An Invasive Plant Management Decision Analysis Tool

Version 1.1

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EXECUTIVE SUMMARY

The purpose of the Invasive Plant Management Decision Analysis Tool (IPMDAT) is to assist The Nature Conservancy (TNC), as well as partner agencies and organizations, in deciding if an invasive plant management project is likely to be successful. A successful invasive plant management project should not only control an invasive plant, it should also achieve conservation goals such as maintaining or restoring the viability/health/resilience of desired species, natural communities, and/or ecosystem processes. The IPMDAT may also be used in cases where the invasive plant species threatens economic or human health, recreational use, or meeting legal obligations.

The IPMDAT is comprised of a strategy-selection decision tree and three control-strategy decision trees (eradication, containment/exclusion and suppression) as well as associated worksheets and documentation. The strategy selection tree is used to determine if the harm caused by an invasive plant species is significant enough to warrant control. Then the tree is used to identify the appropriate control strategy based on the abundance and distribution of the invasive plant. Subsequent trees are used to determine whether control is feasible given the socio-political environment, biological attributes of the plant, effectiveness of control methods, risk of non-target impacts or unintended consequences, and available resources. If the project is determined to be feasible, then the user is asked to weigh the cost and benefits of control project. Lastly, a pre-and post-control monitoring plan is required for a control project to proceed.

The IPMDAT contains three potential control strategies: eradication, containment/exclusion and suppression.

- The goal of eradication is to eliminate all individuals and the seed bank from an area with the low likelihood of needing to address the species again in the future.
- A containment/exclusion project aims to prevent infestations of invasive species from spreading to uninfested areas.
- The goal of a suppression project is to reduce an invasive plant population in size, abundance, and/or reproductive output below the threshold needed to maintain a species or ecological process. Suppression is only feasible at the local scale due to resource constraints.

The IPMDAT has four possible outcomes: 1) Proceed with control strategy implementation – project has a high probability of success and has conservation value, 2) Stop – secure sustainable funding source, 3) Stop – control not feasible and/or not warranted, or 4) Peer-review required – feasibility and/or conservation value is uncertain.

The IPMDAT will help ensure that conservation organizations and agencies utilize limited resources most effectively by evaluating the feasibility of control strategies and identifying a clear conservation outcome.

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INTRODUCTION

The primary purpose of the Invasive Plant Management Decision Analysis Tool (IPMDAT) is to assist The Nature Conservancy (TNC) and partner agencies and organizations in deciding if an invasive plant management project is likely to be successful: i.e. to achieve desired conservation outcomes with acceptable costs. A successful invasive plant management project should not only remove or reduce an invasive plant – it should also result in long-term maintenance or restoration of the viability/health/resilience of desired species, natural communities, and/or ecosystem processes. The IPMDAT will help ensure that limited resources are used most effectively. Our approach is designed for invasive plants, but a similar method could be used for invasive animals and insects. The IPMDAT is an iterative process and will be updated as needed.

We adopt the definition of an invasive species as defined in the federal Executive Order 13112, signed in 1999, which also was adopted by the NYS Invasive Species Task Force. Thus, for the purpose of the IPMDAT, an invasive species is a species that is: 1) nonnative to the ecosystem under consideration, and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. In the latter case, the harm must significantly outweigh any benefits."

The primary focus of the IPMDAT is on the control of invasive plant species that have negative ecological impacts on native species and natural communities, and on the ecological processes essential for the health of those species and communities. However, the IPMDAT also may be used in situations where the invasive plant species has negative impacts on other values, such as human health, the economy, recreational uses, ecosystem services, legal mandates, and programmatic or other obligations. Whatever the circumstances, the harm caused by the species must be significant and clearly documented.

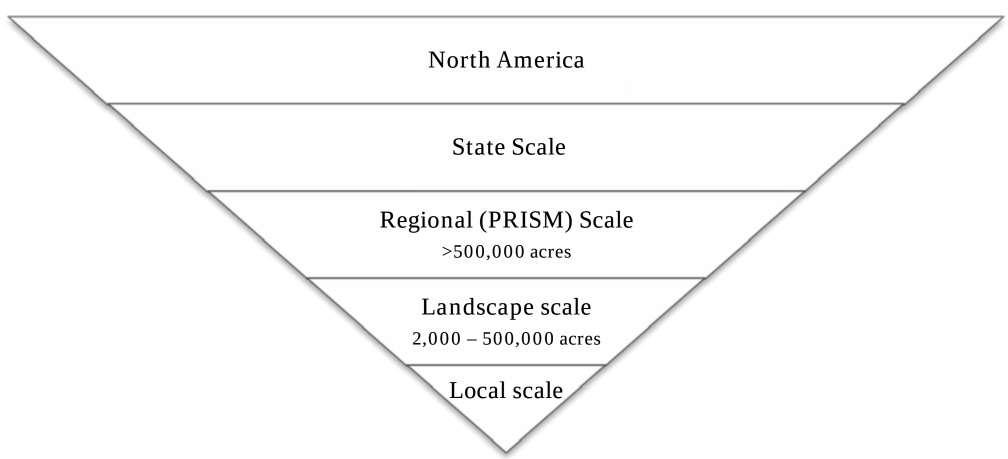
The ecological impact of the invasive plant must be placed in the context of conservation goals. Conservation organizations and government agencies have different means to establish conservation priorities. Invasive plant management projects must clearly identify a desired conservation outcome. TNC uses Ecoregional Assessments (TNC 2000) and Conservation Acton Planning (CAP) (TNC 2007) to establish priorities and a vision for conservation success. An Ecoregional Assessment identifies conservation targets that represent the diversity of species, communities and ecosystems to inform comprehensive conservation within an ecoregion. The Conservation Action Planning (CAP) process helps practitioners to develop strategies for conservation targets, to abate threats, measure their success, and adapt and learn over time (TNC 2007). Ecoregional Assessments and CAP provide a basis for ranking the level of invasive species threat to the health of a conservation target and selecting strategies to abate the threat, leading to a clear conservation outcome.

The decision tool is comprised of four decision trees. The first tree – the Strategy Selection Tree – is used to determine if the ecological impact of an invasive plant species on a conservation target is significant enough to warrant control. This determination is based primarily on documentation compiled in the New York State Ranking System for Evaluating Non-Native Plant Species for Invasiveness (Jordan et al. 2011). If the species has not been assessed for NYS, or if the species threatens a different value (health, economy, etc.) appropriate alternative guidelines for assessing harm should be used. The Strategy Selection Tree is then used to identify the appropriate control strategy based on the abundance and distribution of the invasive plant. The size and number of infestations increases control cost substantially and influences the probability of successfully meeting control objectives.

Subsequent trees are used to determine whether control is feasible given the socio-political environment, biological attributes of the plant, effectiveness of control methods, risk of non-target impacts or unintended consequences, and available resources. If the project is determined to be feasible, then the user is asked to weigh the cost and benefits of the control project. Lastly, a pre-and post-control monitoring plan is required for a control project to proceed.

Invasive plant management projects are implemented at a variety of spatial scales based on the distribution of the species. We recognize five spatial scales, organized in a hierarchal structure, ranging from North America to the local scale (Figure 1). We consider the regional scale to encompass one of the eight New York State Partnerships for Regional Invasive Species Management (PRISM) (Appendix 1). These scales roughly correspond to the geographic scales of biodiversity identified by Poiani et al. (2000). Invasive plant control projects at the PRISM, landscape or local scales are considered actions taken within a "project area". The threat (ecological impact) to a conservation target (element of diversity) should be clearly identified at the appropriate scale.

Figure 1. Geographic scales at which invasive species management are implemented.



We acknowledge that information on the ecological impact of an invasive species to conservation targets may be limited depending on the amount of research completed. Often, limited information is available on new invaders (i.e. species new to the continent). Additionally, the identification of the conservation target may vary depending on the scale of the control project. The ecological impact of a new invader, which is engaged at the broadest spatial scales (continent or state), may be identified for a coarse scale target such as a major habitat type (i.e. Temperate Broadleaf Forest). However, at finer spatial scales (PRISM, landscape and local) the invasive species threat should also be directly related to conservation targets in an Ecoregional Plan or CAP.

