Maryland Department of Agriculture

Weed Risk Assessment for *Corydalis incisa* (Thunb.) Pers. (Papaveraceae) – Incised fumewort

October 2017

Version 2

Left: A patch of *C. incisa* (small-statured plants) in New York growing among emerging Japanese knotweed [source: Christina Andruk (2017), Iona College]. Top right and bottom right: Flowers and fruit pods of plants growing in Virginia [source: Gary Fleming (2017), Virginia Department of Conservation and Recreation]. Additional images can be found in Appendix B.

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Introduction

The Maryland Department of Agriculture regulates terrestrial ornamental invasive plants under the authority of Md. AGRICULTURE Code Ann. § 9.5-101 et seq. Invasive Plant Prevention and Control. An invasive plant is defined as “a terrestrial plant species that a) did not evolve in the State, and b) if introduced within the State, will cause or is likely to cause, as determined by the Secretary: economic harm; ecological harm; environmental harm; or harm to human health.”

Maryland’s Invasive Plant Advisory Committee (IPAC) was established by legislative mandate in October 2011. The IPAC’s primary responsibility is to advise the Secretary of Agriculture on regulating the sale of invasive plants, and on preventing them from entering Maryland or from spreading further in the state. The IPAC evaluates the risk potential of plants already present in Maryland, newly detected in the Maryland or the United States, those proposed for import, and those emerging as weeds elsewhere in the world.

The IPAC evaluates the potential invasiveness of plants using the weed risk assessment (WRA) process developed by the Plant Protection and Quarantine (PPQ) Program of the US Department of Agriculture’s Animal and Plant Health Inspection Service (Koop et al. 2012). PPQ’s risk model uses information about a species’ biological traits and behavior to evaluate its risk potential (Koop et al. 2012).

Because the PPQ WRA model is geographically and climatically neutral, it can be used to evaluate the baseline invasive/weed potential of any plant species for the entire United States, or for any specific region in the United States. In the PPQ process, the geographic potential of the species is evaluated separately so that risk managers can make decisions appropriate for their regions. With respect to Maryland’s evaluation process, we use PPQ’s Geographic Information System overlays of climate to evaluate the potential for a plant to establish and grow in Maryland. The PPQ weed risk assessment also uses a stochastic simulation to evaluate how the uncertainty associated with the assessments affects the model’s predictions. Detailed information on the PPQ WRA process is available in the document, Guidelines for the USDA-APHIS-PPQ Weed Risk Assessment Process (APHIS PPQ 2015), which is available upon request.

The IPAC uses a second tool, the Maryland Filter, to assign plant species that score as highly invasive either Tier 1 or Tier 2 status. Maryland regulations define Tier 1 plants as “invasive plant species that cause or are likely to cause severe harm within the State” and Tier 2 plants as “invasive plant species that cause or are likely to cause substantial negative impact within the State.” The Maryland Filter considers the actual and potential distribution of a species in Maryland, its threat to threatened and endangered ecosystems and species in the state, the difficulty of control of the species, and whether added propagule pressure would be likely to increase its persistence and spread significantly. The IPAC then recommends regulations to reduce the risk of the Tiered invasive plants in Maryland.

1. Plant Information and Background

SPECIES: *Corydalis incisa* (Thunb.) Pers. (NGRP, 2017).

FAMILY: Papaveraceae (NGRP, 2017), but also listed in the Fumariaceae (NRCS, 2017).

SYNONYMS: *Fumaria incisa* Thunb. (NGRP, 2017), *Capnoides incisa* Kuntze (The Plant List, 2017). The Plant List (2017) lists additional synonyms at the infraspecific level.

COMMON NAMES: Incised fumewort (EDDMapS, 2017; NRCS, 2017), purple keman (Atha et al., 2014a), murasa-kike-man (Japanese; Tebbitt et al., 2008).

BOTANICAL DESCRIPTION: *Corydalis incisa* is an annual or biennial, spring-ephemeral herb growing 10-50 cm tall (Atha et al., 2014b; Ohwi, 1984; Tebbitt et al., 2008; Zhang et al., 2008; Zhang et al., 2009). Seeds germinate in the spring and develop small rosettes, which wither during the summer. They emerge again as rosettes throughout the winter and produce compact flowering racemes the following spring (Tebbitt et al., 2008). Leaves are stalked and twice pinnately compound with acutely serrate leaflets (Tebbitt et al., 2008). Racemes are 3-12 cm tall (Ohwi, 1984) and 6- to 23-flowered (Zhang et al., 2009). Flowers are rose-purple, 12-18 mm long (Ohwi, 1984) and possess a nectary in the floral spur (Zhang et al., 2008). Seed capsules are oblong, 12-18 × 2.5-3 mm in size and 6-12-seeded. Seeds are about 1.5 mm in size (Nakanishi, 1994) and possess a small elaiosome[1] (Zhang et al., 2008). See Zhang et al. (2008) for a line drawing of the species, and Anonymous (2017) for a line drawing of a seed and burst seed capsule. For a full botanical description, see Zhang et al. (2008).

INITIATION: USDA APHIS evaluated this species due to concerns originating in New York state (see below), where the plant is newly introduced but is already creating ecological problems in floodplain systems. For most of its WRAs, APHIS uses only international literature and data to assess a species. When IPAC uses an APHIS-completed WRA, we add any available US information to complete the risk assessment. We decided to adopt the APHIS WRA for Corydalis incisa without modification because: 1) US data were included in this APHIS analysis; 2) the species is relatively new in the nursery trade and so not widely distributed, but we have at least one escaping population reported in the state; and 3) we have addressed the impacts on rare species in the Maryland Filter rather than the body of the WRA.

On May 11, 2017, Renee Johnson with the Congressional Research Service asked an APHIS representative whether PPQ regulates this plant in any way (Rudyj, 2017). In a follow-up inquiry, she asked why, if it is invasive, we do not regulate its movement. According to an APHIS Legislative and Public Affairs specialist, these questions originated with Senator Schumer's office in New York (Rudyj, 2017). Senator Schumer's office had also contacted Dr. Christina Andruk (Andruk, 2017) in response to an article that appeared on the species in the Lower Hudson Journal News (Reiner, 2017). As a way to better understand the status of this species and the risk that it poses, Jonathan Jones, PPQ Federal

[1] Elaiosomes are small, lipid and protein rich, fleshy structures that are attached to plant seeds and which help attract dispersers.

Noxious Weed policy manager, asked PERAL on May 18, 2017, to characterize the risk of this species. After reviewing that analysis (PPQ, 2017) on June 12, 2017, the PPQ Weeds Cross-Functional Working Group decided that the species needed to be evaluated more carefully, and requested that PERAL conduct a weed risk assessment.

WRA AREA[2]: Entire United States, including territories.

FOREIGN DISTRIBUTION: *Corydalis incisa* is native to China, Korea, Japan, and Taiwan (NGRP, 2017), and is reported to be widespread and common in this range (Choi et al., 2007; Ohwi, 1984; Tebbitt et al., 2008). It has been introduced to Australia (Randall, 2007) and the United Kingdom (Rare Plants, 2017). It is cultivated in the United Kingdom (Rare Plants, 2017) and possibly France, where seeds are sold online by one vendor (B&T World Seeds, 2017). This species does not appear to be commonly cultivated in Europe, as it does not appear in the European Garden Flora (Cullen et al., 2011). It is thought to have been recently introduced from China into cultivation (Tebbitt et al., 2008). Of the approximate 400 species in the genus *Corydalis*, there are about 150 species in cultivation in Europe and North America (Burrell, 2003; Tebbitt et al., 2008). Many of these species have recently entered into cultivation through commercial Chinese internet-based companies that ship seeds globally (Tebbitt et al., 2008). In a review of the horticultural and introduction history of *Corydalis*, Tebbitt et al. (2008) do not specifically discuss *C. incisa*, supporting the idea that this species is not commonly cultivated.

