

**Assessment of Invasive Species in  
Indiana's Natural Areas**

**\*\*\*OFFICIAL Japanese Barberry (*Berberis thunbergii*) ASSESSMENT\*\*\***

Answers are underlined and in **bold**, comments are inserted in *italics*

*Members of 5/25/07 assessment subcommittee: Ellen Jacquart (TNC), Hilary Cox (Leescapes Garden Design), Kate Howe (Midwest Invasive Plant Network), Don Miller*

<b>Invasive Ranking Summary</b>	<b>Score</b>	
Ecological Impacts	27	
Potential For Expansion	38	
Difficulty of Management	29	
<b>Total Score:</b>	<b>94</b>	<b>High</b>
<i>Rankings: Low &lt; 45, Medium 45 – 80, High &gt; 80</i>		

**Contents of the Assessment:**

**Section I** – Invasion Status. Determines whether the species being evaluated is invasive in Indiana.

**Section II** – Ecological Impacts of Invasion. Evaluates the significance of impacts of the species.

**Section III** – Potential for Expansion. Evaluates the actual and/or potential expansion of the species.

**Section IV** – Difficulty of Management. Evaluates how hard it is to control the invasive species.

**Section V** – Commercial Value. Evaluates how valuable the species is economically in Indiana.

Questions in Sections I – V may direct you to one or more of the following sections for particular invasive species:

**Section A.** For species which have impacts limited to a few sites, assesses the potential for further spread.

**Section B.** For species which have medium impacts but high value, assesses whether species could be used in specific circumstances that would prevent escape and invasion.

A worksheet for use with the assessment is found on page 9.

**Automatic Exemption From the Assessment**

Is this species listed on any federal or on an Indiana state noxious, or prohibited plant lists?

If **YES** then do not proceed with assessment but indicate a conclusion of **Do not use this plant** on the front of the response form.

If **NO** then go to Section I.

**Section I**

**Invasion Status**

**1-a Current Invasion in Indiana**

1. Does this species occur in any natural areas in Indiana?

If **NO** then go to Section III-c.

If **YES** then go to 1-a 2.

2. Does it **ONLY** occur in natural areas of Indiana because it has persisted from its previous cultivation (e.g., in abandoned farmland or homesteads)?

If **YES** then go to Section III-c.

If **NO** then go to Section 1-b (below).

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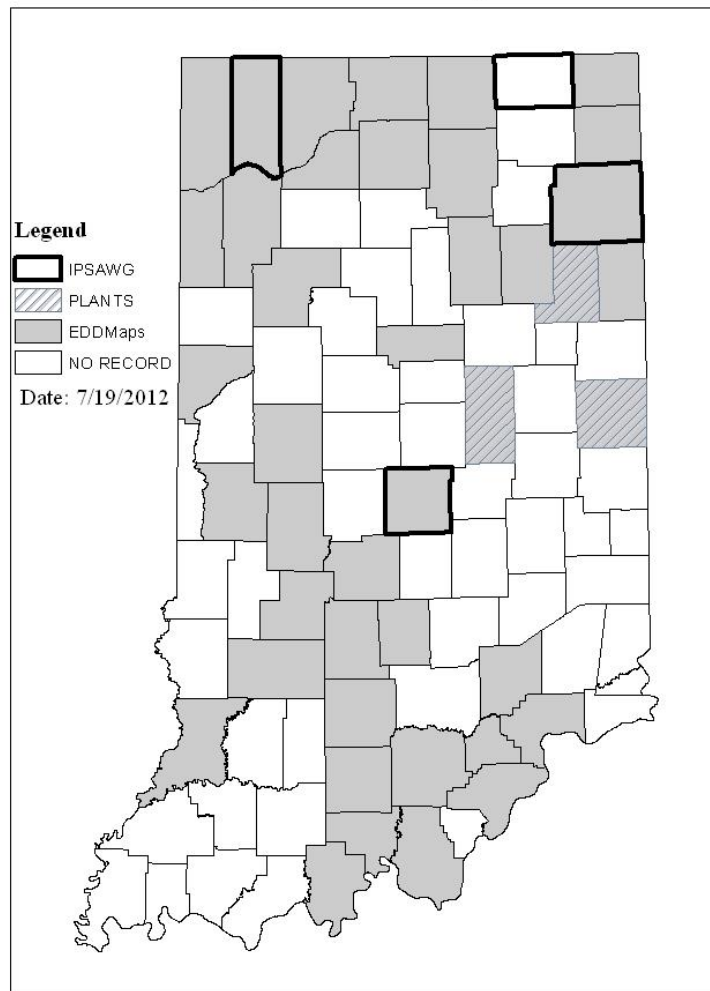
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### 1-b Invasion Status in Indiana