CONTROL STRATEGIES

Control strategies are commonly grouped into three categories: eradication, containment and suppression (USFWS 2008). Eradication, containment, and suppression may not be mutually exclusive in some instances (Hulme 2006). Eradication and containment employ similar tactics, but have different goals. Often, the goal of a control project may be to contain and suppress an invasive plant. We use the following definitions to identify the general goal of each strategy and to structure the decision tool.

Eradication

The goal of eradication is to eliminate all individuals and the seed bank from an area with low likelihood of needing to address the species in the future. The term eradication in its strict definition applies only to the scale of a continent or island. However, eradication tactics are often applied at smaller project scales.

Eradication is considered successful when no plants are recovered from the initial infested area for three consecutive years (Rejmánek and Pitcairn 2002). Eradication is practical only for small-scale infestations, generally in the introduction phase. Eradication of infestations < 1 ha (2.47 acres) in gross area (area over which the weed is distributed) were shown to have the highest likelihood of success in California (Rejmánek and Pitcairn 2002). Only one-third of infestations between 1 and 100 ha were successfully eradicated. Thus early detection of an invasive species when the infestation is small can mean the difference between a successful eradication project and implementing a containment strategy that usually means an infinite financial and time commitment.

In order to be successful long term, the cause of the invasion must be addressed (see below: “Preventing reinvasion”) and all potential seed sources removed. It is also essential to avoid replenishment of the seed bank (Panetta 2009). The likelihood of reinvasion of an eradication site from outside seed sources is based on the predicted rate of spread of the species from the nearest known occurrence to the project area. A tenyear timeframe was chosen to differentiate between a control project that requires resources for a short timeframe, as opposed to a project that requires a long-term commitment of resources.

An example of a large-scale successful eradication project is the eradication of *Caulerpa taxifolia* in California. That effort cost over $5 million (Walters et al. 2006) but was justifiable based on the severe impacts of this “killer alga.” Success may be uncertain in the long term due to continued Internet availability of the genus *Caulerpa*, despite state and federal laws forbidding its sale and transport. Aquarium dumping into storm sewers likely caused the invasion.

Containment and Exclusion

The goal of containment is to prevent an infestation which can’t be eliminated from spreading into an uninfested portion of the project area (Hulme 2006, USFWS 2008). Containment may involve methods that prevent reproduction and dispersal, treating the perimeter of a large infestation, and/or eliminating small satellite infestations. Containment is most effective with species that spread slowly, move short distances, and for which effective barriers can be established (Hulme 2006).

Exclusion is the reverse of containment: the goal is to eliminate any occurrences within the project area and/or prevent the invasive species from spreading into the project area from the surrounding landscape. The IPMDAT uses one decision tree for containment and exclusion since these strategies are similar in goals and tactics.

In Hawaii, a containment program has been implemented at Volcanoes National Park since 1985. The National Park Service established management units called Special Ecological Areas (SEA) to contain 20+ high threat invasive plant species that were too widespread to eradicate. As of 2007, over 66,000 ac of SEAs and buffer zones were managed for target weeds. The program has been successful in containing high threat invasive plants by reducing their abundance to manageable levels. With the reduction in invasive plant abundance, control costs have been reduced by five-fold. However, program managers recognize that follow-up treatment is required indefinitely, surrounding areas will most likely increase in alien plant densities and new recruitment may become unmanageable if SEAs are too small.

An example of a project where 100% eradication was not possible, but which was successful in containment that requires only one day of limited annual follow-up is the removal of *Ludwigia peploides* from an impoundment on the Peconic River on Long Island. The Peconic Estuary Program and 350 partner volunteers worked for a total of 1,600 hours in 2006—2008 and hand-pulled more than 126 cubic yards of the plant. Ludwigia abundance was reduced to <1% of its former extent. Complete eradication is not possible because a few plants grow under riparian shrubs beyond the reach of people in boats. Ludwigia may have been introduced through aquarium dumping or an escape from a nursery. However its survival and rapid growth was possible due to warm, slow moving, and nutrient-rich water in the dammed river impoundment. Removal of the dam and nutrient inputs from septic tank leachate is unlikely. If these “causes” could be removed eradication might be possible.

Suppression

The goal of suppression is to reduce an invasive plant population in size, abundance, and/or reproductive output (i.e., density, cover, seed production) below the threshold needed to maintain a species or ecological process (USFWS 2008). Suppression should only be undertaken if there is a clear conservation outcome that can be attained with an effective use of resources.

The timeframe of a suppression project may vary depending on the invasive plant and desired conservation outcome. For example, an invasive plant may be suppressed in a restoration effort for a few years in order for planted desired species to establish and become competitive. Suppression may also be justifiable if a new, effective control method is likely to become available in the near future, and in the interim competition pressure on desired species needs to be reduced so that they may persist. Alternatively, an invasive plant may be suppressed over a longer timeframe to maintain a rare species. Since no project is likely to have sufficient resources in perpetuity eventual cessation of suppression is inevitable. Thus careful consideration of the value of suppression is needed before undertaking a suppression effort that may have to be implemented for a very long time.

Invasive plant suppression by chemical or mechanical means, or by using prescribed fire or grazing, is most likely to be effective only at a local scale. Long-term suppression at a larger scale is likely feasible only with the use of an effective, well-tested, host-specific biological control agent. Suppression at a large-scale for a long time without biocontrol is unrealistic, as it would require massive resource inputs over the long-term. An example of an effective suppression program is the use of biological control agents to reduce purple loosestrife density to levels low enough for native plant species to increase and persist.

DECISION ANALYSIS CRITERIA

A number of studies have identified factors that influence the feasibility of weed eradication efforts (Rejmánek and Pitcairn 2002, Panetta and Timmins 2004, Cacho et al. 2006, Panetta 2009). Additionally, a number of government agencies and conservation organizations have developed invasive plant ranking systems for different purposes and use at different scales (Morse et al. 2004, Jordan et al. 2008). We drew upon these studies and ranking systems to select criteria to determine the ecological impact of an invasive plant and evaluate the feasibility of a potential invasive plant management project. The criteria are: 1) ecological impact, 2) distribution and abundance, 3) social-political environment, 4) control (kill) effectiveness, 5) ability to prevent reinvasion, 6) ease of detection, 7) resource availability and 8) return on investment. The discussion that follows is intended to describe the criteria, aid in the decision making process and clarify terms used in the IPMDAT.

Ecological Impact and/or Harm to other Values

The first step in determining if a control project should proceed is determining if the invasive plant is or has the potential to cause significant ecological impact or harm to human health, the economy or other values. The ecological impact of an invasive species is evaluated based on the severity and current/potential scope of the impact to a conservation target. High threat invasive species alter ecosystem processes and/or alter native species composition and/or structure and have the potential to become widespread. The IPMDAT utilizes assessment criteria developed for the Invasiveness Ranking System for Non-native Plants of New York (Jordan et al. 2011). An invasive plant control project also may be undertaken if an invasive plant species has negative impacts on other values, such as human health, the economy, recreational uses, ecosystem services, legal mandates, and programmatic or other obligations. For additional information on human health and economic impacts review federal and state noxious weed lists and assessments.

Distribution and Abundance

The size and number of infestations increase control cost substantially, influencing the probability of successfully meeting control objectives (Rejmanek and Pitcairn 2002). Infestation area is commonly described as the "net" area that requires treatment, and the "gross" area that must be searched. In the IPMDAT we use "gross" area unless otherwise noted. The first decision tree (Tree #1) uses infestation size and abundance to guide the selection of the appropriate strategy at the right scale.