U.S. DISTRIBUTION AND STATUS: *Corydalis incisa* was first detected outside of cultivation in Bronx County, NY, in 2005, and may have been present there for a few years before that (Lamont et al., 2011). Since then, it has been reported in Washington, DC (Anonymous, 2017), and in eight counties in six U.S states: Westchester County, NY (Kartesz, 2017; NRCS, 2017); Fairfax, Albemarle, and Rock-Bridge counties, VA (EDDMapS, 2017; Virginia Botanical Associates, 2017; Weakley, 2015); Greenbrier County, WV (Tuckwiller, 2006); Montgomery County, MD (Anonymous, 2017); Chester County, PA (Anonymous, 2017); and Davidson County, TN (SERNEC Data Portal, 2017). In the Bronx River Parkway Reservation, it is infesting 13,971 m^2 of forests across 39 separate populations [Andruk, Hudson, and Nolan, unpublished data (provided by Andruk, 2017)]. In Virginia, it is known from five sites in three counties (Virginia Botanical Associates, 2017). In New York, it was recently detected at two other sites (Teatown Lake Reservation Nature Preserve and Nature Study Woods) in Westchester County, but in a watershed different from that corresponding to the Bronx River (Schuler, 2017). It was also found in a flower bed at Scarsdale Public Library that was nowhere near a river (Andruk, 2017). Given its rapid appearance over the last 12 years, this species is probably more widespread than records indicate (Andruk, 2017; Fleming, 2017). What is believed to be *Corydalis incisa* has also been reported growing in a plant bed at Cornell Botanic Gardens in New York, but these plants have not

[2] "WRA area" is the area in relation to which the weed risk assessment is conducted [definition modified from that for "PRA area"] (IPPC, 2012).

become naturalized as they are being actively pulled up as they emerge (Maurer, 2017). Figure 1 shows the current known U.S. distribution of *C. incisa.*

It is unknown how *C. incisa* was introduced to the United States (Anonymous, 2017), but it was most likely imported as an ornamental, given the horticultural interest in the genus (Sundue, 2005; Tebbitt et al., 2008). Atha et al. (2016a) report that it is cultivated in the United States and has been sold by one botanical garden in Virginia, which stopped selling it once they were informed that it was invasive. Other authors report that *C. incisa* has become a popular ornamental plant (Lamont et al., 2011); however, we found no evidence that it is commonly cultivated (e.g., Amazon, 2017; Bailey and Bailey, 1976; Brenzel, 1995; Dave's Garden, 2017; eBay, 2017; Page and Olds, 2001; also see Ossi, 2017). Plant Information Online (Univ. of Minn., 2017) lists only one nursery that is selling this species. However, when we visited the nursery's website, their list of plants reflects their plant collection and not necessarily the plants they have available for sale (Glick, 2017b). Tebbitt et al. (2008) report that a few specialist nurseries occasionally offer the species for sale. We found no evidence that this species is regulated in the United States.

Resource managers and volunteers are removing plants from natural areas along the Bronx River and the grounds of the New York Botanical Garden (Atha et al., 2016b; Schuler, 2017). Officials with the Fairfax County government removed plants that appeared at the Confederate Fortifications Historic Site (Kyde, 2017). A few homeowners in Washington, DC; Clarksburg, MD; and Virginia have been struggling to get rid of plants that have become established in their yards through hand-pulling and use of a flame-torch (Dave's Garden, 2017; Fleming, 2017; Kaufman, 2017). Experts believe that *C. incisa* can be eradicated from the Bronx River Parkway Reservation in Westchester County given that it occupies only one percent of the area (Andruk, 2017; Atha et al., 2016a).

3. Analysis

ESTABLISHMENT/SPREAD POTENTIAL

As demonstrated by its status in the United States, *C. incisa* exhibits a strong ability to escape and spread. It is a shade-tolerant (Fleming, 2017; Glick, 2017b) annual/biennial (Zhang et al., 2008) that is self-compatible (Zhang et al., 2009) and has a high reproductive capacity (Nakanishi, 1994). Plants ballistically eject seeds out of the fruit pods up to three meters away (Nakanishi, 1994). Seeds can then be further dispersed by either ants (Andruk, 2017; Zhang et al., 2008) or water (Atha et al., 2016a). U.S. evidence indicates that plants are likely being dispersed as contaminants in nursery material (Maurer, 2017). Plants are able to form dense patches and seem tolerant to hand-pulling and clipping at certain stages of their life cycle [Atha et al., 2016a; Atha et al., 2014b; Andruk, Hudson, and Nolan, unpublished data (provided by Andruk, 2017)]. Overall, we had low uncertainty for this risk element.

