A. **The Goal of Rare Plant Reintroduction: (/node/525)** *Joyce Maschinski, Matthew A. Albrecht, Jeremie Fant, Leonie Monks, and Kristin E. Haskins*

B. **Justifying and Deciding Whether to Conduct a Reintroduction or Other Conservation Translocation:** (/node/526) *Joyce Maschinski, Matthew A. Albrecht, Jeremie Fant, Leonie Monks, and Kristin E. Haskins*

C. **Preparing the Reintroduction:** (/node/527) *Joyce Maschinski, Matthew A. Albrecht, Jeremie Fant, Leonie Monks, and Kristin E. Haskins*

D. **Implementing the Reintroduction:** (/node/528) *Joyce Maschinski, Matthew A. Albrecht, Jeremie Fant, Leonie Monks, and Kristin E. Haskins*

E. **After the Installation:** (/node/534) *Joyce Maschinski, Matthew A. Albrecht, Jeremie Fant, Leonie Monks, Jimmy Lange, Emily Coffey, Holly Forbes, Jennifer Ceska and Kristin E. Haskins*

Overview

Roadmap for Conducting a Reintroduction

Part 4 describes the framework for conservation actions that can improve the chance of successful rare plant reintroductions to the wild.

BEFORE YOU BEGIN

Justify the Need

- Evaluate whether reintroduction is appropriate.

Logistics

- Collect from 50 plants and up to 3000 seeds.
- Make a plan.
- Review and follow laws.
- Collaborate with landowners.
- Procure funding.

Know the Species

- Record and share data.
- Gather information about the species' biology, ecology, & distribution.
- Consider genetics of existing and source populations.
- Assess a suitable recipient site.
- Select and match source material to site.
- Use good horticulture.
- Begin with large founder size.
- Plan for population (/taxonomy/term/142) growth.

IMPLEMENTATION

Prepare the Site

- Label plants for long-term tracking.
- Plant in pattern and microsite conducive to good growth and pollination.

Logistics

- Choose best season for transplanting or seeding.
- Organize and bring all necessary materials and equipment to the site.
- Enlist enough people to help prepare and install the plants.
- Bring snacks and water.
- Limit the number of generations in cultivation.

AFTERWARDS

Aftercare

- Water, weed, and protect plants from herbivores and vandalism.

Monitoring Plan

- Managing long-term commitment.
- Analyze and report data.
- Document activities.
- Publish results.

next > (/best-practices/after-installation-reintroduced-rare-plants)

Have a question or info about Rare Plant Reintroduction?

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Suggested Citation

Center for Plant Conservation. Rare Plant Reintroduction and Other Conservation Translocations in *CPC Best Plant Conservation Practices to Support Species Survival in the Wild.* Web Version. https://plantnucleus.com/best-practices/rare-plant-reintroduction-and-other-conservation-translocations (https://plantnucleus.com/best-practices/rare-plant-reintroduction-and-other-conservation-translocations) Accessed: 08/11/2020 - 5:54pm

Related Videos

Joe Davitt and Emily Burson, San Diego Zoo Global, planting corms for an augmentation. **Photo credit:** Joyce Maschinski, Feb 2019.

Introduction

The ultimate goal of rare plant conservation is to ensure that unique taxa experience continued evolution within a natural context. The science of reintroduction is rapidly evolving. Over the past 30 years, conservation officers working with the Center for Plant Conservation (CPC) have conducted over 140 plant reintroductions and other conservation translocations of many species in many habitats. As we gather more information from our reintroductions, we have had an opportunity to modify our practice, incorporating the best of what experience has taught us. These updated *CPC Best Practices for Rare Plant Reintroduction and Other Conservation Translocations* reflect this collective experience and recent findings from peer-reviewed literature.

The updated *CPC Best Practices* provide a quick reference for practitioners to use when planning and executing rare plant reintroductions (see Overview (/node/524#4-overview)). The new digital format aids accessibility while providing the most current information. The sections address frequently asked questions and provide supporting documents that provide further information about the basis for the guidelines. Checklists and templates guide planning the reintroduction and documenting its details.

For more details, we refer readers to previous publications with reintroduction guidelines: *Guidelines for Developing a Rare Plant Reintroduction Plan* (CPC 1996), *IUCN Guidelines for Reintroductions* (IUCN 1998, 2013), *The SER Primer on Ecological (/taxonomy/term/53) Restoration* (SER 2002), *Guidelines for the Translocation of Threatened Plants in Australia* (Vallee et al. 2004) and *Center for Plant Conservation Best Reintroduction Practice Guidelines* (Maschinski, Albrecht et al. 2012).