The distribution of an invasive plant needs to be put in the context of political, jurisdictional, or ecological boundaries to identify an appropriate control strategy and objective. At the North American, state and PRISM scales, political and jurisdictional boundaries are established. At the local and landscape scale, a project boundary needs to be identified and mapped. This may be a preserve or park with a few hundred acres, up to hundreds of thousands of acres. The Nature Conservancy establishes conservation project boundaries based on the extent of elements of biological diversity. The Nature Conservancy's CAP Handbook (2007) defines a conservation project area as "The place where the biodiversity of interest to the project is located." Invasive species distribution data is not only required within the conservation area, but also within the surrounding landscape or buffer. Propagule pressure from the surrounding landscape needs to be considered when determining the feasibility of control.

Comprehensive survey data is required to determine the number of infestations and their size. The distribution of an invasive plant in North America can be found using the

USDA Plants database (http://plants.usda.gov/java/), and in NYS using the NYS Natural Heritage Program's iMap Invasives database (http://www.imapinvasives.org/index.html) and the New York Flora Atlas (http://newyork.plantatlas.usf.edu/). However, currently the distribution of many species may be greater than is reported in databases. Additional distribution information should be sought from local agencies, organizations or experts. Survey and early detection efforts need to be ongoing, accurate, efficient and cost effective. Rew et al. (2006) provides a review of different inventory and survey methods. See Prather (2006) for directions to determine the "gross" infested area of an invasive plant.

Socio-Political Environment

Social-political considerations can determine the success of an invasive plant eradication program. We recognize that social-political factors also influence the success of invasive plant containment and suppression projects. Panetta and Timmins (2004) identified two factors impeding eradication success; 1) whether the invasive plant is cultivated (i.e. distributed for horticultural of agricultural purposes) and 2) whether the land over which control must occur is accessible. We acknowledge that answers to social-political questions are often hard to determine. We include three questions: 1) Is social resistance to eradication expected? 2) Is the invasive cultivated for horticultural or agricultural uses? 3) Within the invaded area, do all the agencies, organizations and/or landowners agree to participate?

Control (Kill) Effectiveness

The effectiveness of control methods are based on a number of factors. Panetta and Timmins identified the number of treatments required to kill the largest plants, and longevity of seed or vegetative propagules, as important factors. Invasive control programs must also consider permits and/or special procedures that may be required for infestations near sensitive areas (i.e. aquatic herbicide applications). A feasible eradication project must have a control method that can effectively kill the plant and eliminate the seed bank within a reasonable timeframe (i.e. five to ten years).

Non-target Impacts and Unintended Consequences

Even if an invasive plant species is successfully eradicated, contained or suppressed a project can be a failure (or worse) if conservation goals are not achieved, due to persistent non-target impacts or undesirable consequences. For example, a control effort may damage non-target, desired species due to trampling or herbicide spray drift, impact water quality or contaminate the soil. Such non-target impacts could also could lead to public opposition to all future control efforts regardless of their safety.

Unintended consequences must also be carefully thought about and anticipated when planning any type of control effort. For example, after removing an invasive species the unoccupied site might be taken over by a different invasive species instead of the desired species. A research project in Ohio found that cut-stump application of Amur honeysuckle (*Lonicera maackii*) led to an increase in garlic mustard (*Alliaria petiolata*) and exposed native plants to high deer herbivory (Cipollini 2009). Also problematic is sudden and complete elimination of needed wildlife habitat without any replacement. A recent example is the use of a biocontrol beetle to eliminate tamarisk, which has degraded rivers and waterways over two million acres in the Southwestern United States and Mexico. Unfortunately, tamarisk died rapidly and there was no plan for restoration. The loss of habitat has seriously impacted recovery of the endangered Southwestern willow flycatcher and led to eroding riverbanks and impacts on other wildlife.

Preventing Reinvasion and Spread

In order to prevent reinvasion after control actions cease, the underlying causes or facilitators of invasion must be removed, such as: high nutrient inputs, frequent anthropogenic disturbance, and road salt runoff. In addition, spread of invasive plant propagules into and within the project area must be prevented or greatly reduced to ensure success over the long-term. The Center for Invasive Plant Management has identified prevention practices in the Invasive Plant Prevention Guidelines (Clark 2003). The guide contains best management practices to minimize disturbance of desirable vegetation and limit spread of weed seeds.

Invasive plants with abundant viable seeds or vegetative reproduction in combination with human or long-distance dispersal can colonize an area rapidly and be difficult to control. We identified five factors affecting the long-term likelihood of new invasions based on Panetta and Timmins (2004), Radosevich (2007) and Jordan et al. (2011): 1) abundant sexual reproduction 2) reproduction through vegetative fragmentation, 3) innate potential for long-distance dispersal, 4) potential to be spread by humans, and 5) high abundance in adjacent areas.

Abundant reproduction for purposes of assessing invasiveness potential of non-native plant species is defined by Jordan et al. (2011) as more than 100 viable seeds per plant and if viability is not known, then maximum seed production reported to be greater than 1000 seeds per plant –or with extensive vegetative spread one of the plants prime reproductive means.

Long-distance dispersal strongly influences invasion dynamics, leading to satellite infestations well beyond an invasion front. Natural vectors for long-distance dispersal include birds, animal hair, or buoyant fruits. Possible mechanisms of human dispersal include commercial sales, use as forage/revegetation, transport on boats, contaminated compost, and land and vegetation management equipment such as mowers and excavators. Eradication or containment may not be feasible if there is high propagule pressure coupled with long-distance dispersal. In short, invasive plant patches must be eliminated at a rate faster than new occurrences are established (Panetta 2009).

Detectability

Ease of invasive plant detection has often been overlooked as a determining factor in the success of eradication and containment projects (Cacho et al. 2006). The detection effort is comprised of the resources required to delimit the infested area (as described above), find all the individuals for control, and survey for new occurrences (Panetta 2009). One of the highest resource costs is the size of the infested area that must be searched (gross area) (Cacho et al. 2006, Panetta 2009). Over the course of the control project, the density of individuals will decrease, but the original infested area must still be searched. Invasive plant detection can be impeded by the plant community in which the invasive plant occurs and the characteristics of the plant (Panetta and Timmins 2004). For example, it is more difficult to detect a short statured invasive plant in a dense shrubland than in a grassland habitat. We utilize detection criteria from Panetta and Timmins (2004) in the decision trees.

Resource Availability

Resource availability is one of the primary factors determining the feasibility of an invasive plant control project (Panetta 2009). Organizational support for the project must be secured in order to maintain sufficient long-term funding. Resources are required to complete control treatments, as well as prevent, detect and control new occurrences. Resource requirements should decrease with time if control treatments and prevention strategies are successful.

It is difficult to estimate the required investment at the initiation of a complex control project. However, a project budget should be completed for a five-year period using the best available information. Project feasibility is dependent on funding for a minimum of two years and with the likelihood of funding for five. Control projects requiring a high resource investment, high uncertainty, or investment over the long-term should develop a detailed budget for a sufficient timeframe (i.e. ten years or more).

Panetta and Timmins (2004) proposed a scoring system to approximate effort required to control agricultural weeds in Australia. The effort required (E) is estimated by multiplying "gross" infested area (A) by an impedence score (I) calculated from logistics, biological characteristics, detectability and control effectiveness (E = A x I) (Appendix 2). We want to evaluate the usefulness of this approach for ecological weeds, and propose draft thresholds for low, moderate and high E scores (Table 1).

Table 1. Project cost and eradication effort score by cost category.

Cost Categories	Draft Eradication Effort Score (E)	Cost (estimated over 5 yrs)
Low	< 1,000	< $25,000
Moderate	1000 – 5,000	$25,000 – $100,000
High	> 5,000	>$100,000

Return on Investment

Return on investment (ROI) is a means to evaluate the conservation benefits of an invasive plant control project in relation to cost (Murdock et al. 2007). We acknowledge that estimating conservation benefit and cost are highly complex. Our intention is to provide a simple qualitative approach to consider the cost of a project in addition to the benefits (Figure 2). In most cases, cost and benefit is considered relative to other invasive plant control and conservation projects, however this is not always possible and often a project is evaluated alone. The previous section provides guidance on determining cost and provides a method to categorize projects as low, moderate or high.

