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An Invasive Species Assessment Protocol: Evaluating Non-Native Plants for Their Impact on Biodiversity, Version 1

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NatureServe

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AN INVASIVE SPECIES ASSESSMENT PROTOCOL

EVALUATING NON-NATIVE PLANTS
FOR THEIR IMPACT ON BIODIVERSITY

VERSION 1



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Front Cover: Yellow star-thistle (*Centaurea solstitialis*), a native of the Mediterranean region, has infested millions of acres of rangelands and natural grasslands in the western United States. Here the plant is crowding out a rare native Mariposa lily (*Calochortus* sp.). *Photo by Jerry Asher, U.S. Bureau of Land Management, courtesy of www.invasive.org.*

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VERSION 1

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May 2004



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Executive Summary

NatureServe, in cooperation with The Nature Conservancy and the U.S. National Park Service, developed this Invasive Species Assessment Protocol as a tool for assessing, categorizing, and listing non-native invasive vascular plants according to their impact on native species and natural biodiversity in a large geographical area such as a nation, state, province, or ecological region. This protocol is designed to make the process of assessing and listing invasive plants objective and systematic, and to incorporate scientific documentation of the information used to determine each species' rank. NatureServe's methodology has previously included assessments of the conservation significance of native species; this protocol extends that scope to non-native species as well. The protocol is used to assess species (or infraspecific taxa, as appropriate) individually for a specified "region of interest" and to assign each species an Invasive Species Impact Rank (I-Rank) of High, Medium, Low, or Insignificant to categorize its negative impact on natural biodiversity within that region. The protocol includes 20 questions, each with four scaled responses (A-D, plus U = unknown). The 20 questions are grouped into four sections: Ecological Impact, Current Distribution and Abundance, Trend in Distribution and Abundance, and Management Difficulty. Each species is assessed by considering these questions, with the answers used to calculate a subrank for each of the four sections. An overall I-Rank is then calculated from the subranks. Text comments and citations to information sources should be provided as documentation for each answer selected, along with a concise text summary of the major considerations leading to the overall rank. While designed for use in a specified large, contiguous, biogeographically diverse region, the protocol can be adapted to specified noncontiguous regions (such as the 50 states of the United States), and may also be applied to assess the impact in the non-native range of a species that is also present elsewhere in a region as a native. NatureServe is now using this protocol to assess the biodiversity impact of the approximately 3,500 non-native vascular plant species established outside cultivation in the United States. The protocol is offered here in generalized form for others who might wish to use it to conduct similar assessments and create lists of invasive plants for other nations, states, provinces, ecological regions, or comparable areas.

Introduction and Background

NatureServe, in cooperation with The Nature Conservancy and the U.S. National Park Service, developed this Invasive Species Assessment Protocol as a tool for assessing, categorizing, and listing non-native invasive vascular plants according to their impact on biodiversity in a large area such as a nation, state or province, or ecological region. This protocol is designed to make the process of assessing and listing invasive plants objective and systematic by using a specified set of questions and requiring documentation of the scientific information used to determine each species' rank. Species (or infraspecific taxa, as appropriate) are assessed one at a time for a specified "region of interest" to determine an Invasive Species Impact Rank (I-Rank) categorizing the species' negative impact on natural biodiversity within that region as *high*, *medium*, *low*, or *insignificant*.

The protocol is designed for assessing the biodiversity impact of those species considered non-native in a specified region of interest, or at least non-native in a portion of the region different from their native range.

- **Native species** are those present in part or all of a specified region without direct or indirect human intervention, growing within their native range and natural dispersal potential. Other terms for native species include *indigenous* and *aboriginal*.
- **Non-native species** are those present in a specified region only as a direct or indirect result of human activity. Other terms that are often used as synonyms for non-native include *alien*, *exotic*, *introduced*, *adventive*, *non-indigenous*, and *non-aboriginal*. Non-native species maintaining themselves outside of cultivation or other human care may be considered *naturalized*.

See Morse *et al.* (1999), Randall and Hoshovsky (2000), and Richardson *et al.* (2000) for further discussion. Note that a species is considered native to a region if it is (or historically was) present as a native in at least one place within that region, even if the species is present as a non-native in a different portion of the same region.

Some but not all of the non-native species present in a given region of interest actually threaten biological diversity. The protocol can be used to rank and list the **non-native invasive plant species that threaten biological diversity**, which we define as those species that:

1. are present but not native in the region of interest,
2. maintain themselves or recurrently appear in conservation areas or other native species habitats,
and

3. negatively affect the native species and other natural biodiversity within the region of interest, generally by outcompeting or hybridizing with native species, or by altering ecological communities or ecosystem processes.

Similar terms include *harmful invasive plants* and *environmental weeds*.

Assessing the biodiversity impact of the non-native species in a region of interest requires an understanding of the various native plant, animal, fungal, and other species there, as well as the region's ecological communities and important ecosystems processes, and the conservation importance of various lands and waters within the region of interest. **Biodiversity** (or biological diversity) has been defined as the variety of life on earth (Wilson, 1988), but is often considered as the variety of naturally occurring life in a specified area. Biodiversity can be assessed at any geographic scale (*e.g.*, county-wide, ecoregional, state/provincial, national, continental, or global) and includes:

- Genetic diversity, or variations in genetic structure among individuals of a species or populations;
- Species diversity, or the variety of species (and infraspecific taxa);
- Higher taxonomic diversity, or the variety of higher taxonomic groups (*e.g.*, families or orders);
- Community diversity, or the variety of identifiable groups of species that occupy and interact in the same habitats;
- Ecosystem diversity, or the variety of ecological units composed of biological communities interacting with the physical environment.

See Wilson (1992) for further discussion.

The protocol gives particular attention to impacts occurring on conservation areas and other native species habitats. **Conservation areas** are lands and waters designated and managed specifically to protect and preserve undomesticated organisms, ecological communities, and/or ecosystems. We consider **native species habitats** to be conservation areas plus a wide variety of other places that support viable or otherwise long-persisting occurrences of native plants, animals, fungi, or other species. Note that vegetation remnants within otherwise developed agricultural or urban areas may be important habitats for various native species, particularly those with restricted ranges. NatureServe's (2002) Element Occurrence Data Standard provides guidance for assessing viability or persistence of various occurrences of a species.

The Invasive Species Assessment Protocol consists of two yes-no screening questions and 20 weighted multiple-choice assessment questions grouped into four sections which address four major aspects of an invasive species' total impact (Table 1):

- I. Ecological Impact (5 questions)
- II. Current Distribution and Abundance (4 questions)
- III. Trend in Distribution and Abundance (7 questions)
- IV. Management Difficulty (4 questions)

Table 1. Summary of NatureServe’s Invasive Species Assessment Protocol

| |
|--|
| I. Ecological Impact (5 questions; 50% of I-Rank Score) |
| 1. Impact on Ecosystem Processes and System-Wide Parameters (33 points) |
| 2. Impact on Ecological Community Structure (18 points) |
| 3. Impact on Ecological Community Composition (18 points) |
| 4. Impact on Individual Native Plant or Animal Species (9 points) |
| 5. Conservation Significance of the Communities and Native Species Threatened (24 points) |
| II. Current Distribution and Abundance (4 questions; 25% of I-Rank Score) |
| 6. Current Range Size in Region (15 points) |
| 7. Proportion of Current Range Where Species Is Negatively Impacting Biodiversity (15 points) |
| 8. Proportion of Region’s Biogeographic Units Invaded (3 points) |
| 9. Diversity of Habitats or Ecological Systems Invaded in Region (3 points) |
| III. Trend in Distribution and Abundance (7 questions; 15% of I-Rank Score) |
| 10. Current Trend in Total Range Within Region (18 points) |
| 11. Proportion of Potential Range Currently Occupied (3 points) |
| 12. Long-Distance Dispersal Potential Within Region (9 points) |
| 13. Local Range Expansion or Change in Abundance (18 points) |
| 14. Inherent Ability to Invade Conservation Areas and Other Native Species Habitats (6 points) |
| 15. Similar Habitats Invaded Elsewhere (9 points) |
| 16. Reproductive Characteristics (9 points) |
| IV. Management Difficulty (4 questions; 10% of I-Rank Score) |
| 17. General Management Difficulty (18 points) |
| 18. Minimum Time Commitment (15 points) |
| 19. Impacts of Management on Native Species (15 points) |
| 20. Accessibility of Invaded Areas (3 points) |

For each question, assessors may select one of four defined answers (A-D) or specify Unknown (U). These answers are used to calculate subbranks for each of the sections and an overall Invasive Species Impact Rank (“I-Rank”) for the species.

