Conservation Assessment

for

American Barberry (Berberis canadensis) Mill.

Photo: Gary Cote

USDA Forest Service, Eastern Region

7 March 2003

Steven R. Hill, Ph.D.
Illinois Natural History Survey
Center for Biodiversity
607 East Peabody Drive
Champaign, Illinois 61820

This document is undergoing peer review, comments welcome

This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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

Table of Contents

ACKNOWLEDGMENTS

I would like to thank the staffs of the United States Forest Service, Shawnee and Hoosier National Forests, for the opportunity to compile these conservation assessments and for their invaluable assistance with data and field opportunities. Mark Basinger, Stan McTaggart, Steve Olson, Beth Shimp, and Steve Widowski were particularly helpful in facilitating both the cost share agreement and fieldwork.

I would also like to thank the staff of the Illinois Natural History Survey, Champaign, for their assistance with logistics necessary to complete these reports. I would especially like to thank John Taft for help in initiating these studies.

Several people assisted by contributing information on this rare shrub. Among these, John Schwegman was particularly helpful in providing information on *Berberis canadensis* in Illinois, Mike Homoya provided information on the plant in Indiana, George Yatskievych provided information on Missouri populations, Steve Ginzbarg provided collection information from the University of Alabama herbarium (UNA), Ted Bradley provided information on Virginia localities from the George Mason University herbarium (GMUF), David Taylor provided information regarding the Daniel Boone National Forest, and Mike Vincent at Miami University (MU) provided information on reports of the species in Ohio.

A special thanks to Ariane Hoard, my student at the University of Illinois during the summer of 2002, for her help in searching for information on the Internet and literature in support of several of these assessments (W-1), and to my assistant Sherry Weaver for her continuing assistance in database management and processing the plant specimen vouchers.

This material is based upon work supported by the U.S.D.A. Forest Service, Eastern Region, under Cost Share Award No. AG 01CS-11090804-032 (1-5-28861). Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the U.S.D.A. Forest Service, Eastern Region.

EXECUTIVE SUMMARY

This Conservation Assessment is a review of the distribution, habitat, ecology, and population biology of the American barberry, *Berberis canadensis* Mill., 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 status, potential threats, and conservation efforts regarding American barberry to date. American barberry is a low, clonal, spreading shrub with pale yellow flowers, elliptical red berries, and a spiny stem that is distinctly yellow beneath portions of the tan-brown bark. The species is found only in the United States, and it is restricted to the hilly portions of thirteen eastern and southeastern states including a small area of the Midwest. It grows mainly on open, exposed hillside slopes that are well drained, but are at least seasonally wet and seeping, in slightly acidic or neutral to basic thin soils over bedrock. It propagates primarily by seeds, but it is capable of developing suckers and rhizomes that can establish new shrubs if isolated from the main colony. Globally, its ranking is G3 (vulnerable world-wide). American barberry is listed as Extirpated in Maryland and Pennsylvania and it is

probably extirpated in Alabama. It has been listed as Endangered in Illinois, Indiana, and Kentucky and it is ranked as of Special Concern in Tennessee. American barberry 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 judged to be vulnerable because it is a North American endemic with a limited overall range and because it has few populations remaining. It is also vulnerable because of the continuing agricultural programs to eradicate the species and it faces extirpation 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 species 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: *Berberis canadensis* Mill.

Common Names: American barberry; Allegheny barberry

Synonymy: *Berberis vulgaris* L. var. *canadensis* (Mill.) Ait.; *Berberis angulizans* hort. ex Massias; *Berberis fischeri* hort. ex K.Koch, an invalid name.

Class: Magnoliopsida (Flowering Plants - Dicotyledons)

Family: Berberidaceae (the Barberry family)

Plants Code: BECA2 (USDA NRCS plant database, W-2)
http://plants.usda.gov/cgi_bin/topics.cgi

The genus *Berberis* is now generally considered to include members of the once separate but closely related genus *Mahonia*. According to the most recent treatment, *Berberis* contains 22 species in North America north of Mexico, 18 of which are native and 4 of which are not (Whittemore 1997). Some botanists prefer to keep the two genera separate (Kartesz and

Meacham 1999). In this case, there would be two species of barberry in the strict sense (*Berberis*) generally recognized to be native in North America north of Mexico along with three additional species that are not native here, or five species, total, that have been found in the United States. *Berberis canadensis* is a member of *Berberis* in the strict sense and one of the two native species.

The name *Berberis* was derived from the Arabic name, *berberys*. The barberry is a well-known European and Asian genus and its common name was derived from the scientific name and fruit type. It may be of interest to note that many of the plants described in the 1700's received the epithet of "canadensis" if they grew anywhere in northeastern North America, and, as the land became better known, quite a few of these species were found not to be growing in the Canada of more recent times. Therefore, we do not call these "Canadian..." despite the specific epithet, but, instead, we usually call them "American...".

DESCRIPTION OF SPECIES

Berberis canadensis is a few-stemmed deciduous shrub that varies from 0.4-2 m tall, but it is usually about 1 m tall. The shrub generally has rhizomes and so an individual plant may cover a large area with multiple stems (*i.e.*, ramets, similar to Deerberry, see Hill 2002a) each of which is genetically identical to its neighbors. Each stem is erect and sparsely branched, and the younger twigs can be purplish or reddish to brown, and are hairless. The inner bark of the mature stems, roots, and rhizomes are yellow. The youngest branches are fast growing and elongated, and have alternate leaves. The older branches have short-shoots that appear to bear whorled clusters of leaves that are actually alternate leaves on very short stems, and these are associated with spines at their bases. The spines on the stem rarely can be simple but they usually occur in threes (actually trifid, deeply divided into 3s), they are 1-1.5 cm long, and they tend to curve downward. The alternate leaves have petioles 2-8 (-13) mm long; the blades are thin and flexible, 1.8-7.5 cm long and 0.8-3.3 cm wide, and they are oblanceolate to narrowly elliptic or ovate in shape, with a long attenuate base and rounded apex, and the leaf margins have several (2-12) spinose teeth 0.2-1.2 mm long (several references, including Steyermark 1963, say that the teeth have no apical bristles, but the 1997 Whittemore treatment specifically describes bristles on these teeth). The leaf surfaces are dull and somewhat whitened (glaucous) beneath. The flowers are in a nodding raceme 2-5 cm long and have 3-12 flowers. The six petals are yellow or pale yellow, and are normally 2.5-3.5 mm long; the six sepals are 3-4 mm long, and the calyx is 8-11 mm wide; there are six stamens. The stamens are contact-sensitive, and they respond to a tactile stimulus by snapping toward the stigma (Fleurat-Lessard and Millet 1984). The fruit is a dull to bright scarlet berry 5-7 mm long that is firm but moist, and oblong-ellipsoid to globose; there can be 1-10 seeds. The chromosome number is $2n = 28$ (adapted from Whittemore 1997, Gleason and Cronquist 1991, and Radford *et al.* 1968).

Some training is needed in order to identify the American barberry with confidence. The species can be distinguished from two similar and more common introduced species by several characters. *Berberis thunbergii* DC. (Japanese barberry) has solitary or umbellate flowers, simple spines, and its leaf margins are always entire. *Berberis vulgaris* L. (Common barberry) is harder to distinguish; it has gray bark on its second-year branches (rather than brown, purple, or reddish), each margin of its leaf blade has (8-) 16-30 teeth (rather than 2-12 teeth), and its racemes are 10-20 flowered (rather than 3-12 flowered). According to one source (Gleason and

Cronquist 1991) other important differences between the two include the notch-tipped petals and indistinctly-veined leaves (beneath) of *Berberis canadensis*, vs. the round-tipped petals and prominently reticulate-veined leaves (beneath) of *Berberis vulgaris*.

The red, fleshy berries of *Berberis canadensis* are said to be edible (Small 1933). The plant is often grown for ornamental purposes because of its attractive foliage, flowers, and fruit (W-3). It is also useful for wildlife food and cover and erosion control. The majority of barberry species are susceptible to black stem rust of wheat (see Potential Threats, below). Roots of barberry can be used to obtain a yellow dye. The plants contain an alkaloid called berberine, which is used for medicinal purposes in some areas (Rudolf 1974).