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Related Videos

Recent Revisions

Figure 4.1 "Threats facing reintroduced plant populations" was inserted on 9/9/2019.

Key Tree Cactus habitat and plants were hit hard by Hurricane Irma. **Photo credit:** Jimmy Lange, Fairchild Tropical Botanic Garden.

Summary

- Reintroduction is not the first step toward the conservation of a species, but rather follows a careful process of gathering information about the species, threats, alternative actions, and future needs.
- There are several considerations for justifying a reintroduction.
- Acknowledge that there are clear reasons to avoid reintroduction.

CPC does not support or promote reintroduction as an alternative to *in situ (/taxonomy/term/88)* ecosystem protection. All those working in plant conservation firmly agree that the **priority is to conserve species in situ and to preserve wild populations in natural habitats in as many**

locations as possible. Reintroduction is never the first action to take for a critically endangered species, even when crisis is imminent. First steps for species in dire straits must be *ex situ* collection, threat control, and habitat management (Guerrant et al. 2004).

Prior to conducting any reintroduction, thorough status surveys and careful review of rarity status and threats should be undertaken (Figure 4.1). Reintroductions should only be considered if habitat protection is not possible or if the taxon (/taxonomy/term/174) is critically imperiled and appropriate sites and propagule source materials are available. CPC recognizes that reintroductions may need to be used as a tool to mitigate the impacts of climate change, because some in situ rare plant populations will be unsustainable within their current historical ranges.