Assessing the conservation benefit of an invasive plant control project requires a well-defined conservation goal or outcome (Murdock et al. 2007). If the goal or outcome cannot be well defined, then the project should probably not be attempted. Previously we discussed utilizing Ecoregional Assessments and Conservation Actions Plans (CAPs) to identify goals for conservation targets. The conservation benefit of an invasive plant control action can be estimated by the rarity (global rank) and richness (number of species) and viability/integrity (size, condition and landscape context) of the conservation target(s) (species, communities and/or ecosystems) that will be maintained or restored through the action. We consider maintaining/restoring conservation targets identified in an Ecoregional Assessment and/or CAP as having moderate to high conservation benefit.

In general, projects with high cost and low conservation benefit have low ROI and should not proceed (Figure 2). Projects with a low cost and high conservation benefit have the greatest ROI and should proceed. If a project has low benefit it probably should not precede, given the many demands for a land manager's time. If a project has both high cost and high benefit it may still be worth proceeding, but careful evaluation is needed.

Figure 2. Diagram illustrating potential cost and conservation benefit of invasive plant control projects.

Cost	High Cost and Low Conservation Benefit (Do not proceed)	High Cost and High Conservation Benefit (Peer Review)
	Low/Moderate Cost and Low Conservation Benefit (Peer Review)	Low/Moderate Cost and High Conservation Benefit (Proceed)
	Conservation Benefit	

LEARNING TO LIVE WITH INVASIVE SPECIES WE CANNOT CONTROL

In many instances, invasive plants are too widespread to be feasibly controlled, except in selected situations where the impact is significant and the control costs acceptable. Despite our best efforts, invasive plant management may not be successful in all situations where it is attempted. So what can be done when faced with invasive plants that cannot be adequately controlled in valued conservation areas? John Randall (2009)(TNC) advises these four general approaches:

1. Provide native species with refugia from invasive species or otherwise mitigate their harmful effects (e.g. protecting isolated sites or deer exclosures).
2. Manage/restore ecosystem processes that favor natives (e.g. fire, hydrology).
3. Identify individuals/populations of native species with increased abilities to compete with or persist alongside the invasive species and use propagules in restoration efforts.
4. Change the conservation goal from restoration of a pre-existing community to the 'rehabilitation' of a portion of that community or even to a 'new' mixed community of native and non-native species with desirable ecosystem functions and properties possible.

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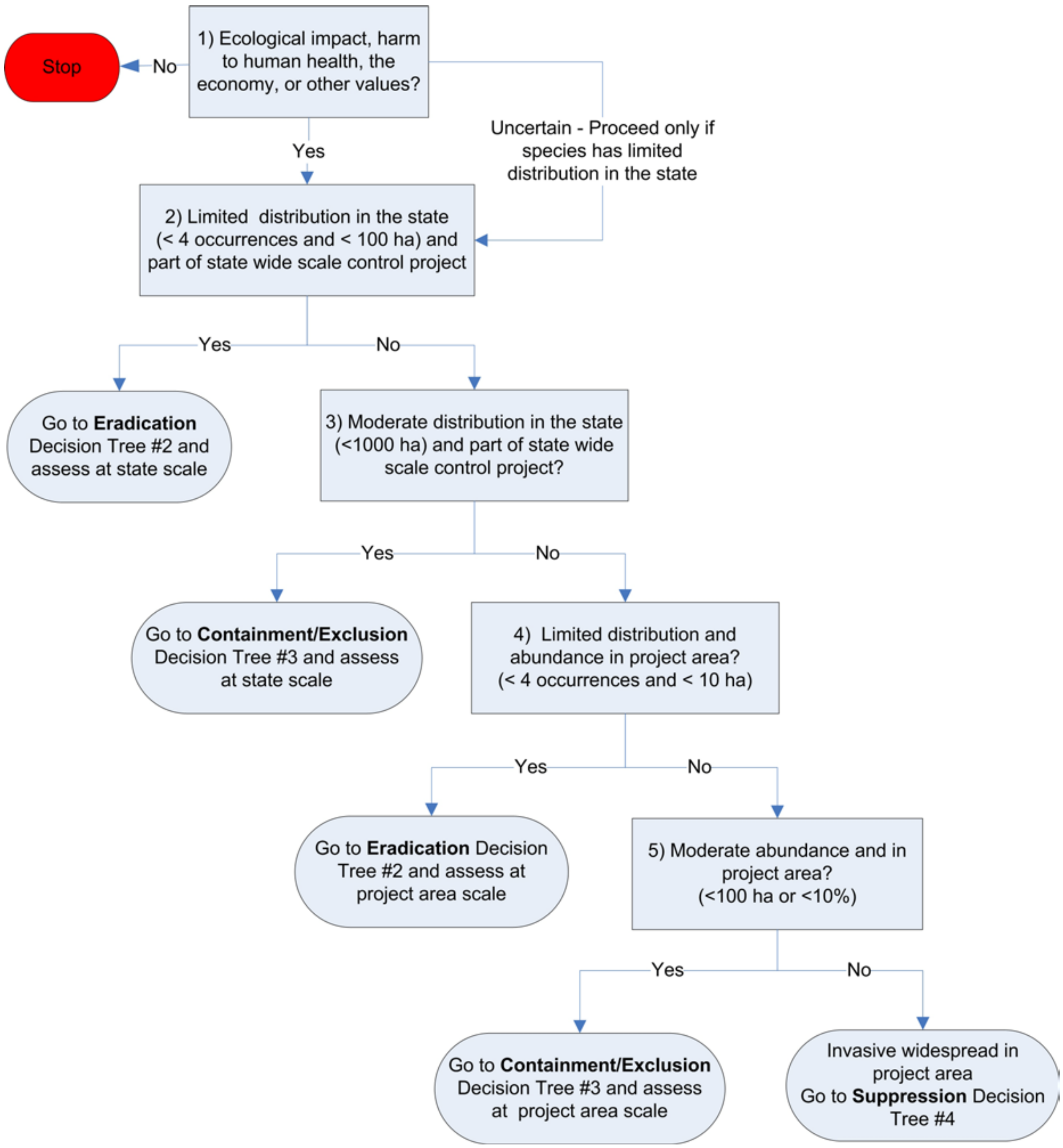
DECISION TREES

Tree 1. Strategy Selection Decision Tree.