Evidence of invasion (forming self-sustaining and expanding populations within a plant community with which it had not previously been associated) must be provided. If not available in a published, quantitative form, this evidence must include written observations from at least three appropriate biologists.

1. Is species invasive ONLY when natural disturbance regime and scale have been altered? (e.g. where frequency, extent, or severity of fires have been reduced by human activity).  
If **YES** then go to questions 1-b 2.  
If **NO** – the species is invasive, go to Section II (below).
2. Has this species ever been known to persist, following colonization, when the natural regime is resumed and the natural flora/communities recover? (e.g., is not an early successional species that only temporarily invades disturbed sites.)  
If **YES** (or unknown) - the species is invasive, go to Section II (below).  
If **NO** (known not to persist) the species is currently not invasive in Indiana. Go to Section III-c to assess the species' potential for future invasion.

### Reported Status of Japanese Barberry, *Berberis thunbergii*



**II-a Known Impacts at WORST SITE(S) (without, or before, any control effort)**

Add up points for ALL impact statements (i through vi) that are true at the worst affected site(s) then go to question II-b. Evidence of impacts must be provided. If not available in published, quantitative form, this evidence must include written observations from at least *three* appropriate biologists, including specific locations of observations. Scientific names of impacted species (e.g., State-listed or native species with which hybridization occurs) must be included on the response form. If there is no evidence of an impact, then assign 0 points unless the impact is considered very likely (e.g., fixes N<sub>2</sub> in low nutrient soil that can change the flora) or the impact (except vi) has been demonstrated in similar habitats in states. In these cases assign 0.5 points.

*There were numerous reports of sites with barberry scattered throughout woods in Steuben, Jackson, Jennings, LaPorte, Parke, Marion, Brown, Harrison, Floyd, Martin and Fayette counties. However, survey reports were filled out only for dense populations. There were 7 survey reports from four counties (Porter, LaGrange, Allen and Marion).*

Points

- i) Causes long-term, broad alterations in ecosystem processes changing the community as a whole (e.g. invasion of cattails changes hydrology, drying the site and allowing open aquatic systems to become forested). **15**
- Kourtev et al, 2002 found that Japanese barberry invasion had profound impacts on the microbial community of the soil, including the microbial community structure and function. Building on this, Elgersma et al., 2011 found: "... our data do support previous studies showing that the long-term presence of Berberis results in altered soil microbial communities (Fig. 1) and enzyme activities (Fig. 3), reduced ammonification rates, and greatly increased nitrification rates (Fig. 6)."*

*This paper demonstrated that changes in the microbial community altered nutrient cycling in soils where Japanese barberry grew. While this study did not directly demonstrate that these changes in nutrient cycling caused changes in the plant community, other studies have demonstrated the impacts of altered nutrient cycling on native plants. We believe it is logical to draw the conclusion that major changes to soil properties will necessarily cause major changes to the plant community.*

- ii) Has negatively impacted Indiana State-listed or Federal-listed plants or animals (choose one of the following):

Displacement, death or hybridization has been documented AND occurs in at least 20% of known locations of the listed species, OR these effects occur in less than 20% of known locations of the listed species, but at least 4 different listed species are affected. **12**

Displacement, death or hybridization occurs in less than 20% of locations of the listed species OR impacts are considered likely because the listed and invasive species closely co-habit (e.g., compete for light). **4**