HABITAT AND ECOLOGY

Berberis canadensis grows mainly on open, exposed hillside slopes in basic, neutral, or slightly acidic usually thin soils (over bedrock) that are well drained but are at least seasonally wet and seeping (pers. obs.). Its preferred habitat has also been described as a rocky woods (Gleason and Cronquist 1991), as rocky bluffs, creek banks and roadsides (Radford *et al.* 1968, W-3), as dry woodlands and sandstone cliffs (Mohlenbrock 1986), or as "woods or glades, on rocky slopes and near rivers" (Whittemore 1997). Through most of its range it is considered to be a piedmont or mountain species. According to the Nature Conservancy (W-3), American barberry was formerly found in fire-maintained habitats which kept the canopy open, *i.e.*, it was an inhabitant of savannas and open woodlands, and fire suppression has significantly restricted its habitat to sites with shallow soil (such as glades and cliffs) or areas with mowing or other canopy-clearing activities (such as powerline corridors, railroad/road rights-of-way and riverbanks).

At its northern limit of range in Pennsylvania, *Berberis canadensis* was known from one historic occurrence in the western portion of the state (W-3). Habitat for the occurrence was described as "woods and waste places around abandoned buildings" and "rocky woods" and there has been some debate on whether the occurrence was native or if it was introduced to the site. Historically, *Berberis canadensis* also occurred in Maryland near its northern range limit in dry, calcareous woodlands, open fields and serpentine barrens in the mountains (W-3; Brown and Brown 1972).

In the central and southern Appalachian Mountains and piedmont, the species persists in similar habitats. In Virginia (W-3) *Berberis canadensis* habitat includes dry, open woodlands over limestone, dolomite, richer sandstone, or shale substrates, and in rocky and cliffy areas and open areas and glades with naturally thin soil. Associated plant species in the glades can include *Helianthus divaricatus, Juniperus virginiana*, and *Schizachyrium scoparium*. In rocky areas it is found with *Cercis canadensis, Pellaea atropurpurea*, and *Quercus muehlenbergii*. Historic habitat in Kentucky is listed as limestone woodlands (W-3) and a river gravel / scour bar on a river (Taylor, DBNF, pers. comm.). Collections at the University of Tennessee-Knoxville Herbarium (TENN) suggest that occupied habitat is relatively open woodlands (W-3). Collections have been made from wooded slopes, shale slopes, bluffs, terraces along river bluffs and river banks.

In North Carolina, *Berberis canadensis* occurs in the Piedmont on mafic rocks (such as diabase, amphibolite and gabbro) and in the Blue Ridge on calcareous (limestone, dolomite, marble) and

mafic rocks (amphibolite) and it generally occurs in glade, open woodland, bluff or cliff situations (W-3). Because of its association with mafic and calcareous rocks (uncommon to rare in the state), *Berberis canadensis* is often associated with other rare species. Typical associated plant species in North Carolina include *Aquilegia canadensis*, *Cercis canadensis*, *Clematis ochroleuca*, *Desmodium* spp., *Echinacea laevigata*, *Matelea decipiens*, *Parthenium auriculatum*, *Pycnanthemum* spp., *Rhus aromatica*, *Silphium trifoliatum*, *Solidago rigida*, *Symphoricarpos orbiculatus* and *Viburnum rafinesquianum* (W-3, W-4).

At its southern edge of range in Georgia and South Carolina the habitat is described as dry, hard soil on upper, west-facing slopes and dry, rocky woods (W-3). The exposed hillside slopes with slightly acidic or neutral thin soils (over gneissic bedrock) are well drained but are at least seasonally wet and seeping (pers. obs.). At one South Carolina site it is associated with *Allium cernuum*, another rare species in the state, as well as *Hypericum nudiflorum*, *Clematis viorna*, *Aster patens*, *Vernonia glauca*, *Viola pedata*, *Phlox nivalis*, *Rudbeckia* sp., and *Desmodium* spp., and it is in close proximity to *Alnus* along a creek.

At its western range limit in the Midwest, American barberry is found in only a few disjunct populations. The single extant population in Indiana is restricted to steep banks along the Tippecanoe River and associated plant species include *Besseya bullii*, *Lithospermum* sp. and liverworts (W-3). Prior to eradication efforts (see Potential Threats below), Deam (1940) observed long stretches of the species along the banks of the Tippecanoe River, occupying an area "a few feet back from the edge of the bank and down the slope to high water mark".

In Illinois, *Berberis canadensis* has been reported from two historic sites on a steep bluff and at the rim of a dry sandstone cliff in dry woodlands (Mohlenbrock 1986; Illinois Department of Natural Resources [IDNR] 1992; Schwegman, pers. comm.). No extant populations are known from the state, the last sightings being made in 1973, 1977, and 1987 (Schwegman, pers. comm., IDNR 2002). Its associates included large patches of *Vaccinium pallidum*, scattered oaks (*Quercus* spp.), *Juniperus virginiana*, and *Polypodium virginianum* and bryophytes generally grew on the outcrops, along with the rare vine *Lonicera flava* (Hill, unpub. data). This shrub has been included within the Dry Upland Forest natural community at its margin or transition to the Sandstone Cliff Community (as defined by White and Madany 1978). According to John Schwegman (pers. comm.) this shrub grew at the Tazewell County site on high, steep bluffs, growing with *Campanula rotundifolia*, *Carex sprengleri*, *Besseya bullii*, *Coreopsis palmata*, and *Heuchera richardsonii*. Trees shading the area included *Quercus velutina* and *Q. rubra*.

The southern Illinois plants were found growing precariously at the rim of a dry sandstone cliff in dry woodlands in Jackson County (Mohlenbrock and Wilson 1985). Botanists and ecologists have speculated on the original landscape in this part of Illinois based mostly upon land survey records and field observations (Ulaszek, pers. comm.). Evidence suggests that the original pre-settlement landscape was a ‘barrens’, a savanna or prairie-like community with scattered oak trees and oak brush, that was periodically burned by Native Americans. The Jackson County site is on an isolated sandstone ridge at the margin of the Mississippi River floodplain and it lies within the Greater Shawnee Hills Section of the Shawnee Hills Natural Division of Illinois (Schwegman *et al.* 1973, Herkert *et al.* 1991).

At its western limit of range in Missouri, where it is has been found historically in three counties,

this species is restricted to usually north- or northwest-facing upper edges of rocky, wooded limestone bluffs where the soil is leached out, or near the contact between chert or sandstone with limestone, at the margins of river valleys (W-3, Steyermark 1963, Roedner *et al.* 1978, Holt *et al.* 1974). Substrate composition usually consists of limestone, dolomite, or sandstone with a somewhat basic pH (W-3). Associated with American barberry in Missouri are other rare relict species such as *Galium boreale* var. *hyssopifolium*, *Campanula rotundifolia*, *Trautvetteria caroliniensis*, and *Zigadenus glaucus* (Steyermark 1963), as well as the more common small trees *Carpinus caroliniana* and *Juniperus virginiana*.

DISTRIBUTION AND ABUNDANCE

Berberis canadensis is found only in the United States, and it is restricted to the hilly portions of several eastern and southeastern states including a small area of the Midwest. There are approximately 50 occurrences known across its range (W-3). More specifically, the shrub has been found historically in 13 states, namely, Alabama, Georgia, Illinois, Indiana, Kentucky, Maryland, Missouri, North Carolina, Pennsylvania, South Carolina, Tennessee, Virginia and West Virginia, and this is its entire known range world wide. Individuals or colonies are infrequent and very local, and often only a single colony occurs at any one site. The populations are restricted to a specific habitat, and if this habitat is infrequent the American barberry will also be infrequent. American barberry was formerly much more common than it is today but it has been systematically eradicated as part of a United States government effort (see Potential Threats below). Representative specimens of this rare shrub, many of them from sites at which it has been exterminated, have been listed in Appendix 1. A summary of its entire known distribution in the United States has been presented in Appendix 2.

There is some disagreement concerning the reported historic distribution of the American barberry. According to Kartesz and Meacham (1999), the species has been reported from the thirteen states listed above. Whittemore (1997) noted its range in twelve states, excluding South Carolina. However, it is known to be extant in that state (W-5; Hill, pers. obs., see Appendices 1 and 2). The Nature Conservancy Internet site (W-3) also reported American barberry in Ohio. However, it has been shown by Loconte and Blackwell (1984) that *Berberis canadensis* was erroneously reported for that state. Additional details on the distribution of American barberry can be found in the references cited within Appendix 2.

In the northeastern United States at its northeastern range limit, American barberry was historically known in Pennsylvania and Maryland, but it has been eradicated (extirpated) in both states. It does not appear to have been common in those states even before eradication efforts. In Pennsylvania, a single historic occurrence was reported in the western portion of the state, and there has been speculation concerning if it was truly native there (W-3).