Some users may find certain subranks, or combinations of subranks, to be at least as informative and useful as the overall I-Rank. For example, agencies and land managers that seek to prevent and contain newly established species may be especially concerned about a species that has subranks of High for Ecological Impact, Low for Current Distribution and Abundance, and High for Trend in Distribution and Abundance.

The style and organization of this protocol draws heavily on NatureServe's long-established methodology for assessing conservation significance of various native plant or animal species, used by natural heritage programs and conservation data centers in all the U.S. states and Canadian provinces, as well as several Latin American or Caribbean nations. The protocol's availability, and its recent implementation within NatureServe's Biotics information-management system, extend NatureServe's species assessment methodology to non-native as well as native species.

Earlier drafts of this protocol were described by Randall *et al.* (1996 and 2001), and further background, including comparisons with other invasive plant ranking and predictive systems, will be provided in a companion paper by Randall *et al.* (in prep.). NatureServe is now using this protocol to assess and categorize each of the approximately 3,500 non-native vascular plant species recorded by Kartesz (1999) or other sources as established outside cultivation in the United States. The protocol is offered here in generalized form for others who might wish to use it to conduct similar assessments and create lists of invasive plants for other nations, states, provinces, ecological regions, or comparable areas.

Description of the Protocol

The Invasive Species Assessment Protocol includes two screening questions plus 20 assessment questions, grouped into four sections. Four scaled answers (A-D) are provided for each of the 20 questions. The Invasive Species Impact Rank (I-Rank) is determined from answers to these questions, with text comments and information-source citations providing explanation and documentation for each response.

Screening Questions

Each assessment begins with two screening questions to determine whether the species under consideration is a non-native established outside cultivation in the region of interest (Question S-1), and if it occurs (or is suspected to occur) within conservation areas or other native species habitats there (Question S-2). The protocol is not applicable to native species within their native ranges (even if weedy), nor to non-native species that are present only in cultivation or known in the region of interest only historically. However, for species that are native in a part of the region of interest and also present as non-natives within a different part of the region, the protocol can be used with adaptations discussed further below. An I-Rank of

Not Applicable is assigned to non-native species not known to be currently established outside cultivation, even if the species was historically known as an escape. Species that are established outside cultivation but are not known or suspected to occur in native species habitats are assigned an I-Rank of Insignificant and need not be assessed further. Predictive assessment systems, such as those described by Reichard and Hamilton (1997), Lehtonen (2001), Pheloung (2001), or FICMNEW (2003) may be useful in assessing potential impact on biodiversity of species not yet established within the region of interest.

Assessment Questions

If the answers to the two screening questions are both yes, the 20 assessment questions in the protocol should then be considered for that species. A provisional assessment may be conducted if the screening questions cannot be readily answered. These 20 questions are grouped into four sections.

Section I. Ecological Impact

Section I, with five questions, is based on the premise that species with the largest negative impacts on native plant, animal, and other species populations, ecological communities, and ecosystems generally cause the most severe problems, particularly if they change ecosystem processes, or harm rare native species, keystone species, or communities of conservation significance. The questions in this section evaluate the species' overall effects on natural biodiversity on a rough per-unit-area basis. Impacts should be assessed for areas with abundances (cover, density, frequency, *etc.*) commonly seen in the field. The first four questions are arranged in hierarchical order, beginning with the most wide-ranging, all-encompassing types of impacts, those on ecosystem processes and parameters. In general, species that have strong impacts on ecosystem processes or parameters will also have strong impacts on many lower scales, including community composition and structure and native species populations. Effects of other non-native species appear at only lower scales, and for some the impacts are not noticeable. A final question in this section focuses on the conservation significance of the species and ecological communities impacted by the non-native species under assessment.

Section II. Current Distribution and Abundance

Section II, with four questions, is based on the premise that the greater the range and abundance of a species in a region, and the more ecological regions or habitats that it invades there, the greater the overall damage it can cause. One question in this section is designed to determine the rough proportion of the range occupied where the species under assessment has significant impacts, since some non-native species are established over wide areas but are known or suspected of causing harm to biodiversity only in part of the overall area where they are established, or only in certain habitats. For example, tamarisks (*Tamarix* species)

are severe riparian and wetland pests from California to west Texas and north at least to Kansas and Montana, but while they escape occasionally in the eastern United States, they have not been reported as problems east of the Mississippi River.

In considering a species' current distribution, as well as its trend in distribution (Section III, below), one seldom knows all of its occurrences. Instead, it is often more practical to determine the species' *generalized range*, often taken as the entire area within one or more broadly drawn, generally convex areas including all sites occupied by the species (as often shown in field guides). Note that the species does not necessarily occur everywhere within this broad range. In considering generalized ranges, large unoccupied areas should be omitted, using multiple areas to address major disjunctions or significant outliers. Stott (1981) provides further discussion of the production and use of such outline maps.

Section III. Trend in Distribution and Abundance

Section III, with seven questions, is based on the premise that species with a high potential for further spread have the potential to cause greater damage, especially if they are likely to spread to distant but currently uninfested portions of the region of interest. The questions in this section therefore assess the likelihood and rate at which the species (if not controlled) will spread to new areas and/or increase in abundance within areas it already occupies. Estimates of the species' current range, its possible potential range in the region, and its current rate of spread help to answer questions in this section.

Section IV. Management Difficulty

Section IV, with four questions, is based on the premise that a species that is difficult to manage (control or prevent from spreading) will have a greater chance of causing significant damage because it is more likely to persist and spread. The questions in this section assess the difficulty of control, the accessibility of invaded sites where it threatens natural diversity, and the likelihood that known control measures will cause collateral damage to native species.

Answering the Questions

Each question has five possible precise answers: A, B, C, D, or U, where:

A = High significance

B = Moderate significance

C = Low significance

D = Insignificant

U = Unknown

If possible, a precise answer (single-letter answer) that best characterizes the species should be selected, even if it does not describe it exactly. However, answer ranges (AB, BC, CD, AC [= A, B, or C], or BD [= B, C, or D]) may be used as provisional answers if assessors can eliminate at least one of the four choices (A, B, C, or D), but do not have enough information to give a more precise answer. ‘U’ (Unknown) should be selected only if none of the four choices can be eliminated after a reasonable attempt to answer the question. The answer should be left null (*i.e.*, not reviewed) if the question has not been considered substantially.

A brief text comment (including examples), with citations for all important information sources used, should be provided to justify and document each answer (including the screening questions).

