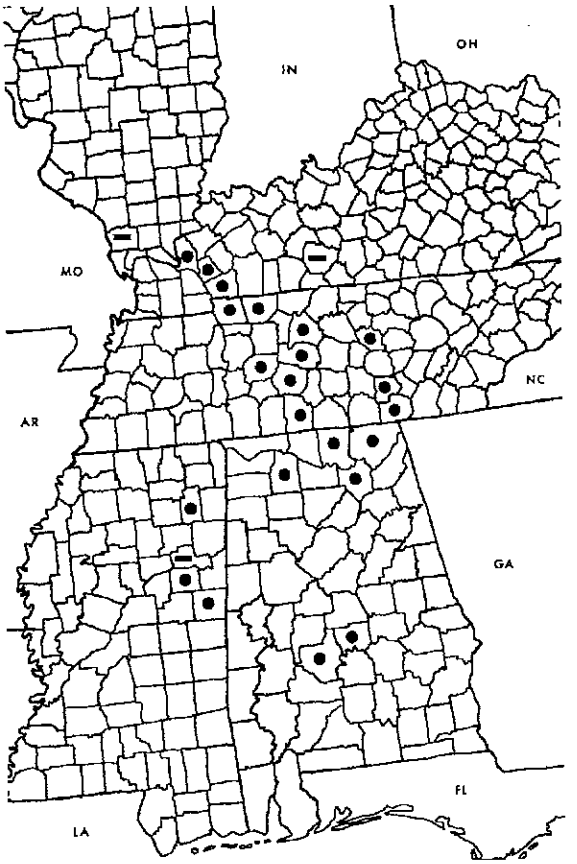

Figure 4. Map showing distribution of *Apios priceana*. Symbols: • = extant populations, — = extinct populations.

Pursh (1814) transferred *Glycine frutescens* to *Apios frutescens* and described the species as having nine leaflets, coriaceous legumes, terminal racemes, and purplish blue flowers. These characters did not coincide with Fabricius' 1759 description of *Apios*. Therefore, Poiret (1823) correctly transferred *G. frutescens* to Nuttall's (1818) genus *Wisteria* (*nom. con.*).

DISCUSSION

Both *Apios americana* Medikus and *A. priceana* Robinson form a natural group and the two subgenera, *Tylosemium* and *Euapios*, proposed by Robinson (1898) are not justified. The stylobi of *A. priceana* (subgenus *Tylosemium*) is spongy and larger (5.8–7.8 mm long) than the stylobi of *A. americana* and the three Asian species (subgenus *Euapios*), which range from 1.5–5.5 mm long. However, the basic structure and function of the stylobi of all five species are the same. Additionally, the single, irregularly spheroidal tuber Robinson recognized as a characteristic of subgenus *Tylosemium* does not separate the species into natural groups. Although *A. americana* has rhizomes with 4–12 moniliform, fleshy, oblong, oval, or globose tubers, the three Asian species exhibit a considerable amount of variation in the below the ground portion of the plants. Some specimens of *A. fortunei* Maximowicz have a single tuber while others have moniliform tubers. Both *A. carnea* (Wallich) Bentham *ex* Baker and *A. delavayi* Franchet have a rhizome but do not produce tubers.

Of the twenty-eight characteristics useful in delimiting taxa, three are vegetative parts and twenty-five are reproductive parts (Table 1). Vegetative characteristics, both within and between the two species, exhibit a significant amount of variation. The three vegetative characteristics that are of taxonomic significance include petiole length, pulvinus length and

stipule length. Floral characteristics are fairly consistent within a species but most vary significantly between species. The size (length and width) of the various flora parts are most useful in separating the two species.

Both species are latex producing, herbaceous perennial with a tuber, or tubers, and adventitious roots. *Apios americana* produces 4–12 moniliform, fleshy, oblong, oval, or globose tubers, 2–10 cm in diameter at 3–10 cm intervals along the rhizome. *Apios priceana* produces a single oblate spheroidal tuber, 15–20 cm in diameter.