Berberis canadensis still persists in the central and southern Appalachian Mountains and piedmont. It appears to be most common in Virginia where it has been found in 19 mountain counties in the southwestern part of the state (Harvill *et al.* 1986; W-3). The Kentucky Natural Heritage Program (W-3) has indicated that no extant populations are known from that state. According to David Taylor at the Daniel Boone National Forest (pers. comm.) it may occur nearby in Tennessee on a river gravel / scour bar on the Big South Fork River within the boundary of the protected Big South Fork National River and Recreation Area not far from the

National Forest. Also, suitable habitat for it occurs within the national forest in Kentucky but no extant populations are known. American barberry has been found, historically, in eleven counties in the eastern third of Tennessee. In North Carolina, *Berberis canadensis* occurs in the Piedmont and in the Blue Ridge in 13 counties (W-4) but how many of these populations are extant is not clear. In South Carolina, the species has been recorded from two counties (W-5); I have investigated the only known extant site in Pickens County. Two historic populations are known from Georgia, but no recent efforts have been made to relocate them (W-3). American barberry was found once in a single county in Alabama (Jefferson County) but it was last collected in 1944 (Ginzbarg, pers. comm.) and it is considered to have been extirpated from the state.

In the Midwest there is little remaining American barberry. The single extant population known in Indiana is restricted to steep banks along the Tippecanoe River (W-3). Prior to eradication efforts (see Potential Threats below), Deam (1940) reported its presence in seven counties in Indiana. Its distribution has been reduced from seven counties to one in the state.

In Illinois, American barberry has been found at two locations. It was first found in 1924 at Spring Lake in Tazewell County (Jones 1963) and, more recently, in 1973 at a single location south of the glacial boundary in Jackson County on Fountain Bluff (IDNR 2002). It was seen as recently as 1987 at the latter site. However, searches were conducted in 1988 and 2002, and no individuals were found; therefore, no extant populations are known from the state (Schwegman, pers. comm.).

According to John Schwegman (pers. comm.): "One other observation on *Berberis* in the midwest is that it appears to be a relic of a widespread plant association inhabiting the midwest in the past, probably in the Mesophytic Maximum after the close of the Pleistocene but before the onset of the Xerothermic period. Two relic species from this association now consistently occur together as relicts. These are *Campanula rotundifolia* and *Berberis canadensis*. They occur together at Spring Lake, Fountain Bluff, and Jam Up Bluff on the Jacks Fork River in the heart of the Missouri Ozarks and are absent from the rest of Missouri."

It is believed that most native plants have reached the limits to which they can travel under present conditions of climate (that is, temperature and rainfall), substrate, dispersal mechanism, and other pertinent factors. In other words, species are in balance with their environment as long as the environment is stable. In many biological simulations, however, ecological extremes are more important than the means in controlling plant distribution (Webb *et al.* 1975). An obvious example is that of frost tolerance (temperature extremes). A plant species completely intolerant of freezing can persist in a site indefinitely until the first time extreme temperatures cause it to freeze. One such freeze in a century may be enough to eliminate a species entirely from a wide area of its range, and changes in climate historically have caused the greatest changes in plant distributions (see Hill 2003).

In the case of *Berberis canadensis*, historical distribution appears to be dependent primarily on hydrology, substrate type (including pH), and the openness of the habitat rather than from temperature extremes alone. Nevertheless, its historical distribution suggests that it is not adapted to extreme cold. The current very limited distribution and scarcity of this species is primarily a result not of local factors, but, instead, it is the result of very effective eradication

efforts by government agencies (discussed below in Potential Threats). With a limited number of individuals currently living, and a somewhat specific habitat requirement, it may be unable to increase its range in the future despite its effective dispersal methods (by birds).

PROTECTION STATUS

The Nature Conservancy currently lists *Berberis canadensis* as a G3 plant (W-3), indicating that the species is vulnerable world-wide. In the United States the species is given the National Heritage rank of N3 (for similar reasons).

The state rankings vary considerably. Official protection for the species outside of Forest Service lands depends upon state and local laws because it is not listed as Federally threatened or endangered. The limited number of herbarium specimens and available reports concerning this species may indicate that its status may require further review in states where it grows. It appears to be in a far more serious decline than is generally recognized, and it appears to need additional protection.

American barberry is listed as extirpated in Maryland and Pennsylvania and it is also thought to be extirpated in Alabama. It has been listed as Endangered in Illinois (IESPB 1999), Indiana, and Kentucky; it is ranked as of Special Concern in Tennessee. It is possible that *Berberis canadensis* has actually been extirpated in Illinois and Kentucky as of this writing.

American barberry is included on the Regional Forester Sensitive Species list (RFSS) for the Shawnee National Forest but not the Hoosier National Forest, where it has not been found. It has been included on the RFSS list for Region 8, and particularly for the Daniel Boone National Forest where suitable habitat occurs but no current populations are known.

In Missouri, *Berberis canadensis* was previously listed as endangered, but current law in the state only allows the listing of federally listed taxa as state endangered (Yatskievych, pers. comm.); however, it is tracked and protected in the state as a S2 species.

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-3). Appendix 3 explains the meanings of the acronyms used (W-6).

A summary of the current official protection status for the American barberry follows:

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

U.S. Forest Service: Region 9, Sensitive (Illinois only, Shawnee National Forest); Region 8, Sensitive

Global Heritage Status Rank: G3

U.S. National Heritage Status Rank: N3

Table 1: S-ranks for *Berberis canadensis* [Heritage identifier: PDBER02010].

State	Heritage S-rank	State	Heritage S-rank
Alabama	SH	North Carolina	S2
Georgia	S1	Ohio	SR [reported in error]
Illinois	S1	Pennsylvania	SX
Indiana	S1	South Carolina	SR
Kentucky	S1	Tennessee	S2
Maryland	SH	Virginia	S3S4
Missouri	S2	West Virginia	S1
New Hampshire	SR		

LIFE HISTORY

Berberis canadensis is a perennial shrub. Colonies of the species can be extensive because of the ability of the plant to produce ramets from a system of rhizomes. This can result in a colony of apparently separate individuals as the rhizomes break. It also reproduces sexually by means of flowers and seeds. No information is available on how many stems in a colony may be of the same genotype, or how many distinct individuals exist at any particular site. In fact, very little has been published on details of its life history.

This shrub is deciduous and dormant in the winter. The leaves normally emerge in late April or early May and it flowers in May and June, depending upon location. The flowers are short-lived and quickly shed their petals. In Missouri and South Carolina it flowers in May, and in West Virginia it is said to flower in June (Steyermark 1963, Strausbaugh and Core 1952-1964, Hill, pers. obs.). Fruits are produced in June-July (August). The fruit is a dull to bright scarlet berry. There can be 1-10 seeds per berry. The seed coat is thick and stony. Seed dispersal by both birds and mammals is widespread within the genus (Rudolf 1974, Vines 1960).

The most critical detail of the life history of the American barberry is that it, along with the majority of barberries, is an alternate host for the black stem rust (*Puccinia graminis*) of wheat, oats, barley, and various wild and cultivated grasses (Steffey 1985, Rudolf 1974, Steyermark 1963). The U.S. Department of Agriculture and state agriculture offices initiated a comprehensive barberry eradication program in the past to eliminate black stem rust. As a result, numerous populations of this species were destroyed (W-3, Steyermark 1963). This eradication program has not been discontinued, and we have the unusual case of one government agency committed to extirpate a rare species while also committed to protect it from harm, both at the same time.

Of some significance is the fact that American barberry is one of the few native shrubs that is not vulnerable to the effects of black walnut toxicity, and it can be used in plantings with the black walnut and it can be an effective hedge plant in areas where the walnut is grown or is native (W-7).

POPULATION BIOLOGY AND VIABILITY

Very little is known of the American barberry's population biology. It does not appear to produce very many fruits in a given year (pers. obs.). It is also possible that all stems in some populations are all clones of a single individual. If this is true, this could help explain the limited amount of fruit and seed production, because fertility is generally 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. In subsequent periods of vegetation increase, pioneers are often substituted by other, more competitive species (W-8).

Maintaining the open habitat in which it grows is one of the most important means to insure the viability of this species throughout its range, and it is especially critical at the margins of its range where suitable habitat is so scarce. However, the complete elimination of the official barberry eradication program with regard to this native species is a far more important requirement for its future viability.

In Illinois, the species viability is very uncertain. In fact, it may no longer exist in the state. Despite a search of many hours at its single known site in Jackson County in July 2002, no individuals were found (Hill, unpub. data). The habitat did appear to be suitable, the search area was large, much of it was potentially dangerous, and not all of the area was investigated, so it may still occur somewhere at the site. There appears to have been no management for the plant at this site and it also may have died out because of too much shade or another unknown factor. Concerning the only other reported site in Illinois, John Schwegman (pers. comm.) has stated:

> "I made a specific search for *B. canadensis* in Tazewell County back in the 1970s when I lived in Springfield, and found 3 plant[s] growing together on the sand and gravel bluff fronting on Spring Lake....As I recall they were growing about a third of the way up from the bottom of the bluff which is at the bottom of the steep part of the bluff. A year or two after this collection I returned to check on its status and could not find it. The Site Supt. said that an agent from the Department of Agriculture had come to the park looking for Barberry to eradicate because it is the alternate host for wheat rust and he knew it was reported from the area. The Supt showed him the plant and told him it was an endangered species. Neither of us ever saw the plants again but we could not say for sure that the agent returned later and eradicated them."