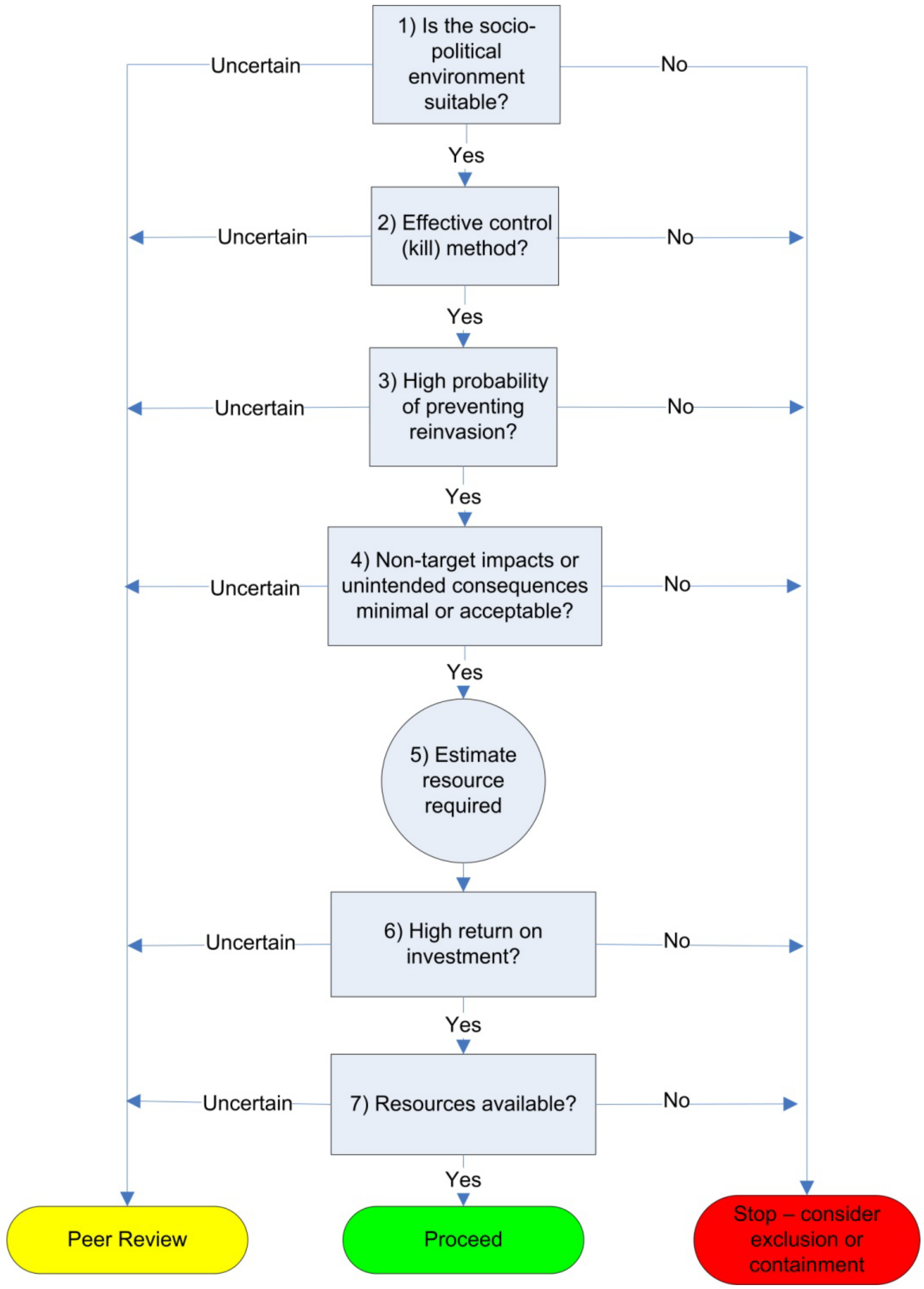
Use with associated worksheet.



* Project area is defined as local, landscape, or PRISM scale.

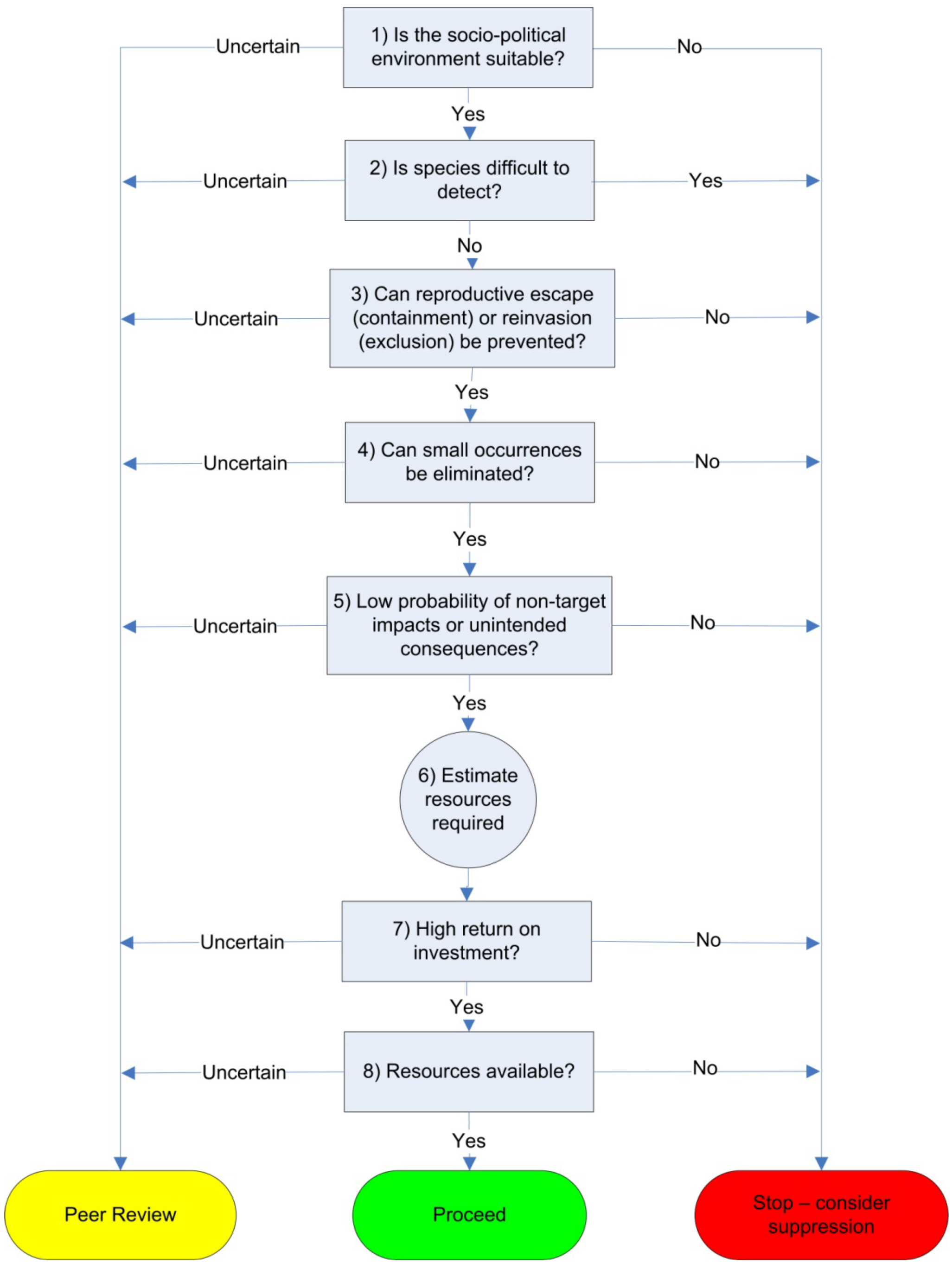
Tree 2. Eradication Decision Tree - State and Project Scale Assessments (Adapted from Panetta and Timmins, 2004). Use with associated worksheet.

The goal of eradication is to eliminate all individuals and the seed bank with the low likelihood of needing to address the species in the future.