Risk score = 18 Uncertainty index = 0.12

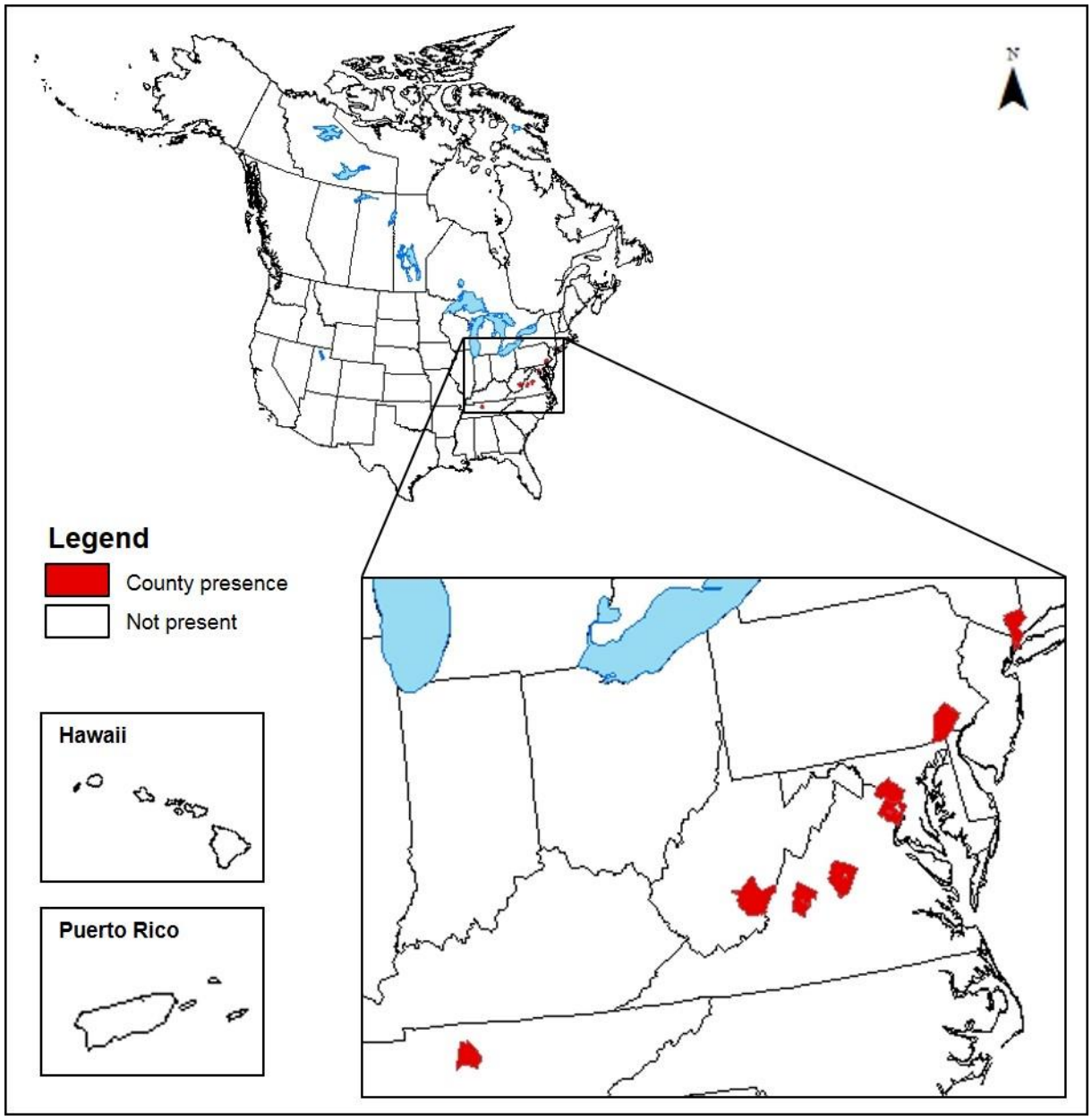

Figure 1. Known naturalized distribution of *Corydalis incisa* in the United States and Canada. The records shown here were obtained from various sources as described under U.S. Distribution and Status. Scales differ for Hawaii, Puerto Rico, and the continental United States and Canada.

IMPACT POTENTIAL

Given that this species has only recently become invasive, there is little detailed information on its impacts. In New York, dense populations of *C. incisa* dominate the understory, displacing native species and increasing the density of the herbaceous community (Atha et al., 2016a; Schuler, 2017). It may pose a threat to rare spring ephemerals, particularly if *C. incisa* emerges before native species and it usurps the available niche. Andruk (Andruk, 2017) found during the 2016-2017 winter season, green plants covered by snow, supporting the idea that they could rapidly grow and flower in early spring. Although we found no specific evidence that this species is toxic, *Corydalis* species in general are toxic to livestock and can result in death within a few hours of consumption (Burrows and Tyrl, 2013). The majority of *C. incisa*'s impact risk score obtained was due to the fact that it is weedy and controlled in natural, anthropogenic, and productions systems. In New York and Virginia, staff and volunteers are removing it from natural areas (Atha et al., 2014a; Kyde, 2017), and a researcher is investigating the effectiveness of different control strategies (Andruk, 2017). In Maryland and Virginia, homeowners have been struggling to remove plants from their gardens (Dave's Garden, 2017; Fleming, 2017; Kaufman, 2017). Park officials with the Fairfax County, VA, government removed plants that appeared at the Confederate Fortifications Historic Site (Kyde, 2017). The owner of a West Virginia nursery is removing *C. incisa* plants as soon as they appear, as the species has become invasive there (Glick, 2017a; Tuckwiller, 2006). Overall, we had very high uncertainty for this risk element.

Risk score = 3.1 Uncertainty index = 0.30

GEOGRAPHIC POTENTIAL

Based on three climatic variables, we estimate that about 37 percent of the United States is suitable for the establishment of *C. incisa* (Fig. 2). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and general areas of occurrence. The map for *C. incisa* represents the joint distribution of Plant Hardiness Zones 6-10, areas with 20-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: humid subtropical, marine west coast, humid continental with warm summers, and humid continental with cool summers. Although we found no evidence that *C. incisa* occurs in Mediterranean climates, we believe this climate class is potentially suitable because the plants are normally dormant during the summer (Tebbitt et al., 2008) when conditions are driest in Mediterranean climates. Consequently, *C. incisa* may also be able to grow in coastal regions of the western United States.

The area of the United States shown to be climatically suitable (Fig. 2) for species establishment considered only three climatic variables. Other variables, for example, soil and habitat type, novel climatic conditions, or plant genotypes, may alter the areas in which this species is likely to establish. In its native range in Asia, *C. incisa* occurs along stream valleys, irrigation channels, and forest margins; in wastelands, roadsides, and forestlands; and on rock walls (Nakanishi, 1994; Zhang et al., 2008; Zhang et al., 2009). In the United States, it grows in mesic and alluvial forest habitats (Fleming, 2017). Under horticultural conditions, *C. incisa* prefers cooler exposures (Tebbitt et al., 2008).

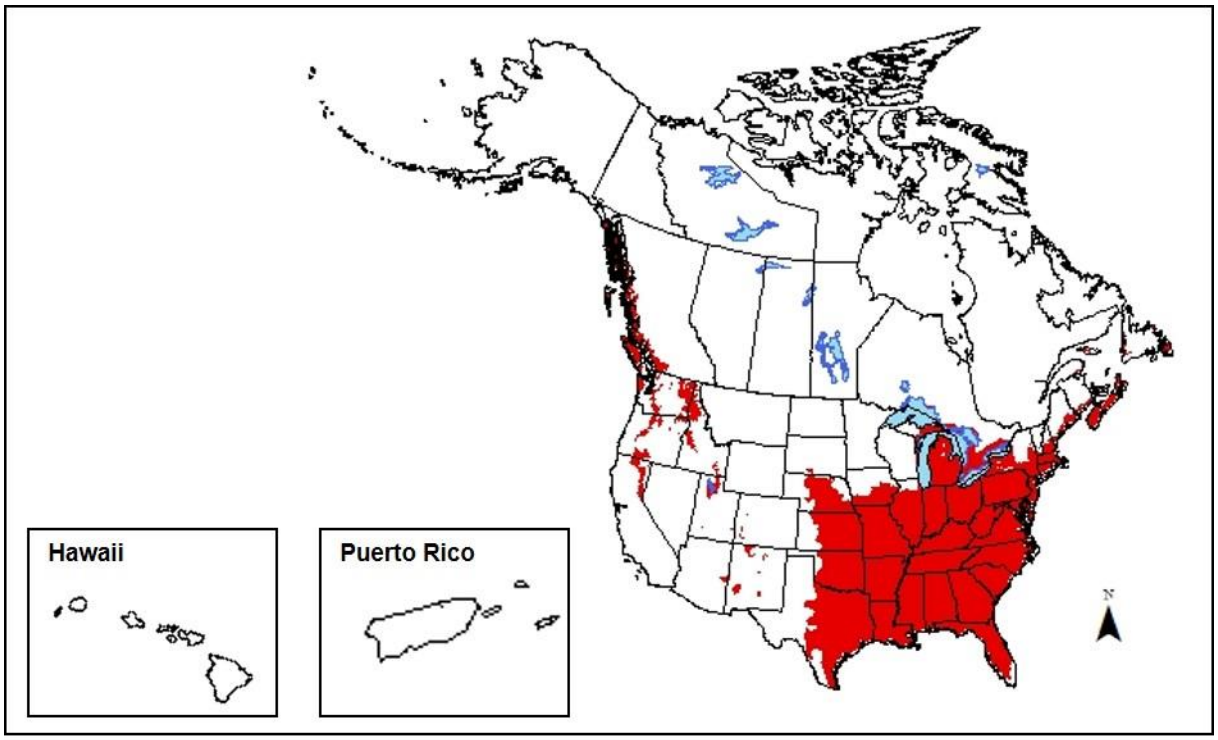

Figure 2. Potential geographic distribution (shown in red) of *Corydalis incisa* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

ENTRY POTENTIAL

Corydalis incisa is already present in the United States in a few localities along the east coast (Fig. 1). It was most likely introduced for cultivation. We categorized its entry potential to evaluate the overall likelihood of its introduction. On a scale of 0 to 1, where 1 represents the maximum likelihood, *C. incisa* obtained a value of 0.58 on our assessment scale. The most likely pathway by which additional material of this species would enter the United States is plants for planting. *Corydalis incisa* is a member of a popular genus of ornamental plants that add a variety of color to spring gardens (Tebbitt et al., 2008). However, because it is used in China and Japan in folk medicine to treat inflammation, headaches, skin diseases, and other ailments (Choi et al., 2007), it may also be imported as an herbal plant for cultivation or by researchers interested in studying its phytochemistry (e.g., Choi et al., 2007; Kim, 2002; Nonaka and Nishioka, 1974). *Corydalis incisa* may also potentially enter the United States as a contaminant of nursery stock (Maurer, 2017; Nolan, 2017).