Part of the pessimism concerning its future survival arises because American barberry habitat has been observed to be decreasing (see Potential Threats below). It may or may not occur at other suitable sites in the state, but few searches have been made specifically for the American barberry in recent years. Suitable habitat for the species appears to exist in several parts of the state, but it appears that it may have never been common here. Additional searches are suggested. If individuals are relocated, or if new sites are found, they may persist with proper habitat management.

POTENTIAL THREATS

Globally, this species has been judged to be vulnerable because it is a North American endemic with a limited overall range and because there are few reported populations remaining, based upon the literature and herbarium specimens. It is also vulnerable because of the continuing agricultural program to eradicate the species.

The primary threat to the survival of *Berberis canadensis* is from the government comprehensive barberry eradication program. As mentioned briefly above, this and most other barberries are alternate hosts for wheat rust (*Puccinia graminis*), a fungus that has caused major losses in certain grain crops here and in Europe. In 1918, the U.S. Department of Agriculture (USDA) initiated a barberry eradication program in cooperation with 13 north-central States (Colorado, Illinois, Indiana**,** Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming). In 1935, four additional states (Missouri, Pennsylvania, Virginia, and West Virginia) joined the program, followed by Washington State in 1944 (W-9, Appendix 4). This time, the program resulted in the destruction of several hundred million susceptible barberry shrubs in over 700,000 square miles. According to Strausbaugh and Core (1952-1964) "a program for their eradication, sponsored by the U.S. Department of Agriculture, the West Virginia Department of Agriculture, and West Virginia University, has been in progress since 1935; during the years 1935-1950, a total of 150,087,197 bushes were destroyed." As a result of this USDA eradication program, numerous populations of this species were destroyed throughout its range (W-3, Steyermark 1963). The barberry eradication program includes all species of barberry that are known to be alternate hosts for the rust, and this includes the native species as well as the introduced (exotic) species *Berberis vulgaris*, European barberry. USDA eradication data generally do not distinguish between the native and introduced species, so those figures above do not accurately indicate the number of American barberry shrubs once present or destroyed. The exotic *Berberis thunbergii*, Japanese barberry, is not an alternate host for the fungus and is not being controlled. The official USDA Barberry Inspection Manual with these and additional details has been presented in this report as Appendix 4.

Loss of primary habitat has also played a significant role in the demise of this species (W-3). The elimination of the natural fire regime throughout most of its historic range has resulted in the succession of savanna and open woodland habitats into closed-canopy woodlands. In the absence of fires, *Berberis canadensis* can persist in significant populations today only at sites with extremely shallow soils or areas that are frequently mowed or cleared. Since settlement, much of the previously available habitat has been destroyed, converted to cultivated fields, or has succumbed to land development and urbanization (W-3). These threats continue for the few extant populations.

Grazing is another possible potential threat to extant populations, and in some areas the plants appear to be grazed by cattle (W-3). Grazing may serve to maintain the open character of woodlands, but its effects on *Berberis canadensis* plants may be detrimental. Mature stems are armed with rigid spines and are not likely to be very heavily grazed if other edible plants are available; also, most members of the genus and family contain a bitter alkaloid, berberine, which is avoided by most grazers. Soil compaction and disturbance from livestock, as well as from off-road recreation vehicles, may negatively impact individual plants and populations as well.

Unlike its more aggressive exotic relatives Common barberry and Japanese barberry, the American barberry is not an aggressive invader species, and it produces far fewer fruits than those shrubs as well. Competition from exotic plant species (such as *Lonicera japonica*, *Lonicera tatarica*, and *Rhamnus cathartica*) is a threat to the remaining populations (W-3). These species can form dense stands and eliminate ground layer herbaceous and shrub species, including *Berberis canadensis*. Excessive shading and canopy closure in woodlands may be another factor in reducing seed production in the species, as has been noted in Missouri (W-3).

The difficulty in maintaining this species is that active management appears to be necessary, but the ideal means and combination of maintaining sufficient water availability along with an open canopy has not been fully determined.

Complete clearing or cutting of a forest stand would probably eliminate this species through the effects of drying and sudden erosion from increased water flow, just as a dense canopy would damage it from shading, and therefore such practices could not be enacted where a colony occurs without adverse effects. In addition, the areas where these plants grow should be closed to most recreational use because of the increased erosion and physical damage possible to the shrub's shallow roots and rhizomes, and increased enforcement of these restrictions may be needed. It would appear because of the fragmentation of habitat resulting from a mix of public and private ownership, that a strong effort should be made to add to the buffer around existing colonies and their habitats by purchasing nearby public lands as a means of protection for the habitat and the species.

Habitat fragmentation can have profound effects on the success and persistence of local populations. Any activities that result in barriers to dispersal, such as developments, clearcuts, road/utility line corridors, and mined areas limit the possibility of population expansion and genetic exchange in many species. Deleterious effects of fragmentation could possibly go unnoticed for a long period of time, making the short term effects on species viability less apparent, particularly in such a rarely-seen species as *Berberis canadensis*. 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), random genetic drift may have already occurred and may have caused negative effects to the species.

At the current time, it appears that the population of *Berberis canadensis* in the Shawnee National Forest, if still present, is threatened with elimination from habitat change unless selective management is undertaken.

RESEARCH AND MONITORING

Very little research has been conducted on this species. The taxonomy of the genus mostly has been worked out and there seems to be no great problem with the nomenclature or status of the species. However, it appears that a great deal of additional basic research and monitoring is needed regarding *Berberis canadensis*, particularly in fields other than taxonomy. The basic data on the location of extant populations is nearly lacking. Moreover, it is generally recommended that its habitat quality should be monitored and an assessment of the threats to all populations

should be made (W-3).

Berberis canadensis is so rare in Illinois and Indiana that the initial primary emphasis should be, first, to determine if it even remains in Illinois and to locate and vigorously protect all remaining populations. The two historic sites in Jackson and Tazewell Counties should be methodically re-surveyed and similar habitat should be explored for the plant. There is a small to moderate area of additional suitable habitat in north central and extreme southern Illinois where *Berberis canadensis* could also exist, and continued searches for the species should be conducted.

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 fruit/seed production, and an assessment of recruitment rates are greatly needed in order to monitor population dynamics and to assess the viability of any populations found. Counts should be made not only of individual stems, but whether or not these stems are connected, if possible, and an attempt should be made to find immature individuals at the same sites. It is recommended that surveys be conducted during the flowering and fruiting period because it is very difficult to determine population fertility otherwise. Some populations of *Berberis canadensis* are being monitored by botanists working on behalf of the state Natural Heritage programs and other organizations in the areas where it is listed as endangered or threatened (W-2, W-3). Populations in Missouri, for example, have been revisited every several years in order to update their status in the Heritage Database (W-3). Most sites were revisited between 1984 and 1990.

In addition to the basic effort of locating additional populations of the species and conducting population counts, it would be useful to initiate a genetic investigation of the diversity within and between the known populations using DNA methodology. It would be especially important to discover if colonies are clonal or contain related individuals. This could be expanded to compare the local populations with the nearest populations in adjoining states to assess their origin or degree of genetic distance between them. The techniques for several aspects of monitoring and studying rare plant species are presented in Collins *et al.* (2001), Philippi *et al.* (2001), and Imm *et al.* (2001).

Investigations into the reproductive biology, genetic variation, pollination vectors, and the factors effecting seed production are also needed (W-3). Individual plants should be monitored over time on site. Such basic facts as fungal associations (if any), longevity, yearly variations in population size, pollination and pollinators, flower behavior, and seed establishment are not precisely known. Perhaps the plants (flowers) are self-incompatible, but this is not known. One study on an Asiatic species demonstrated that fruit set and fruit weight can be improved by spraying with 200 ppm gibberellic acid (GA3) at full bloom and again 15 and 30 days later (Malasi *et al.* 1989).

No research programs directed at management needs are known at this time (W-3). *Berberis canadensis* is a species of open woodlands, glades and savannas and most of these habitats have grown closed with trees and shrubs since the elimination of a natural fire regime (W-3). Research on prescribed fire or selective thinning of the canopy should be conducted in order to determine the effects of increased light levels to the habitat and populations for the purpose of better management (W-3). There is a need to determine the best habitat for the species and how to best maintain the character of these areas (W-3). Long-term monitoring of known

populations should be conducted every 1-2 years to track their status with respect to these current management activities.