Recording and Documenting Species Assessments

Species data may be compiled, analyzed, and recorded in a variety of formats (database, spreadsheet, word-processed or paper forms, *etc.*). Generally, some kind of species-by-species Dataform would be used, coupled with a Scoresheet for calculating the subranks and the I-Rank for each species. Examples of a spreadsheet Dataform and Scoresheet in Microsoft® Excel are available through NatureServe’s web site (www.natureserve.org). NatureServe has incorporated database forms for this protocol into its Biotics information-management system for use in its assessment of non-native U.S. vascular plants.

For each species (or infraspecific taxon) assessed, the Dataform should include a header section recording such information as the scientific and common names of the species, region of interest, assessor’s name, and date the current assessment was completed.

Applying the Protocol to Mixed-Status Species

For mixed-status species, native in part of the region of interest but established as a non-native species in a different (although perhaps adjacent) part of the region, the protocol can be applied by ignoring the native range of the species, and considering the region being assessed to be only the remainder of the original region of interest (including any portion in which the species does not occur at all). Impacts are therefore considered only within the species’ non-native range, the geographically scaled questions are adapted as needed to reflect the reduced baseline area and diversity, trends are considered only for the species non-native range, and management considerations focused on control in places where this species is not native. If the original native range of the species is not well known, then answer ranges should be used as needed for various answers to indicate the variation resulting from inclusion or exclusion of the controversial portion of the species’ range within the region.

These adjustments for mixed-status species should be carefully documented in the individual comments accompanying answers to the protocol’s 20 questions, and briefly mentioned in the I-Rank Reasons

Summary. Such cases of mixed-status species should also be distinctly indicated in reports or lists produced from these data, perhaps by use of the percent symbol (%), to indicate that this species is considered non-native in part of the region, but is also native somewhere else in the region.

Determining the I-Rank

The protocol recognizes that a non-native plant species may impact natural biodiversity in a variety of ways, that these factors vary in their contributions, and that some important factors may be mutually exclusive. For example, a species that has a wide current range and already occupies all appropriate habitats within a region of interest (Section II) can not continue to expand its range in the same region of interest (Section III). Also, since it is unusual to be able to answer all questions precisely in the first attempt at assessing a species, it may be necessary to reply 'Unknown' or with an answer range (*e.g.*, AB or BD) to some of the questions. These considerations are taken into account by using points and point ranges in determining the four subranks and the I-Rank for each species assessed.

I-Rank Values

I-Rank values range from High to Insignificant as follows:

- High:** Species represents a severe threat to native species and ecological communities
- Medium:** Species represents moderate threat to native species and ecological communities
- Low:** Species represents a significant but relatively low threat to native species and ecological communities
- Insignificant:** Species represents an insignificant threat to native species and ecological communities

Generally speaking, factors which can push a species' I-Rank upward (towards High) are the ability to change ecosystem processes; ability to invade relatively undisturbed ecological communities; ability to cause substantial impacts on rare or vulnerable species or ecological communities, or high-quality examples of more common communities; wide distribution and general abundance where present; ability to disperse to new areas readily; and difficulty of control. Conversely, species with minimal impacts on ecosystem processes, native species, and ecological communities will generally be assigned an I-Rank of Low or Insignificant. Other factors that can push a species' I-Rank downward are lack of potential to spread beyond a small existing range, stable or decreasing abundance within the current range, and ease of control.

Calculating the Subranks

Each answer for each question is assigned a point value, and these points (or point ranges for answer ranges such as AB or BC) are used to calculate subranks for each of the four sections. The various questions in each section are weighted differently to reflect their relative contributions to the topic addressed by that section. For example, impacts to biodiversity are considered in Section I. Since species that significantly alter ecosystem processes have profound impacts on biodiversity, Question 1, which addresses this, is weighted more heavily than any of the other questions in that section.

Table 2. Subranks Calculation

| | A | B | C | D | Points | |
|---|----|----|----|---|--------|-------------------------------------|
| I. ECOLOGICAL IMPACTS | | | | | | <u>Subrank I Intervals</u> |
| Q1. | 33 | 22 | 11 | 0 | 0-33 | 78 – 102 High |
| Q2. | 18 | 12 | 6 | 0 | 0-18 | 52 – 77 Medium |
| Q3. | 18 | 12 | 6 | 0 | 0-18 | 27 – 51 Low |
| Q4. | 9 | 6 | 3 | 0 | 0-9 | 0 – 26 Insignificant |
| Q5. | 24 | 16 | 8 | 0 | 0-24 | |
| II. CURRENT DISTRIBUTION AND ABUNDANCE | | | | | | <u>Subrank II Intervals</u> |
| Q6. | 15 | 10 | 5 | 0 | 0-15 | 28 – 36 High |
| Q7. | 15 | 10 | 5 | 0 | 0-15 | 19 – 27 Medium |
| Q8. | 3 | 2 | 1 | 0 | 0-3 | 10 – 18 Low |
| Q9. | 3 | 2 | 1 | 0 | 0-3 | 0 – 9 Insignificant |
| III. TREND IN DISTRIBUTION AND ABUNDANCE | | | | | | <u>Subrank III Intervals</u> |
| Q10. | 18 | 12 | 6 | 0 | 0-18 | 55 – 72 High |
| Q11. | 3 | 2 | 1 | 0 | 0-3 | 37 – 54 Medium |
| Q12. | 9 | 6 | 3 | 0 | 0-9 | 19 – 36 Low |
| Q13. | 18 | 12 | 6 | 0 | 0-18 | 0 – 18 Insignificant |
| Q14. | 6 | 4 | 2 | 0 | 0-6 | |
| Q15. | 9 | 6 | 3 | 0 | 0-9 | |
| Q16. | 9 | 6 | 3 | 0 | 0-9 | |
| IV. MANAGEMENT DIFFICULTY | | | | | | <u>Subrank IV Intervals</u> |
| Q17. | 18 | 12 | 6 | 0 | 0-18 | 39 – 51 High |
| Q18. | 15 | 10 | 5 | 0 | 0-15 | 27 – 38 Medium |
| Q19. | 15 | 10 | 5 | 0 | 0-15 | 14 – 26 Low |
| Q20. | 3 | 2 | 1 | 0 | 0-3 | 0 – 13 Insignificant |

For each of the 20 questions, the four answers are scaled with answer A indicating the greatest negative effect on biodiversity, and the steps between answers A,B, C, and D being relatively evenly proportioned. Point values for the four answers are accordingly assigned in the proportion 3:2:1:0, respectively. Table 1 shows the relative weights of the questions in each section, and Table 2 shows the point values assigned to each possible letter answer.

For each section, the maximum possible point total is divided into four equal subrank intervals representing subranks of High, Medium, Low, and Insignificant (from the highest to the lowest intervals, respectively). Break points between the subrank intervals are rounded to integers where necessary. The points for each answer in a section are totaled, which determines the corresponding subrank.

To accommodate situations in which one or more questions are answered with an answer range (*e.g.*, AB) or with 'Unknown' (effectively the answer range AD), the minimum and maximum possible point totals for each section can then be calculated by separately adding up the lowest and highest possible points for each answer. For example, for questions answered 'Unknown' the points assigned to answers D and A are used respectively for the minimum and maximum point totals. On the other hand, for questions answered with a single letter (*e.g.*, A), the minimum and maximum point totals are the same.

If the maximum and minimum point totals for a subrank both fall in a single subrank interval, the result is a precise subrank (*e.g.*, Medium). However, if they fall into different subrank intervals, the result is a subrank range (*e.g.*, High/Medium). Note that if the maximum and minimum point totals yield a subrank range of High/Insignificant, the subrank should be listed as 'Unknown' since no possibilities have been excluded. All of these calculations can be easily programmed into a database or spreadsheet, as done in the Scoresheet available through NatureServe's web site (www.natureserve.org).