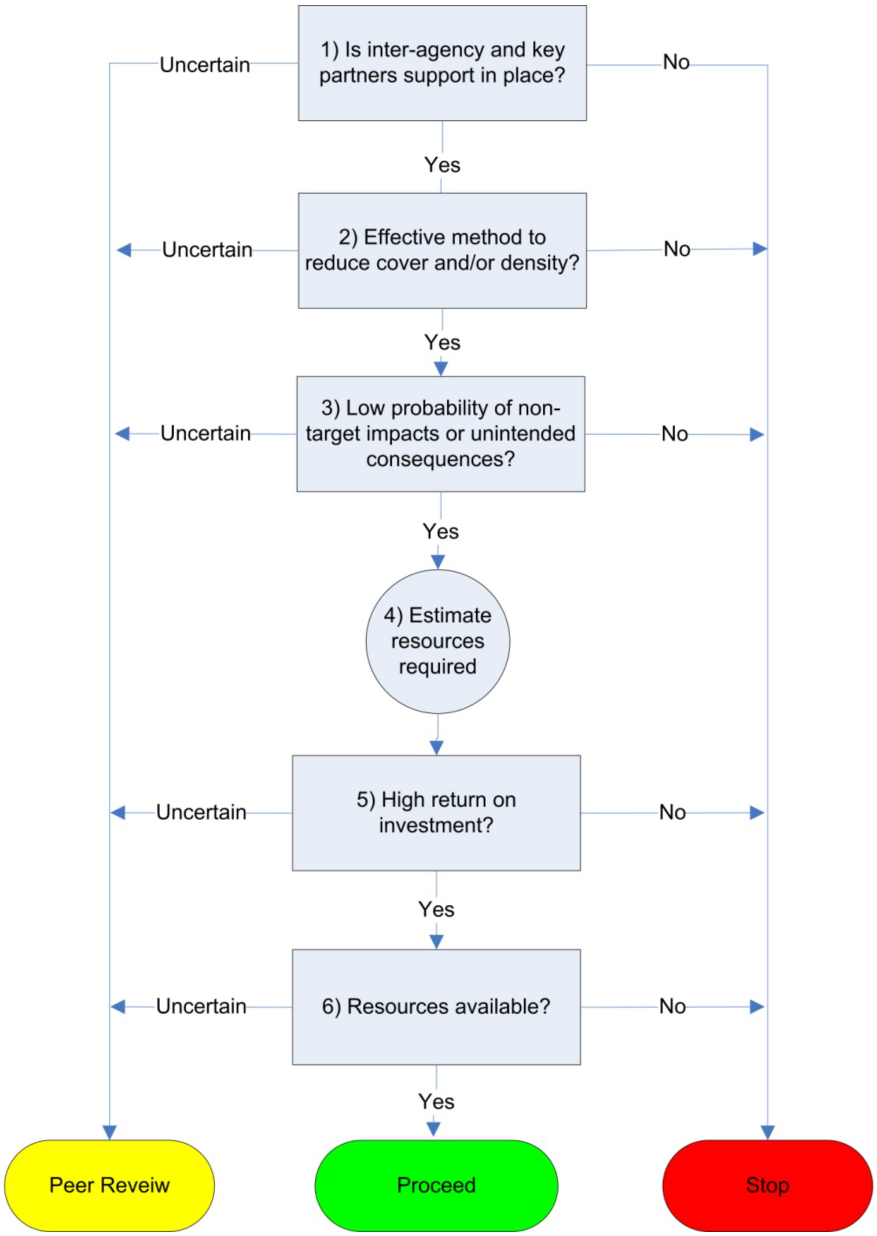
Tree 3. Containment/Exclusion Decision Tree - State and Project Scale assessments Adapted from Panetta and Timmins, 2004). Use with associated worksheet.

The goal of containment or exclusion is to prevent infestations that cannot be eradicated from spreading into the uninvaded areas.



Tree 4. Suppression Decision Tree.

The goal of suppression is to reduce the cover and/or density of an invasive plant below a threshold that mitigates ecological impacts or other harm.



WORKSHEET INSTRUCTIONS

The IPMDAT is comprised of a strategy selection decision tree and three control strategy decision trees (eradication, containment/exclusion and suppression). The assessor(s) should first fill in the project description information on the project cover sheet. Next, use the strategy selection decision tree and worksheet to determine the appropriate control strategy based on the species distribution and abundance. Then use the appropriate control strategy decision tree following instructions on the associated worksheet.

Use the best available information to answer each question thoroughly (cite references when appropriate). Record answers using worksheet check boxes and spaces provided for documentation. Extensive information on ecological impacts, biological characteristics, distribution and control effectiveness has been compiled on NYS non-native plant invasiveness ranking forms for 178 species (Jordan et al. 2011 at http://nyis.info/Resources/IS_Risk_Assessment.aspx), TNC's element stewardship abstracts (http://www.invasive.org/gist/esadocs.html), and Nature Serve assessments

The IPMDAT has four possible outcomes: 1) Proceed with implementation – project has a high probability of success, has conservation (or other) value, and is cost effective; 2) Stop – secure sustainable funding source; 3) Stop - control not feasible and/or not warranted; or 4) Peer-review required – feasibility and/or conservation value is uncertain (See below for additional information).

Complete the IPMDAT in the following order: 1) project summary section on the cover sheet, 2) worksheets, 3) Part 1 of the coversheet, and if the analysis indicates that the project should proceed or that a peer-review is required, complete Part 2 of the coversheet and assemble a project package that includes the following plus any pertinent maps or references:

1. Coversheet
2. Strategy selection and control strategy worksheets
3. Eradication effort scoring form (if applicable)
4. Budget
5. Monitoring plan
6. Restoration plan (if applicable)
7. NYS and PRISM ranking forms for the invasive plant species
8. Outcome of peer review (if peer review is needed)

If a peer review is needed, the review should consider the following questions:

1. Review the decision tree criteria. Is the information presented complete?
2. Are there partner contributions to the project?
3. How does the project rank in relation to other priorities?
4. Estimate the cost and consequences of <u>not</u> undertaking or completing the control project. What would be the impact on the conservation target of not acting? Would the target persist? In what condition? What other targets or values would be compromised?
5. Can the control project be sustained until completion given current and potential future resources?

INVASIVE PLANT MANAGEMENT DECISION ANALYSIS TOOL
PROJECT COVER SHEET

Project Summary

Scientific name: ______________________

Common name(s): ______________________

Scale (See Figure 1, page 2) ______________________

PRISM or Weed Management Area ______________________

Conservation target impacted: ______________________

Project area (site) name and size: ______________________

Property owner(s) ______________________

IPMDAT date assessed: ______________________

Assessors: ______________________

Reviewers (if peer review required):

Part 1 - Decision Analysis Summary (Refer to completed worksheets)

Control Decision

- ☐ Proceed (project feasible and warranted)
- ☐ Stop (project not feasible and/or warranted)
- ☐ Peer Review (project feasibility uncertain)
- ☐ Stop (secure sustainable funding source)

Total Project Cost:

Project Timeframe Years: From: To:

Distribution and Abundance: (Obtain from Strategy Selection Worksheet questions)

Total gross invaded area: (hectares) (acres) (square meters)

Total number of occurrences:

- ☐ Limited in the state (question 1.2)
- ☐ Limited in project area [b] (question 1.4)
- ☐ Moderate in the state (question 1.3)
- ☐ Moderate in project area [b] (question 1.5)
- ☐ Widespread in the state (question 1.3)
- ☐ Widespread in project area [b] (question 1.5)

Control Strategy Selected:

- ☐ Eradication at state scale
- ☐ Containment/Exclusion in project area
- ☐ Containment at state scale
- ☐ Suppression
- ☐ Eradication in project area scale

Project Goal: (Desired outcome)

Ecological Impact or Harm to other Values: (Obtain from Strategy Selection Worksheet question 1.1)

Treatment Type:

☐ Manual ☐ Herbicide ☐ Mechanical ☐ Biological Control

Treatment Description:

Cause of Invasion: (What is the likely cause of the invasion? Is the cause persistent and likely to lead to reinvasion?)

Additional Information: (History of the species in the project area, vector of the species, etc.)

Part 2 – Measuring Success and Restoration Needs (Complete if project proceeding or if peer review)

Monitoring Plan Description: (Briefly describe methods, analysis and timeline. Attach monitoring plan)

Control Objective: (i.e. Reduce stem density by 95% by 2020)

Restoration Needs: (Is active restoration necessary? Attach restoration plan if applicable)

STRATEGY SELECTION WORKSHEET

Use with Strategy Selection Decision Tree (Tree 1)

1.1 Does the species cause significant ecological impact, harm to human health, the economy, or other values?

- Enter the total NYS Ecological Impact point score below from Section 1 of the appended New York State Ranking System for Evaluating Non-Native Plant Species for Invasiveness (Jordan et al. 2011 at http://nyis.info/Resources/IS_Risk_Assessment.aspx). Species with a score of either 7 or 10 for at least one question in Section 1 meet ecological impact criteria.
- If the species has not been assessed for NYS, use assessments from other states in the northeast, or other suitable information. Explain in the Documentation box below and attach supporting documents.
- If impacts to other values (e.g. human health, the economy, etc.) explain in the Documentation box below and attach supporting documents.

☐ 1a Significant ecological impact - If the score for any of the four questions 1.1 through 1.4 in NYS ranking form was 7 or 10 points, then go to 1.2.