The leaves are alternate, pinnately compound. With the exception of petiole length, pulvinus length and stipule length, the other leaf characteristics overlap between the two species. Although these characteristics (leaf and leaflet length and width, rachis, secondary pulvinus and stipel lengths) tend to be larger in *A. priceana*, there is always overlap between the upper measurements of *A. americana* and the lower measurements of *A. priceana*. The base of the leaflets of *A. americana* is commonly asymmetrical. Some specimens, however, have leaflets with both asymmetrical and symmetrical bases, while other specimens have leaflets which are all symmetrical at the base. All three base types (asymmetrical, combination and symmetrical) are scattered throughout the geographical range of the species. The leaflet bases of all specimens of *A. priceana* examined during this study were symmetrical.

The inflorescences of both species are a nodose pseudoraceme in the leaf axil. Although the inflorescences are primarily unbranched and occur mostly single or in twos, the inflorescences of some specimens of *A. americana* are branched and may occur in threes. The keel of *A. priceana* does not coil after tripping, instead, it bends sharply backwards at the mid-point. This bending is allowed by a thin triangular pouch located at the mid-point of the keel. Seabrook (1973) proposed the name "articulum" for this specalized pouch.

The androecium consists of 10 diadelphous stamens. In *A. americana*, the single free stamen is 15.5–17.0 mm long. Of the 9 fused filaments, the outer 2 are free the upper 1.5–3.0 mm. The remaining 7 filaments are free the upper 0.5–1.5 mm, increasing in length from the inside toward the outside. The anthers are filantherous, 0.5–0.6 mm long. *Apios priceana* has a single free stamen 20–24 mm long. Of the 9 fused filaments, the outer 2 are free the upper 2.5–3.3 mm. The remaining 7 filaments free 1.0–2.3 mm, increasing in length from the inside toward the outside. The anthers are filantherous, 0.8–1.0 mm long.

The gynoecium consists of a single pistil that is stipitate on a disk. The ovary is 5.5–7.0 mm long with 6–11 ovules in *A. americana*. In *A. priceana*, the ovary is 13–15 mm long with 8–12 ovules. The style of *A. americana* is smooth and glabrous, whereas, the style of *A. priceana* is grooved along the outer surface and is bearded with simple trichomes.

The fruits and seeds of both species are olive green when fresh. In *A. americana*, mature fruits are tannish brown and the seeds are brown to reddish brown when dry. Mature fruits of *A. priceana* are brownish red with tan lines and the seeds are brown and glaucous when dry.

The highly variable characters of *A. americana* are so overlapping that no definite lines of demarcation can adequately separate the infraspecific taxa. This conservative species concept allows for the expected morphological phenotypic variation of a species within its overall distributional range. The primary reason Daniels (1911) described forma *boulderensis* was because of its disjunct distribution (it was previously unknown west of eastern Kansas) and its larger, thinner, long-acuminate leaflets and smaller brownish to deep-violet flowers. Although Boulder County, Colorado represents the western range of *A. americana*, it is no longer disjunct, as it has been documented from seven counties in central and western Kansas and two additional counties in Colorado (Denver and Yuma). The leaflet size and shape, and, flower color all fall within the range of variability for typical *A. americana*. The type of forma *cleistogama* appears to be an immature specimen of typical *A. americana*. The floral parts, when compared to immature flowers from other plants, are equivalent in size and shape. In addition, there is no evidence of fruit development on the type specimen. Fernald (1939) described the typical variety of *A. americana* as having compact and thick racemes that are strongly rounded at the summit (Figure 1, number 1). He described variety *turrigera* as having lax, lanceolate or ovoid-attenuate racemes that are prolonged at the apex (Figure 1, number 2). Wilbur (1963) did not consider this infraspecific taxon worthy of recognition, because he had examined specimens with both typical