Research is needed to more accurately assess the role of *Berberis canadensis* as an alternate host to stem rust. While it is known to be a potential alternate host for the disease, existing populations may not be infected and they may not be located close enough to any agricultural land where the susceptible cereal crops are grown to pose any threat even if they are infected. Those responsible for the lands where this species grows should work cooperatively with state and federal regulatory agencies (*e.g*., USDA and state departments) to eliminate the effects of continued *Berberis* eradication efforts on this rare native shrub (W-3). In Indiana, some monitoring of plants is being done by the Indiana Department of Natural Resources, Division of Entomology, for signs of black stem rust as part of eradication efforts there (W-3).

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, 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 more qualified field botanists to achieve these goals.

RESTORATION

There are no known restoration efforts being conducted on *Berberis canadensis* anywhere in its range and the restoration potential of this species is largely unknown (W-3).

The generally recommended method to restore populations of this and other rare plants is to protect and manage its habitat. Protection of the hydrology and thin soil layer of the sites may be crucial, along with the maintenance of an open habitat. Girdling trees may be effective, as may be selective mowing (trimming) at a prescribed height (perhaps 1 meter). Exotic and aggressive species must be completely eliminated from each site. This would entail physically pulling them out because it is very likely that herbicide application would eliminate this species at a site. The use of controlled burns, the thinning of the overstory, and the thinning of competing understory species may be very beneficial to this plant. In the relatively healthy *Berberis canadensis* population that I have observed in South Carolina, the rhizome mass is so dense that, once established, it effectively prevents other species from becoming established in the small area of thin soil over the bedrock on which it grows. It is possible that once a colony has achieved this mature state at a protected site, only occasional overstory maintenance will be needed for it to persist.

Restorations of any native plant species are recommended using only nursery propagated

material grown from native, local populations to avoid interbreeding with 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 can not 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 if it can be done with this species.

This shrub is rarely seen in cultivation and is rarely, if ever, commercially available in this country. Most of this is because of the USDA barberry eradication effort that also restricts its use (Appendix 4). Barberry, in general, is known to be readily propagated by means of stem cuttings. Several deciduous species are known to be best rooted when propagated from softwood cuttings collected in the summer (Dirr and Heuser 1987). Establishment or augmentation of populations is dependant upon seed germination, but the detailed conditions under which germination is triggered in this species are unknown. While survival from seed to shrub stage in barberries is often low (22 % of the seeds of common barberry survived to produce shrubs; Swingle 1939) propagation by this method is the best means to insure genetic variability.

Therefore, the management for extant and restored colonies of *Berberis canadensis* should include the use of prescribed fire, the selective thinning of the canopy or controlled mowing in order to maintain high light levels, and the elimination of woody plant encroachment. Habitats and the species itself need protection from eradication efforts, urbanization, agricultural activities, destructive recreational activities, land development, indiscriminate herbicide application, excessive grazing, and exotic species (W-3). At a site where some individuals persist, and given the cessation of eradication programs and some success in germinating seeds and propagating woody material, coupled with an active habitat management program designed to maintain open woodland / savanna conditions, restoration could be successful.

SUMMARY

Berberis canadensis, American barberry, is a low, clonal, spreading shrub with pale yellow flowers, elliptical red berries, and a spiny stem that is found only in the United States, and it is restricted to the hilly portions of thirteen eastern and southeastern states including a small area of the Midwest. It grows mainly on open, exposed hillside slopes that are well drained but are at least seasonally wet and seeping, in slightly acidic or neutral to basic thin soils over bedrock. It propagates primarily by seeds, but it is capable of developing suckers and rhizomes that can be rooted and can establish new shrubs. Globally, its ranking is G3 (vulnerable world-wide). American barberry is listed as extirpated in Maryland and Pennsylvania and it is probably extirpated in Alabama. It has been listed as Endangered in Illinois, Indiana, and Kentucky; it is ranked as of Special Concern in Tennessee. The most recent data suggest that it may no longer occur in Illinois and Kentucky. American barberry 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 judged to be vulnerable because it is a North American endemic with a limited overall range and because it has few populations remaining. It is also vulnerable because of continuing federal and state agricultural programs to eradicate the species and it faces extirpation in several states if it is not properly protected. Nationally, the eradication policy should be changed to exclude this species if it is to

survive. The highest priority regarding the species in Illinois is to determine if it survives in the state, and searches should be conducted for the location of historic and previously unknown populations in far southern and north-central regions in suitable habitat. Management through enforced protection of its habitat, through controlled use of fire, and by means of thinning surrounding trees to open the habitat, as well as by creation or enforcement of rules for restricted access to the sites (particularly recreational access) appear to be necessary to allow it to persist where it may occur.

REFERENCES

Barrett, B.C.H. and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: implications for conservation. [pp. 3-30 *In* Genetics and conservation of rare plants, D.A. Falk and K.E. Holtzinger, eds. Oxford University Press, New York, NY.

Brown, M.L., and R.G. Brown. 1972. Woody Plants of Maryland. Port City Press, Baltimore, MD. 346 pp.

Chester, E.W., B.E. Wofford, and R. Kral. 1997. Atlas of Tennessee Vascular Plants. Volume 2. Angiosperms: Dicots. Misc. Publication No. 13. The Center for Field Biology, Austin Peay State University, Clarksville, TN.

Collins, B., P.S. White, and D.W. Imm. 2001. Introduction to Ecology and Management of Rare Plants of the Southeast. Natural Areas Journal 21:4-11.

Deam, C.C. 1940. Flora of Indiana. Indiana Dept. of Conservation. Indianapolis, Indiana. 1236 p.

Dirr, M.A. and C.W. Heuser, Jr. 1987. The reference manual of woody plant propagation: from seed to tissue culture. Varsity Press: Athens, GA. 239 pp.

Fleurat-Lessard, P., B. Millet. 1984. Ultrastructural features of cortical parenchyma motor cells in *Berberis* stamen filaments of *Berberis canadensis* and tertiary pulvini of *Mimosa pudica*. Journal of Experimental Botany 35(158): 1332-1341.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. 2nd edition. The New York Botanical Garden, Bronx. 910 pp.

Harvill, A.M., Jr., T.R. Bradley, C.E. Stevens, T.F. Wieboldt, D.M.E. Ware, and D.W. Ogle. 1986. Atlas of the Virginia Flora. 2nd ed. Virginia Bot. Assoc., Farmville, VA. 135 pp.

Herkert, J.R. (ed.) 1991. Endangered and Threatened Species of Illinois: Status and Distribution, Volume 1 - Plants. IL Endangered Species Protection Board, Springfield.

Hill, S.R. 2002. Some recent changes in the Illinois flora. Illinois Natural History Survey Reports. Summer 2002. No. 3722.

Hill, S.R. 2002a. Conservation Assessment for Deerberry (*Vaccinium stamineum* L.). Prepared for the U.S.D.A. Forest Service, Eastern Region; Shawnee and Hoosier National Forests,

by the Illinois Natural History Survey, 31 December 2002. 36 pp.

Hill, S.R. 2003. One botanist's view of the landscape. Illinois Natural History Survey Reports No. 374, Winter 2003. p. 2.

Holt, F.T., J.F. Keefe, W.H. Lewis, W.L. Pflieger, and M.H. Sullivan, eds. 1974. Rare and endangered species of Missouri. Missouri Dept. Conservation and U.S. Dept. Agriculture, Soil Conservation Service. Unpaginated.

Illinois Department of Natural Resources. 2002. Natural Heritage Database, maintained in electronic format, Springfield.

Illinois Endangered Species Protection Board (IESPB). 1999. Checklist of endangered and threatened animals and plants of Illinois. Springfield. 20 pp.

Imm, D.W., H.E. Shealy, Jr., K.W. McLeod, and B. Collins. 2001. Rare Plants of Southeastern Hardwood Forests and the Role of Predictive Modeling. Natural Areas Journal 21:36-49.

Jones, G.N. 1963. Flora of Illinois. The American Midland Naturalist, Monograph No. 7. Notre Dame, IN. 401 pp.

Jones, S.B., and N.C. Coile. 1988. The Distribution of the Vascular Flora of Georgia. University of Georgia, Athens, Georgia.

Kartesz, J. T. (data) and C. A. Meacham (software). 1999. Synthesis of the North American Flora. Version 1.0. CD-ROM. Biota of North America Program, North Carolina Botanical Garden, Chapel Hill.

