Conservation Assessment

for

Yellowwood

(Cladrastis kentukea (Dum.-Cours.) Rudd)

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ILLINOIS
NATURAL
HISTORY
SURVEY

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Cladrastis kentukea (Dum.-Cours.) Rudd, from the Nyugat-Magyarországi Egyetem Botanikus Kertje page, Botanic Garden of the University of Sciences, Budapest, Hungary

http://columbia.nyme.hu/~novenytan/botkert/kepek/Cladlute/Cladlute.htm

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EXECUTIVE SUMMARY

This Conservation Assessment is a review of the taxonomy, distribution, habitat, ecology, and status of Yellowwood, *Cladrastis kentukea* (Dum.-Cours.) Rudd, 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 Yellowwood to date. Yellowwood is a small tree in the bean family that grows to 15 (-20) m tall, with yellow heartwood, thin smooth bark, alternate, pinnately-compound leaves, and showy, fragrant clusters of white flowers that appear in the spring. The species is found in portions of the eastern United States and in adjacent Ontario, Canada, in nutrient-rich upland forests and calcareous bluffs often located on or at the base of north-facing slopes. While it has been recorded historically from twenty states and one Canadian province, its distribution is irregular and discontinuous. It is thought to have been historically (and currently) native to just thirteen states, and the other occurrences are a result of the establishment of widely cultivated individuals. Yellowwood is listed as Endangered in Illinois, and as Threatened in Indiana. It is included on the Watch List for species of conservation concern in Georgia, Mississippi, Missouri, and North Carolina, it is a species of Special Concern in Alabama, and it is of Regional Concern in South Carolina. Currently, Yellowwood has no formal federal protection status. Yellowwood 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. Globally, this species has been ranked as apparently secure, but it is a North American endemic, an ancient relict with a limited overall range, and it appears to be declining overall in the wild. It could face extirpation in the wild in several states if it is not properly protected.

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: *Cladrastis kentukea* (Dum.-Cours.) Rudd [1972]
Common Names: Yellowwood; Yellow-wood; Yellow Wood; Kentucky Yellowwood; American Yellowwood; Virgilia
Synonymy: *Sophora kentukea* Dum.-Cours. [basionym – 1811]
Virgilia lutea Michx.f. [1813]
Cladrastis fragrans Raf. [1824]
Cladrastis tinctoria Raf. [1825]
Virgilia kentukensis Dum.-Cours. ex Raf. [1825, as *Virgilia kentuckensis*]
Cladrastis albiflora Raf. [1836]
Cladrastis lutea (Michx.f.) K.Koch [1869]

Class: Magnoliopsida (Flowering Plants - Dicotyledons)
Family: Fabaceae (= Leguminosae; The Bean Family)
Plants Code: CLKE (USDA NRCS plant database, W-1)
http://plants.usda.gov/

The legume genus *Cladrastis* Raf. contains a single species in North America north of Mexico. The genus is a small one, and six other similar species occur in eastern Asia, namely, two Japanese species, *Cladrastis platycarpa* (Maxim.) Makino and *Cladrastis sikokiana* Makino, and four Chinese species, *Cladrastis parvifolia* C.Y.Ma, *Cladrastis scandens* C.Y.Ma, *Cladrastis sinensis* Hemsl., and *Cladrastis wilsoniana* Takeda (Li 1952, Spongberg and Ma 1997). The genus *Maackia* Rupr. & Maxim., with eleven species also in eastern Asia, is very closely related to *Cladrastis* and it is sometimes united with it (Andrews 1997). Both *Cladrastis* and *Maackia* are members of the large widely distributed plant family Fabaceae (= Leguminosae).

Yellowwood was first named *Sophora kentukea* by Dumont de Courset in 1811. In 1813, Francois Andre Michaux (= Michx. f.) described the same plant as *Virgilia lutea*, apparently unaware of Dumont de Courset's earlier description. In 1825, Rafinesque used the name *Virgilia kentuckensis*, presumably based upon *Sophora kentukea*, though this was an incorrect spelling. In 1869, the respected dendrologist K. Koch made the new combination *Cladrastis lutea* based on *Virgilia lutea*, perhaps unaware of the earlier names used by Rafinesque and Dumont de Courset. Velma Rudd (1971, 1972) finally corrected this error and made the new combination *Cladrastis kentukea* based upon the earliest name for the plant, following the Botanical Rules of Nomenclature, first using the epithet *kentuckea* (Rudd 1971), and later correcting that to *kentukea* (Rudd 1972). The isolated taxonomic positions of *Cladrastis* and *Maackia* are generally accepted, and they have been included within the subfamily Faboideae (= Papilionoideae) tribe Sophoreae by most botanists. This places the tree close to the genus *Sophora*, a more common genus of the warm-temperate and tropical areas of the world. The

generic name appears to have been derived from the Greek *clados*, a branch, and *thraustos*, brittle (Fernald 1950). The specific epithet *kentukea* derives from the state of Kentucky from which it was first described and *lutea* is the Latin adjective meaning yellow, from the yellowish color of the wood.

Most floras have included this plant as *Cladrastis lutea* (Michx.f.) K.Koch, and several have been hesitant to use the current name, yet the botanical rule of priority establishes the correct name without question. The common name Yellowwood, and its etymological variations, is generally used for this tree, and it is based upon the yellowish colored wood of the trunk.

DESCRIPTION OF THE SPECIES

Cladrastis kentukea, Yellowwood, is a small deciduous **tree** to 15 (20) m tall with a DBH of up to 0.91 m, and its vegetative parts are generally hairless, though individuals from Alabama and elsewhere sometimes have pubescent twigs and leaf undersides, at least when young; the **bark** of the trunk is smooth, thin, and silvery gray; the **leaves** are compound, odd-pinnate (with a terminal leaflet), and 10-50 cm long; there are (5-) 7-11 **leaflets** and these are alternate on the rachis, broadly ovate to obovate, 6-10 (-18) cm long x (2.5-) 4-8 (-12) cm wide, and the terminal leaflet is rhomboid and 6-13 cm long; leaflet stipules are lacking; the **petiole** completely encloses the winter bud and is 10-15 cm long; the **inflorescence** is pendulous, and it is a many-flowered raceme or panicle 10-30 (-50) cm long; the white (rarely pink-tinted) **flower** is typically faboid (papilionaceous), and sweetly fragrant; the **calyx** is campanulate and 5-lobed, the tube is 5-7 mm long and the blunt lobes are 1.5-2 mm long; the **corolla** has a reflexed standard with a rounded blade about 15 mm long with a claw 2.2-3 mm long, the wings and keel are distinct and similar with a claw 6-8 mm long and an oblong blade16-20 mm long; there are 10 **stamens**, none are fused (typical of the tribe Sophoreae); the ovary is linear and short-stalked; the **fruit** is pendent, a typical legume, glabrous at maturity, indehiscent or tardily dehiscent, light brown, thin and flat, linear, tapering to each end, short-stipitate, (4-) 6-10 cm long and 8-12 mm wide, and it normally persists on the tree until the leaves drop; the 4-6 seeds are about 7 mm long x 4 mm wide. The chromosome number is $2n = 28$. (Adapted from Isely 1990, Gleason and Cronquist 1991, Radford *et al.* 1964, and Zanoni *et al.* 1979).