Risk score = 0.58 Uncertainty index = 0.10

4. Predictive Risk Model Results

Model Probabilities: P(Major Invader) = 87.8%
P(Minor Invader) = 11.8%
P(Non-Invader) = 0.4%
Risk Result = High Risk
Secondary Screening = Not Applicable

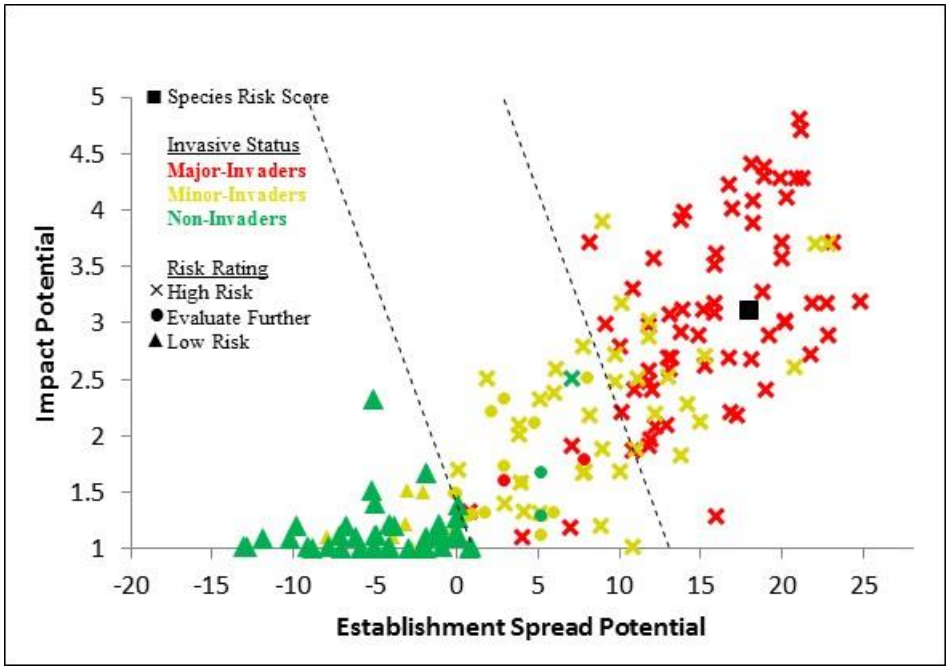

Figure 3. *Corydalis incisa* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

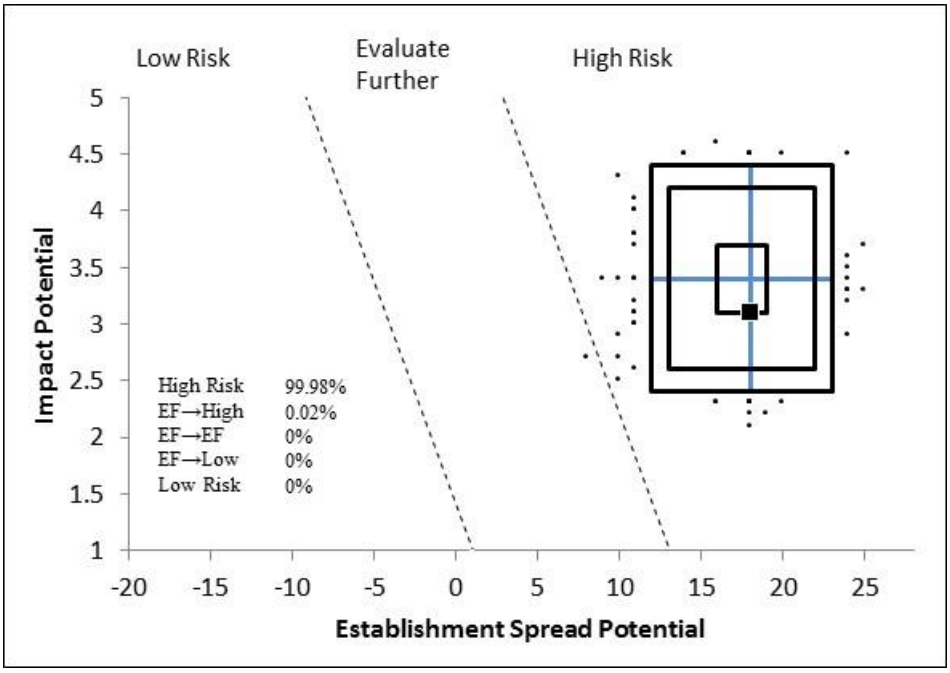

Figure 4. Model simulation results (N=5,000) for uncertainty around the risk score for *C. incisa*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

5. Discussion

The result of the weed risk assessment for *Corydalis incisa* is High Risk (Fig. 3). Overall, we had a low level of uncertainty about this species' ability to establish and spread, but a very high level of uncertainty about its potential impact. This is not surprising, given that it only recently became naturalized, and that it often takes many years before the full set of impacts of an invasive species is realized and documented. Some of the answers in this assessment were based on evidence provided through personal communication with garden staff, researchers, and others who have observed this species in the United States. It is important that this information be verified or quantified with formal studies, and that it be published in peer-reviewed journals to reduce uncertainty. However, despite the uncertainty associated with the assessment, our simulation shows that our final conclusion of high risk is statistically robust (Fig. 4).

Corydalis incisa is an emerging invader that poses a threat for some natural, production, and anthropogenic systems in the United States (e.g., Atha et al., 2014a; Kyde, 2017; Ossi, 2017). Of particular concern is its ability to form dense patches and disperse long distances. Since this species was first detected in New York in 2005 (Lamont et al., 2011), the original population has expanded (Atha et al., 2014b) and the species has been detected in about two dozen other sites in eight counties

in six U.S. states and the District of Columbia (Fig. 1). While its population growth rate[3] has not been measured, in all likelihood, it is probably relatively high. For example, the population growth rate of *C. aurea*, a similar biennial species that is native to the United States, was 2.05 for control plants and 2.83 for ant-dispersed plants (Hanzawa et al., 1988), indicating that the studied populations were at least doubling in size each year. *Corydalis incisa* may be experiencing similar, if not higher, population growth rates.

6. Acknowledgments

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SUGGESTED CITATION

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[3] The average rate of increase in the population per individual per year.