*None reported.*

- iii) Displaces or precludes native vegetation (affecting mortality and/or recruitment) by achieving infestations in the state that have at least 50% coverage of this species (as defined in the glossary) in the affected stratum that meet any of the following criteria:
- collectively add up to at least 10 acres
  - are 5 infestations of at least 0.25 acres
  - are 5 infestations that cover an entire localized community (e.g. sinkhole, seeps, fens, bogs, barrens, cliffs)
  - are 5 infestations some of which are at least 0.25 acres and others of

August 3, 2005 template version

- which cover entire localized communities. 12
- From the IPSAWG survey reports, most of the infestations were less than 50% cover, therefore this is not counted.*
- iv) Changes community structure in ways other than vegetation displacement (e.g., alters wildlife abundance, adds a new stratum, or increases stem density within a stratum by more than 5-fold). 4
- v) Hybridizes with native Indiana plants or commercially-available species. 4
- vi) Covers over 15% of invaded stratum (but if 12 points were assigned for statement iii, do not assign points here) on > 10 acres in the state. **3**
- Total points** (place in worksheet page 9): **18**

## II-b Range of Habitats in Which Species is Invasive

- Forest: **1)Dry upland, 2)Dry-mesic upland, 3)Mesic upland, 4)Mesic floodplain, 5)Wet-mesic floodplain, 6)Wet floodplain, 7)Bluegrass till plain flatwoods\*, 8)Boreal flatwoods\*, 9)Central till plain flatwoods, 10)Dry flatwoods\*, 11)Sand flatwoods\*, 12)Southwestern lowland mesic flatwoods\***
- Savanna: 13)Mesic savanna\*, 14)Dry sand savanna\*, 15)Dry-mesic sand savanna\*
- Barrens: 16)Limestone bedrock\*, 17)Sandstone bedrock\*, 18)Siltstone bedrock\*, 19)Chert\*, 20)Gravel\*, 21)Sand\*, 22) Clay\*
- Prairie: 23)Dry-mesic prairie\*, 24)Mesic prairie\*, **25)Wet prairie\***, 26)Dry sand prairie\*, 27)Dry-mesic sand prairie\*, 28)Wet-mesic sand prairie\*, **29)Wet sand prairie\***
- Wetland: **30)Marl beach\*, 31)Acid bog\*, 32)Circumneutral bog\*, 33)Fen\*, 34)Forested fen\*, 35)Muck and Sand flats\*, 36)Marsh, 37)Sedge meadow\*, 38)Panne\*, 39)Acid seep\*, 40)Calcareous seep\*, 41)Circumneutral seep\*, 42)Forest swamp, 43)Shrub swamp**
- Lake: **44)Lake, 45)Pond**
- Stream: **46)Low-gradient creek, 47)Medium-gradient creek, 48)High-gradient creek, 49)Low-gradient river, 50)Medium-gradient river, 51)Major river**
- Primary: **52)Aquatic cave\***, 53)Terrestrial cave\*, 54)Eroding cliff\*, 55)Limestone cliff\*, 56)Overhang cliff\*, 57)Sandstone cliff\*, 58)Lake dune\*, 59)Gravel wash\*

Is this species known to be invasive in at least four habitat-types (note – rare habitat-types are marked with a \* and count as 2 when adding) OR does it occur in at least one habitat-type of each of the terrestrial and palustrine/aquatic lists (palustrine/aquatic habitats are shown in **bold**) *4 habitat types affected.*

If YES then multiply total score from II-a by 1.5  
then go to Section II-c (Below)

If NO then multiply total score from II-a by 1  
then go to Section II-c (Below)

Place point total in worksheet, page 9.

*“Japanese barberry (*Berberis thunbergii* DC.) (*Berberidaceae*) has become a widespread component of the forest understory since its introduction in 1869. It is found throughout the east coast, and ranges as far west as the Dakotas and Wyoming (Anon., 1998 as cited in Ehrenfeld, 1999). It is frequently found in protected forest areas in metropolitan regions, even in relatively large parks and forests (> 8000 ha; Ehrenfeld, 1997 as cited in Ehrenfeld, 1999). It occurs in a wide variety of forest types and habitat conditions, ranging from wetlands with saturated, organic soils to xeric ridgetops, although it tends to be less abundant on northwestfacing slopes (Ehrenfeld, 1999) and in oak-dominated forests (Kourtev et al.,*

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**II-c Proportion of Invaded Sites with Significant Impacts**

Of the invaded sites, might any of the worst impacts [items i-v in section II-a] only occur under a few, identifiable, environmental conditions (i.e., edaphic or other biological conditions occurring in 1-10% of the sites)? Documentation of evidence must be provided for a **YES** answer.