☐ 1b Ecological impact uncertain - If total score for Section 1 of the NYS ranking form was at least 9 but no question scored 7 points. Go to 1.2 only if the species has a limited distribution in state.

☐ 1c Negligible impact or harm - If total score for Section 1 of the NYS ranking form was <7, then stop.

☐ 1d Significant harm to human health, the economy, or other values.

Total NYS Ecological Impact Score: (maximum 40 points possible)

Documentation:

1.2	Does the invasive plant have limited distribution and abundance in the state (< 4 occurrences and < 100 gross hectares (247 acres) and part of a statewide initiative?
☐ If "Yes" go to Eradication Decision Tree (Tree 2) and assess at state scale. ☐ If "No" go to 1.3.	
Documentation:	

1.3	Does the invasive plant have moderate abundance in the state (<1,000 gross hectares (2,471 acres) and part of a statewide initiative?
☐ If "Yes" go to Containment Decision Tree (Tree 3) and assess at state scale. ☐ If "No" invasive plant widespread across the state or not part of statewide initiative, go to 1.4 and assess distribution at project area scale.	
Documentation:	

1.4	Does the invasive plant have limited distribution and abundance in project area (< 4 occurrences or < 10 gross hectares (24.7 acres)?
☐ If "Yes" go to Eradication Decision Tree (Tree 2) and assess at the project area scale. ☐ If "No" go to 1.5.	
Documentation:	

1.5	Invasive plant has moderate abundance in the project area (<100 gross hectares (247 acres) or covers <10 % of project area (if project area is <1,000 acres).
☐ If "Yes" go to Containment/Exclusion Decision Tree 3 and assess at the project area scale. ☐ If "No" invasive plant widely distributed, go to Suppression Decision Tree 4 and assess at the project area scale.	
Documentation:	

ERADICATION WORKSHEET

Use with Eradication Decision Tree (Tree #2) at the state or project scale

2.1 Is the social-political environment suitable? Is social resistance to eradication expected? Within the invaded area, do all the agencies, organizations and/or landowners agree to participate?
☐ If “Yes” go to 2.2. ☐ If “No” do not proceed. Consider containment (Decision Tree 3). ☐ If “Uncertain” initiate peer review process and go to 2.2.
Comments:

2.2 Effective control (kill) method available? Is there a method available to kill the plant, prevent reproduction and eliminate seed bank within 10 years? Species with seeds (or vegetative propagules) that remain viable in soil for more than 10 years may not be able to be eradicated. Document the type of treatment that is anticipated to be used. Refer to NYS Plant Ranking System (Jordan et al. 2011) questions 4.1 and 4.3.
☐ If “Yes” go to 2.3. ☐ If “No” do not proceed. Consider containment (Decision Tree 3). ☐ If “Uncertain” initiate peer review process and go to 2.3.
Documentation:

2.3 High probability of preventing reinvasion? A. Are spread prevention measures (i.e. inspections, cleaning stations, regulations, sanitation protocols and/or focused education efforts), early detection, and rapid response program underway and funded for 2 years? B[1]. If assessing feasibility of eradication at the *state scale*, is the species not likely to reach state within 10 years determined by the predicted spread of the species from the nearest known occurrence? B[2]. If assessing feasibility of eradication at the *project scale*, is the species not likely to reach the project area within 10 years determined by the predicted spread of the species from the nearest known occurrence? Preventing reinvasion may be difficult if the species has the potential to spread rapidly (abundant reproduction (vegetative or by seed) and/or long distance or human dispersal including commercial sale) and/or if the initial cause of the invasion persists (e.g. regular natural or human disturbance or road runoff). Refer to NYS Plant Ranking System (Jordan et al. 2011) questions 2.1, 2.2 and 2.3 for guidance.
☐ If "Yes" to both A and B go to 2.4. ☐ If "No" do not proceed. Consider exclusion or containment (Decision Tree 3). ☐ If "Uncertain" initiate peer review process and go to 2.4.
Documentation:

2.4 Is the risk low that the proposed control action could result in a non-target impact or unintended consequences that are unacceptable to the land manager, stakeholders or the public? For example, long-term damage to native plants; chemical contamination of soil, surface water or groundwater; removal of important habitat for wildlife that cannot easily be replaced; another invasive species replaces the one that was removed; or native plants are exposed to high deer herbivory.
☐ If "Yes" go to 2.5. ☐ If "No" do not proceed. ☐ If "Uncertain" initiate peer review process and go to 2.5.
Documentation:

2.5 Estimate resources required to achieve eradication. Complete eradication effort scoring system (See Appendix I), estimate project cost, and then proceed to Question 2.6. Eradication effort is calculated by multiplying the gross infested area times the impedance factor score (Eradication effort = gross infestation area x impedance score). See Appendix III for a budget worksheet. Cost estimate should include resources required for early detection survey work.	
Gross infestation area =	Impedance score =
Eradication effort =	Estimated project cost = $
Comments:	

2.6 Is there a high return on investment? Compare estimated invasive plant control project cost (Question 2.4) to conservation benefits of maintaining/restoring conservation target. See Figure 2 on page 7 and associated text for guidance on determining conservation benefit and return on investment. In general, high cost projects with low conservation benefit should not proceed.
☐ If “Yes” go to 2.7. ☐ If “No” do not proceed. Consider containment (Decision Tree 3). ☐ If “Uncertain” initiate peer review process and go to 2.7.
Comments:

2.7	Resources available? Funding for core operations is secure for at least two years, and the project has undertaken the necessary financial planning and achieved partial success in developing sources of long-term funding to sustain core costs for the next 5 years.
☐ If "Yes" Proceed – complete coversheet parts 1 and 2. ☐ If "No" do not proceed with implementation. Complete part 1 of the coversheet and secure sustainable funding source. ☐ If "Uncertain" initiate peer review process and complete coversheet parts 1 and 2.	
Comments:	

CONTAINMENT/EXCLUSION WORKSHEET

Use with Containment Decision Tree (Tree #3), at the state or project scale

3.1 Social-political environment suitable? Is social resistance to control expected? Within the containment area, do all the agencies, organizations and/or landowners agree to participate?
☐ If "Yes" go to 3.2. ☐ If "No" do not proceed. Consider suppression if applicable (Decision Tree 4). ☐ If "Uncertain" initiate peer review process and go to 3.2.
Comments:

3.2 Is the invasive plant species difficult to detect? Is the species always inconspicuous within the matrix vegetation (non-emergent with non-distinct features)? See Panetta and Timmins (2004) for addition information on detection.
☐ If "No" go to 3.3. ☐ If "Yes" do not proceed. Consider suppression if applicable (Decision Tree 4). ☐ If "Uncertain" initiate peer review process and go to 3.3.
Documentation:

3.3 Can reproductive escape (containment) or reinvasion (exclusion) of the invasive species be prevented or greatly reduced?

A. Are spread prevention measures (i.e. inspections, cleaning stations, regulations, sanitation protocols and/or focused education efforts) and/or early detection/rapid response program underway and funded for 2 years?
B. Can infestations in or surrounding the project area that cannot be killed (due to size etc.) be managed to prevent or greatly reduce seed production and dispersal or can new occurrences be eliminated as quickly as they are established?

Preventing reproductive escape may be difficult if the species has abundant reproduction (vegetative or by seed) and/or long distance or human dispersal. Refer to NYS Plant Ranking System (Jordan et al. 2011) questions 2.1, 2.2 and 2.3 for guidance.

☐ If "Yes" to both A and B go to 3.4.
☐ If "No" do not proceed. Consider suppression if applicable (Decision Tree 4).
☐ If "Uncertain" initiate peer review process and go to 3.4.

Documentation:

3.4 Can small satellite occurrences be control (killed)?

Is there a method available to kill small patches (i.e. 0.25 hectare) (0.62 acres) of the invasive and eliminate the seed bank within 10 years? (Refer to NYS Plant Ranking System (Jordan et al. 2011) questions 4.1 and 4.3) Satellite occurrences must be eradicated at a rate faster than they occur. Document the type of treatment that is anticipated to be used.