Yellowwood can be recognized by its alternate leaflets and by the pendent panicles of white flowers followed by flat pods. The smooth bark of the trunk is also distinctive. There are other compound-leaved woody legumes in the eastern United States, such as *Gleditsia* and *Robinia*, but those are easily distinguished from *Cladrastis* by their much smaller and more numerous leaflets as well as the spines and / or thorns that are often present on their trunks and branches. Likewise, the Kentucky Coffee Tree, *Gymnocladus*, can be easily distinguished from *Cladrastis* by its far more complex leaves with numerous tiny leaflets, and its non-faboid flowers.

Yellowwood is often planted as an ornamental tree, and its wood has been used as a source of a yellow dye [and so once named *Cladrastis tinctoria* Raf.]. The wood was also once popular for gunstocks (Steyermark 1963).

HABITAT AND ECOLOGY

A review of the literature demonstrates that this tree has a limited variety of plant associates and habitats throughout its range (W-2, W-3, Robertson and Pusateri 1976, Turner 1935). *Cladrastis kentukea* grows mainly in rich, mesic upland forests and calcareous (limestone) bluffs, often as an understory tree in more mature forests, and sometimes on stream banks (Fernald 1950, Herkert and Ebinger 2002, W-2). This forest type has traditionally been called the mixed mesophytic forest (Robertson and Pusateri 1976). It is often found on north-facing slopes, ravines, and river bluffs (Isely 1990). While it is frequently found to be associated with calcareous (alkaline) or circumneutral soils, Yellowwood is frequently cultivated on many different kinds of substrates, in sunny exposures as well as in shade, and it is grown well outside of its native range. In general, Yellowwood is said to grow best in the same moist, alkaline, well-drained soils similar to those in which the native populations grow (Robertson and Pusateri 1976).

At the eastern portion of its range in the southern Appalachians of Georgia, North Carolina, South Carolina and Tennessee, Yellowwood is a component of the Rich Montane Type of Southern Appalachian Cove Forest (W-2). This forest has a canopy dominated by various combinations of the **tall trees** *Acer saccharum, Aesculus flava*, *Carya cordiformis*, *Fraxinus americana, Halesia tetraptera* var. *monticola*, *Quercus rubra*, and *Tilia americana*. Instead of shrubs, which are very sparse in this plant community, there tends to be a subcanopy layer of **small trees** present including both *Cladrastis kentukea* and *Ostrya virginiana*. The herbaceous flora is rich and diverse and has many species characteristic of circumneutral or alkaline soils. **Vines** are rather infrequent, but *Aristolochia macrophylla* and *Parthenocissus quinquefolia* are commonly found. Commonly associated **forbs** include *Actaea pachypoda*, *Ageratina altissima*, *Arisaema triphyllum*, *Asarum canadense*, *Aster divaricatus*, *Caulophyllum thalictroides*, *Cimicifuga americana*, *Cimicifuga racemosa*, *Disporum lanuginosum*, *Galium triflorum*, *Hepatica acutiloba*, *Hydrophyllum canadense*, *Impatiens pallida*, *Monarda clinopodia*, *Monarda didyma*, *Osmorhiza claytonii*, *Panax quinquefolius*, *Polygonatum pubescens*, *Sanguinaria canadensis*, *Sedum ternatum*, *Solidago curtisii*, *Solidago flexicaulis*, *Stellaria pubera*, *Thalictrum* spp., *Tiarella cordifolia*, *Trillium grandiflorum*, *Trillium rugelii*, *Uvularia* spp., and *Viola canadensis*. Relatively few **graminoids** can be found, including *Carex plantaginea* and the unusual *Cymophyllus fraserianus*. **Ferns** can be rather common and diverse, and can include *Adiantum pedatum*, *Cystopteris protrusa*, *Deparia acrostichoides*, *Diplazium pycnocarpon*, *Dryopteris goldiana*, *Dryopteris intermedia*, *Dryopteris marginalis*, and *Polystichum acrostichoides*. This association is especially well known in Great Smoky Mountains National

Park and the national forests of that region.

At its western range limit in northwestern Arkansas and northeastern Oklahoma, Yellowwood grows on steep, mesic slopes in shallow, rocky pockets of soil, and along rivers at the edges of cliffs or on ledges (Zanoni *et al.* 1979). It is most frequently found in a White Oak – Red Oak – Red Maple – Sugar Maple – Shagbark Hickory Association in this region (*Quercus alba – Quercus rubra – Acer rubrum – Acer saccharum – Carya ovata*; Turner 1935). This association has also been described as an *Acer saccharum – Quercus muehlenbergii – Cotinus obovatus* forest (Hoagland 2000). **Canopy trees** can be quite variable, but generally include *Acer rubrum, Acer saccharum, Carya cordiformis, Carya ovata, Carya tomentosa, Fagus grandifolia, Fraxinus americana, Juglans nigra*. *Magnolia acuminata, Nyssa sylvatica, Platanus occidentalis, Quercus alba, Quercus macrocarpa, Quercus muehlenbergii, Quercus rubra, Quercus velutina, Sassafras albidum, Tilia americana, Ulmus americana,* and *Ulmus rubra*. **Smaller trees** are also common, and often include *Acer leucoderme, Aesculus glabra, Amelanchier canadensis, Asimina triloba, Carpinus caroliniana, Cercis canadensis, Cladrastis kentukea, Cornus florida, Cotinus obovatus, Crataegus* spp., *Gymnocladus dioica, Morus rubra, Ostrya virginiana, Rhamnus caroliniana,* and *Viburnum rufidulum*. Again, few shrubs are present, and these may include *Philadelphus pubescens* and *Staphylea trifoliata*. Vines, forbs, graminoids and ferns are also diverse as in the southern Appalachian cove forest described above, and many of the same species can be found. A few of the more local species growing in this association with *Cladrastis* are the forb *Antennaria parlinii*, *Tradescantia ozarkana,* and the fern *Woodsia obtusa*.