If NO or NO SCORE on items i to v in section II-a  
then go to Section III  
If YES then go to Section A

<b>Section III</b>	<b>Potential for Expansion</b>	<b>Potential Index</b>
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This section evaluates a species’ actual and/or potential for expansion in Indiana.

**III-a Potential for Becoming Invasive in Indiana**

1. Is information available on the occurrence of new populations of this species in Indiana over the last 5 years?

If **YES** then go to section III-b  
If **NO** go to Section III-c to estimate potential for expansion based on the biology of the species.

**III-b. Known Rate of Invasion.**

1. Was this species reported in more than two new discrete sites (e.g., lakes, parks, fragments of habitats at least 5 miles apart) in any 12 month period within the last 5 years?

If **NO** then P = Low; then go to Section IV  
If **YES** then P = High; then go to Section IV

**III-c. Estimated Rate of Invasion.** This section is used to predict the risk of invasion for species that are 1) not currently invasive in the state, and 2) invasive in the state but for which no data on current rate of spread exists. These questions are based on Hiebert et al. 1995.

1. Does this species hybridize with any State-listed plants or commercially-important species? (E.g., exhibit pollen / genetic invasion.)

If **YES** then go to Section B  
If **NO** then go to question III-c 2.

2.	Add up all points from statements that are true for this species.	<u>Points</u>
	i. Ability to complete reproductive cycle in area of concern	
	a. not observed to complete reproductive cycle	0
	b. observed to complete reproductive cycle	<u>5</u>
	ii. Mode of reproduction	
	a. reproduces almost entirely by vegetative means	1
	b. reproduces only by seeds	3
	c. reproduces vegetatively and by seed	<u>5</u>
	iii. Vegetative reproduction	
	a. no vegetative reproduction	0
	b. vegetative reproduction rate maintains population	1
	c. vegetative reproduction rate results in moderate increase in	

population size	<u>3</u>
d. vegetative reproduction rate results in rapid increase in population size	5
iv. Frequency of sexual reproduction for mature plant	
a. almost never reproduces sexually in area	0
b. once every five or more years	1
c. every other year	3
d. one or more times a year	<u>5</u>
v. Number of seeds per plant	
a. few (0-10)	1
b. moderate (11-1,000)	3
c. many-seeded (> 1,000)	<u>5</u>
<i>Some cultivars produce &gt;1000 seeds/plant (Lehrer et al., American Nurseryman Oct. 15, 2006, pp. 30-36)</i>	
<i>Two thousand or more fruits (each fruit is one to few-seeded) can occur on a single plant, although some cultivars (e.g., 'Aurea', 'Bogozom', 'Crimson Pygmy', 'Kobold', 'Monlers') produce much less fruit and seed (Lovinger &amp; Anisko, 2004; Lehrer et al., 2006a, 2006b).</i>	
vi. Dispersal ability	
a. little potential for long-distance dispersal	0
b. great potential for long-distance dispersal ( <i>bird dispersed</i> )	<u>5</u>
<i>Fruits are eaten by birds, small mammals and wild turkeys and transported long distances by this means. Silander and Klepeis (1999) report that most seedlings are generally found beneath existing plants, with some found tens of meters away from nearest adult, but this is not direct evidence that there is not long-distance dispersal.</i>	
<i>Sources of information:</i>	
<i>Silander &amp; Klepeis, 1999; Mehrhoff et al, 2003; Lehrer pers. comm</i>	
vii. Germination requirements	
a. requires open soil and disturbance to germinate	0
b. can germinate in vegetated areas but in a narrow range or in special conditions	3
c. can germinate in existing vegetation in a wide range of conditions	<u>5</u>
<i>(Reports and literature citations indicate it is able to establish in full shade with no soil disturbance).</i>	
<i>Seeds readily germinate in varied habitat types, soil types and disturbance regimes. Observed germinating in existing vegetation.</i>	
<i>Sources of information:</i>	
<i>Silander &amp; Klepeis, 1999; Lehrer unpublished; author's (Moore's) personal observations.</i>	
viii. Competitive ability	
a. poor competitor for limiting factors	0
b. moderately competitive for limiting factors	3
c. highly competitive for limiting factors	<u>5</u>
<i>Some places where it has invaded it is growing in head-high, dense clumps in forest understories, taking full advantage of limited available light and displacing other species.</i>	
<i>Shade tolerant, perennial habit, grows on infertile soils, unpalatable to white-tailed deer.</i>	
<i>Sources of information:</i>	
<i>Ehrenfeld, 1997, 1999; Eschtruth and Battles, 2008; authors', Lehrer's and Jordan's</i>	