Calculating the I-Rank

The four subranks (either precise subranks or subrank ranges) are in turn used to determine the overall I-Rank. The subranks for each section are assigned their own relative weights to reflect their relative contributions to the species' overall impact on biodiversity. The Ecological Impact subrank is given the greatest weight (50% of the I-Rank score), since so many kinds of biodiversity impacts are addressed under that topic. On the other hand, the subrank for Management Difficulty has the least influence on the I-Rank (10% of the I-Rank score), in general affecting the I-Rank only when the point total from the other three subranks leaves a species near the borderline between two ranks. Table 3 shows the relative weights of the subranks and their use in calculating the I-Rank. Note that the weights of individual questions (and the point values of various answers) apply only within their respective section, and are not comparable across sections.

Table 3. Invasive Species Impact Rank Calculation

| SECTION | SUBRANK VALUES | | | | POINTS | I-RANK INTERVALS | I-RANK |
|--|----------------|--------|-----|---------------|--------|------------------|----------------------|
| | HIGH | MEDIUM | LOW | INSIGNIFICANT | | | |
| I. Ecological Impact | 50 | 33 | 17 | 0 | 0 – 50 | 76 – 100 | High |
| II. Current Distribution and Abundance | 25 | 17 | 8 | 0 | 0 – 25 | 51 – 75 | Medium |
| III. Trend in Distribution and Abundance | 15 | 10 | 5 | 0 | 0 – 15 | 26 – 50 | Low |
| IV. Management Difficulty | 10 | 7 | 3 | 0 | 0 – 10 | 0 – 25 | Insignificant |

The I-Rank (either a precise I-Rank or an I-Rank range) is determined by a process similar to that used to calculate the individual subranks. To calculate the I-Rank, the maximum possible point total for the I-Rank, 100 points, is divided into four equal I-Rank intervals (>75, 50-75, etc.) representing the I-Ranks of High, Medium, Low, and Insignificant (from the highest to the lowest intervals, respectively). Each of the four subrank values is assigned points in the proportion of 3:2:1:0 (rounding if necessary) for subranks of High, Medium, Low, and Insignificant, respectively. For example, 50, 33, 17, and 0 points are assigned respectively for the four possible ranks for the Ecological Impact subrank. The points for the four subranks are totaled, and when compared to the I-Rank intervals, the point total determines the I-Rank.

If any subrank is not precise, but is instead a range (e.g., High/Medium) or is ‘Unknown’ (effectively High/Insignificant), the minimum and maximum point totals for the pertinent section are calculated by separately tallying the lowest and highest points. The resulting precise I-Rank or I-Rank range is then determined. A two-step or three-step I-Rank range is acceptable (e.g., Medium/Low or High/Low) since at least one possible rank has been excluded. However, if the maximum and minimum point totals do not exclude any of the four possible I-Ranks (High/Insignificant), the I-Rank should be listed as ‘Unknown’.

It is not always necessary to answer all 20 questions to assess a species. Quite often, an I-Rank can be determined even if some questions answered with ranges (e.g., AB or BD), or even if a few questions are left unanswered. Even in cases where the answers to several questions are unknown or imperfectly known, an I-Rank range (such as High/Medium or Low/Insignificant) can often be obtained. The process of determining an I-Rank is therefore *polythetic* (cf. Morse, 1971), drawing upon an overall fact pattern that does not require any prespecified set of individual questions to be addressed. Answering the more heavily weighted and/or more easily addressed questions facilitates determination of the I-Rank, which is a skill gained through experience.

In nearly all cases, the calculated rank should be acceptable as the final I-Rank. However, if additional biological or ecological considerations not adequately addressed in the protocol's 20 questions are so significant that the calculated rank is clearly inappropriate (when considered along with the ranks of other non-native species in the same region of interest), then the I-Rank (precise I-Rank or I-Rank range) should be adjusted accordingly, with reasons for the adjustment presented as a text comment. If desired, such an adjusted rank may be presented with an asterisk (*) appended to indicate that it differs from the calculated rank. Note that only the I-Rank itself may be adjusted if necessary; the individual subranks are always those calculated from their respective point totals.

Using the Protocol

You must make several one-time decisions to tailor the protocol for your region of interest before you can use it. You will also need to develop or obtain a Dataform or information-management system before beginning to assess species.

Tailoring the Protocol for Specific Regions of Interest

As presented here, the protocol is not tailored to any specific region of interest. To assure meaningful responses to the questions presented here, the geographical region of interest should be large enough to: (1) be dominated by within-region dispersal of species, as contrasted with dispersal across the region's boundaries, (2) have persisting internal habitat diversity and biogeographic patterns, and (3) require multiple serial dispersal events for a species to become widespread within the region of interest. The protocol questions, as provided here, work best for contiguous regions with a substantial proportion of internal area in contrast to edge. Hiebert and Stubbendieck (1993), Heibert (1997), and the Alien Plants Ranking System Implementation Team (2001) offer guidance for prioritizing invasive plant species in smaller areas.

In general, the protocol is configured for use for regions of interest that are contiguous, as opposed to those with two or more separate parts such as the 50 states of the United States. However, the protocol may be used for a region of interest with two or more separate parts, such as the United States, including Alaska and Hawaii, if slight adaptations are made in questions 6 and 8 to provide comparability with geographical ranges and habitat amplitudes shown by native species in the same region. However, a highly fragmented area (such as an assemblage of scattered land holdings of a single government agency) should not be used as a region of interest with this protocol, since only a small sampling of a species' regional status, impacts, trends, and dispersal dynamics would be considered.

In order to use the protocol, you must tailor it to your region of interest by taking the following six implementation steps :

1. Select and describe (or map) the exact geographical region of interest. You may specify nations, states, provinces, and other well-known areas by name, providing that you clarify whether you are excluding any areas sometimes considered part of that area, or including any outlying places not always regarded as part of that area.
2. Select one or more sources for the taxonomic classification to be used for the species of interest in your region. For example, the vascular plant classification by Kartesz (1999) might be used for regions in North America north of Mexico.
3. For Question 6, if the size or configuration of your region of interest is biogeographically unusual, make suitable adjustments (if needed) to the geographic distribution thresholds used as guidance for the A, B, C, & D answers. Any adjustments to the percentage ranges for this question should be clearly specified and explained, and applied uniformly to all species assessed for your region.
4. For Question 8, specify the primary biogeographic system to be used for your region, preferably one available as a map. If desired, different (but comparably scaled) secondary system(s) may be used for a specified subset of the species being considered (*e.g.*, a terrestrially oriented system for most species, but a watershed-based system for aquatic species). You should choose a biogeographic system(s) that is suitably scaled for your region. For example, Bailey's (1995) or The Nature Conservancy's (2001) ecoregions might be appropriate for the U.S., while the Jepson Manual's Geographic Subdivisions (Hickman, 1993) might be appropriate for California.
5. Also, for Question 8, if the biogeographic system that you have selected contains very few biogeographic units for your region of interest, or if they are highly disproportionate in area, you may need to make systematic adjustments to the suggested percentage thresholds distinguishing answers A, B, C, and D to provide a more meaningful range of responses. Any adjustments to the scaling for this question should be clearly specified and explained, and applied uniformly to all species assessed for your region of interest.
6. For Question 9, select, if desired, a specified set of habitats or ecological systems for your region of interest, such as NatureServe's ecological communities (Grossman, 1998) or ecological systems (Comer *et al.*, 2003) for the United States, or Holland's (1986) natural communities for California.