Loconte, H. and W.H. Blackwell, Jr. 1984. Berberidaceae of Ohio. Castanea 49: 39-43.

Malasi, C.B., J.S. Chauhan, and G.S. Paliwal. 1989. Influence of growth substances on pollen germination, fruit-set and fruit growth in *Berberis asiatica* Roxb. Indian Journal of Forestry 12(1): 29

Mohlenbrock, R.H. 1986. Guide to the Vascular Flora of Illinois. Revised and enlarged edition. Southern Illinois University Press. xii + 507 pp.

Mohlenbrock, R.H. and K. Wilson. 1985. A floristic study of Fountain Bluff, Jackson County, Illinois. Erigenia 6: 29-55.

Philippi, T., B. Collins, S. Guisti, and P.M. Dixon. 2001. A multistage approach to population monitoring for rare plant populations. Natural Areas Journal 21:111-116.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. The University of North Carolina Press: Chapel Hill.

Rhoads, A.F. and T.A. Block. 2000. The plants of Pennsylvania: an illustrated manual. University of Pennsylvania press, Philadelphia. 1061 pp.

Roedner, B.J., D.A. Hamilton, and K.E. Evans. 1978. Rare Plants of the Ozark Plateau: A Field Guide. North Central Forest Expt. Station, U.S. Forest Service, St. Paul, MN. 238 p.

Rudolf, P.O. 1974. *Berberis* L., Barberry, Mahonia, *in* U.S. Dept. Agric. Handbook 450: 247-251. Washington, DC.

Schwegman, J.E., G.B. Fell, M.D. Hutchinson, G. Paulson, W.M. Shephard, and J. White. 1973. Comprehensive plan for the Illinois Nature Preserve system. Part 2. The natural divisions of Illinois. Illinois Nature Preserves Commission, Rockford. 32 pp.

Small, J.K. 1933. Manual of the southeastern flora. Two vols. Hafner Publishing Co., NY.

Steffey, J. 1985. Strange relatives: The barberry family. Am. Hort. 64(4):4-9.

Steyermark, J.A. 1963. Flora of Missouri. The Iowa State University Press: Ames 1728 pp.

Strausbaugh, P.D. and E.L. Core. 1952-1964. Flora of West Virginia. 4 parts. West Virginia University Bulletin, Morgantown, West Virginia. Part II. Second Edition.

Swingle, C.F. 1939. Seed propagation of trees, shrubs, and forbs for conservation planting. SCS-TP-27, U.S.D.A. Soil Conservation Service, Washington, DC. 198 pp.

Vines, RA. 1960. Trees, shrubs, and woody vines of the Southwest. Univ. TX Press: Austin.

Webb, W.L., H.J. Schroeder, and L.A. Norris. 1975. Pesticide residue dynamics in a forest ecosystem: a compartmental model. Simulation 24: 161-169.

Wherry, E.T., J.M. Fogg and H.A. Wahl. 1979. Atlas of the Flora of Pennsylvania. Morris Arboretum of the University of Pennsylvania, Philadelphia, PA.

White, J. and M. H. Madany. 1978. Classification of natural communities in Illinois. Pages 310-405 (Appendix 30) *in*: White, J. Illinois Natural Areas Technical Report, Volume 1. Survey Methods and Results. Urbana. Illinois Natural Areas Inventory.

Whittemore, A.T. 1997. *Berberis*, pp. 276-286 In: Flora of North America Editorial Committee, eds., Flora of North America, Vol. 3. Oxford University Press: New York.

WEBSITES CONSULTED

W-1. Preliminary Conservation Assessment - Hoard and Hill (2002) http://www.life.uiuc.edu/hughes/undergrad_prog/abstracts/summer02/hoard.html

W-2. USDA, NRCS. 2002. The PLANTS Database, Version 3.5. National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

http://plants.usda.gov/cgi_bin/topics.cgi

W-3. NatureServe Explorer (The Nature Conservancy): An online encyclopedia of life. 2002. Version 1.6. Arlington, Virginia, USA. http://www.natureserve.org/

W-4. The North Carolina Natural Heritage Program; Species Search page. http://www.ncsparks.net/nhp/search.html

W-5. Atlas of the Flora of South Carolina. http://cricket.biol.sc.edu/herb/doc41/

W-6. California Native Plant Society http://www.cnpsci.org/html/PlantInfo/Definitions2.htm

W-7. Walnut and butternut toxicity. The Bruce Company, Middleton, Wisconsin. http://www.bruceco.com/Information/plant%20lists/juglans.html

W-8. Botany On-line - Reproductive Isolation. University of Hamburg, Germany. http://www.biologie.uni-hamburg.de/b-online/e38/38d.htm

W-9. Barberry Inspection Manual. Animal and Plant Health Inspection Service, U.S. Department of Agriculture, Washington, DC. http://www.aphis.usda.gov/ppq/barberry/manual/manual.htm

CONTACTS

Shawnee National Forest; 50 Highway 145 South, Harrisburg, IL 62946

Elizabeth L. Shimp (618) 253-7114; e-mail: eshimp@fs.fed.us
Stephen P. Widowski (618) 658-2111; e-mail: swidowski@fs.fed.us

Hoosier National Forest; 811 Constitution Avenue, Bedford, IN 47421 (812) 275-5987

Steven D. Olson (719) 553-1400; e-mail: solson01@fs.fed.us
currently: Pike-San Isabel National Forests,
Cimarron-Comanche National Grasslands,
Kachina Drive, Pueblo, CO 81008

Illinois Natural History Survey, 607 E. Peabody Drive, Champaign, IL 61820

Dr. Steven R. Hill (217) 244-8452; e-mail: srhill@mail.inhs.uiuc.edu
Dr. L. Richard Phillippe (217) 244-2181; e-mail: rickp@mail.inhs.uiuc.edu
Dr. John B. Taft (217) 244-5046; e-mail: taft@mail.inhs.uiuc.edu

Illinois Endangered Species Board

Dr. John E. Ebinger (217) 345-3815; e-mail: cfjee@eiu.edu

Indiana Department of Natural Resources, 402 W. Washington St., Indianapolis, IN 46204

Michael A. Homoya (317) 232-0208; e-mail: mhomoya@dnr.state.in.us

Biological Consultant

John E. Schwegman (618) 543-9429; e-mail: botany@midwest.net

Missouri Department of Conservation, 2901 W. Truman Blvd., Jefferson, MO 65109

Tim E. Smith (573) 751-4115 ext. 3200; e-mail: smith2@mdc.st
Dr. George A. Yatskievych (314) 577-9522; e-mail: george.yatskievych@mobot.org

APPENDICES

APPENDIX 1

Representative specimens of *Berberis canadensis* examined or cited in the literature

Herbaria:

CLEMS = Clemson University, Clemson, SC. F = Field Museum, Chicago, IL. GMUF = George Mason University, Fairfax, VA. MIN = University of Minnesota, Saint Paul. MO = Missouri Botanical Garden, St. Louis. MU = Miami University, Oxford, OH. NCU = University of North Carolina herbarium, Chapel Hill. NY = The New York Botanical Garden, Bronx, NY. TENN = University of Tennessee, Knoxville. UNA = University of Alabama herbarium, Tuscaloosa. VT = University of Vermont herbarium, Burlington. WIS = University of Wisconsin, Madison.

ALABAMA: JEFFERSON CO., in woods, partly cleared, along Tarrant Spring Creek, near Killough Springs, 17 Apr 1944, *Harper 3962* (UNA)

ILLINOIS: JACKSON CO., Fountain Bluff, May 1973, Wilson s.n. (herbarium?); TAZEWELL CO., Spring Lake, 21 Oct 1924, *Curran s.n.* (herbarium ?); Spring Lake State Park, 14 Apr 1977, *Schwegman s.n.* (Schwegman herbarium)

MISSOURI: HOWELL CO., County Hollow by the bluffs of Eleven Points River, NE of Peace Valley, *Steyermark 14502* (F [?]); SHANNON CO., Jam-up Bluff and Bear Hole Bluff along Jack's Fork of Current River, *Steyermark 26890* (F [?]); cliffs, Jam-up Bluff, NW of Montier, 8 June 1941, *Steyermark & Fassett 21354* (MIN, MO, WIS); Montier, high hills, 8 Oct 1905, *Bush 3601* (MO); TEXAS CO., between Barn Hollow Canyon and Hwy. 17 along Jack's Fork of Current River, 25 May 1935, *Steyermark 19086* (MO)