and *turrigera* type racemes on the same plant. Seabrook (1973) reported that racemes on plants in the northern part of the range were short and truncate, while racemes on plants from the southern part of the range are usually longer and pointed at the apex. She suggested the shorter photoperiod in the north caused the apex of the racemes to senesce and fall off. In addition, the author has observed plants from the southern part of the range with elongated racemes on the upper portion of the plants but more compact, truncate racemes toward the base where they are more shaded. This suggests that photodensity, along with photoperiod, is an important factor in determining raceme shape. There is so much variation in pubescence that forma *pilosa* cannot be recognized as a distinct taxon. Results from this treatment show a wide variety of pubescent patterns and numerous intermediate combinations on specimens in the field and grown in the greenhouse. Some specimens are pubescent on the main stems while rameal stems are glabrous. On other specimens, the upper portions of the plants are pubescent while the lower portions are glabrous. Tubers from different populations, grown in the greenhouse, reveal that some plants are pubescent when young but became glabrous with age. The types of the two color forms of *A. americana*, forma *keihneri* and forma *mcculloughi*, could not be located, and therefore were not studied during this revision. However, the variation in flower color (yellow-green to deep maroon) and the requirements for correct identification described by Oswald (1961a, 1961b) justify not recognizing these two infraspecific taxa as distinct. Oswald instructs for correct identification that *Color Standard and Color Nomenclature* (Ridgway 1912) should be used and the standard, wings, and keel should to be matched separately to prevent the creation of a false tone. In addition, only freshly opened flowers should be used and the color test should be conducted out of the sun, but in bright open shade, and only during the late morning or early afternoon hours.

Apios priceana was designated as threatened throughout its entire range in 1990 due to the small number of populations and the threats to its habitats (United States Fish and Wildlife Service 1990). At the time it was listed as threatened it was known from only 11 populations in 11 counties and four states (Alabama, Kentucky, Mississippi, and Tennessee). Presently, there are 47 populations from 22 counties in the same four states (Figure 4). There are 12 populations from 6 counties in Alabama (Al Scholz, Alabama Natural Heritage Program, pers. comm.), 7 populations from 3 counties in Kentucky (Deborah White, Kentucky State Nature Preserves Commission, pers. comm.), 4 populations from 3 counties in Mississippi (Ronald Wieland, The Mississippi Natural Heritage Program, pers. comm.) and, 24 populations from 10 counties in Tennessee (Claude J. Bailey, Tennessee Department of Environment and Conservation, Natural Heritage Program, pers. comm., Estes 2004).

Both species display a rather narrow ecological amplitude. *Apios americana* occurs in eastern North American primarily in wet soil along creeks, rivers and lakes (Figure 2). *Apios priceana* occurs in the southeastern United States in rocky, open woods and forest borders, usually associated with mixed oak woods, limestone and a drainage area (Figure 4).

Diploid and triploid populations of *A. americana* are almost entirely restricted to different sections of the overall geographical range. Triploid individuals are primarily located in the section of eastern North American that was covered by ice during the Wisconsinan glaciation 18,000 years ago. This includes the areas north of Pennsylvania, central Ohio, southern Indiana, central Wisconsin, and central Iowa. The diploid individuals also occur in the Wisconsinan glaciation area but are more abundant outside of the area in the southern part of the range. Triploidy is considered to have evolved several times as four different clones have been described. Clones east of the Appalachian Mountains have light-colored flowers and very little stem pubescence, whereas the western clones have dark-colored flowers and heavy stem pubescence (Joly and Bruneau 2004).

ACKNOWLEDGMENTS

The author would like to thank the Department of Plant Biology at Southern Illinois University at Carbondale for providing facilities used during the conduction of this research.

The Graduate School of Southern Illinois University for financial assistance provided by the Delyte Morris Dissertation Research Award. Thanks to the curators of the various herbaria that loaned specimens for this study and Mr. Michael Mibb who processed many of these loans. Special appreciation is extended to Dr. Robert H. Mohlenbrock for his guidance and encouragement during this project. In addition, I thank Ms. Linda Gucciardo for preparing the two illustrations of *Apios*. Finally, I thank Dr. Marty F. Wojciechowski for comments made concerning the current phylogeny of *Apios*.

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Received February 26, 2004; Accepted August 16, 2004.

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