Selecting Species to Assess

Distinguishing native from non-native species in a region of interest is fundamental to use of this protocol. Regional taxonomic, floristic, horticultural, and weed-management references often provide native/non-native status for individual species. For example, the (incomplete) *Flora of North America* (1993-) and the *Synthesis of the North American Flora* (Kartesz and Meacham, 1999) indicate whether or not most of the species they cover are native to North America north of Mexico, and additional information is available on NatureServe Explorer (www.natureserve.org/explorer).

When you cannot conduct prompt assessments of all the non-native species established in your region of interest, due to resource or time limitations, consider those of greatest or most urgent interest first. For example, early attention might be given to:

- Species currently involved in management decisions
- Species for which biodiversity impacts in the region are currently being debated
- Species generally considered invasive for which better documentation would strengthen management capabilities or priorities
- Species recently discovered to be established in the region
- Species used for landscaping or restoration within conservation areas
- Species for which monitoring or research is under way or being considered
- Species of general public interest in the region

Ideally, all non-native species known to occur in the region of interest should eventually be considered, in order to assure completeness as well as permit comprehensive presentation and analysis.

Assessing Individual Species

Species are generally assessed individually, following the data-development flow summarized here. Whatever the particular Dataform (paper or computerized) being used, the capability should be provided to record the various kinds of data (data fields) needed to implement the protocol.

Dataform Header

Certain standard information should be provided in a header section, including the species' scientific name and any pertinent synonyms, its common name(s), the region of interest being considered, the assessor(s), and the date the current assessment was completed. Also, for mixed-status species that are present in one part of the region as a native, but present in a different part of the region as a non-native, that fact should be noted, and a brief summary provided of its native range within the region.

Screening Questions

Consider the two initial screening questions (S-1 and S-2) before investing effort in assessing a species further. If you answer ‘No’ to the first screening question, do not answer the remaining questions in the protocol; the I-Rank is ‘Not Applicable’ and should be recorded as such. If you answer ‘Yes’ to the first screening question and ‘No’ to the second, the I-Rank is automatically ‘Insignificant’ and should be recorded as such; do not complete the remaining questions of the protocol. If you answer ‘Yes’ to both questions (or have difficulty answering them), proceed to consider the 20 assessment questions that follow.

Assessment Questions

The 20 assessment questions, which are grouped into four sections, form the main part of the assessment. In all cases, the ‘A’ answer indicates the greatest negative effect on native species and natural biodiversity, with the B, C, and D answers corresponding respectively to lesser degrees of impact. These 20 questions, along with the pertinent A-D answers and other guidance, are presented in Appendix I.

For each question, attempt to select one precise answer (single-letter answer) that best characterizes the species you are assessing, and enter it on the Dataform. If one of the choices does not exactly describe the species being reviewed, but is clearly more appropriate than the other choices, select it, and note the discrepancy in the accompanying comments. If you can eliminate at least one of the four choices (A, B, C, or D) based on the information available, specify an answer range (AB, BC, CD, AC [A, B or C], or BD [B, C, or D]) to indicate the answers that remain. If you have not eliminated any of the four answers after making a reasonable attempt to answer the question, record the answer as ‘U’ (Unknown). If you have not substantially considered the question, leave the answer null (*i.e.*, not reviewed).

In situations in which there are not enough questions with a single-letter answer to obtain precise subranks or a precise I-Rank, additional research may yield enough information to refine the results. Note however that you generally do not need to answer all 20 questions to obtain a precise I-Rank, particularly if precise answers can be given for several of the more heavily weighted questions.

Comments

To document the scientific basis for the assessment, enter a brief text comment on the Dataform for each question answered, justifying the answer(s) selected by summarizing pertinent information about this characteristic of the species, presenting pertinent examples, and indicating the source(s) of this information. The comments should justify and support your answers; do not include detailed biological or management information that was not used to answer the question. If there are issues that are not directly addressed or adequately covered by the available answers (A-D), describe them briefly in the comments.

Use any reasonable, generally accepted scientific style for citing sources in the comments. For example, traditional publications may be cited by brief title or in short-citation format (author, year). When citing

personal communications, consider a form such as: (Name of person cited, pers. comm., year). For field sightings or other personal observations (including your own), consider a form such as: (Name, pers. obs., year).

Other Considerations

Use this text field, which is not linked to any single question, to provide any additional information not readily accommodated by the 20 questions, as well as any general comments on major gaps in information that would be critical to improving the accuracy of the assessment of this species.

Rank Calculations

Calculate the four section subranks and the Invasive Species Impact Rank (I-Rank) with a Scoresheet, or by other means. If the calculated I-Rank (either a precise rank or a rank range) is acceptable, enter it in the I-Rank field. However, if the calculated I-Rank is clearly inappropriate due to extraordinary biological or ecological considerations, provide an adjusted I-Rank instead, along with a text justification for the change.

I-Rank Reasons Summary

Concisely summarize the key information underlying the species' four subranks and its I-Rank in a text comment. This text should be written to stand alone, suitable for use as a summary paragraph in reports or other products.

Information Sources

Finally, cite the various publications, experts, and other information sources referred to in the text comments, as well as other important sources consulted in completing the assessment. Provide full references (in a generally acceptable scientific style) for all such publications, internet resources, individual experts, institutional collections, and other information sources. Assessors with substantial personal experience with the species should cite themselves here as well. Depending on the implementation, these various citations might be maintained in one or more information-sources (bibliography) files, or they might be entered individually in text form.

Reassessing Species

Reassesses all species periodically, and reassess particular species promptly in such situations as:

- It is unexpectedly detected in a new portion of the region (such as a new state of the U.S.)
- There are major changes in abundance or distribution
- Additional means of dispersal become evident
- Research indicates substantial ecological impacts that were previously not known

- There are major changes in management strategies, or there is new information on the impacts of current management strategies to this species or to desirable native species
- Other significant new information is obtained that might change the I-Rank or any of the subranks

Training Species Assessors

Based on experience using various drafts of this protocol, the authors strongly recommend that assessments of all species be conducted by small teams of biologists familiar with the protocol, the types of information needed to answer the individual questions, and the pertinent literature, internet resources, and expertise for their region of interest, rather than by a large number of untrained contributors. Trained assessors can more consistently and more efficiently answer the 20 questions, using readily available reference materials as well as interviews with others personally familiar with the species and its distribution, impacts, and management requirements. They can also assure that the available information is addressed under the appropriate questions, and will develop experience in deciding which questions to address first in various situations.

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Appendix 1.

NatureServe's Invasive Species Assessment Protocol

This Appendix provides in detail the 20 questions, the scaled choices of answers (A, B, C, or D), and accompanying guidance for Version 1 (May 2004) of the Invasive Species Assessment Protocol. For each species being assessed, first consider the two screening questions (S-1 and S-2) to determine whether use of the protocol is appropriate. If the answers to both screening questions are yes, then consider the 20 assessment questions.

Screening Questions

Consider the two screening questions (below) before investing substantial effort in assessing a species.

S-1. Establishment in Region of Interest

Is this species currently established outside cultivation as a non-native (*i.e.*, as a direct or indirect result of human activity) somewhere within the region of interest (either being present within the region solely as a non-native, or being a mixed-status species that is established as a non-native in a portion of the region different from the species' native range there)?

- **Yes.** Proceed to screening question S-2, below.
- **No.** STOP. The Invasive Species Assessment Protocol is not applicable to this species. Enter 'Not Applicable' as the Invasive Species Impact Rank (I-Rank), summarize reasons in the I-Rank Reasons Summary, and cite at least one information source.

Note: If this question is not readily answered, assessment of the species may either be deferred, or provisionally begun while further information on the species' status in the region is sought.