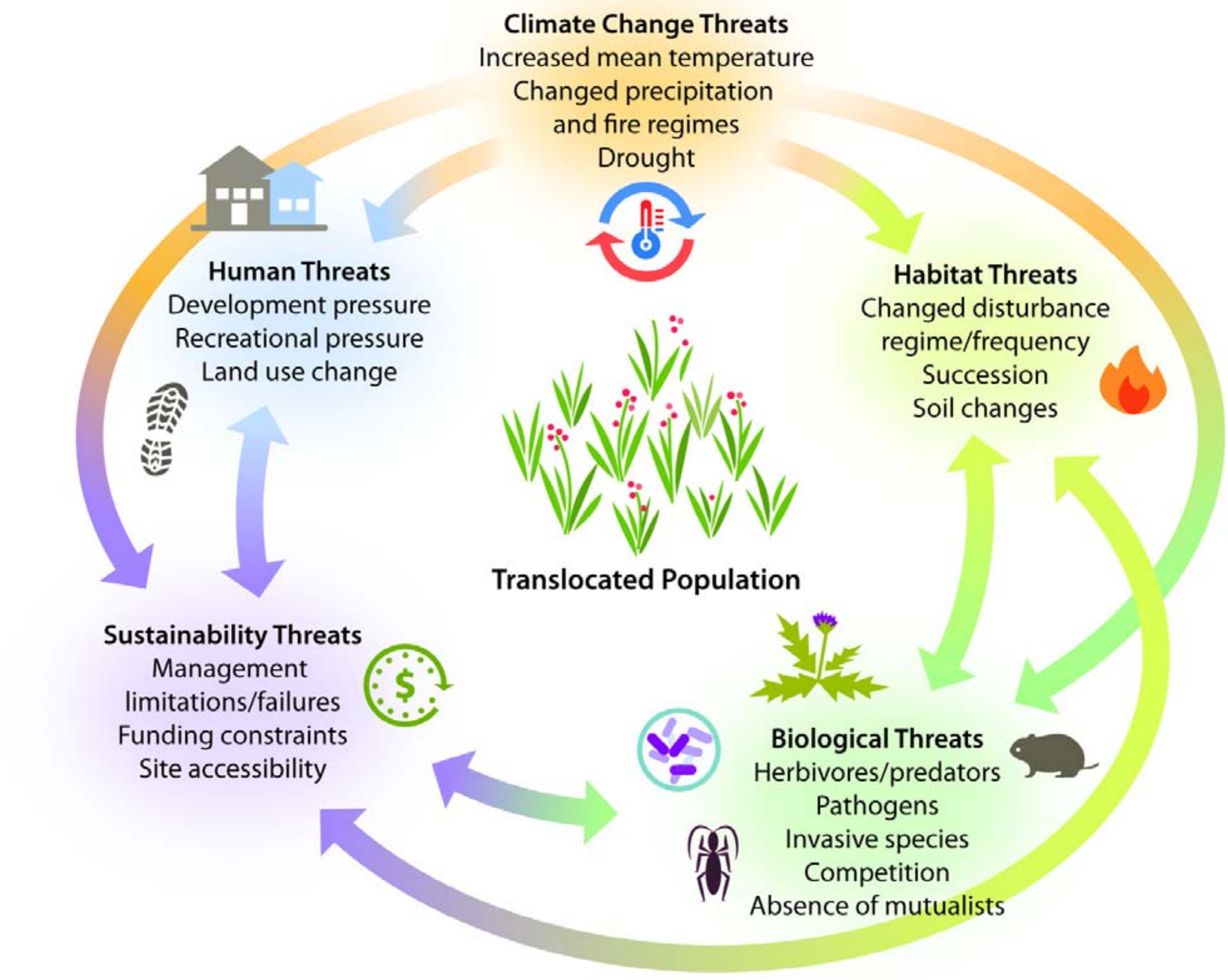

Figure 4.1 Possible threats to a reintroduced population (/taxonomy/term/142) include those imposed directly by humans that cause habitat destruction or degradation; changes in temperature, precipitation and sea level resulting from climate change; biological threats from insect or mammalian herbivores or pathogens; changes to the condition of the habitat via invasive species incursion, changes in disturbance regime or frequency

(i.e., fire, storms, flood events), altered or degraded microclimate conditions due to changes in succession and competition (/taxonomy/term/25), changes in soil microbial communities, and sustainability threats caused by funding constraints, personnel changes, changes in land protection, land ownership, or land management.

To determine whether a species should be considered for reintroduction, it should meet the criteria described in the "Questions to Ask When Justifying a Reintroduction" box. If the species does not meet these criteria, a reintroduction should not be attempted at this time. If conditions should change in the future, a second evaluation could be done. For some taxa, it may never be appropriate to conduct reintroductions. For others, changed conditions and improved horticultural, genetic, and ecological (/taxonomy/term/53) knowledge may make it feasible to conduct a reintroduction at a future time.

Document the species status and distribution.

- Conduct surveys and obtain population (/taxonomy/term/142) information.
- Map or obtain maps of the known populations to determine the current and historical distribution as it relates to ecoregions, habitat, geology, and soil type.
- Assess habitat-specific population information (Knight 2012). In each population, count or estimate the percentage of reproductive, juvenile, seedling stages, and if possible, measure growth and reproduction.
- Note abiotic (/taxonomy/term/1) and biotic (/taxonomy/term/20) conditions in occupied patches. Whenever possible, quantify these factors (for example, near adults and seedlings record the canopy cover, associated species, plant density, soil moisture, light, and other factors).

Questions to Ask

When Justifying a Reintroducton

A reintroduction may be justified if:

1. Species is extinct in the wild OR;
2. The distribution of the species is known and there are few, small, and declining populations; AND

3. Alternative management options have been considered and conducted, yet have been judged to be inadequate for long-term conservation of the species; AND
4. Threats have been identified; AND
5. Threats from habitat destruction, invasive species, land conversion and/or climate change are imminent and are uncontrollable. Species has high risk of extinction if only managed in situ (/taxonomy/term/88).

If the species meets any one of the following criteria, then do NOT proceed with reintroduction. Consider ex situ (/taxonomy/term/58) conservation practices (Guerrant et al. 2004). If the unmet criterion is resolved in future, then re-evaluate.

7. Reintroduction will undermine the imperative to protect existing sites.
8. Previous tests indicate that it has not been possible to propagate plants or germinate seeds.
9. High-quality, diverse source material is not available.
10. Existing threats have not been minimized or managed.
11. The reintroduced species may potentially negatively impact species in the recipient site via competition (/taxonomy/term/25), hybridization (/taxonomy/term/85) or contamination.
12. There is evidence that the reintroduced taxon (/taxonomy/term/174) would harm other threatened and endangered species or conflict with their management.
13. The reintroduction is not supported legally, administratively, or socially.
14. Suitable habitat is not available, nor understood.

(Falk et al. 1996; Vallee et al. 2004; Maschinski, Albrecht et al. 2012)

Ascertain the threats and, when possible, take action to remove, control, or manage them.

- Note specific abiotic (/taxonomy/term/1) and biotic (/taxonomy/term/20) factors that may be causing the population (/taxonomy/term/142) decline. Realize that threats may be direct or indirect (Dalrymple et al. 2012).
- If you are currently monitoring the population, note conditions present so that you will be able to pinpoint changes in future years.

Engage land managers in discussion about best options for the species conservation.

- Attempt or consider all alternative management options before considering reintroduction.

- Discuss which options are feasible to implement.
- Ensure the population will have long-term protection and management (that is, invasive species removal, controlled burns, etc.).

Do not proceed with a reintroduction if you cannot justify it. Use other conservation options for the species.

Do no harm to a recipient community or to existing wild populations.