NORTH CAROLINA: BUNCOMBE CO., Railroad right-of-way at Alexander, 7 May 1968, *Leonard 1465* (NCU, UNA, WIS); dry hillsides, Biltmore, 5 May 1896, *Biltmore Herbarium 303* (MU); woodlands, 12-26 May 1897, *Biltmore Herbarium 303b* (WIS); HAYWOOD CO., narrow country roadside, Lake Junaluska, 10 Jul 1934, *Oosting 34653* (MU); MADISON CO., S of Marshall, 15 Jun 1963, *Bradley et al. 841* (GMUF)

SOUTH CAROLINA: PICKENS CO., between Six Mile and Clemson, Todds Creek, 6 May1990, *Hill 21472* (CLEMS, NY, VT)

TENNESSEE: SULLIVAN CO., on bluff, Bluff City, 19 May 1934, *Sharp 832* (TENN, WIS)

VIRGINIA: GILES CO., SE of Pembroke, limestone cliff, 3 Sep 1993, *Fleming 8543* (GMUF); LEE CO., SSE of Beech Spring, 22 Jul 1996, *Fleming 11921* (GMUF); MONTGOMERY CO., NW of Christiansburg, 10 Aug 1992, *Fleming 7141* (GMUF); Allegheny mountains, rocky sandstone cliffs in woods, Bear Cliff, Mountain Lake Biological Station, 23 July 1958, *Iltis 19683*(WIS); on slope by road, east of Goodwins Ferry RR Station, open steep south-facing cleared slope, shallow dry soil with frequent limestone outcrops, 9 August 1943, *Iltis 2090*

(WIS); RUSSELL CO., SW of Cleveland, 24 Jul 1996, *Fleming 11980* (GMUF); SMYTH CO., middle fork of Holston River, 6 mi W of Marion, 20 Jul 1892, *Small s.n.* (MU); vicinity of Marion, 19 May 1892, *Britton, Britton, & Vail s.n.* (MU)

APPENDIX 2.

The Distribution of *Berberis canadensis* in the United States.
Information from herbarium specimens and the literature.
[Incomplete; many historic only.]

STATE	COUNTIES	NOTES
Alabama	Jefferson [extirpated ?]	last collection known - 1944; Ginzbarg, pers. comm.
Georgia	Meriwether, Towns	see Jones and Coile 1988, W-2
Illinois	Jackson, Tazewell	includes Shawnee N.F.; IL Dept. of Natural Resources 2002; Schwegman, pers. comm.
Indiana	Fulton, Pulaski, Saint Joseph, Scott, Tippecanoe, Washington, White	Deam 1940
Kentucky	McCreary	see W-2; includes Daniel Boone N.F.
Maryland	Allegany, Garrett [? both]: "only in the Mountain Zone of Maryland."	Brown and Brown 1972
Missouri	Howell, Shannon, Texas [southern Ozark section]	see W-2; Steyermark 1963; Yatskievych, pers. comm.; including Mark Twain N.F.
North Carolina	Alamance, Alexander, Buncombe, Durham, Granville, Guilford, Haywood, Iredell, Madison, Orange, Person, Randolph, Transylvania [Piedmont, Mountains]	see W-2, W-4; Radford *et al.* 1968
Pennsylvania	Huntingdon	formerly known from a single locality; believed to be extirpated; see Wherry *et al.* 1979, Rhoads and Block 2000
South Carolina	Pickens, York	see W-2, W-5
Tennessee	11 counties, eastern third of state	see Chester *et al.* 1993; includes Cherokee N.F.
Virginia	19 counties, southwestern half of state, mountains and piedmont	W-2; Harvill *et al.* 1986
West Virginia	Greenbrier, Mercer, Monroe, Pocahontas, Raleigh, Summers	see W-2; Strausbaugh and Core 1952-1964

APPENDIX 3.

Natural Diversity Database Element Ranking System

modified from: http://www.cnpsci.org/html/PlantInfo/Definitions2.htm [W-6]

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.

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.

SR
Reported to occur in the state. Otherwise not ranked.

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

Notes:

1. Other considerations used when ranking a species or natural community include the pattern of distribution of the element on the landscape, fragmentation of the population/stands, and historical extent as compared to its modern range. It is important to take a bird's eye or aerial view when ranking sensitive elements rather than simply counting element occurrences.

2. Uncertainty about the rank of an element is expressed in two major ways: by expressing the rank as a range of values (*e.g.,* **S2S3** means the rank is somewhere between S2 and S3), and by adding a '?' to the rank (*e.g.* S2?). This represents more certainty than S2S3, but less than S2.

APPENDIX 4. BARBERRY INSPECTION MANUAL, USDA, APHIS

Barberry

INSPECTION MANUAL

Program History

U.S. farm lands produce more than 3 billion bushels of wheat, oats, barley, and rye from about 100 million acres each year. These four small-grain crops are all potential hosts to the organism causing black stem rust (BSR). Under suitable conditions (e.g., susceptible host plant varieties, virulent races of the pathogen, suitable environmental conditions) BSR may be responsible for losses in the United States of as much as 37 million bushels of grain a year. Without resistant crop varieties and effective barberry control programs, losses could grow to 10-30 times present losses. Although chemical control of BSR through the application of fungicides is possible, treatment of a low-value crop such as wheat is rarely initiated due to the relatively high cost.

Breeding varieties of small grains for resistance to BSR began in the United States around 1900 meeting with rapid success from crosses with wheat varieties from Russia and Turkey. By 1938, farmers were planting resistant wheat varieties in the areas of the United States where BSR had been most destructive and continued to develop new resistant crop varieties. The difficulty with this approach is that while an individual crop variety may be resistant to several races of BSR, there are more than 200 existing races of BSR. The presence of BSR-susceptible barberry bushes providing the opportunity for new hybrid races of BSR to develop complicates the problem further. The use of resistant crops alone would never provide farmers with adequate protection from BSR. With the increasing demand for U.S. wheat, an alternative method of defense against a catastrophe the magnitude of the BSR epidemic of 1916 was needed.

The eradication in northern grain-growing regions of susceptible barberry bushes was this alternative method. Eradication would delay the onset of the annual rust infestations and slow the development of new BSR races. Farmers could now safely use resistant varieties for longer periods. In addition, breeders would have additional time to develop new resistant varieties.

An early attempt at barberry eradication in New England in 1726 had failed because scientists of those times did not understand the exact nature of the relationship between barberry and BSR

until 1865. In 1918, the U.S. Department of Agriculture (USDA) initiated a barberry eradication program in cooperation with 13 north-central States (Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming). In 1935, four additional states (Missouri, Pennsylvania, Virginia, and West Virginia) joined the program, followed by Washington State in 1944. This time, the program resulted in the destruction of several hundred million susceptible barberry and mahonia bushes in over 700,000 square miles.

Although barberry eradication is a cooperative project with State personnel, USDA has always played a leading role. USDA established Quarantine 38 (7 CFR Part 301.38), the black stem rust (BSR) quarantine with the following goals: To prevent the importation of susceptible *Berberis* and *Mahonia* varieties into the United States.

- o To prevent the importation of susceptible *Berberis* and *Mahonia* varieties into the United States
- o To regulate the interstate movement of susceptible *Berberis* and *Mahonia* varieties.
- o To prevent the reintroduction of susceptible *Berberis* and *Mahonia* into eradication areas.
- o To eradicate susceptible *Berberis* and *Mahonia* varieties from the United States.

USDA supported the eradication program by providing funding for it and performing the following crucial program activities-- nursery inspections

- o surveys
- o destruction of susceptible plants
- o certification of resistant plants

USDA's funding for the barberry eradication program ended in 1980. Although several States continued some barberry eradication activities, the extensive eradication program also ended in 1980. When USDA's Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ) proposed ending the black stem rust quarantine in 1981, 17 States and the Crop Quality Council requested that PPQ retain the BSR quarantine. PPQ agreed in the absence of a more satisfactory solution. In 1985, PPQ and the regional plant boards reevaluated the needs of the BSR program, and PPQ decided to retain the quarantine with the following significant changes: Movement of rust susceptible nursery stock in the genera *Berberis*, *Mahonia*, and *Mahoberberis* into or through a protected area (i.e., former eradication areas that continued to conduct nursery inspections to maintain their "susceptible-free status") would be prohibited.

- o Movement of rust resistant nursery stock into or through protected areas would be regulated.
- o Restrictions for growing or shipping susceptible or resistant varieties between unregulated states would be lifted.