S-2. Occurrence in Native Species Habitat

Is this species known or suspected to be present in conservation areas or other native species habitats somewhere within the region of interest?

- **Yes.** Proceed to the assessment (20 questions), below.
- **No.** STOP. This species is an insignificant threat to natural biodiversity in the region of interest. Enter 'Insignificant' as the Invasive Species Impact Rank (I-Rank), summarize reasons in the I-Rank Reasons Summary, and cite at least one information source.

Note: If this question is not readily answered, assessment of the species may be deferred, or provisionally begun while further information on the species' presence in native species habitats is sought. Until this point is verified, the I-Rank should either be 'Insignificant,' be a range of ranks including 'Insignificant,' or be 'Unknown.'

Assessment Questions

The following 20 questions are grouped into four sections, for which separate subranks are determined. The Invasive Species Impact Rank (I-Rank) is then determined from the four subranks. The "Other Considerations" data field may be used to present and document significant information not readily accommodated under any of the 20 assessment questions.

Section I. Ecological Impact

Assess the current impact of the species on ecosystem processes, ecological communities, and native species within the region of interest, to the extent it is known. Where appropriate, give greatest attention to the cumulative impact (*e.g.*, over a period of several decades) of the species on conservation areas and other native species habitats where it is abundant or well established in the region, recognizing that impacts may be less severe in places where the species is less well established. Impacts on areas that are recovering from disturbance or being restored to native species habitats may be included. However, do not consider impacts restricted to areas such as croplands, orchards, roadsides, industrial sites, and other developed areas that are not native species habitats, even if such places are included within the boundaries of parks, preserves, or other lands managed for conservation purposes. For mixed-status species, consider impacts only in the non-native portion of the species' range within the region.

1. Impact on Ecosystem Processes and System-Wide Parameters

Some non-native species can alter the natural range and variation of abiotic ecosystem processes and system-wide parameters in ways that significantly diminish the ability of the native species to survive and reproduce. Alterations in ecosystem processes and system-wide parameters that determine the types of communities that exist in a given area are of greatest concern.

Examples of abiotic ecosystem processes include:

- fire occurrence, frequency, and intensity
- geomorphological changes (*e.g.*, erosion and sedimentation rates)
- hydrological regimes (including soil water table)

- nutrient and mineral dynamics

Examples of system-wide parameters include:

- system-wide reductions in light availability (*e.g.*, an aquatic invader covering an entire water body which would otherwise be open)
- changes in salinity, alkalinity, or pH

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. **Document** your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Major, possibly irreversible, alteration or disruption of abiotic ecosystem processes and system-wide parameters, such as:
- The species promotes fire in habitats that otherwise rarely support fires;
 - The species drains water from open water or wetland systems through rapid transpiration, making these unable to support native wetland plant and animal species; or
 - The species is a nitrogen fixer and invades systems with few or no known native nitrogen fixers, and consequently causes soil nitrogen availability to increase to levels that favor other non-native invaders at the expense of native species
- B. **Moderate significance.** Significant alteration in abiotic ecosystem processes and system-wide parameters (*e.g.*, increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)
- C. **Low significance.** Influences abiotic ecosystem processes and system-wide parameters (*e.g.*, has perceivable but mild influence on soil nutrient availability)
- D. **Insignificant.** No perceivable impact on abiotic ecosystem processes and system-wide parameters
- U. **Unknown.**

2. Impact on Ecological Community Structure

Some non-native species overtop other vegetation, or otherwise alter the vegetation structure (at least at some sites), thereby affecting many native species.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. **Document** your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Major alteration of ecological community structure (*e.g.*, covers canopy or creates new canopy, changing or eliminating most or all layers of vegetation below)
- B. **Moderate significance.** Changes number of layers below canopy, or significantly alters structure of at least one layer of the vegetation (*e.g.*, creation of a new layer, elimination of an existing layer, substantial change in density or total cover of an existing layer)
- C. **Low significance.** Influences structure of at least one layer (*e.g.*, moderately changes density or total cover of a layer)
- D. **Insignificant.** No impact; establishes within existing layers without influencing their structure
- U. **Unknown.**

3. Impact on Ecological Community Composition

Some non-native species greatly alter the composition of ecological communities (whether or not they also alter their structure), changing the relative abundance of native species or altering successional patterns.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Causes major alteration in ecological community composition. For example, results in:
 - the extirpation or sharp reduction in abundance of several locally common native plant, animal, or fungal species (*e.g.*, effects of increased shade, competition for water or nutrients, or allelopathy), or
 - significant increases in the proportion of other non-native species in the community, or
 - suppression of seedlings of native successional or climax species, leading to altered community composition over time
- B. **Moderate significance.** Significantly alters ecological community composition (*e.g.*, produces a significant reduction in the population size of one or more locally common native species in an ecological community)
- C. **Low significance.** Influences ecological community composition (*e.g.*, reduces recruitment of one or more locally common native species which will likely result in significant reduction in the long-term abundance of these species)
- D. **Insignificant.** No impact; causes no perceivable change in locally common native species populations
- U. **Unknown.**

4. Impact on Individual Native Plant or Animal Species

Non-native species often impact the native species of an area broadly, in rough proportion to their local abundance. However, some non-native species disproportionately affect particular individual native plant, animal, fungal, or other species (at least at some sites), even if their impacts on community structure or composition are not great. For example, butterflies or other invertebrates that feed on specific native plants may deserve particular consideration here.

Examples of such *disproportionate* individual impacts on one or more particular individual native species include:

- Strongly outcompetes a particular native species
- Hybridizes with a particular native species
- Parasitizes a particular native species
- Poisons a particular native species
- Hosts a non-native disease which damages a particular native species
- Distracts pollinators from a particular native species

Note that this question focuses on unusual, disproportionate impacts on particular native species, and should not be used to catalog long lists of species generally impacted.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Major impacts on particular native species (*e.g.*, in places they co-occur, has negative impacts on more than 50% of the individuals of one or more native species)
- B. **Moderate significance.** Significant impact on particular native species (*e.g.*, has negative impacts on 20 to 50% of the individuals of one or more native species)
- C. **Low significance.** Occasional impact on particular native species (*e.g.*, has negative impacts on 5 to 20% of the individuals of one or more native species)
- D. **Insignificant.** Little or no impact on particular native species (*e.g.*, no known reports of competitive suppression, hybridization, parasitism, or other particular disproportionate negative impacts)
- U. **Unknown.**

5. Conservation Significance of the Communities and Native Species Threatened

Many non-native plants occur primarily in disturbed, low quality habitats that are dominated by widespread native species and other non-native species. Non-native plants have a greater impact if they:

- Directly or indirectly threaten native species or ecological communities that are considered rare or vulnerable (*e.g.*, legally protected in the region, such as those federally listed in the U.S.; or considered globally rare, such as those ranked G1-G3 by NatureServe), or
- Threaten outstanding, high quality occurrences of common ecological communities (*e.g.*, those with NatureServe Element Occurrence Ranks A or B).

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** For example, often threatens one or more rare or vulnerable native species or ecological communities, and/or high-quality occurrences of more common ecological communities
- B. **Moderate significance.** For example, may occasionally threaten one or more rare or vulnerable native species or ecological communities, and/or high-quality occurrences of more common ecological communities
- C. **Low significance.** For example, usually inhabits common, unthreatened habitats and rarely threatens rare or vulnerable native species or ecological communities, and/or high-quality occurrences of more common ecological communities
- D. **Insignificant.** For example, found primarily or only in human-disturbed habitats and not known to threaten any rare or vulnerable native species or ecological communities, and/or any high-quality occurrences of more common ecological communities
- U. **Unknown.**

Section II. Current Distribution And Abundance

Assess the current distribution and abundance of the species within your region. For mixed-status species, consider the species' distribution and abundance within the portion of the region in which the species is not native (including areas where it does not occur at all).