- Consider whether your reintroduction will do any harm to a recipient community or to existing wild populations. If so, consider alternative conservation strategies.
- Determine whether potential collateral impacts of the species in the recipient site are negligible. There is little threat of hybridization (/taxonomy/term/85), invasion, or contamination.
- The reintroduction will not undermine the imperative to protect existing populations and their habitats.

Determine that the reintroduction is feasible legally, logistically, and socially.

- Because laws governing rare species protection vary by location and jurisdiction, it is essential to discuss and verify that the reintroduction plan is supported by the law, legal authorities, the recipient site landowner, and the public.
- Ideally, the reintroduction will have been identified as an important step for preserving the species in a legal document, such as the species' recovery plan or a conservation action plan.

Have a question or info about Rare Plant Reintroduction?

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Suggested Citation

Healthy nursery collections of rare plants at Fairchild Tropical Botanic Garden. **Photo credit:** Joyce Maschinski, March 2019.

Summary

- Careful planning of biological, ecological (/taxonomy/term/53), political, and financial support for the reintroduction will help ensure success.
- Designing a reintroduction entails linking genetic source to the recipient site characteristics.
- Conducting reintroductions as experiments will result in a lesson learned and can help build plant reintroduction science (/taxonomy/term/155).

Although it is impossible to say definitively, we believe that many failed reintroductions could have succeeded if appropriate preparation had been undertaken. Being prepared for a reintroduction requires a good strategy coupled with large investments of time and resources. This requires commodities that are often in short supply in our rapidly changing world—patience and persistence. It may not be possible to know all factors we describe below, but the more that is known the higher the likelihood of success, and practitioners should at least be aware of the gaps in their knowledge.

Reviewing your reintroduction plan by addressing the following questions will allow you to assess your degree of preparedness. This comprehensive list is designed to help practitioners identify gaps in their knowledge. Once knowledge gaps are identified, there is an opportunity to weigh whether there is adequate information to proceed. The risk of proceeding without the knowledge can be assessed along with the risk of taking no action and losing the species. We recommend that *reintroductions be conducted as experiments precisely designed to fill in these knowledge gaps.* In this way, each reintroduction can not only help future actions for the target species but may in turn help others doing plant reintroductions around the world.

Previous CPC publications have addressed detailed preparations for reintroductions with regard to demography, genetics, and horticultural practice (Falk and Holsinger 1991; Falk et al. 1996; Guerrant 1996). Specific guidance for *ex situ (/taxonomy/term/58)* collection and management is essential preparation for reintroductions (Guerrant et al. 2004). Our aim here is to provide guidance for establishing sustainable populations in the wild where they may have opportunities for adaptation, evolution and interactions within a natural ecosystem. Although it is necessary to describe the steps of the plan sequentially, often several steps are conducted simultaneously. (See the “Questions to Ask When Planning a Reintroduction” below.)

Questions to Ask

When Planning a Reintroduction

1. Is the taxon (/taxonomy/term/174) already living at the recipient site, was it historically present there, or is this a completely new location?
2. Have you considered legal issues, logistics, and land management? (McDonald 1996)
3. Is the biology and ecology of the species understood? (Menges 2008; Maschinski, Albrecht et al. 2012)
4. Are genetic studies needed? (Neale 2012)
5. Have germination (/taxonomy/term/81) protocol and propagation methods been determined? (Guerrant 1996; Guerrant et al. 2004; Haskins and Pence 2012)
6. Has a suitable recipient site been identified and are land managers supportive? (Fiedler and Laven 1996; Maschinski, Albrecht et al. 2012)
7. Are pollinators known and present?
8. Are plants susceptible to herbivory? Will they be protected?
9. Have threats been reduced or eliminated?
10. How many plants or seeds are available and how many are needed? (Guerrant 1996; Albrecht and Maschinski 2012; Knight 2012)

11. What is the experimental design? (Falk et al. 1996)
12. How will success be measured? (Pavlik 1996; Monks et al. 2012)
13. What kind of aftercare for plant and site management will be needed and how frequently should it be performed?
14. What is the involvement of the land manager/owner?
15. What is the monitoring design and plan for reporting results?
16. In what ways will you involve the public in your project? (Maschinski, Wright et al., 2012)
17. Suitable habitat is not available, nor understood.

(Falk et al. 1996; Vallee et al. 2004; Maschinski, Albrecht et al. 2012)

Making the Plan

Design the reintroduction as an experiment and seek peer review.