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Appendix A. Weed risk assessment for *Corydalis incisa* (Thunb.) Pers. (Papaveraceae)

Below is the evidence and associated references used to evaluate the risk potential of this taxon. We also include the answer, uncertainty rating, and score for each question. The Excel file, where this assessment was conducted, is available upon request.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 [What is the taxon's establishment and spread status outside its native range? (a) Introduced elsewhere =>75 years ago but not escaped; (b) Introduced <75 years ago but not escaped; (c) Never moved beyond its native range; (d) Escaped/Casual; (e) Naturalized; (f) Invasive; (?) Unknown]	f - negl	5	*Corydalis incisa* is native to China, Korea, Japan, and Taiwan (NGRP, 2017) and is reported to be widespread and common in this range (Choi et al., 2007; Ohwi, 1984; Tebbitt et al., 2008). It has been introduced to Australia (Randall, 2007) and the United Kingdom (Rare Plants, 2017), and is cultivated in the United Kingdom (Rare Plants, 2017). *Corydalis incisa* was first detected outside of cultivation in Bronx County, NY, in 2005, and may have been present there for a few years before that (Lamont et al., 2011). Since then, it has been reported in Washington, DC (Anonymous, 2017), and in eight counties in six U.S. states (Anonymous, 2017; EDDMapS, 2017; Kartesz, 2017; NRCS, 2017; SERNEC Data Portal, 2017; Tuckwiller, 2006; Virginia Botanical Associates, 2017; Weakley, 2015).The U.S. occurrences represent the first records of this species naturalizing beyond its native range. Along one part of the Bronx River, NY, *C. incisa* forms a more or less continuous population for two kilometers (Atha et al., 2016a). The population along the Bronx River has persisted and expanded since it was first discovered (Atha et al., 2014b). At the New York Botanical Gardens, new patches appear every year, and old ones expand in size (Schuler, 2017). "In Virginia, *Corydalis incisa* has gone from being "new to the state's flora (at a single site) to being known from several sites in three far-flung counties in a period of about three years" and there is "little doubt that this species has been spreading 'under the radar' for some time..." (Fleming, 2017). In a residential garden in Washington, DC, this species volunteered and quickly spread throughout the garden (Dave's Garden, 2017). This species is becoming invasive in the United States (SERNEC Data Portal, 2017; Weakley, 2015). Alternate answers for the uncertainty simulation were both "e."
ES-2 (Is the species highly domesticated)	n - negl	0	*Corydalis incisa* appears to have only recently entered into cultivation (Tebbitt et al., 2008). We found no evidence of domestication or breeding efforts.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-3 (Significant weedy congeners)	n - mod	0	There are about 400 species in the genus *Corydalis* (Mabberley, 2008), and 32 of them have been reported as weedy, invasive, or naturalized (Randall, 2017). Of these, only two may represent significant weeds based on the number of cited references in the Global Compendium of Weeds (*Corydalis lutea*) or the species' global risk score (*C. solida*) (Randall, 2017). However, additional review does not indicate that either of these species should be considered significant weeds.
ES-4 (Shade tolerant at some stage of its life cycle)	y - negl	1	*Corydalis incisa* grows in shady (Fleming, 2017) and semi-shade habitats (PFAF, 2017). It is shade-tolerant (Ossi, 2017) and does equally well in sun as in shade (Glick, 2017b). *Corydalis lutea* is reported to grow in full shade (MBG, 2017).
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - low	0	*Corydalis incisa* is a terrestrial herb growing 10 to 50 cm tall (Atha et al., 2014b; Ohwi, 1984; Tebbitt et al., 2008; Zhang et al., 2008). It is not a vine. Although seedlings form a rosette of leaves in their first year (Tebbitt et al., 2008), we found no evidence that they form a rosette of tightly appressed leaves.
ES-6 (Forms dense thickets, patches, or populations)	y - negl	2	Along the Bronx River, *C. incisa* forms dense populations (Atha et al., 2014b). Along one part of the Bronx River, it forms a more or less continuous population for two kilometers (Atha et al., 2016a). At one site, plants occurred at an average density of 42 plants per square meter, with one square-meter plot reaching 112 plants (Atha et al., 2016a). Thirty-two seedlings were detected in an area of 15 square inches in New York (Atha et al., 2014a). Other estimates report an average of 29 adults and 20 juveniles per square meter [Andruk, Hudson, and Nolan, unpublished data (provided by Andruk, 2017)].
ES-7 (Aquatic)	n - negl	0	*Corydalis incisa* is a terrestrial herb growing 10 to 50 cm tall (Tebbitt et al., 2008; Zhang et al., 2009); it is not an aquatic plant.
ES-8 (Grass)	n - negl	0	This species is not a grass. It is an herb in the Papaveraceae family (NGRP, 2017).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that this herbaceous species fixes nitrogen. Because it is neither a woody plant nor a member of a plant family that is known to contain nitrogen-fixing species (Martin and Dowd, 1990; Santi et al., 2013), we used negligible uncertainty.
ES-10 (Does it produce viable seeds or spores)	y - negl	1	*Corydalis incisa* is an annual or biennial species that reproduces through seed production (Tebbitt et al., 2008). In the United States, it is spreading through seed production (Atha et al., 2014a). We found no evidence that it reproduces vegetatively.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-11 (Self-compatible or apomictic)	y - negl	1	This species is a facultative outcrosser, indicating that it sets seed through both selfing and outcrossing. Seed set of caged flowers was about 21 percent, while that of hand-pollinated and open-pollinated flowers was 67 and 80 percent, respectively (Zhang et al., 2009). "Like most annual or biennial *Corydalis* species, *C. incisa* is self-fertile, so only a single plant is needed to set seed" (Tebbitt et al., 2008).
ES-12 (Requires specialist pollinators)	n - negl	0	Because the flowers of this species can self-pollinate, it does not depend on pollinators, although pollinators do enhance seed set (Zhang et al., 2009). Flowers have spurs that collect plant nectar that is attractive to bees (Zhang et al., 2008). In one portion of its native range in China, flowers are pollinated by the following bees: *Apis cerana*, *Colletes arnicularis*, and *Amegilla zonata*. The bees *Xylocopa sinensis* and *Bombus pyrosoma* act as nectar robbers (Zhang et al., 2009).
ES-13 [What is the taxon's minimum generation time? (a) less than a year with multiple generations per year; (b) 1 year, usually annuals; (c) 2 or 3 years; (d) more than 3 years; or (?) unknown]	b - low	1	*Corydalis incisa* is an herbaceous species with annual and biennial forms (Tebbitt et al., 2008; Zhang et al., 2008). The annual form of this species is more common in northern China (Zhang et al., 2008). Because we found no evidence of multiple generations per year, we answered this question as "b." Both alternate answers for the uncertainty simulation were "c."
ES-14 (Prolific seed producer)	y - mod	1	*Corydalis incisa* produces a 3-12 cm raceme that is 6- to 20-flowered (Atha et al., 2016a; Tebbitt et al., 2008). Seed capsules are oblong, and 6- to 12-seeded (Zhang et al., 2008). In one Chinese study, the percentage of ovules resulting in seeds ranged from 62 to 74 percent (Zhang et al., 2009). In a Japanese study, there were on average about 12 seeds per capsule and the authors estimated that plants produce on average 10,741 seeds per plant (Nakanishi, 1994). Although we found no data on reproductive rates expressed on a per-square-meter basis, it seems quite likely that each square meter could have several flowering adults, as these are small herbaceous plants. Assuming that at least half of the seeds are viable, and that there is at least one adult plant per square meter, this species would exceed our threshold of 5000 viable seeds per square meter. At densities of about 42 plants per square meter (Atha et al., 2016a), tens of thousands of seeds are likely being produced. Based on reproductive rates from June in New York, Andruk et al. estimate reproductive rates of about 459 viable seeds per square meter (Andruk, Hudson, and Nolan, unpublished data), but believe total season fertility could exceed 5000 seeds per square meter (Andruk, 2017). Other U.S. field biologists