States must also enforce restrictions on the intrastate movement of regulated articles equivalent to those in the BSR quarantine for interstate movement. Other State responsibilities are:

o Employing inspectors with the responsibility for issuing and canceling certificates and compliance agreements
o Training inspectors
o Maintaining and enforce an inspection program
    # Inspect every plant nursery within the State at least once a year
    # Ensures that the nurseries are free of plants susceptible to BSR

o Enforcing the quarantine
    # Issuance of certificates and limited permits
    # Conducting periodic surveys to maintain the protected area free of rust-susceptible barberry plants

Biology

The fungus *Puccinia graminis* causes the disease black stem rust. Although plant pathologists take pains to distinguish between the symptoms and the causative organism, in common use, BSR can refer to both. This pathogen has a wide host range among species in the grass family, including wheat, oats, rye, barley, and timothy, as well as several other wild and cultivated grasses. BSR fungus can attack any aboveground part of wheat or other grasses, resulting in smaller, fewer, and lower quality kernels from reductions in root and foliage development. Because BSR is a heteroecious ("two houses") rust, it also has alternate hosts in a different plant family. In this case, the alternate hosts are various species and hybrids of *Berberis* and *Mahonia* (of the barberry family). Although damage to the alternate hosts is minor and mostly cosmetic, the economic significance of the disease to the grain crop varieties it infects is extensive.

BSR can exist in all areas where host crops are grown, but the disease is usually most damaging in moderately moist and northern areas. In the United States, this corresponds to the spring wheat areas of the upper Mississippi Valley and the areas to the north. The amount of damage depends upon the age of the plant at the time infection. Since northern farmers plant their grain crops relatively late in the spring, infection in this area occurs when the plants are young and causes extensive damage. The symptoms on wheat appear as long, narrow blisters, parallel to the axis of leaves, stems, and sheaths. As the blisters mature, the covering ruptures, revealing powdery masses of brick-red spores ("red rust" urediospores). The urediospores can splash or blow to other susceptible wheat or other small grain plants where additional infections occur. Several generations of urediospores can be produced in a single growing season; it is these repeating infections that cause the most damage to crops.

Urediospores do not survive the winter in northern areas. Late in the season, the lesions that had earlier produced urediospores become dark to black. The second spore type, the teliospores, form in the lesion and overwinter on stems and straw of wheat or other grass family hosts. The teliospores germinate in the spring producing basidiospores that can infect any susceptible barberry plants in the immediate vicinity. It is in the basidiospore stage in the life cycle of the rust that sexual recombination occurs, providing the opportunity for developing new races of BSR. Later in the spring, aeciospores form on the leaves of infected barberry plants. Aeciospores complete the life cycle of BSR by being blown by wind and to wheat or other susceptible grass family hosts and germinating. The life cycle then begins again.

In southern areas where the weather conditions are mild, BSR does not depend on having to complete its entire life cycle in a single growing season. In these areas the fungus can live from year to year by overwintering in the uredial stage on susceptible grains and grasses. It is possible for infestations to develop early in these areas. If these urediospores blow north in large numbers, epidemics of BSR may occur where susceptible grain hosts are present. In the south, the typical infestation involves the more gradual development of urediospores, while in the north, infection areas occurs later in the season. Eradication of susceptible barberry plants from northern grain-growing areas can reduce the negative impact by BSR for a number of reasons--Early season infections are rare; therefore, destructive epidemics are also extremely rare.

The opportunity for the development of new BSR races in barberry is reduced significantly.

BSR races and resistant varieties of grain maintain their stability for longer periods.

Breeders have more time to develop new varieties of resistant wheat and barberry.

Farmers can enjoy the benefits of planting resistant varieties with high yield potentials for longer periods.

Compliance Agreements

Compliance agreements may be executed with nurseries and/or shippers to facilitate the movement of regulated articles into or through protected areas in accordance with the requirements stated in Section 301.38-6 of the BSR regulations. Written compliance agreements may authorize the issuance of either limited permits (for the movement of regulated articles through protected areas) or certificates (for the movement of regulated articles into or through protected areas).

Limited Permits

Limited permits may be issued, either individually or under compliance agreement, for regulated articles not eligible for certification when the applicant can meet the following conditions:

The destination(s) to which the regulated articles are to be moved must be specified on the limited permit.

The destination(s) to which the regulated articles are to be moved must be outside of a protected area.

The regulated article(s) to be moved must be placed in a closed, sealed container that prevents the unauthorized removal of the regulated article, and the container must remain sealed until the regulated article(s) reaches the final destination stated on the limited permit.

At the final destination, the sealed container must be opened only in the presence of an inspector or with the authorization of an inspector obtained expressly for that shipment.

These conditions can be met in a variety of ways. It will be up to the inspector issuing the limited

permit or drawing up the compliance agreement to insure that the agreements section of the compliance agreement contains language sufficient to insure that the four conditions stated above are met.

Certificates

Certificates may be issued, either individually or under compliance agreement, for regulated articles that are eligible for movement into or through protected areas, when the applicant can meet the following conditions:

* Plants of the genus *Berberis* must be rust resistant by belonging to a species and/or variety listed in Section 301.38-2[b].

* Plant parts capable of propagation (seeds, fruits, etc.) of the genus *Berberis* must be identified as being rust resistant by coming from plants belonging to species and/or varieties listed in Section 301.38-2[b].

* Plants, seedlings, and plant parts capable of propagation (seeds, fruits, etc.) of the genera *Mahoberberis* and *Mahonia* must be identified as being rust resistant by belonging to a species and/or variety listed in Section 301.38-2[c].

* Seed of any of the genera listed above can only be issued a certificate when it can be determined that the property at which the seed is produced contains only rust resistant species and/or varieties of these genera (Section 301.38-2[a] and [b]). In addition, visual inspections must have been conducted to confirm that all *Berberis, Mahoberberis,* and *Mahonia* plants within one-half mile of the property at which the seed is produced are rust resistant.

If the identity of plants can be determined by tags or labels attached to the individual plants or pots, the certificate may be a stamp affixed to an appropriate shipping document. If the individual plants are not labeled as to species and/or variety, each plant (or pot) must have affixed a sticky-back certificate or other evidence that the plant meets the APHIS requirements for certification as stated above.

General Aids to Identification

Inspectors must be able to distinguish between susceptible and resistant species of barberry. This is necessary to insure that plants are correctly labeled, that plants are true to type, and in order to identify unlabeled plants. In many cases, recognizing a few simple characteristics will enable the inspector to identify rust-susceptible barberry species. The rust-susceptible species most likely to be encountered is the common European barberry, *Berberis vulgaris*. Other rust-susceptible species that may be encountered will frequently have characteristics similar to those that distinguish the common barberry. Five types of characteristics will be most helpful in distinguishing rust-susceptible from rust-resistant barberry varieties. A guide to how these characteristics may be used is shown in the table below:

	RUST SUSCEPTIBLE	RUST RESISTANT
LEAVES	saw tooth edge	smooth edge
BARK	grey	reddish brown
BERRIES	in bunches	singly or in twos
SPINES	groups of three	single
STEMS	straight	angled at nodes

When all of the characteristics commonly associated with a susceptible or resistant species occur together, a correct identification can be almost always made. Barberry plants found to have sawtooth-edged leaves, grey outer bark, berries occurring in bunches, spines in groups of three, and straight stems will usually belong to a rust-susceptible species. Barberry plants found to have smooth-edged leaves, brown to reddish-brown bark, berries single or in twos, single spines, and strongly angled stems will usually belong to rust-resistant species.

Unfortunately, many of the plants encountered in the field will not be as easily identified. In some cases the characteristics may be indistinct leaves may be "sort of rough" on the edge, or stems may change color, depending on age. In other cases, the plant may have some characteristics associated with rust-susceptible species and other characteristics associated with rust-resistant species. This may be due to the fact that the plant is not one of the "typical" species, or that the plant belongs to a hybrid variety resulting from a cross between susceptible and resistant species.

When plants having characteristics that are not as well defined as those listed above, and/or have a mixture of types of characteristics are encountered, further effort will be required to identify the particular species or variety to which the plant belongs. To aid in making this identification, two additional types of identification systems are provided. The first is taken from an earlier barberry survey manual and requires matching of characteristics of the unknown plant with those contained in a series of pictures with descriptions of a number of more common berberis and mahonia species.

The second identification system involves the use of a key developed by Agriculture Canada. Identification using this system involves following the key and making choices depending on the characteristics that are present in the unknown plant. This is a more conventional, and often more accurate, method but does require that the identifier understand a number of terms that are used by taxonomists to describe plant characteristics.

Some people will find that one or the other of these two identification systems will work best for them. Many people will find that being able to use both systems will be most effective. Regardless of which identification system is used, there will be occasions in which the unknown plant does not fit any of the descriptions that are provided. This may be due to a poor specimen, inexperience on the part of the identifier, or to the fact that the plant in question is not included in either of the keys. If this is the case, contact David Long in St. Paul, MN to submit a specimen of the plant for testing of its resistance to black stem rust.