6. Current Range Size in Region

The range size considered here is the entire generalized range where the species is present within the region as a non-native outside cultivation, not just the range where it has its greatest impacts. The area of the generalized range is usually much greater than actual acreage infested.

Note that the percentage thresholds used for A, B, C, and D may need to be adjusted for certain biogeographically unusual regions of interest, such as those with large disjunct areas such as the 50 states of

the United States. If such adjustments are made however, they must be used for all species assessments for that region of interest in order to assure comparability and repeatability of the results.

For mixed-status species, consider as a baseline the size of the remaining portion of the region of interest after the species' generalized native range is excluded.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources. Also provide approximate date(s) of range-size information (if available), especially if estimated from multiple sources.

- A. **High significance.** Widespread in region (e.g., >30% of region; >1,000,000 sq. mi. in the contiguous United States).
- B. **Moderate significance.** Substantial part of region (e.g., 10-30% of region; 300,000 - 1,000,000 sq. mi. in the contiguous United States).
- C. **Low significance.** Small part of region (e.g., 0.1-10% of region; 3,000 - 300,000 sq. mi. in the contiguous United States).
- D. **Insignificant.** Isolated or spotty range in region (e.g., <0.1% of region; <3,000 square miles in the contiguous United States).
- U. **Unknown.**

Note that 3,000 square miles is approximately the size of a few Midwestern U.S. counties; 300,000 sq. mi. is approximately the size of Texas, or of California and Nevada combined; 1,000,000 sq. mi. is approximately one-third of the contiguous United States.

7. Proportion of Current Range Where Species Is Negatively Impacting Biodiversity

Within what proportion of the species' generalized range (from Question 6 above) is the species causing noticeable negative impacts on biodiversity?

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Impacts occur in >50% of the species' current generalized range in the region of interest
- B. **Moderate significance.** Impacts occur in 20 - 50% of the species' current generalized range

- C. **Low significance.** Impacts occur in 5 - 20% of the species' current generalized range
- D. **Insignificant.** Impacts occur in <5% of the species' current generalized range in region
- U. **Unknown.**

8. Proportion of Region's Biogeographic Units Invaded

Select and consistently use a biogeographic classification or map with a scale appropriate to your region of interest. For example, Bailey's (1995) ecological regions would be appropriate for use for the contiguous United States, but not for the state of Delaware.

For mixed-status species, consider as a baseline the number of biogeographic units (from the selected classification or map) that are represented in the remaining portion of the region of interest after the species' generalized range is excluded.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources. Also provide the number or percentage of biogeographic units in which the species is present.

- A. **High significance.** Present in most biogeographic units (e.g., >50%).
- B. **Moderate significance.** Present in many biogeographic units (e.g., 20-50%)
- C. **Low significance.** Present in a few biogeographic units (e.g., <20%), or one major unit (e.g., Colorado River watershed)
- D. **Insignificant.** Present in only one minor biogeographic unit (e.g., watershed of the Green River, a tributary of the Colorado River)
- U. **Unknown.**

9. Diversity of Habitats or Ecological Systems Invaded in Region

Examples of habitats or ecological systems include:

- coastal dunes
- bottomland hardwood forest
- salt marsh
- savanna
- upland conifer forest

You may choose a general system of classifying natural habitats or ecological systems or one more specific to your region of interest. When possible, use the same system for all assessments in your region. If multiple habitat classifications must be used, it may be necessary to adjust their scaling to provide

comparability for various species being assessed in your region. For example, a habitat classification that divides habitats very finely may require some grouping of similar habitats; similarly, broadly defined habitats might count more heavily if a species is common within them (and presumably present in several of their more minor variants). For mixed-status species, consider only habitats in which the species is established as a non-native (outside the species' native range), regardless of whether the species also occurs in same habitats within its native range.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Many (6 or more) distinct habitats or ecological systems invaded
- B. **Moderate significance.** Moderate number (4-5) of distinct habitats or ecological systems invaded
- C. **Low significance.** Small number (2-3) of habitats or ecological systems invaded, or moderate number (4-5) of similar habitats
- D. **Insignificant.** Only a single habitat or ecological system invaded
- U. **Unknown.**

Section III. Trend in Distribution and Abundance

Assess various trends in the species' distribution and abundance here, as well as its reproductive characteristics and its ability to invade natural habitats.

10. Current Trend in Total Range Within the Region

Trend in the species generalized range is addressed here; more local changes within the species' generalized range are considered separately in Question 13. For mixed-status species, consider only the trend involving its non-native range, not natural changes to its native range.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Range expanding in most or all directions, and/or spreading into new portions of the region
- B. **Moderate significance.** Range increasing in some directions but not most or all

- C. **Low significance.** Range stable, or areas of range contraction balancing areas of expansion
- D. **Insignificant.** Range decreasing
- U. **Unknown.**

11. Proportion of Potential Range Currently Occupied

This question compares (a) the species' current generalized range within the region of interest with (b) the potential generalized range it is considered to be capable of occupying if it is not prevented from spreading. For mixed-status species, only its present and potential non-native range within the region should be considered.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Less than 10% of potential range currently occupied
- B. **Moderate significance.** 10-30% of potential range currently occupied
- C. **Low significance.** 30-90% of potential range currently occupied
- D. **Insignificant.** Greater than 90% of potential range currently occupied
- U. **Unknown.**

12. Long-Distance Dispersal Potential Within Region

What is this species' potential for long-distance dispersal (generally more than 100 km or 60 miles) by humans (intentionally or unintentionally), by other animals, or by abiotic factors (e.g., wind, rivers, or floods)?

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources. Also include examples of long-distance dispersal mechanisms, if known.

- A. **High significance.** Long-distance dispersal frequent (e.g., seed or other propagules frequently carried long distances by humans, wide-ranging birds or mammals, wind [especially spores or tiny seeds], or river currents; or plants commonly sold commercially and transported substantial distances)

- B. **Moderate significance.** Long-distance dispersal infrequent (*e.g.*, seeds carried occasionally by unusually strong winds, more localized birds or mammals, or periodic floods, or plants occasionally transported by human actions)
- C. **Low significance.** Long-distance dispersal rare but known (*e.g.*, major floods, hurricanes, or other unusual weather events)
- D. **Insignificant.** Long-distance dispersal seldom or never
- U. **Unknown.**

13. Local Range Expansion or Change in Abundance

Is the species increasing in abundance (cover, density, frequency, *etc.*) within its current non-native range in the region and/or locally expanding within or at the edges of this range (peripheral expansion, generally <100 km or 60 miles), based on trends of the past 10-20 years?