Yellowwood is well known in southwestern Missouri in a similar forest type with similar associates. Steyermark (1963) described its habitat as rich wooded limestone slopes and bluffs, especially along the White River and its tributaries. Associated plants can include the **trees** *Acer rubrum, Acer saccharum, Carya texana, Carya tomentosa, Cornus florida, Nyssa sylvatica, Ostrya virginiana, Quercus alba, Quercus rubra, Quercus velutina,* and *Tilia americana*, the **shrubs** *Rhododendron prinophyllum, Rhus aromatica,* and *Vaccinium pallidum,* the **vines** *Lonicera flava* and *Vitis aestivalis,* the **herbs** *Amphicarpaea bracteata, Antennaria plantaginifolia, Aruncus dioicus, Aster* spp., *Coreopsis* sp., *Cunila origanoides, Desmodium glutinosum, Eupatorium rugosum, Phryma leptostachya, Silphium asteriscus, Solidago* spp., and *Uvularia grandiflora,* the **sedges** *Carex* spp., and the **fern** *Woodsia obtusa,* among others.

In Illinois (and Indiana), Yellowwood grows in rich woods and calcareous bluffs on mesic wooded slopes and in ravines in the extreme southern tip of the state (W-2; Herkert and Ebinger 2002, Mohlenbrock 1986, 2002, Robertson and Pusateri 1976). Its habitat has been described as a Mesic Upland Forest natural community (as defined by White and Madany 1978), or, more specifically, a Beech – Sugar Maple – Red Oak – Black Oak association (*Fagus grandifolia – Acer saccharum – Quercus rubra – Quercus velutina*) growing on a substrate of thin loess and

silty loam over cherty limestone, with a pH varying from 4.5 to 7.3 throughout the site (Robertson and Pusateri 1976). Individual trees are on small north- to west-facing slopes and the canopy provides approximately 98 % shade cover. An inspection of the associates listed below reveals that some of the components are more characteristically species of stream terraces and floodplain forests, such as *Asimina triloba, Euonymus atropurpurea, Lindera benzoin, Liquidambar styraciflua, Morus rubra, Platanus occidentalis* and others. This is a moist environment not resistant to fire. Associated woody species include the dominant **trees** *Acer saccharum, Fagus grandifolia, Ostrya virginiana, Quercus rubra, Quercus velutina,* along with the less common trees *Acer rubrum, Aesculus glabra, Amelanchier arborescens, Carpinus caroliniana, Carya cordiformis, Carya glabra, Carya ovalis, Carya ovata, Carya tomentosa, Cornus florida, Diospyros virginiana, Fraxinus americana, Fraxinus pennsylvanica, Liquidambar styraciflua, Liriodendron tulipifera, Magnolia acuminata, Morus rubra, Nyssa sylvatica, Platanus occidentalis, Prunus serotina, Quercus alba, Sassafras albidum, Ulmus alata,* and *Ulmus rubra*; in the understory are the **shrubs** *Aralia spinosa, Asimina triloba* (common), *Euonymus atropurpurea, Hydrangea arborescens* (dominant), *Ilex decidua, Lindera benzoin, Styrax grandifolius,* and *Vaccinium pallidum*; **vines** are infrequent but can include *Parthenocissus quinquefolia, Smilax pulverulenta, Toxicodendron radicans,* and *Vitis* spp. The herbaceous component that grows with *Cladrastis* in Illinois has not been recorded in as detailed a fashion, but the **forbs** *Aplectrum hyemale, Cacalia atriplicifolia, Caulophyllum thalictroides, Desmodium canescens, Desmodium paniculatum, Lespedeza intermedia, Solidago ulmifolia*, and *Valeriana pauciflora* certainly have been found at the site; the **graminoids** known from the site include *Agrostis perennans, Arundinaria gigantea, Carex cephalophora, Dichanthelium laxiflorum*, and *Muhlenbergia sobolifera*. The population of this rare tree from which this species list was compiled is located in the Wolf Creek Botanical Area within Shawnee National Forest in Alexander County (W-2), located within the Southern Section of the Ozark Natural Division of Schwegman *et al.* (1973). The Gallatin County population that has not been rediscovered was located within the greater Shawnee Hills section of the Shawnee Hills Natural Division of Illinois.

At its general southern limits in northern –central Alabama, *Cladrastis kentukea* grows in upland forests on dolomitic limestone associated with dolomite glades. Its habitat has been described as a *Quercus muehlenbergii – Carya carolinae-septentrionalis – Acer barbatum – Juniperus virginiana – Croton alabamensis* woodland (W-2). Commonly associated **canopy trees** include *Carya carolinae-septentrionalis, Carya glabra, Carya pallida, Celtis laevigata, Diospyros virginiana, Fraxinus americana, Magnolia acuminata, Pinus echinata, Quercus alba, Quercus muehlenbergii, Quercus shumardii, Quercus velutina, Tilia americana,* and *Ulmus rubra*. Smaller, **understory trees** often include *Aesculus pavia, Cercis canadensis, Cladrastis kentukea, Cornus florida, Fraxinus quadrangulata, Juniperus virginiana, Ostrya virginiana, Ulmus alata,* and *Viburnum rufidulum*. **Shrubs** are somewhat more common here and may include *Asimina parviflora, Callicarpa americana, Croton alabamensis, Euonymus atropurpurea, Forestiera*

ligustrina, Hydrangea arborescens, Philadelphus hirsutus, Ptelea trifoliata, Rhamnus caroliniana, and *Rhus aromatica*. **Vines** can include *Bignonia capreolata, Cocculus carolinus, Parthenocissus quinquefolia, Smilax* spp., and *Vitis rotundifolia*. Because the soil in this forest is rather shallow and rocky, herbs are less diverse. Associated **forbs** can include *Eupatorium coelestinum, Eupatorium rugosum, Euphorbia pubentissima, Galium circaezans, Galium obtusum, Hexastylis arifolia, Lithospermum canescens, Polygala boykinii, Senecio obovatus, Solidago auriculata, Solidago caesia, Verbesina occidentalis, Verbesina virginica*, and *Viola walteri*. **Graminoids** are not common, but can include *Chasmanthium latifolium, Chasmanthium sessilifolium,* and *Dichanthelium boscii*. **Ferns** may include *Asplenium resiliens* and *Pellaea atropurpurea*.