Question ID	Answer - Uncertainty	Score	Notes (and references)
			consider this species as having prolific reproduction (Atha et al., 2016a; Fleming, 2017).
ES-15 (Propagules likely to be dispersed unintentionally by people)	? - max	0	We found no direct evidence that this species is unintentionally dispersed by human activity. Although seeds are explosively dispersed up to three meters away from parent plants (Nakanishi, 1994) and could easily get caught in the shoes and pant-hems of hikers, because seeds are relatively short lived outside of natural conditions (Tebbitt et al., 2008), their potential for long-distance dispersal may be limited. Consequently, we answered unknown.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y – low	2	In 2017, horticulturalists at Cornell Botanic Gardens discovered what they believe to be *Corydalis incisa* growing in an area dedicated to groundcovers (Maurer, 2017). Since the plants were not intentionally accessioned into the garden's collection, garden staff are certain they were introduced as contaminants of nursery stock in the last year or two (Maurer, 2017). Suzanne Nolan, who discovered the plants, noted that they were growing adjacent to some hellebores that were planted in 2013 (Nolan, 2017). Considering that seeds of *C. incisa* are explosively dispersed up to three meters away from parent plants (Nakanishi, 1994), seeds could easily contaminate nursery stock if production sites are not kept weed free. In New York, some plants were recently found in a flower bed at Scarsdale Public Library that was nowhere near an established population, suggesting they were contaminants of the ornamental plants (Andruk, 2017). At the time that *C. incisa* was first detected along the Bronx River, there were several ongoing landscaping and river restoration projects along the river (Nolan, 2017), but there is no definitive evidence that these plantings resulted in the introduction of the species. Ossi (2017) commented that *C. incisa* may spread in soil in shipments of other plants. We found no other evidence that this species or any *Corydalis* species is hitchhiker or trade contaminant (e.g., AOSA, 2014; AQAS, 2017).
ES-17 (Number of natural dispersal vectors)	2	0	Propagule traits for ES-17a through ES-17e: Seed capsules are oblong, 12-18 x 2.5-3 mm, and 6- to 12-seeded. Seeds are ejected out of the pods up to three meters away when the fruit burst open (Nakanishi, 1994). Seeds are about 1.5 mm in size (Nakanishi, 1994) and have a small elaiosome that represents about 10 percent of the weight of the propagule (Nakanishi, 1994; Zhang et al., 2008).
ES-17a (Wind dispersal)	n - negl		We found no evidence that this species is wind dispersed. Because seeds do not possess any traits

Question ID	Answer - Uncertainty	Score	Notes (and references)
			characteristic of wind dispersal, we used negligible uncertainty.
ES-17b (Water dispersal)	y - negl		In central China, populations occur along stream valleys (Zhang et al., 2009). In New York, the populations of *C. incisa* are located along the Bronx river (Atha et al., 2014a). It is believed it is spreading downstream, as new patches continue to appear in areas that flood at the New York Botanical Garden (Schuler, 2017). Seeds are believed to be dispersed down river by floods, as they are buoyant (Atha et al., 2016a). A naturalist in Virginia has noted that it tends to occur near streams and suspects it is dispersed by water (Kyde, 2017). Based on this evidence, we answered yes with negligible uncertainty.
ES-17c (Bird dispersal)	n - mod		We found no evidence.
ES-17d (Animal external dispersal)	y - negl		Seeds of *C. incisa* are dispersed by ants in New York [Andruk, Hudson, and Nolan, unpublished data (provided by Andruk, 2017)] and in China (cited in Zhang et al., 2009). They possess small elaiosomes (Zhang et al., 2008), which are generally attractive to ants (Tebbitt et al., 2008). All species of *Corydalis*, except two, are dispersed by ants (Tebbitt et al., 2008; van der Pijl, 1982). In one experiment in China, ants removed seeds of *C. giraldii,* which also have elaiosomes (Jiang and Wang, 2015). An experiment with another species of *Corydalis* showed that ants moved seeds on average about 6 meters away (Zhu and Wang, 2014).
ES-17e (Animal internal dispersal)	n - mod		We found no evidence.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	We found no information about seed longevity for *C. incisa*. Seeds of the bleeding heart family, which includes *Corydalis*, are intolerant of dry storage (Tebbitt et al., 2008). In a planting experiment involving 4880 seeds of *C. aurea*, 2.6 percent of the seedlings emerged in the first year, 1 in the second year, and none in the following two years (Hanzawa et al., 1988), suggesting that this species does not form a long-term seed bank. Because of the general lack of information on this trait and because it seems odd that an annual/biennial would not have some form of long-term persistence, we answered unknown.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - mod	1	First year plants form fusiform tubers about 12 x 5 mm in size (Atha et al., 2014b; Tebbitt et al., 2008). Hand-pulling first year plants is not recommended because the tubers may break off when plants are pulled; however, hand-pulling is not problematic with second-year plants (Atha et al., 2016a). In a greenhouse study on the effects of photoperiod on

Question ID	Answer - Uncertainty	Score	Notes (and references)
			growth and reproduction of *C. incisa*, researchers incorporated an inflorescence-clipping treatment into the experiment and discovered that clipped plants were able to produce additional flower stalks, indicating some resiliency to biomass loss [Andruk, Hudson, and Nolan, unpublished data (provided by Andruk, 2017)].
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence that this species or any *Corydalis* species has developed herbicide resistance (e.g., Heap, 2017).
ES-21 (Number of cold hardiness zones suitable for its survival)	5	0	
ES-22 (Number of climate types suitable for its survival)	4	2	
ES-23 (Number of precipitation bands suitable for its survival)	9	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	? - max		Plants in the genus *Corydalis*, including *C. incisa*, produce the fungitoxic secondary metabolites corynoline and acetylcorinoline, which have been shown to have significant activity against the plant pathogen *Cladosporium herbarum* and are presumed to be important in plant defenses (Ma et al., 1999). However, we found no evidence of allelopathic effects under field conditions.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that *C. incisa* is a parasitic plant. Because it is not a member of a plant family known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009), we answered no with negligible uncertainty.
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - high	0	We found no evidence of this impact. Because this species invades natural areas and is not well studied, we answered no with high uncertainty.
Imp-N2 (Changes habitat structure)	y - mod	0.2	Because of the dense populations it forms (i.e., herbaceous carpets), it has significantly increased the density of forest understory habitats (Schuler, 2017).
Imp-N3 (Changes species diversity)	y - low	0.2	*Corydalis incisa* forms dense populations that dominate the herbaceous understory and displace natives (Atha et al., 2016a). It competes with native riparian understory plants, including *Polygonum virginianum*, *Ageratina altissima*, *Impatiens capensis*, and *Laportea canadensis* (Atha et al., 2014a). It excludes native species (Schuler, 2017).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	? - max		There are many rare spring ephemerals blooming at the same time as *C. incisa* (Andruk, 2017), so it is possible that *C. incisa* poses a potential threat to these.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - high	0	We found no evidence.
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	c - negl	0.6	*Corydalis incisa* is establishing in mesic and alluvial forest habitats in the United States (Fleming, 2017) and is garnering the attention of plant biologists, conservationists, and invasive species councils as an emerging weed of natural areas (e.g., Atha et al., 2014a; Kyde, 2017; Ossi, 2017). Staff at the New York Botanical Garden are removing plants from wild, semi-natural areas in the garden (Atha et al., 2014a). During a 2016 special survey conducted along a 20-km stretch of the Bronx River, volunteers looked for *C. incisa* plants along 100 meter transects every kilometer, and removed all plants within those transects (Atha et al., 2016a). Experts believe that this species can be eradicated from the Bronx River (Atha et al., 2016a). A homeowner in Virginia found a patch of about 40 plants growing along Red Bud Creek, pulled them up, and returned the following year to pull up new recruits (Kyde, 2017). A study is underway in the Bronx River Parkway Reservation to evaluate the efficacy of alternative control strategies (Andruk, 2017). Alternate answers for the uncertainty simulation were both "b."
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	n - low	0	We found no evidence. Because it seems unlikely that this small-statured biennial herb would have this impact, we used low uncertainty.
Imp-A2 (Changes or limits recreational use of an area)	n - low	0	We found no evidence. Because it seems unlikely that this small-statured biennial herb would have this impact, we used low uncertainty.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	? - max		A homeowner reported in the Dave's Garden forum (2017) that they had to weed out plants from their garden after it quickly spread through their garden. Because they never stated whether it actually affected or outcompeted their garden plants, we answered this question as unknown.
Imp-A4 [What is the taxon's weed status in anthropogenic systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	c - negl	0.4	*Corydalis incisa* is considered a weed in Japan (Enomoto, 2003), including in gardens (Anonymous, 2012). Staff at the Cornell Botanic Garden have been removing plants that have become established (Atha et al., 2014a; Atha et al., 2016b; Maurer, 2017). A few homeowners in Washington DC; Clarksburg MD; and Virginia have been struggling to get rid of plants that have become established in their yards through hand-pulling and use of a flame-thrower (Dave's Garden, 2017; Fleming, 2017; Kaufman, 2017). Officials with the Fairfax County, VA, government removed plants that appeared at the Confederate Fortifications