- Identify the project leader and key collaborators, who will be responsible for planning, supporting, implementing, site management, monitoring and reporting findings of the project.
- Identify areas of expertise needed to execute the reintroduction. If not represented in the collaborative group, then seek outside experts to join the team. For example, enlist the help of a scientist with experience in experimental design and statistical analysis to ensure that you have adequate replication to answer your research question. Or you may need to ask an experienced horticulturist to help you grow sufficient numbers of plants.
- Plan the reintroduction based upon the best scientific information available. Rely on peers to review your reintroduction plan and provide feedback and alternative points of view. Finding peers to review your reintroduction plan may be easy or difficult depending upon where you reside. Rely on the global community to assist you. (See the “Potential Reviewers for Reintroduction Plans.')

Potential Reviewers for Reintroduction Plans

In some regions, there are panels of plant conservation experts who review reintroduction plans as a part of ongoing legislative process. For example, the North Carolina Plant Conservation Program (http://www.ncagr.gov/plantindustry/plant/plantconserve/index.htm) requests and evaluates reintroduction plans as part of the process of granting legal permission to proceed with a plant reintroduction in the state of North Carolina, US.

Experts operating in different areas of the world are also available. The Center for Plant Conservation provides a resource to learn about reintroductions that have been done and is a source for potential peer reviewers (info@saveplants.org (mailto:info@saveplants.org)).

The Re-introduction Specialist Group IUCN has a Re-introduction Practitioner's Directory 1998 (http://www.iucnsscrsg.org/) intended to facilitate communication between individuals and institutions undertaking animal and plant re-introductions.

The Global Restoration Network (http://www.globalrestorationnetwork.org/) provides a web-based information hub linking research, projects, and practitioners.

Questions to Ask

When Designing Reintroduction Experiments

1. What additional knowledge is needed about the species biology or other factors? How can the reintroductions be planned as experiments to address these unknowns?
2. What is the experimental design? How much replication is needed for adequate statistical power? How will the study be analyzed?
3. Have you considered testing aspects of ecological (/taxonomy/term/53) theory, such as founder events, small population (/taxonomy/term/142) dynamics, establishment-phase competition (/taxonomy/term/25), dispersal and disturbance ecology, succession, metapopulation (/taxonomy/term/105) dynamics, patch dynamics (/taxonomy/term/131) on population persistence, resilience and stability over time?
4. Using the reintroduced population as a cohort, will you examine natural variation in survival, mortality, and recruitment and tie these to environmental factors?

5. Will the reintroduction test key habitat gradients of light, moisture, elevation, or temperature?
6. Will the underlying environmental drivers of population growth be measured? (Knight 2012)
7. Will genetic factors be part of the experimental design?
8. What traits will be monitored and how will they be analyzed?
9. Will the reintroduction further our knowledge of key principles related to rare species' ability to cope with climate change?
10. Are you testing factors within a single site or across multiple sites?
11. Has a monitoring plan been developed? How long will monitoring be conducted? Have you considered an adaptive (/taxonomy/term/4) monitoring plan? What will the duration of the experiment be?
12. Have you developed a clear unambiguous datasheet to track reintroduced plant growth, reproduction and survival? If the monitoring persists for decades, will your successors be able to interpret the data you have collected?
13. Will the data be housed within your institution or elsewhere so that your successors will able to use it?
14. How will the plants be mapped and marked/numbered?
15. If plants are susceptible to herbivory, will their response be included in the design or should the plants be protected?

(Falk et al. 1996; Vallee et al. 2004; Maschinski, Albrecht et al. 2012)

- Train and adequately manage all personnel and volunteers that are involved.
- Consider addressing theoretical questions in the reintroduction experiment/project to advance the field of reintroduction biology. (See "Questions to Consider When Designing Reintroduction Experiments.")
- Define goals of reintroduction related to the recovery of the species. Set objectives.
- Develop methods, decide the plant and population (/taxonomy/term/142) attributes that will be measured, determine monitoring protocol, frequency and duration, and reference the analysis.

The Law, the Land, and Funding

Obtain legal permission to conduct the reintroduction.

- Familiarize yourself with the laws and regulations associated with a reintroduction. Note that these may differ for augmentations, reintroductions, and/or introductions.
- In some locations you may be required to obtain one or many permits before conducting a reintroduction (for example, from the landowner/ land manager, local, regional or national authorities).
- Often a carefully written plan for the reintroduction is required for the permit.
- Note expiration date of all permits involved and requirements for periodic reports or updates to permitting agency.
- If reintroduction is done as a mitigation (/taxonomy/term/112), it is critical that all preliminary planning steps be taken within legal parameters. (See Falk et al. 1996 for extensive discussion regarding mitigation.)

Involve landowners and land managers.