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Local range and/or species abundance increasing rapidly (*e.g.*, area occupied likely to double within 10 years in most areas where it doesn't already fully occupy its potential habitat), and/or abundance increasing significantly (by >25% of current values) in >75% of the area that it has already invaded
- B. **Moderate significance.** Local range expanding at a moderate rate (*e.g.*, area occupied likely to increase by 50% in 10 years or to double within 50 years) and/or species abundance increasing significantly (by >25% of current values) in 25%-75% of the area that it has already invaded
- C. **Low significance.** Local range expanding slowly and/or abundance increasing significantly (by >25% of current values) in only a small portion (<25%) of the area that it has already invaded
- D. **Insignificant.** Species abundance and local range stable or decreasing across the entire area it has already invaded within the region
- U. **Unknown.**

14. Inherent Ability to Invade Conservation Areas and Other Native Species Habitats

Consider information indicating the extent to which this species invades well-established, mature natural vegetation (within the region or elsewhere), which helps predict whether it will do so in other places. When possible, use information from areas where the species is not native (including both the region of interest and other parts of the world). However, if no information is available on the species' behavior in its non-native

range, cautiously consider any available information from its native range (such as involvement in succession or response to disturbance), but be aware that this may yield a conservative view of its potential behavior since pathogens, predators, and competitors likely limit the species' population expansion in its native range.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Regularly establishes in undisturbed portions of intact or otherwise healthy, late-successional or mature native vegetation
- B. **Moderate significance.** Regularly establishes in mid-successional native vegetation, but may establish in late-successional or mature vegetation following minor one-time or recurrent disturbances (*e.g.*, tree falls, hiking trails, streambank erosion); however, rarely if ever establishing in undisturbed portions of intact mature native vegetation
- C. **Low significance.** Often establishes in areas where major natural or human-caused disturbance has occurred in the previous 20 years (*e.g.*, post-hurricane sites, landslides, highway corridors), but seldom if ever in undisturbed areas or areas with only minor disturbance
- D. **Insignificant.** Not known to spread significantly into conservation areas or native species habitats on its own (*e.g.*, species may be present only along edges, or may persist from former cultivation)
- U. **Unknown.**

15. Similar Habitats Invaded Elsewhere

Is this species established outside its native range in places besides the region of interest, such as other continents, other nations, other ecoregions, or other island groups? If so, has this species escaped in habitats/ecosystem types that are comparable or analogous to habitats/ecosystem types that exist in the region of interest, but which it has not yet invaded?

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources. Include summary of other regions where escaped, with pertinent habitats for each where known.

- A. **High significance.** Escaped in 3 or more habitats or ecosystem types which it has not yet invaded in the region of interest but which exists there (*e.g.*, for the United States, a species that has invaded

Mediterranean grasslands, savanna, and maquis in southern Europe may threaten such analogous U.S. habitats as California grasslands, savanna, and chaparral)

- B. **Moderate significance.** Escaped in 1-2 habitats or ecosystem types which it has not yet invaded in the region of interest
- C. **Low significance.** Escaped elsewhere but only in habitat types comparable to those it has already invaded in the region of interest
- D. **Insignificant.** Not known as an escape except in the region of interest
- U. **Unknown.**

16. Reproductive Characteristics

The following are some reproductive characteristics typical of invasive plant species; consider which of these characterize this species.

- Produces over 1,000 seeds or spores per plant annually
- Reproduces more than once per year
- Grows more rapidly to reproductive maturity than most plants of its lifeform
- Reproduces readily both vegetatively and by seed or spores
- Has seeds (or spores) that remain viable in soil for three or more years
- Has quickly spreading rhizomes or stolons that may root at nodes
- Resprouts readily when broken, cut, grazed, or burned
- Fragments easily, with fragments capable of dispersing and subsequently becoming established
- Has other comparable reproductive factors suggesting potential aggressiveness (*Explain in comments*)

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Extremely aggressive (*e.g.*, strongly exhibits three or more of the above characteristics)
- B. **Moderate significance.** Moderately aggressive (*e.g.*, strongly exhibits two of the above characteristics)
- C. **Low significance.** Somewhat aggressive (*e.g.*, strongly exhibits one of the above characteristics, or more weakly exhibits a few)
- D. **Insignificant.** Not aggressive (*e.g.*, has none of the above characteristics or weakly exhibits only one)
- U. **Unknown.**

Section IV. Management Difficulty

In addressing the questions in this section, consider particularly known control methods for this species that are feasible and appropriate for use in conservation areas and other native species habitats.

17. General Management Difficulty

Given the current state of knowledge regarding management methods, how difficult is it to control an established stand of this species? Consider both the difficulty of control and the extent of existing knowledge regarding the management of this species.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. Document your response with a text comment summarizing information considered (with examples), and include citations to information sources. Provide brief examples, but not details on control methods.

- A. **High significance.** Managing this species normally requires a major, long-term investment of human and/or financial resources or is not possible with available technology (e.g., >\$1,500 per hectare [or >\$600/acre] per year for 5 years or more)
- B. **Moderate significance.** Management requires a major short-term investment of human and financial resources, or a moderate long-term investment (e.g., >\$1,500 per hectare per year for less than 5 years or \$500 per hectare [\$200/acre] per year for 5 years or more)
- C. **Low significance.** Management is relatively easy and inexpensive; requires a minor investment in human and financial resources (e.g., <\$100 per hectare [\$40/acre] per year for less than 5 years)
- D. **Insignificant.** Managing this species is not necessary (e.g., species does not persist without repeated human disturbance and/or reintroduction)
- U. **Unknown.**

18. Minimum Time Commitment

What is the minimum time commitment needed to control this species (e.g., reduction to acceptable levels which can be maintained with little effort) at a 1-hectare (~2.5 acre) site in which it is abundant or well established, including follow-up survey and monitoring? Consider longevity of seed, shoot, or root banks as appropriate, including time necessary for restoration if this is necessary.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the

answer null. **Document** your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Control requires at least 10 years
- B. **Moderate significance.** Control requires 5-10 years
- C. **Low significance.** Control requires 2-5 years
- D. **Insignificant.** Control (if needed) can normally be accomplished within 2 years
- U. **Unknown.**

19. Impacts of Management on Native Species

Do the effective methods for managing this species normally cause significant and persistent reductions in the abundance of native species (sometimes referred to as collateral or non-target damage)?

*Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. **Document** your response with a text comment summarizing information considered (with examples), and include citations to information sources.*

- A. **High significance.** Management impacts often severe, with the only effective methods for managing this species normally causing significant and persistent reductions in the abundance of native species (>75% of the time)
- B. **Moderate significance.** Management impacts moderate, with the only effective methods for managing this species reducing native species abundance or causing other unacceptable damage 25-75% of the time
- C. **Low significance.** Management impacts minor, with the only effective methods causing significant persistent reductions in native species abundance <25% of the time
- D. **Insignificant.** Management impacts insignificant or rare, with effective control methods rarely or never causing significant reductions in native species abundance, or causing only ephemeral reductions (lasting <2 years)
- U. **Unknown.**

20. Accessibility of Invaded Areas

The accessibility of infestations within conservation areas or other native species habitats is considered here, because species found in inaccessible areas are more difficult to control. Consideration should also be given here to accessibility of adjacent areas that are sources of recurrent reintroduction, but not infestations remote from conservation areas or native species habitats.

Select the single-letter answer (A,B, C, or D) that best characterizes the species, or an answer range (AB, BC, CD, AC, or BD) if only some answers can be eliminated, or else 'U' (Unknown) if none of the four

answers have been eliminated. However, if you have not substantially considered the question, leave the answer null. **Document** your response with a text comment summarizing information considered (with examples), and include citations to information sources.

- A. **High significance.** Accessibility problems high, with many invaded areas (hundreds of thousands of acres, or >30% of area it infests) not accessible for treatment (*e.g.*, they are on very steep slopes or canyon walls, in roadless areas, along remote shorelines, or on private lands where permission to enter is difficult to obtain)
- B. **Moderate significance.** Accessibility problems medium, with a substantial percentage of the area invaded by this species inaccessible (tens of thousands of acres, or 5-30% of the area it infests)
- C. **Low significance.** Accessibility problems low, with a significant but relatively small percentage of the area invaded by this species inaccessible (thousands of acres or <5% of area it infests)
- D. **Insignificant.** Accessibility problems insignificant or rare, with little or none of the area infested by this species inaccessible
- U. **Unknown.**