DISTRIBUTION AND ABUNDANCE

Cladrastis kentukea, Yellowwood, is limited in range, and it is endemic to the eastern United States, generally in the southeastern states and the Ozark region. It has been determined to be native from Indiana and southern Illinois, southwestern Missouri, north and central Arkansas, extreme eastern Oklahoma, and east to eastern Tennessee, North Carolina, and northern Georgia (Little 1977, Robertson 1977). Within this rather wide range, it occurs infrequently and in relatively small colonies. The Oklahoma populations represent the western limits of the species distribution, mainly on the Ozark Plateau. Yellowwood has been reported to occur as a native plant historically in the eastern United States in thirteen states, namely, Alabama, Arkansas, Georgia, Illinois, Indiana, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, and Tennessee (W-1; W-2; Isely 1990). Its distribution suggests that it survived in both the southern Appalachian and Ozark Mountain regions during the Ice Ages. It has rarely escaped from cultivation in Connecticut, Massachusetts, Maine, New York, Ohio, Pennsylvania, and Rhode Island as well as in Ontario, Canada (W-2; Magee & Ahles 1999). Therefore, its total range in North America can be said to include twenty states and one Canadian province (W-1, W-2). Its natural range includes only lands south of the southernmost extent of glaciation (Robertson and Pusateri 1976). A very few disjunctions have been reported at the western portions of its range, most notably along the border of Arkansas and Oklahoma. Towards the northern and eastern limits of its native range, and beyond, Yellowwood has been reported to occasionally escape from cultivation and it has sometimes been thought to be native in Connecticut, Ohio, Pennsylvania, and Rhode Island, but this is unlikely, and local botanists in those states do not believe it to be native (*e.g.*, Mike Vincent, pers. comm.); it is an attractive tree often planted as an ornamental in the same general areas as is its Asian relative *Sophora japonica* L. It is also planted within its general native range leading to some confusion in the literature, but its habitat preferences are distinct enough that it is normally easy to distinguish native trees and those escaped from cultivation. Yellowwood appears to be an ancient species because the distribution of this and its closest relatives in eastern Asia demonstrate that the genus was widespread long before glaciation. Additional details on the distribution of Yellowwood can be

found in Chester *et al.* (1993), Kartesz and Meacham (1999), Magee and Ahles (1999), Radford *et al.* (1964), Smith (1978), and Steyermark (1963) and several Internet sites (*e.g.*, W-1, W-2).

Yellowwood is most frequent in the Appalachian and Ozark highlands and along the river bluffs of central Kentucky and Tennessee. In Tennessee, it has been reported from at least 31 counties, followed by 21 counties in Arkansas. In Kentucky it has been found in 16 counties concentrated in the eastern third of the state. Recent searches have found Yellowwood in nine counties in Oklahoma, and in eight counties each in Alabama and Mississippi. In nearly all cases, the tree is concentrated in highlands in association with limestone or dolomite.

Yellowwood is at its southern limit of distribution in northern portions of Louisiana, Mississippi, Alabama, and Georgia. It does not reach the coastal plain near the Gulf Coast. Its western limit is in extreme northeastern Oklahoma (W-1, W-2, Zanoni *et al*. 1979) and adjacent northwestern Arkansas (Smith 1978). In the Midwest it has been found in southern Illinois (its northwestern range limit) and Indiana as well as in southwestern Missouri, but it has not been found in Iowa, Wisconsin or Michigan (W-1, W-2, Mohlenbrock and Ladd 1978, Deam 1940). In the Appalachian Mountains, this species is restricted to Tennessee, North Carolina, South Carolina, and Georgia, and it has not been reported in the mountains of Virginia and West Virginia. Because of the many reports of escaped or planted trees in other states, the distribution of native populations has been difficult to interpret in the literature.

Representative specimens of this tree have been listed in Appendix 1. A summary of the distribution of Yellowwood in the United States has been presented in Appendix 2.

Within the U.S. Forest Service Eastern Region (Region 9) *Cladrastis kentukea* is present within the Shawnee National Forest in Illinois and the Mark Twain National Forest in Missouri, but is uncommon or rare, and it has not been found within the Hoosier National Forest in Indiana (W-4). In the Southeastern Region (Region 8), Yellowwood has been documented within several national forests, including the Daniel Boone, Nantahala and Pisgah, Cherokee, and the Chattahoochee National Forests.

In Indiana, *Cladrastis kentukea* is known only from deep, forested ravines in Brown County (Deam 1940, Homoya, pers. comm.). Very few small groves of this tree remain and essentially all of them are located in Yellowwood State Forest (W-5).

In Illinois, where it is listed as Endangered, the species has been reported historically in Alexander and Gallatin Counties, but it is currently known to survive only in Alexander County in Shawnee National Forest where several small populations still occur (W-3, Mohlenbrock and Ladd 1978, Herkert and Ebinger 2002, Shawnee National Forest 2005). Yellowwood approaches its northern range limit in southern Illinois. One Illinois population is known within

the Wolf Creek Botanical Area within the Shawnee National Forest. Here the species grows within a 9 acre stand of up to 76 stems that has been the subject of monitoring at least from 1987 to 1992 (W-3). The Gallatin County population was reported more than 30 years ago and it has not been relocated (Herkert and Ebinger 2002). The southern Illinois sites fall within the Greater Shawnee Hills Section of the Shawnee Hill Natural Division of Illinois (Schwegman *et al.* 1973) just south of the glacial boundary. In 1976 the approximate number of individuals recorded at the Wolf Creek site was 64 with an additional 17 individuals located several km east of this site (Robertson and Pusateri 1976). In 1992, up to 76 individuals were noted in a 9-acre stand at the site (W-3).

The populations in Illinois and other parts of the Midwest are small and they are isolated from one another, and this is actually rather typical of the species throughout its range. It is likely that the species was not common in the region at the time of European settlement because the amount of suitable habitat available then was also limited. It appears to have persisted in the area as a rare relict only since the time of glaciation.

PROTECTION STATUS

The Nature Conservancy ranking for *Cladrastis kentukea* is G4 (apparently secure globally; W-2, Appendix 3). In the United States the species is given the National Heritage status rank of N4 with a similar meaning. The national ranking for Canada is NNA (not native, classification not applicable).

Currently, Yellowwood has no formal federal protection status.