- Ensure that landowners and land managers are involved and supportive of the project and can account for possible changes in the future.
- Discuss the long-term support and management of the proposed recipient habitat with land managers. Lack of management can doom a restored population to fail.
- Develop a written agreement outlining who will be responsible for what action and any special protocols that need to be followed by parties working on the site.
- Set a schedule to meet with the recovery team (/taxonomy/term/153) periodically to assess the species' condition and the status of the restored population.
- If future changes require intervention, determine a process for evaluating impacts on the restored population. For some agencies, it may be necessary to develop a protocol or decision tree to trigger management action.
- Develop a mechanism for handling any conflicts that may arise (for example, management for one species is detrimental to another species, etc.).

Conservation colleagues carry water and Florida endangered *Passiflora sexflora* to reintroduction site. **Photo credit:** Kristie Wendelberger.

Secure adequate funding to support the project.

- Ideally, funding should be garnered for implementation and for several years, if not decades, following the installation. At the very least, parties proposing a species' reintroduction should be committed to seek long-term funding support for the project. This requires that you have detailed the cost of implementing, monitoring, and management of the restored population (/taxonomy/term/142). Committed partners, who are willing to provide in-kind services and/or volunteer citizens, who are willing to monitor the restored population will help make this aspect feasible.
- Determining the outcome of a reintroduction takes time. Expect to devote >10 years to monitoring to determine whether a population is sustainable (Monks et al. 2012). There are few recorded reintroductions that have created sustainable populations in which multiple generations have been completed within 25 years (Dalrymple et al. 2012). Key life-cycle events such as next generation seedling recruitment and reproductive maturation can take years to decades in long-lived species. Thus, a few decades may be required before fates of reintroduction can be determined.

Understanding Species' Biology

Knowing the biology and ecology of your taxon (/taxonomy/term/174) will benefit the reintroduction plan and experimental design. We advise gathering information from the literature on your target taxon and closely related congeners. If possible, conduct experiments if there are gaps in your knowledge. (See the North Carolina Reintroduction Documentation Form (http://ncbg.unc.edu/uploads/files/Reintroductionguidelines.pdf).)

Know the species' biology and ecology.

- Knowing the mating system (/taxonomy/term/103) will determine whether source material should come from a single population or from mixed populations and the spatial pattern of outplanting (/taxonomy/term/130). For example, due to remnant populations lacking compatible alleles for successful reproduction, reintroductions done with Florida ziziphus required carefully selecting compatible individuals from more than one location to achieve reproductive success (Weekley et al. 1999; Weekley et al. 2002). In contrast, *Schiedea obovata*, which is capable of selfing (/taxonomy/term/165) or outcrossing (/taxonomy/term/129), requires keeping all outplantings separate (Kawelo et al. 2012). Highly inbreeding (/taxonomy/term/90) taxa are more likely to form ecotypes (/taxonomy/term/55) than outcrossing species.
- If a species is dioecious, the spatial design of plantings should place male and female plants in close proximity (for example, *Zanthoxylum coriaceum* in Maschinski et al. 2010).
- Species or conditions that may require special techniques for growing and implementing a reintroduction include: edaphic endemics (/taxonomy/term/56), species with specialist pollinators (/taxonomy/term/170), and species requiring symbionts for germination (/taxonomy/term/81) and growth.
    - Edaphic endemics: In *Astragalus bibullatus* an edaphic specialist of limestone cedar glades, translocations are only successful when conducted on a specific type of limestone even though multiple types of limestone occur in the historic range of the species. The species can only be propagated in very well-drained soil and must be watered from below to prevent disease (Albrecht, Missouri Botanical Garden, personal observation).
    - Specialist pollinators: Using pollinator baiting techniques at potential reintroduction sites can ensure pollinators are present before the outplanting occurs (Reiter et al. 2016). Lack of pollinators limits orchid distributions, thus knowing pollinators are present before conducting a reintroduction is advised (Phillips et al. 2014).
    - Mutualists: Providing inoculated soils containing mycorrhizal fungi may help establish the outplanted population (Haskins and Keel 2012). Because some taxa require symbionts to germinate or grow (Ogura-Tsujita and Yukawa 2008; Janes 2009; Haskins and Pence 2012) knowing whether there are obligate mutualists

(/taxonomy/term/123) will influence reintroduction success. Attempting to germinate or grow such species without their obligate mutualists will fail. Providing inoculated soils containing mycorrhizal fungi may help establish the outplanted population (Haskins and Keel 2012).