☐ If "Yes" go to 3.5.
☐ If "No" do not proceed. Consider suppression if applicable (Decision Tree 4).
☐ If "Uncertain" initiate peer review process and go to 3.5.

Documentation:

3.5	Is the risk low that the proposed control action could result in a non-target impact or unintended consequences that are unacceptable to the land manager, stakeholders or the public? For example, long-term damage to native plants; chemical contamination of soil, surface water or groundwater; removal of important habitat for wildlife that can't easily be replaced; another invasive species replaces the one that was removed; or native plants are exposed to high deer herbivory.
☐ If "Yes" go to 3.6. ☐ If "No" do not proceed. Consider suppression if applicable (Decision Tree 4). ☐ If "Uncertain" initiate peer review process and go to 3.6.	
Documentation:	

3.6	Estimate required resources to fund containment program. Estimate containment/exclusion program cost for five years and then proceed to question 3.7 (See Appendix III for a budget worksheet). When estimating the cost of containment, assessors need to recognize that resources will be required in perpetuity for early detection and rapid response. Cost estimate should include resources required for early detection surveys, monitoring and control of satellite occurrences. For containment programs at the state, PRISM or landscape scale, consider completing the control effort scoring system to estimate resources required (See Appendix II).
Estimated project cost: $	
Comments:	

3.7	Is there a high return on investment? Compare estimated invasive plant control project cost (Question 3.5) to conservation benefits of maintaining/restoring conservation target. See Figure 2 on page 7 and associated text for guidance on determining conservation benefit and return on investment. In general, high cost projects with low conservation benefit should not proceed.
☐ If "Yes" go to 3.8. ☐ If "No" do not proceed. Consider suppression if applicable (Decision Tree 4). ☐ If "Uncertain" initiate peer review process and go to 3.8.	
Comments:	

3.8	Are resources available? Funding for core operations is secure for at least two years, and the project has undertaken the necessary financial planning and achieved partial success in developing sources of long-term funding to sustain core costs for the next 5 years.
☐ If "Yes" Proceed - complete coversheet parts 1 and 2. ☐ If "No" do not proceed with implementation. Complete part 1 of the coversheet and secure sustainable funding source. ☐ If "Uncertain" initiate peer review process and complete coversheet parts 1 and 2.	
Comments:	

SUPPRESSION WORKSHEET

Use with Suppression Decision Tree (Tree #4) at project scale

4.1 Is key partner and landowner support in place? Do all the agencies, organizations and/or landowners in the conservation area agree to participate (sufficient participation to maintain conservation target)?
☐ If "No" do not proceed. ☐ If "Yes" go to 4.2. ☐ If "Uncertain" initiate peer review process and go to 4.2.
Comments:

4.2 Is there an effective control method to reduce cover and/or density? Technology available to adequately suppress occurrence in perpetuity? Can species cover and density be maintained below threshold that will mitigate ecological impact to conservation target? Document the type of treatment that is anticipated to be used.
☐ If "Yes" go to 4.3. ☐ If "No" do not proceed. ☐ If "Uncertain" initiate peer review process and go to 4.3.
Documentation:

4.3 Is the risk low that the proposed control action could result in a non-target impact or unintended consequences that are unacceptable to the land manager, stakeholders or the public? For example, long-term damage to native plants; chemical contamination of soil, surface water or groundwater; removal of important habitat for wildlife that can't easily be replaced; another invasive species replaces the one that was removed; or native plants are exposed to high deer herbivory.
☐ If "Yes" go to 4.4. ☐ If "No" do not proceed. ☐ If "Uncertain" initiate peer review process and go to 4.4.
Documentation:

4.4 Estimate resources required to fund suppression project. Estimate suppression project cost for five years and then proceed to question 4.5 (See Appendix III for a budget worksheet). When estimating cost, assessors need to recognize that resources will be required in perpetuity unless the species can be brought under effective biological control. Cost estimate should include monitoring and active restoration if needed.
Estimated project cost: $
Comments:

4.5 Is there a high return on investment? Compare estimated invasive plant control project cost (Question 4.4) to conservation benefits of maintaining/restoring conservation target. See Figure 2 on page 7 and associated text for guidance on determining conservation benefit and return on investment. In general, high cost projects with low conservation benefit should not proceed.	
☐ If “Yes” go to 4.6 ☐ If “No” do not proceed. ☐ If “Uncertain” initiate peer review process and go to 4.6.	
Source of information:	

4.6 Are resources available? Funding for core operations is secure for at least two years, and the project has undertaken the necessary financial planning and achieved partial success in developing sources of long-term funding to sustain core costs for the next 5 years.	
☐ If “Yes” Proceed - complete coversheet parts 1 and 2. ☐ If “No” do not proceed with implementation. Complete part 1 of the coversheet and secure sustainable funding source. ☐ If “Uncertain” initiate peer review process and complete coversheet parts 1 and 2	
Source of information:	

APPENDIX I. BOUNDARIES OF THE NEW YORK STATE PARTNERSHIPS FOR REGIONAL INVASIVE SPECIES MANAGEMENT.

APPENDIX II: PANETTA AND TIMMINS (2004) ERADICATION EFFORT SCORING SYSTEM

Scores can be calculated using the excel workbook provided

Logistic considerations (L)

L1) How many infestations[A] are there?

$>3 = 6$
$2–3 = 3$
$1 = 0$

L2) What is the general accessibility of infestations?

Low (most sites difficult to access)[B] = 6
Medium (most sites readily accessible) = 3
High (all sites readily accessible) = 0

Weed detectability (D)

D1) Is the species conspicuous within the matrix of invaded vegetation?[C]

Yes: Conspicuous stage lasting for:
<1 month = 6
1–3 months = 3
>3 months = 0
No, i.e. always inconspicuous = 12

D2) For plants that reproduce by propagules, how detectable is the species prior to reproduction?

Difficult to detect (non-emergent from vegetation and with no distinctive features) = 6
Moderately easy to detect (either emergent or with distinctive features) = 3
Very easy to detect (emergent and with distinctive features) = 0

Weed biological characteristics (B)

B1) Can the species reproduce through vegetative fragmentation?

Yes = 3
No = 0

B2) For species that reproduce by seeds or vegetative propagules, what is the minimum length of the pre-reproductive period?

<1 month = 6
1–12 months = 4
1–2 years = 2
>2 years = 0

B3) What is the maximum longevity of seeds or vegetative propagules?

>10 years = 6
5–10 years = 4
2–5 years = 2
<2 years = 0
Default in absence of information = 4 for seed-producing species; 0 for those producing vegetative propagules

Control effectiveness (C)

C1) How many treatments are required to control the largest plants?[D]

Number of treatments = n

C2) Does more than 10% of the total infestation occur in situations that require control procedures that are more expensive than standard methods?[E]

Yes = 3
No = 0

C3) Potential for managing propagule dispersal

Dispersal primarily abiotic (e.g. wind and/or water) or biotic but not involving humans = 6
Dispersal occurs through a balanced mixture of human- and non human-mediated modes = 3
Dispersal primarily human-mediated (includes stock) = 0

[A] Infestations must be independently searched and controlled, i.e. geographically distinct.
[B] Seasonal difficulties (e.g. flooding) in gaining access to infestations should be considered.
[C] Score for the type of vegetation in which the weed would be expected to be least visible. 'Vegetative propagules' include bulbs, bulbils and corms, but exclude rhizomes and stolons.
[D] 'Largest plants' may be clones in vegetatively reproducing species.
[E] For example, proximity to watercourses may limit use of herbicides.

APPENDIX III: BUDGET WORKSHEET

Estimate cost of implementing control project for 5 years.

	FY	**FY**	**FY**	**FY**	**FY**	**Total**
Staff						
Project planning (permits etc)						
Implementation						
Monitoring						
Survey work (detection)						
Contractual						
Supplies						
Travel						
Total						