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**Section IV****Difficulty of Management****Management Index**

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**IV Factors That Increase the Difficulty of Management**

Add up all points from statements that are true for this species then go to Section V. Assign 0.5 point for each statement for which a true/false response is not known.

- |  | <u>Points</u> |
|--|---------------|
| i) Control techniques that would eliminate the worst-case effects (as listed in Section II) have been investigated but none has been found.  | 15            |
| ii) This species is difficult to control without significant damage to native species because: it is widely dispersed throughout the sites (i.e., does not occur within discrete clumps nor monocultures); it is attached to native species (e.g., vine, epiphytes or parasite); or there is a native plant which is easily mistaken for this invader in: (choose one)   |               |
| ≥ 50% of discrete sites in which this species grows;   | 10            |
| 25% to 50% of discrete sites in which this species grows.  | <u>7</u>      |
| <i>2003: Based on Don Miller's experience, the scattered nature of the majority of the plants means that foliar spraying or dormant stem spraying inevitably results in significant non-target damage. 2012 update: Don Miller has had more experience in barberry control at this point and is finding it in more low quality habitats where non-target damage is not as great a concern. Therefore, this answer is being changed from 10 points to 7 points.</i> |               |
| iii) Total contractual costs of known control method per acre in first year, including access, personnel, equipment, and materials (any needed re-vegetation is not included) > \$2,000/acre (estimated control costs are for acres with a 50% infestation)  | <u>5</u>      |
| <i>The thorn-covered, many stemmed plants are similar to multiflora rose from a control standpoint. Based on Don Miller's experience, a stem oil-based herbicide treatment during dormant season works best, but requires both a lot of herbicide (all stems must be wetted) and for the large dense stands, tangling with the thorns increased the difficulty of the treatment. This results in it a higher than average control cost.</i>                        |               |
| iv) Further site restoration is <i>usually</i> necessary following plant control to reverse ecosystem impacts and to restore the original habitat-type or to prevent immediate re-colonization of the invader.   | 5             |
| <i>Due to the scattered nature of most infestations, plenty of seed sources exist nearby to recolonize treated areas.</i>  |               |
| v) The total area over which management would have to be conducted is: (choose one).   |               |
| ≥ 100 acres;   | <u>5</u>      |
| < 100 but > 50 acres.  | 2             |
| ≤ 50 but > 10 acres.   | 1             |
| ≤10 acres  | ½             |
| <i>Based on survey reports</i>   |               |
| vi) Following the first year of control of this species, it would be expected that individual sites would require re-survey or re-treatment, due to recruitment from persistent seeds, spores, or vegetative structures, or by dispersal from outside the site: (choose one)   |               |