Site Selection

Choosing a recipient site should be done with great care and intention. Several conditions influence a species' ability to colonize a new site including functional ecosystem processes, appropriate associated species, and ongoing management to remove threats and maintain ecosystem health. In general, seek a recipient site with great similarity to the place where the rare species is thriving. Knowing the site history may help explain existing conditions. Although it is impossible to know with certainty what a site will become in the future, as much as possible practitioners should try to imagine the future conditions the reintroduced population will face. Ongoing management and threat abatement are essential for maintaining conditions conducive to population sustainability.

In addition, it is important to think about any recipient site in the context of the species' whole distribution. Because corridors may facilitate migration and dispersal between patches, especially with the onset of climate change (Noss 2001), a reintroduced population can serve an important function of connecting existing populations either by forming a stepping-stone between patches or by expanding the size of existing patches. Connecting 15 or more patches will improve chances for the entire metapopulation (/taxonomy/term/105) capacity (see Hanski and Ovaskainen 2000). (See the "Questions to Ask about the Recipient Site" below.)

Questions to Ask

About the Recipient Site

1. Have you researched the history of the recipient site?
2. Have you incorporated species-specific factors related to optimal population (/taxonomy/term/142) growth to assess suitable recipient sites for your taxon (/taxonomy/term/174)?
3. Have you identified species-specific environmental and community factors in occupied versus unoccupied patches?

4. Have you ranked several potential suitable recipient sites to determine the best place for the reintroduction to occur?
5. Is there still suitable habitat left within the species' range? (See Falk et al. 1996 for discussion of range.)
6. Are recipient sites of sufficient quality and with sufficient long-term protection to ensure the long-term security of the reintroduced population?
7. Are threats absent or adequately managed at the site?
8. What were the previous threats that may have caused the species to become extirpated from site?
9. What is the potential for future threats?
10. Is current and future land use of the recipient site and surrounding sites compatible with sustainability of the reintroduced population?
11. Are potentially hybridizing congeners present at recipient site? Which ones? Are they present at nearby sites? Are they present within the target species' range?
12. Is the recipient site within the species' climate envelope now? Are there models suggesting the location will be safely within the climate envelope in the future?
13. What site preparation is required before the plants can be installed (for example, canopy thinning, invasive removal, etc.)? Will habitat manipulation continue after plants are installed?
14. Does the species require habitat conditions that no longer exist on site (for example, fire, periodic inundation, etc.)? Can those conditions be mimicked?

(Falk et al. 1996; Vallee et al. 2004; Maschinski, Albrecht et al. 2012)

Choose a suitable recipient site.

- Determine the cause of declines in wild populations. Ensure that threats can be ameliorated in the recipient reintroduction site (Dalrymple et al. 2012; Knight 2012).
- Evaluate potential reintroduction sites using a recipient site assessment or quantitative assessment (Maschinski, Falk et al. 2012). Base your evaluation on the natural habitat where a population (/taxonomy/term/142) has positive (or at least stable) growth rate (Dalrymple et al. 2012; Knight 2012).
- To choose among several potential sites, rank reintroduction sites incorporating logistics or ease of implementation, quality of habitat, and management influencing the species' ability

to persist at a site (Maschinski, Falk et al. 2012; see Figure 4.1).

- To account for uncertainty, incorporate heterogeneity into the reintroduction plan. Use multiple sites and multiple microsites (even outside of our expectations) to test heterogeneity of conditions needed for optimal growth for all life stages of a species (Dalrymple et al. 2012; Maschinski, Falk et al. 2012; Maschinski, Albrecht et al. 2012).
- Because the fine-scale requirements for individual plant growth and optimal population growth are often unknown, using microsite as an experimental factor is good practice. Measure abiotic (/taxonomy/term/1) conditions (for example, soil, precipitation, temperature) and biotic (/taxonomy/term/20) conditions (for example, predators, mutualists, invasive species) at the reintroduction site that are associated with plant performance and population growth (Knight 2012; Maschinski, Falk et al. 2012). Ensure that there are adequate areas for population expansion (that is, microsites within the recipient site and adjacent suitable habitat outside of the recipient site).
- Realize that if environments conducive to positive population growth are rare or non-existent, additional reintroduction activities, beyond simply reintroducing propagules, will be necessary (Knight 2012; Maschinski, Falk et al. 2012).
- Note that using existing populations and their habitat conditions as reference points for reintroductions will not always be appropriate if the species does not have positive growth rate at these locations (Possley et al. 2009; Dalrymple et al. 2012; Knight 2012; Maschinski, Falk et al. 2012; Maschinski, Wright et al., 2012).
- It will be essential to use an experimental context to determine key factors necessary for positive population growth.
- Reference points may not be available within core habitat under climate change conditions (Dalrymple et al. 2012). Similarly, geographic distribution may not be a good reference for fundamental niche space (/taxonomy/term/120). For this reason, known historic range may not necessarily be the only guide to assess optimal habitats for successful reintroduction (Maschinski, Falk et al. 2012; Maschinski, Wright et al., 2012).