The state rankings vary, but it has been designated as Endangered in Illinois (as *Cladrastis lutea*, Illinois Endangered Species Protection Board. 2005) and it has been designated as Threatened in Indiana. While not designated as endangered or threatened in Louisiana or South Carolina, its ranking of S1 indicates that it is critically imperiled in those states yet it is without official protection there. It is included on the Watch List for species of Conservation Concern in Georgia, Mississippi, Missouri, and North Carolina, and it is on the list of plants of Special Concern in Alabama. In South Carolina it is considered to be of Regional Concern.

Cladrastis kentukea has been included on the Regional Forester Sensitive Species list (RFSS) for the Eastern Region, and it is considered to be At Risk in the Shawnee National Forest (W-4).

Protection for this tree in the wild is currently dependent primarily on habitat protection, and its survival will probably depend on this as well as on the protection of individual trees. Most populations in Illinois and Indiana are found on lands that are currently protected from development.

Table 1 lists the official state rank assigned by each state's Natural Heritage program according to the Nature Conservancy at their Internet site (W-2). Appendix 3 explains the meanings of the acronyms used (W-6). A summary of the current official protection status for Yellowwood follows:

U.S. Fish and Wildlife Service: Not listed (None)

U.S. Forest Service: At Risk in the Shawnee National Forest only

Global Heritage Status Rank: G4

U.S. National Heritage Status Rank: N4

Canada National Heritage Status Rank: NNA

Table 1: S-ranks for *Cladrastis kentukea* [Heritage identifier: PDFAB0Y010]

State/Province	Heritage S-rank	
UNITED STATES		
Alabama	S3	
Arkansas	SNR	
*Connecticut	SNR	
Georgia	S3	
Illinois	S1	[endangered]
Indiana	S2	[threatened]
Kentucky	S3S4	
Louisiana	S1	
*Maine	SNA	
*Massachusetts	SNA	
Mississippi	S2	
Missouri	S3	
*New York	SNA	
North Carolina	S2S3	
*Ohio	SNR	
Oklahoma	S2S3	
*Pennsylvania	SNR	
*Rhode Island	SNR	
South Carolina	S1	
Tennessee	S4	
CANADA		
*Ontario	SNA	

* = Not native; data based on escaped and established individuals

LIFE HISTORY

Cladrastis kentukea is a tree that may live to a great age. Its growth rate is slow to moderate, and it can achieve a height in 20 years of 8 m (W-1). Large roots are often visible at the surface of the ground, especially where the soils are thin. It is able to survive to temperatures as low as - 20

F, but temperatures this low as well as late freezes tend to discourage flowering in wild populations (W-3). The distribution of the species, then, appears to be controlled at least in part by temperature regimes and it is not tolerant of extremely cold temperatures. Flowering under normal conditions occurs yearly and seeds are successfully produced and, apparently, fertile. While Yellowwood is known to readily resprout after being cut or injured, it is most commonly propagated from seeds rather than vegetatively from cuttings (W-1). Unlike many other legumes, *Cladrastis* does not have nitrogen-fixing bacterial nodules on its roots (Foster, Horner and Graves 1998).

Yellowwood produces most of its growth in the spring and early summer, and flowering occurs in May or June. Only larger individuals flower (observations in Illinois revealed that trunk diameters of the smallest flowering individuals were at least 6.7 cm; W-3). In cultivation, trees do not flower until they are 10 years old, and flower production varies in two to five-year cycles (W-7). Pollinators appear to be various bees as well as black swallowtail butterflies, and perhaps others, and pollinators appear to be common in its habitat (W-3). The flowers are showy and have a sweet vanilla-like aroma that is attractive to insects. The papery legume fruits are eventually produced upon fertilization, and numerous seeds are shed from these by mid-to late July. Seedlings have been observed in dense leaf litter leading to speculation that this leaf litter mulch may be necessary for seedling germination. The seedlings are normally found in the immediate vicinity of the parent tree. Studies have shown that the seeds germinate best after cold-stratification, but this is not always required. The trees are deciduous and therefore lack leaves in the winter months. The limited size of populations of Yellowwood combined with its sporadic and limited distribution seems somewhat unusual because the trees grow very well in cultivation and often naturalize. They are often planted and grow in very exposed and disturbed conditions along roads and among residences and larger buildings in heavily developed areas where they flower abundantly. Their great similarity to the very aggressive and successful tree *Robinia pseudoacacia*, Black Locust, suggests that they should be more widespread and capable of colonization of new areas, but this is not the case. The reason for this lack of apparent success as compared to its more common relatives may very well be because the plant is not able to nodulate – in other words, it cannot fix nitrogen and so it cannot supplement soil nutrients as can many of its fellow legumes, putting it at a competitive disadvantage to those that can.

The trees normally flower from 1 May to 20 May in Illinois (W-3), and they may flower in June in some portions of its range, and especially when in cultivation. The fruits are generally mature by late July and the seeds fall by that time, but the empty dried brown fruits may remain on the tree well into September or even later, unlike most other legumes.

POPULATION BIOLOGY AND VIABILITY

Cladrastis kentukea is a tree that may live for many years, and it flowers and fruits regularly. No reproductive problems are known. It has been established that very cold temperatures as well as

late freezes can keep the plants from flowering and fruiting. It is thought that the plant cannot colonize very acidic areas, and this may also cause to restrict its distribution. Populations are generally found in small areas that are relatively cool (not cold) and moist, often north-facing, that are shaded by larger, mature forest trees, and that are associated with either calcareous substrates or circumneutral soils along with well developed humus layers. There are no apparent mechanisms for long distance seed dispersal.

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-8). In plants such as Yellowwood, the populations are small and isolated. Therefore, if pollination should occur, self-fertilization is the most likely outcome because there is almost no chance of fertilization by other genotypes unless they are within dispersal range. Continued self-fertilization can result in severe reproductive problems.

An example of negative effects thought to have arisen through isolation of populations can be seen in the case of a grass, Ofer 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.

According to all reports, Yellowwood seed production is high (e.g., W-1, W-3, W-7) and seedlings are often seen in the wild populations. Insect predation on the leaves appears to be very low. Yet, this tree appears to survive primarily as a local relict species. In addition, a fungal pathogen, *Botryosphaeria dothidea* (W-3) appears to pose a great hazard to this tree, especially at the margins of its range (see Potential Threats below).

Yellowwood habitat may be decreasing (see Potential Threats below). It may occur at other suitable sites in Illinois but because of the tree's conspicuous nature, it probably has not been often overlooked. It is at the extreme margin of its range in southern Illinois, and so truly suitable habitat for the species may not be common and it appears that it probably was never very common locally. At the margins of its range, viability is thought to be very poor, and the precise factors controlling its distribution at these margins are not known, though temperature extremes do appear to be involved. There appears to be little chance of natural colonization of new habitat by this tree in Illinois because of the lack of nearby seed sources and vectors for its

migration here. Therefore, the long-term viability of this very uncommon tree depends entirely on the protection and management of existing populations or its introduction by means of human intervention.