at least once a year for the next 5 years;	10
one to 4 times over the next 5 years;	<u>6</u>
regrowth not known	2
vii) Occurs in more than 20 discrete sites (e.g., water-basins, parks, fragments of habitats at least 5 miles apart). <i>Overlease et al. 2002 notes that this species is reproducing outside of cultivation in more than 20 counties around the state.</i>	<u>3</u>
viii) The number of viable, independent propagules per mature plant (e.g., seeds, spores, fragments, tubers, etc. detached from parent) is > 200 per year AND one or more of the following: A. the propagules can survive for more than 1 year; B. the propagules have structures ( <u>fleshy coverings</u> , barbs, plumes, or bladders) that indicate they may spread widely by birds, mammals, wind or water; C. the infestations at 3 or more sites exhibit signs of long distance dispersal. Some possible indicators of long distance dispersal include: the infestation has outlier individuals distant [>50 yards] from the core population; the infestation apparently lacks sources of propagules within ¼ mile.	<u>3</u>
ix) Age at first reproduction is within first 10% of likely life-span and/or less than 3 months. <i>Is likely that individuals can live at least 20-50 years, though we don't have documentation on that. They start producing fruits around 5 years of age.</i>	2
<b>Total points</b> (place in worksheet page 9):	<u>29</u>

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<b>Section V</b>	<b>Commercial Value</b>	<b>Value Index</b>
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**V-a    Commercial Value**

Does this species have any commercial value?  
 If response is **NO** then V = 0 and Go to Conversion of  
 Index Scores to Index Categories  
If response is **YES** then go to Section V-b

**V-b    Factors that Indicate a Significant Commercial Value**

Add up all points from statements that are true for this species. Assign 0.5 point for each statement for which a true/false response is not known.

	<u>Points</u>
i) This species is sold in national or regional retail stores ( e.g., Wal-Mart, Home Depot, Publix).	<u>10</u>
ii) State-wide there are more than 20 commercial growers of this species.	7
iii) More than five growers in Indiana rely on this species as more than 10% of their production.	3
iv) This species has provided a crop, turf, or feed source (e.g., forage, nectar) that has been, or resulted in, a significant source of income	



for at least five farmers for over 20 years. 3

v) This species is utilized statewide. 3

vi) There are more than 100 retail seed outlets statewide 3

**Total points** (place in worksheet page 9): 13

**Section A (from Section II-c)**

A1 Can the habitats in which the worst-case ecological impacts occur (items i to v in Section II-a) be clearly defined as different from invaded sites where there are no such impacts (e.g., defined by edaphic or biological factors)? (If ecological impacts include negative effects on a State-listed species, then the specific habitats in which that State-listed species occurs must be clearly distinguishable from habitats in which it does not occur.)

If **NO** then return to Section III

If **YES** then Go to question A2 and prepare such a site definition

A2 Can an estimate be made of the maximum distance that propagules (or pollen if hybridization is a concern) might reasonably be expected to disperse?

If **NO** then return to Section III

If **YES** then prepare instructions for Specified and Limited Use based on maximum dispersal distance (e.g., may be acceptable for use in specific areas but not near habitats where impacts are high.) Reassess if the incidence of worst-case impacts increases above 10% or within 10 years, whichever is earlier. THEN resume the assessment at Section III to provide scores for the other indices.

**Section B (from Section III-c or if Value = High and Impact = Medium)**

B1 Are there specific circumstances in which this species could be used that would not be expected to result in escape and invasion? (E.g., foliage plants that are only used indoors and which can be reasonably prevented, by conspicuous labeling, from use or disposal in the landscape.)

If **NO**, then retain the previously derived Conclusion.

If **YES**, then Acceptable for Specified and Limited Use where regulations and educational programs for penalties and enforcement of misuse exist. Reassess this species every 2 years.

**Worksheet for Assessment**

**Section I:**

Follow directions to different sections.

**Section II:**

Impacts Point Total: 18 X (1 or 1.5) = 27 **Impacts**

**Section III:**

Potential = High Medium or Low 38 **Potential for Expansion**

**Section IV:**

Difficulty of Management Point Total: 29 **Difficulty of Management**

**Section V:**

Commercial Value Point Total: 13 **Value**

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**Invasive Ranking Summary:**


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<b>Invasive Ranking Summary</b>	<b>Score</b>	
Ecological Impacts	27	
Potential For Expansion	38	
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<i>Rankings: Low &lt; 45, Medium 45 – 80, High &gt; 80</i>		

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**Discussion-**

*Barberry is currently invading many sites in Indiana at a very low level, so the current Ecological Impact ranks as low. However, survey reports suggest it is expanding rapidly in some areas in Indiana, and reports from east coast locations indicate barberry has the potential to form dense stands that are head high and exclude all other species from forest understories.*