Question ID	Answer - Uncertainty	Score	Notes (and references)
			Historic Site (Kyde, 2017). Alternate answers for the uncertainty simulation were both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - high	0	We found no evidence of this impact.
Imp-P2 (Lowers commodity value)	n - high	0	We found no evidence of this impact.
Imp-P3 (Is it likely to impact trade?)	n - low	0	Although this species is very likely moving as a contaminant in the nursery trade (see evidence under E/S-16), we found no evidence that it or any other species of *Corydalis* is regulated by any government agency (e.g., APHIS, 2017; USDA-AMS, 2016).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0	*Corydalis incisa* occurs along irrigation channels in its native range in China (Zhang et al., 2008). However, we found no evidence that it reduces the availability or distribution water. Because the species is toxic (see evidence under Imp-P5), large infestations might affect the quality of water, but we found no evidence of this.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	y - mod	0.1	We found no specific evidence that *C. incisa* is toxic; however, the genus is toxic, presumably because of the diverse array of isoquinoline alkaloids the species contain (Burrows and Tyrl, 2013). Sympton onset is rapid, usually occurring within a few hours of ingestion and is manifested by depression; increased respiratory and heart rates; twitching of lips, face, and eyelids; and staggering, collapse, and seizures. "Because of the rapid progress of the disease, there are few distinctive pathologic findings, especially if the animal dies within a few hours" (Burrows and Tyrl, 2013). In the United States, animal losses have never been extensive, probably due to the limited distribution of native species. The problems caused by consumption of *Corydalis* did not become apparent until cattle started grazing in the mountain rangelands of the West (Burrows and Tyrl, 2013). Species of *Corydalis* have long been used for medicinal and recreational uses by people as herbal sedatives and antispasmodics. "An Asian species, *C. speciosa*, is suspected as a possible cause of cholestatic hepatitis in a man repeatedly eating the plant as an herbal product" (cited in Burrows and Tyrl, 2013). Thus, these species appear to be potentially toxic at moderate doses to people as well. The most toxicologically troublesome is *C. caseana*, which is succulent and relished by livestock (Burrows and Tyrl, 2013). Some authors of a horticultural book report that few herbivores feed on the genus *Corydalis* because of its toxicity, but

Question ID	Answer - Uncertainty	Score	Notes (and references)
			the butterfly genus *Parnassius* is dependent on it (Tebbitt et al., 2008). This statement may appear to be contrary to the evidence from Burrows and Tyrl (2013), but given the context of the information, we believe Tebbitt et al. (2008) were referring to backyard plant pests. *Corydalis incisa* is consumed by Japanese macaque monkeys (Huffman and MacIntosh, 2012), though this reference did not indicate at what quantities.
Imp-P6 [What is the taxon's weed status in production systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	c - high	0.6	*Corydalis incisa* is reported as a weed of pastures (Lee et al., 2015) and orchards (Hwang et al., 2004) in Korea, but it is not clear whether it is an important weed. It also occurs on the edge of rice paddies (Tebbitt et al., 2008). At one mountaintop nursery in West Virginia, where the nursery owner initially sold plants to customers, *C. incisa* has become invasive, leading the owner to remove plants as soon as they appear (Tuckwiller, 2006). Alternate answers for the uncertainty simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2017).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z5 (Zone 5)	n - high	N/A	One point in Japan. However, because this may be an erroneous record or a casual occurrence, we answered no.
Geo-Z6 (Zone 6)	y - high	N/A	Some points in Japan. Two points in China. Also regional occurrences in the United States (Rockbridge County, VA) (Fig. 1) and southeastern Gansu Province, China (Zhang et al., 2008).
Geo-Z7 (Zone 7)	y - negl	N/A	Many points in Japan. Present in several counties in the eastern United States in New York, Pennsylvania, Maryland, Virginia, and Tennessee that occur in this zone (Fig. 1).
Geo-Z8 (Zone 8)	y - negl	N/A	Japan. A few points in China.
Geo-Z9 (Zone 9)	y - negl	N/A	China and Japan. Some points in Taiwan.
Geo-Z10 (Zone 10)	y - high	N/A	Some points in Japan and Taiwan.
Geo-Z11 (Zone 11)	n - high	N/A	Although two point-occurrences have been reported for Taiwan, these may be erroneous or represent cultivated or casual plants, as *C. incisa* has not been reported in other tropical areas. In general, this species is widely distributed in temperate areas (Zhang et al., 2008). It seems unlikely that this

Question ID	Answer - Uncertainty	Score	Notes (and references)
			temperate species is adapted to tropical climates. None of the other species of *Corydalis* that are included in a major compendium of cultivated plants are reported to grow in Zones 11 or 12 (Page and Olds, 2001). Consequently, we answered no with high uncertainty.
Geo-Z12 (Zone 12)	n - high	N/A	Two points in Taiwan. See discussion under Geo-Z11.
Geo-Z13 (Zone 13)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C3 (Steppe)	n - high	N/A	Two points in China, one of which corresponds to areas receiving 0-10 inches of annual precipitation. It seems doubtful that a species that regularly occurs in moist habitats would be adapted to such dry areas. Perhaps these records represent temporary occurrences or very restricted microhabitats. Without additional evidence, we answered no with high uncertainty.
Geo-C4 (Desert)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C5 (Mediterranean)	n - mod	N/A	We found no evidence, but suspect it may be able to occur in suitable habitats of this climate class because plants are normally dormant during the summer which corresponds to the dry season in Mediterranean climates.
Geo-C6 (Humid subtropical)	y - negl	N/A	China, Japan, and Taiwan. Regional occurrences in three Virginia counties in the United States (Fig. 1).
Geo-C7 (Marine west coast)	y - high	N/A	Reported to occur in Fujian, Guizhou, and Sichuan Provinces in China (Zhang et al., 2008), which include this zone.
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	Many points in Japan. This species is native to South Korea (NGRP, 2017), most of which is represented by this climate class. This species is also present in a few U.S. counties in Maryland, Pennsylvania, and New York, and in Washington, DC (Fig. 1), areas that occur in this climate class.
Geo-C9 (Humid cont. cool sum.)	y - mod	N/A	Some points near the edge of this zone in Japan. One point in China. Reported for southeastern Gansu, China (Zhang et al., 2008), which includes this zone.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
10-inch precipitation bands			