POTENTIAL THREATS

Globally, Yellowwood has been ranked as apparently secure as a species (see Protection Status above) and so it is not generally considered to be threatened. It is, however, a North American endemic with a limited overall range and most wild populations are rather small. It appears to be unable to increase its range and so may be vulnerable in selected areas.

The species is vulnerable at the margins of its range, and this is the typical condition for most state-rare plants. As the species extends into climatic zones and habitats that are only moderately suitable for it, the individuals are often stressed because of the less than optimal conditions. Yellowwood in Illinois and Indiana certainly fits this pattern. Threats to this tree species include forest management practices, accidental or deliberate forest fires, land development, a fungal pathogen, extreme cold, extreme drought, possibly air pollution, and uncontrolled wildlife foraging (W-2, W-3, Shawnee National Forest 2005).

The bark of Yellowwood is thin and easily injured by fire (W-3, Shawnee National Forest 2005). Scars caused by fire damage have been reported in several populations, and the species is not known to occur in areas where frequent forest fires have burned or where fire management techniques are commonly used. Yellowwood is, instead, normally found in mature forests that have not been burned, and these often occur in cool, moist cove forests in the Appalachians and Ozarks as well as in the lower portions of valleys and ravines. Forest fires may have limited its potential to increase its range. Black Locust, its better-known nitrogen-fixing relative, has a thick fire-resistant bark at maturity, and, unlike *Cladrastis*, it can be common in older forests that have a history of fire.

Clear-cutting would have a similar detrimental effect on *Cladrastis*, a tree well adapted to shaded understory situations in shade. Its wide leaflets are efficient at using filtered sunlight, and the reduction of the larger canopy trees in its vicinity would, most likely, cause a loss of individuals from exposure-related problems. The presence of thriving populations growing in deep shade in several states argues against selective cutting or any damage to the larger trees that shade this small tree. The tree is also known to be sensitive to moisture stress, and it will decline in drought years (W-3).

Land development is a distinct danger to native populations of this tree, and the loss of habitat to residential and business interests, and especially to the construction of dams that drown its canyon habitats, has eliminated several large and significant populations (Steyermark 1963). To a significant extent, this tree has been cut for its attractive yellow heartwood, used both as a

source of yellow dye and as lumber, and many large reproductive trees have been eliminated by this means, many before 1940 (Deam 1940, Steyermark 1963). Since European settlement, much of the previously available habitat has been destroyed, converted to cultivated fields orchards or commercial forests, or it has succumbed to land development (W-2). Some 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 how many populations were lost at other sites before field botanists began to document this tree.

By far, one of the best-documented threats to Yellowwood is from a fungal pathogen, identified as *Botryosphaeria dothidea* (W-3). This disease has been shown to kill many stems of this tree by girdling. This fungus is a widespread pathogen that is known to attack stressed plants of several species. Trees growing at the margins of the range that have been stressed by fire damage, extreme cold, moisture stress, or exposure are more susceptible to the attack of this fungus that does not appear to attack healthy trees in other portions of its range. It has also been shown that *Cladrastis* is very susceptible to *Verticillium* wilt (W-7). Robertson and Pusateri (1976) suggested that this pathogen was *Verticillium albo-atrum*. It may be appropriate to note here that while *Cladrastis* is susceptible to fungal pathogens, it is remarkably free of insect pest damage; it may be that the leaves of this plant contain compounds repellent or unsuitable to insects (W-3).

The natural range of *Cladrastis kentukea* appears to be limited by intolerance to extreme cold and extreme drought. These two types of climate stress appear to be most evident in populations at the extreme edges of its range (W-3). Trees have been eliminated by stress when on exposed drier west-facing slopes in Illinois, and cold stress has also been observed, especially as a factor in reducing or eliminating flowering (W-3). Towards the center of its range, and in more mesic, shaded areas, these stresses are not evident. It has also been suggested that air pollution may similarly foster disease by weakening the plants and it may cause an early death for certain individuals (W-3) but this may not have been documented yet.

In Indiana, studies have shown that Yellowwood fails to regenerate in areas suffering from deer overbrowsing (W-5). There is no evidence that older trees are susceptible, but seedlings appear to be readily eaten by foragers such as deer. It is also likely that seedlings are vulnerable to the competition of aggressive exotic species, such as the vine *Lonicera japonica* (Japanese honeysuckle; Shawnee National Forest 2005).

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 population(s) of Yellowwood, 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 *Cladrastis kentukea* in the Shawnee National Forest may be threatened with elimination from habitat change and climate change that could result in the loss of most individuals from fungal invasion resulting from this uncontrollable environmental stress. At this time it is just as likely that it can persist with careful monitoring, and with attempts to successfully establish its seedlings in this and similar habitats nearby to increase its chances of survival.

RESEARCH AND MONITORING

Plants in Illinois have been, and, apparently, still are being monitored within the Shawnee National Forest in Illinois (W-3, Shawnee National Forest 2005). Many people grow the species as an ornamental tree, and so its characteristics and attributes, including disease tolerance and life history, are often described and readily available in the literature and on the Internet. Not all wild populations are being monitored in detail because it is not listed as a sensitive plant in very many states.

As far as is known, there has been little or no research concerning the fertility of the pollen and seeds of this plant, nor on its genetic variability within the species. However, it is a likely candidate for both types of research. Another important area of research is to determine the factors leading to its establishment in natural populations, including the success rate of seedlings, and the success – or lack of success – in establishing new populations. Hypotheses have been offered concerning restrictions on its dispersal and establishment success based on its sensitivity to fire, its lack of nitrogen-fixing root nodules, as well as its sensitivity to the extremes of cold and moisture, but except for observations from cultivated individuals (which are, admittedly, numerous) there are few reports on these attributes in wild populations. Therefore, continued monitoring of wild individuals seems crucial for this species because its habitat is often distant and inaccessible. Populations could be lost at these forest sites from unknown causes without the establishment or continuation of definite monitoring programs. The species itself is unlikely to be lost because of its value in cultivation, but, like the Franklin tree, ginkgo, and dawn redwood, it may be available to us only as cultivated individuals in the not so distant future.