*Dirr (Manual of Woody Landscape Plants 1998) estimates there are 450 cultivars of this species worldwide. Many are based on var. *atropurpureus*, all of which are purple-leaved. Lehrer, Brand and Lubell (J. Envir. Hort. 2006) note that these purple-leaved cultivars often produce green progeny. There is a mix of green and purple invaders in the Spring Pond site and Central Avenue Beach site.*

*Seed production varies widely between cultivars, per Lehrer, Brand, and Lubell in American Nurseryman, Oct. 15, 2006. Initial findings from their study shows almost all cvs. have the ability to produce seeds; to date only Crimson Ruby and Golden Devine have not produced any seed. Four other cvs produced less than 10 seeds/plant. Plants in this study were three year old plants, which is relatively young for fruit production, and the results are based on just one year's observations. Per this article "The findings presented here are preliminary and need to be replicated for at least two more years before firm conclusions can be drawn". Based on only one year's data, with relatively young plants, we do not believe it is possible to authoritatively state that particular barberry cultivars are less invasive. Once more data is collected, and if it provides stronger evidence, our recommendation should be changed to reflect the new information.*

**Literature Cited**

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## Glossary

***Anthropogenic disturbance.*** Human-induced disturbance (e.g., mowing) or human-induced changes in natural disturbance regime (e.g., changing the frequency, extent, or severity of fires).

***Coverage.*** Visual or quantitative estimate of the relative amount of area in a stratum where the canopy of the non-native species intercepts the light that would otherwise be available for other species in or below that stratum. Estimated cover may be dispersed or continuous in a site. Cover is usually measured when foliage is fully expanded. In the case of species that form a dense, continuous mat of rhizomes or stolons, the percent of the soil surface or upper level occupied by that root mat can be estimated as soil, rather than canopy, cover.

***Disturbance.*** Mechanisms that limit biomass by causing its partial or total destruction.

***Discrete sites.*** Disjunct habitat-types or fragments of habitats at least 1 mile apart that support invasive plant populations that likely arose by separate long-distance dispersal mechanisms.

***Documentation of evidence.*** One publication including relevant, original research will suffice if data are specific to the taxon and zone(s) under evaluation. If such documentation is not available or needs to be up-dated, at least three individuals who have the expertise on the particular species and zone in question must be identified.

***Federal- or Indiana -listed.*** Species that are listed by Federal laws or Indiana statutes or rules as threatened or endangered within the State of Indiana. This list with notes is available at <http://www.state.in.us/dnr/naturepr/endanger/plant.htm>

***Formal Risk Benefit Analysis.*** Detailed economic studies of impact and management costs and commercial value for present and future infestations.

***Invasive.*** A species that forms self-sustaining and expanding populations within a natural plant community with which it had not previously been associated (Vitousek *et al.* 1995).

***Long-term alterations in ecosystem processes.*** Examples of ecosystem processes that could be altered: erosion and sedimentation rates; land elevation; water channels; water-holding capacity; water-table depth; surface flow patterns; rates of nutrient mineralization or immobilization; soil or water chemistry; and type, frequency, intensity,

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or duration of disturbance. For further explanation see Gordon (1998).

**Native.** Species within its natural range or natural zone of dispersal (i.e., within the range it could have, or would have, occupied without direct or indirect introduction and/or care by humans. Excludes species descended from domesticated ancestors) (Vitousek *et al.* 1995).

**Natural areas.** Natural areas: Areas with native plant communities supporting native plant and animal species, with long undisturbed soil systems, and hydrological regimes relatively intact or under restoration. Edges of historically or currently disturbed areas (roadsides, trails, adjacent to historically disturbed locations, etc.) should not be included in the assessment of invasion into natural areas. That invasion may have been facilitated by the edges, but has to have extended into the native communities for inclusion in this category.

**Pollen or genetic invasion.** When a native species is displaced by a non-native species through hybridization.

**Stratum.** A distinct layer in the architecture of vegetation (e.g., tree canopy or understory shrubs).