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R1 (0-10 inches; 0-25 cm)	n - mod	N/A	One point in China, but this seems unlikely given the general distribution and habitat preference of this species. Without additional evidence, we answered this question as no with moderate uncertainty.
Geo-R2 (10-20 inches; 25-51 cm)	n - high	N/A	We found no evidence that this species occurs in this precipitation band.
Geo-R3 (20-30 inches; 51-76 cm)	y - high	N/A	One point in China. This species is distributed across numerous Chinese provinces (Zhang et al., 2008) that collectively range from 20-100+ inches of annual precipitation.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Some points in Japan. One point in China. This species is distributed across numerous Chinese provinces (Zhang et al., 2008) that collectively range from 20-100+ inches of annual precipitation.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Some points in Japan. This species is distributed across numerous Chinese provinces (Zhang et al., 2008) that collectively range from 20-100+ inches of annual precipitation.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Some points in Japan. This species is distributed across numerous Chinese provinces (Zhang et al., 2008) that collectively range from 20-100+ inches of annual precipitation.
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Some points in Japan and China. This species is distributed across numerous Chinese provinces (Zhang et al., 2008) that collectively range from 20-100+ inches of annual precipitation.
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Some points in Japan and China. This species is distributed across numerous Chinese provinces (Zhang et al., 2008) that collectively range from 20-100+ inches of annual precipitation.
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Some points in Japan and China. This species is distributed across numerous Chinese provinces (Zhang et al., 2008) that collectively range from 20-100+ inches of annual precipitation.
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Some points in Japan and China. This species is distributed across numerous Chinese provinces (Zhang et al., 2008) that collectively range from 20 - 100+ inches of annual precipitation.
Geo-R11 (100+ inches; 254+ cm)	y - negl	N/A	Some points in Japan and China. This species is distributed across numerous Chinese provinces (Zhang et al., 2008) that collectively range from 20-100+ inches of annual precipitation.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - negl	0	*Corydalis incisa* was first discovered growing wild in North America in 2005 during a biological survey of Bronx Park in New York (Atha et al., 2014a). It is unknown how it was introduced to the United States (Anonymous, 2017), but most likely it was imported as an ornamental from nurseries in Europe (Boom, 2016). Although this species is present in the United States, we answered this question as no to evaluate

Question ID	Answer - Uncertainty	Score	Notes (and references)
			the potential for additional plant material to enter the United States.
Ent-2 (Plant proposed for entry, or entry is imminent)	n - high	0	We found no evidence that *C. incisa* has been proposed for import into the United States. However, some gardeners and taxonomists have collected *Corydalis* species from foreign areas such as the Himalayas and China and introduced them into European and American horticulture (Tebbitt et al., 2008). The genus *Corydalis* has gained popularity in the last few decades (Tebbitt et al., 2008).
Ent-3 [Human value & cultivation/trade status: (a) Neither cultivated or positively valued; (b) Not cultivated, but positively valued or potentially beneficial; (c) Cultivated, but no evidence of trade or resale; (d) Commercially cultivated or other evidence of trade or resale]	d - negl	0.5	*Corydalis incisa* has been used in China and Japan in folk medicine to treat inflammation, headaches, skin diseases, and other ailments (Choi et al., 2007). "Members of the genus *Corydalis* are used in traditional Asian, especially Chinese, medicine to alleviate fever and aches such as those caused by malaria" (Lamont et al., 2011; Tebbitt et al., 2008). Randall (2017) states it is dispersed as an herbal and ornamental species. Several studies have examined its phytochemistry (e.g., Kim, 2002; Nonaka and Nishioka, 1974) and potential cytotoxicity against human tumor cells (Choi et al., 2007). This species may be introduced as seeds or tubers for medicinal purposes (Ossi, 2017). Many species of *Corydalis* have recently entered into cultivation because of commercial Chinese internet-based companies that ship seeds globally (Tebbitt et al., 2008). *Corydalis incisa* is commercially cultivated in the United Kingdom (Rare Plants, 2017). It has been planted as an ornamental in the United States in Virginia and Maryland (Kyde, 2017).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	y - negl		This species is native to China (Zhang et al., 2008)
Ent-4b (Contaminant of plant propagative material (except seeds))	y - low	0.08	This species was likely introduced to the Cornell Botanic Garden on contaminated nursery stock (Maurer, 2017; Nolan, 2017), as well as the Scarsdale Public Library plant beds (Andruk, 2017). Ossi (2017) commented that it may spread in soil in shipments of other plants.
Ent-4c (Contaminant of seeds for planting)	? - max		We found no evidence that *C. incisa* is a contaminant of seeds for planting. However, there are other purple *Corydalis* species that are commonly cultivated and with which it may be confused [e.g., *C. solida* (MBG, 2017)].
Ent-4d (Contaminant of ballast water)	n - mod	0	We found no evidence.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - mod	0	We found no evidence.
Ent-4f (Contaminant of landscape products)	n - mod	0	We found no evidence
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	n - mod	0	We found no evidence.
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	n - mod	0	We found no evidence.
Ent-4i (Contaminant of some other pathway)	? - max		Unknown.
Ent-5 (Likely to enter through natural dispersal)	n - low	0	Because we found no evidence that this species is established in Canada, Mexico, or the Caribbean, we answered no with low uncertainty.

Appendix B. Additional images of *Corydalis incisa*

Figure B1. Inflorescence of *C. incisa* [source: Jessica Schuler (2017), New York Botanical Garden].

Figure B2. A dense patch of *C. incisa* at Bronx Park, NY [source: Jessica Schuler (2017), New York Botanical Garden].

Figure B3. A small patch of *Corydalis incisa* (purple flowers) growing along the Bronx River, NY, with plants of *Ficaria verna* (yellow flowers) [Source: Suzanne Nolan (2017), Bronx River Parkway Reservation Conservancy].

Figure B4. A small patch of *Corydalis incisa* adjacent to a stream in New York [source: Christina Andruk (2017), Iona College].

Figure B5. A patch of *C. incisa* at the New York Botanical Garden [source: Jessica Schuler (2017), New York Botanical Garden].

Maryland Filter questions	Answer	Instructions/Result	Notes
***Corydalis incisa* (Thunb.) Pers.**			
1. Is the plant currently naturalized in Maryland? Yes OR no	**No**	Go to question 2	
2. What is the species' potential distribution in Maryland? wide OR narrow	**Wide**	If Narrow, go to question 3; if Wide, go to question 4	*Corydalis incisa* grows in shaded or semi-shaded conditions in mesic forest or along waterways, with a cold tolerance to 0° F, in Plant Hardiness Zones 5 and 6 in Maryland. This area encompasses all or some of all the physiographic provinces in Maryland except for southern Garrett County.
3. Does or could the species harm threatened or endangered Maryland species or community types or CITES listed species occurring in MD? yes OR no	**Yes**	**Tier 1**	In its United States occurrences, *Corydalis incisa* appears in forested floodplains in both coastal plain and montane regions. *Bromus latiglumis* (S1E), *Carex davisii* (S1E), *Viola esculenta* (S2), and *Carex laxiculmis* (S1?) are all species that occur in these habitats.
4. How feasible is control of the species? easy OR difficult	**Easy**	If Easy, go to question 3; If Difficult, to to question 5	Although hand-weeding in the first year can leave the plant's fusiform tubers in the soil, generally hand pulling is effective in the second year. There is no evidence that the plant is herbicide resistant, or that it reproduces vegetatively. One seed planting study showed little germination in both the first and second years after sowing, but too little research is available to determine whether or not there is a long-lasting seed bank for *C. incisa.*
5. Is added propagule pressure from sales significantly increasing potential of the species to persist and spread? yes OR no			