Certainly, *Cladrastis kentukea* is so rare in Illinois and Indiana that a primary emphasis should continue to 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 extreme southern Illinois where *Cladrastis kentukea* could also exist, and continued searches for the species should be conducted. A list of associates and indicator species 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 tree. The tree may be more frequent than the records indicate, and it could be overlooked because of

its similarity to other pinnately compound leaved tree species. The leaves alone are normally sufficient for the positive identification of this tree, and leaves are generally easy to obtain. Voucher specimens should be made according to techniques described in Hill (1995) or other similar references. It is quite possible that populations of this species have been overlooked because of the lack of adequate voucher material with which to compare specimens.

When located, basic research and on-site investigations are especially needed to determine the best management techniques to be used to preserve this rare tree. It is generally recommended that the habitat quality where rare plants grow should be monitored on a regular basis and an assessment of the specific threats to all populations should be made (W-2). Long-term monitoring of known populations should be conducted every year to track their status with respect to current management activities, the effects of climate and weather extremes, and seed production. 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, if any, that might occur and an assessment of recruitment rates, if any, are greatly 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. Such basic facts as fungal associations or invasion, longevity, and yearly variations in colony size over a long period are important data. Surveys should be conducted during the flowering and fruiting periods of this tree, especially in May and June.

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

There are no known restoration efforts being conducted on *Cladrastis kentukea* anywhere in its range and the restoration potential of this species is largely unknown. However, monitoring studies suggest that the trees are fertile and that seedlings are common within known

populations, even those at the margins of their range (W-3). The tree is common in cultivation, and individuals are easily grown from seed. The establishment of individuals into the wild has, however, not been widely documented.

Several programs recommend Yellowwood as a suitable tree for re-establishment into the wild, especially into riparian buffer zones (W-9). This tree has also been recommended for general plantings of hardwood tree species by the USDA Forest Service, North Central Research Station (Pijut 2005).

The generally recommended method to restore populations of this and other rare plants is to protect and manage their habitat. Protection of the canopy, hydrology, and substrates of the sites may be crucial. When deemed necessary, 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. This tree is normally easily propagated by means of seeds, and seedlings have been documented in local wild populations (W-3). It may benefit the wild seedlings to keep them clear of competition as they progress, and a wire mesh enclosure may also help them to survive, because the effects of animal predation on the seedlings has been shown to be detrimental to the species (W-5).

As stated previously, this tree is commonly in cultivation as an ornamental plant (W-1, W-2, W-7). It is normally readily available in the nursery industry.

In summary, the management for extant colonies of *Cladrastis kentukea* should include habitat protection and detailed monitoring of the individuals in any natural population at the margins of its range. Seedling establishment within a colony may benefit from human intervention. The prevention of forest fires and tree cutting, as well as the prevention of changes in the hydrology within its environment, appear to be crucial to its survival. At this time, with proper management, current populations should persist and they could even increase in size, but the establishment of additional populations will be only through active human efforts.

SUMMARY

Cladrastis kentukea (Dum.-Cours.) Rudd, Yellowwood, is a small tree in the bean family that grows to 15 (-20) m tall, with yellow heartwood, thin smooth bark, pinnately compound leaves, and showy, fragrant clusters of white flowers that appear in the spring. The species is found in portions of the eastern United States and in adjacent Ontario, Canada, in nutrient-rich upland

forests and calcareous bluffs often located on or at the base of north-facing slopes. While it has been recorded historically from twenty states and one Canadian province, its distribution is irregular and discontinuous. It is thought to have been currently and historically native to just thirteen states, and the other occurrences are a result of the establishment of cultivated individuals. Yellowwood is listed as Endangered in Illinois and as Threatened in Indiana. It is included on the Watch List for species of conservation concern in Georgia, Mississippi, Missouri, and North Carolina, it is a species of Special Concern in Alabama, and it is of Regional Concern in South Carolina. Currently, Yellowwood has no formal federal protection status. Yellowwood 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. Globally, this species has been ranked as apparently secure, but it is a North American endemic, an ancient relict with a limited overall range, and it appears to be declining overall in the wild. It faces dangers from climate change, fire, and fungal attacks especially. It could face extirpation in the wild in several states if it is not properly protected.

Suggested research priorities for this rare tree include attempts to locate additional populations and to monitor the remaining individuals in some detail. Protection of the sites from fire and other stress-causing environmental conditions and special protection of the seedlings from browsing animals appears to be necessary to allow it to persist where it may occur.

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APPENDIX 1

Representative specimens of *Cladrastis kentukea* examined or cited in the literature

Herbaria:

CLEMS = Clemson University, Clemson, South Carolina. GH = Gray Herbarium, Harvard University, Cambridge, Massachusetts. ILLS = Illinois Natural History Survey, Champaign. MO = Missouri Botanical Garden, St. Louis. MU = Miami University, Oxford, Ohio. UNAF = University of North Alabama, Florence. VT = University of Vermont, Burlington. WIS = University of Wisconsin, Madison.

ALABAMA: COLBERT CO., Wilson Dam, close to Tennessee River, 10 May 1973, *Gautney s.n.* (UNAF); Rockpile (TVA), 10 May 1973, *Dalrymple s.n.* (UNAF); **LAUDERDALE CO.**, Kendale Gardens, deciduous woodlands, 16 Sep 1984, *Maris s.n.* (UNAF); **TUSCALOOSA CO**., W of Holt Lock and Dam, NW of Peterson, Co. Rt. 93, 25 Aug 1990, *Hill 21861* (CLEMS, GH, VT).

ARKANSAS: BENTON CO., Devil's Eyebrow, 20 Oct 1937, *Moore 4390* (WIS)**;** Siloam Springs, 10 May 1929, *Demaree 6613* (WIS); **CARROLL CO.**, Blue Spring, 16 May 1937, *Moore 4311* (WIS); **INDEPENDENCE CO.**, W of US 167 N of Batesville, 27 Sep 1991, *Thomas 125511* (MU); **LOGAN CO.**, Magazine Mountain, 11 May 1924, *Buchholz 838* (WIS); **MARION CO**., Cotter, rocky bluffs of White River, 1 Sep 1915, *Palmer 8408* (MO); **NEWTON CO.**, "Lost Valley" 2 mi NE of Boxley, 23 May 1954, *Iltis 4809* (WIS); **POPE CO.**, foothills of the Boston Mountains along Piney Creek 11 mi NNW of Dover, 15 May 1955, *Moore 55-116* (WIS); **PULASKI CO.**, Pulaski Heights, Little Rock, 8 Oct 1931, *Demaree 8476A* (MU); **WASHINGTON CO.**, near Evansville, 19 Oct 1937, *Palmer 44425A* (WIS).

GEORGIA: TOWNS CO., 1.5 miles E10 deg. S of Titus, in Hightower Bald region, 1 Jun 1947, *Duncan 7644* (MO; WIS).

ILLINOIS: ALEXANDER CO., 3.5 miles N of Olive Branch, 28 May 1949, *Evers 16698* (ILLS, MU, WIS); 2.5 miles north of Olive Branch, 28 May 1949, *Evers 16663* (ILLS, MU, WIS); SW of Diswood, Wolf Creek Hills, 25 Jul 1956, *Evers 51707* (ILLS, MU, WIS).

KENTUCKY: CASEY CO., N slopes of Green River Knob, Highland Rim Province, 6 May 1962, *Browne & Browne 5138* (MO); **FULTON CO.**, Wilson Hill, 9 May 1973, s.col. (MO); **McCREARY CO.**, Yahoo Creek, 18 Jun 1935, *Braun 987* (MO); **PULASKI CO.**, Cumberland River, 26 Apr 1939, *Braun 2310* (MO); Cumberland River at Burnside, 1 Jul 1940, *Braun 3102* (MO); **WHITLEY CO.,** N side of Pine Mountain, 25 Jun 1935, *Braun 1070* (MO).

MISSOURI: BARRY CO., 4 mi SW of Cape Fair along Piney Creek, 22 Jun 1937, *Steyermark 22607* (WIS); near Roaring River State Park, 13 May 1974, *Christ s.n.* (MO); **STONE CO.**, between White River and Indian Creek Cliffs near Baxter, 17 mi. WSW of Branson, 12 Jun 1953, *Moore & Iltis 79* (WIS); White Rock Bluff, along White River, 1 mi NW of Marmaros, 24 Jun 1937, *Steyermark 22630* (MO, WIS); bluffs of James River near Galena, 23 May 1923, *Palmer 22819* (MO); **TANEY CO.,** Forsyth, 10 Jun 1899, *Bush 84* (WIS; MO); **WAYNE CO**., Sam A. Baker State Park near Big Creek, 13 Jun 1983, *Christ s.n.* (MO).

NORTH CAROLINA: in montibus Carolinae et Georgiae, s.d., *Buckley s.n.* (WIS); **HAYWOOD CO.**, G.S.M.N.P., Cove Creek Gap, 21 Jun 2000, *PhilipE et al. 31759* (ILLS); **JACKSON CO.**, just S of Sylva, Hwy. 107, 16 May 1999, *Heafner s.n.* (MU).

OKLAHOMA: CHEROKEE CO., 9.6 mi SE of Tahlequah, 3 May 1947, *Raunkiaer 86* (MO); **LATIMER CO**., Potato Hills 5 mi NW of Albion, 19 May 1971, *Perino 960* (MU).

SOUTH CAROLINA: GREENVILLE CO., Table Rock Reservoir watershed, north side of Upper South Saluda River, 25 Jun 1992, *Hill 23565* (CLEMS; MO; VT); **PICKENS CO.**, N side Table Rock above reservoir, 15 Jun 1992, *Hill 23409* (CLEMS, VT).

TENNESSEE: BLOUNT CO., G.S.M.N.P., Wear Cove Quadrangle, 8 Oct 2002, *Carroll et al CJC167* (ILLS); **CUMBERLAND CO.**, Daddy's Creek, above crossing of Peavine Road N of Fairfield Glade and I-40, 3 Aug 1988, *Rogers 331* (MO); **DEKALB CO.**, Edgar Evins State Park, above center Hill Lake, 23 Apr 2002, *LoyeR 33924* (ILLS); **SEVIER CO.**, Indian Gap Road, Great Smoky Mountains National Park, Gatlinburg, 5 May 1931, *Jennison 558* (WIS); vicinity Gatlinburg, NW slope of Bull Head Mountain, 29 May 1936, *Jennison 2393* (MO; WIS).

APPENDIX 2.

The Historic Distribution of *Cladrastis kentukea* in the United States.
Information from herbarium specimens and the literature.
(If in > 10 counties, then only number of counties included.)
Native populations only.

STATE	COUNTIES	NOTES
Alabama	Colbert, Jackson, Jefferson, Lauderdale, Madison, Marshall, Monroe, Tuscaloosa	W-1, W-2.
Arkansas	21 counties, central and northwestern	W-1, W-2; Smith (1978); Little (1977).
Georgia	Fannin, Stephens, Towns, Union, Walker	W-1, W-2.
Illinois	Alexander, Gallatin	W-1, W-2, W-3; Mohlenbrock and Ladd (1978); Mohlenbrock (1986) [as *C. kentuckea*]; includes Shawnee N.F.
Indiana	Brown	W-1, W-2; Homoya (pers. comm.).
Kentucky	16 counties concentrated in eastern third of state.	W-1, W-2; includes Daniel Boone N.F.
Louisiana	Caldwell Parish	W-1, W-2; Thomas and Allen (1998).
Mississippi	Carroll, DeSoto, Holmes, Noxubee, Oktibbeha, Tishomingo, Wayne, Yazoo	W-1, W-2.
Missouri	Barry, Ozark, Stone, Taney, Wayne	W-1, W-2; Steyermark (1963); including Mark Twain N.F.
North Carolina	Cherokee, Clay, Graham, Haywood, Jackson, Macon, Madison, Swain	W-1, W-2; Radford *et al.* (1968); Herbarium specimens.
Oklahoma	Adair, Cherokee, Delaware, Latimer, Le Flore, Mayes, McCurtain, Muskogee, Wagoner	W-1, W-2, W-10; Zanoni *et al.* 1979; Taylor and Taylor in Taylor (1978).
South Carolina	Aiken, Greenville, Pickens	W-1, W-2; Herbarium specimens.
Tennessee	31 counties, mostly eastern half of state, few along Mississippi River.	W-1, W-2; Chester *et al.* (1997).

APPENDIX 3.

Natural Diversity Database Element Ranking System

Modified from: http://www.natureserve.org/explorer/ranking.htm [W-5]

Global Ranking (G)

G1
Critically imperiled world-wide. 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 world-wide. 6 to 20 element occurrences OR 809.4 to 4,047 ha (2,000 to 10,000 ac) known on the planet.

G3
Vulnerable world-wide. 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 world-wide. 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. The ranking of **NNA** is used for species that are not indigenous to an area, and are therefore not covered by this ranking system [**NA** = not applicable].

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.

SNA
Not ranked – all populations are introduced and ranking does not apply.

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.