Date:	Observers
Site:	Description:

Criteria for prioritizing potential restoration site		3	2	1	Score
Category 1: Logistics, implementation, management					
A)	Status of relationship with land owner and management	none	some	good	
B)	Commitment level of agency to protect introduced population	none	some	good	
C)	Willingness of agency to manage habitat for target species	none	some	good	
D)	Site preparation, threats removed	no	partially		
E)	Amount of public access/susceptibility to human disturbance	high	medium	low	
F)	Accessibility for planting logistics and future monitoring	poor	fair	good	
G)	Water source present		no	yes	
	Category 1 Total				
	Category 2 Quality habitat characteristics				
A)	Percentage of associated species common with extant sites	0-40%	41-71%	71-100%	
B)	Quantity and diversity of aggressive invasive plant species	high	medium	low	
C)	Current and future impact of invasives	high	medium	low	
D)	Size of potential reintroduction area	small	medium	large	
E)	Quality of adjacent habitat	poor	fair	good	
F)	Quantity of good-quality habitat adjacent to reintroduction site	none	some	abundant	
G)	Soil texture similar to extant sites	no	partial	yes	
H)	Soil nutrients similar to extant sites	no	partial	yes	
I)	Canopy cover optimal for target species	no	partial	yes	
J)	Hydrology similar to extant sites	no	partial	yes	
K)	Topography similar to extant sites	no	partial	yes	
L)	Target species presence at site	never	historic	current	
M)	Special requirements of target species present	no	partial	yes	

Criteria for prioritizing potential restoration site		3	2	1	Score
N)	Mutualists present	no	partial	yes	
O)	Herbivores present	no	partial	yes	
P)	Ecosystem processes functional	no	partial	yes	
Q)	Number of potential translocation areas within site	1	2	3	
R)	Proximity to existing wild populations	>10km	5–10km	<5km	
S)	Natural disturbance regime	excessively high or	moderate	normal	

	low			
*				
Category 2 Total				
All Criteria Total				

* Additional habitat feature of interest for this species (e.g., seasonal flooding, salinity level nurse plant present, etc.)

NOTES: For evaluating a single site: Add total scores; 27 is a perfect score. Scores > 27 < 54 are acceptable reintroduction sites. Any criterion with score of 3 should be improved before moving forward.

For choosing among multiple sites: The best site has the lowest total score and no single criterion scoring 3.

FIGURE 4.1

Recipient site assessment based upon ranking criteria related to logistics and habitat quality. The assessment can be used to score a single or to prioritize among multiple sites. Scores ≥ 27 ≤ 54 are acceptable reintroduction sites. When choosing among multiple sites, the best site will have the lowest total score and no single criterion scoring 3. (Adapted from Maschinski, Falk et al. 2012.)

Questions to Ask

About Habitat or Landscape Level Considerations

1. Does the recipient site contribute to natural patterns of heterogeneity in the species' distribution?
2. Have you considered habitat connectivity? Is healthy suitable habitat nearby that will allow for the restored population (/taxonomy/term/142) to expand in area and number of individuals? Is adjacent property suitable habitat? Is adjacent property protected?
3. Are there metapopulation (/taxonomy/term/105) possibilities? Have you accounted for between site factors as well as within site factors? Is the site located in close proximity to extant populations or other reintroduced populations?
4. What are the distances between the proposed reintroduction and nearby wild populations?
5. What benefits or detriments do the nearby sites give the restored population?

(Falk et al. 1996; Vallee et al. 2004; Maschinski, Albrecht et al. 2012)

Create a sustainable population (/taxonomy/term/142).

- Improve the probability of creating a sustainable population by considering the metapopulation (/taxonomy/term/105) context of your reintroduction site.
- Choose recipient sites that have connectivity and increase the probability of dispersal (Maschinski, Falk et al. 2012).
- Consider landscape level phenomena. (See the "Questions to Ask About Habitat or Landscape Level Considerations" above.)

Genetics Considerations

Ideally, the genetic composition of the source material needs to be a balance between representing the local gene (/taxonomy/term/70) pool and creating a new broadly genetically diverse population. Reasons to consider genetic studies in a reintroduction plan include helping to make decisions about appropriate location(s) for collecting source material, confirming whether hybridization (/taxonomy/term/85) may be a potential problem, confirming the species taxonomy, or determining whether to use mixed or single population source material (Falk and Holsinger 1991; Falk et al. 1996; Neale 2012). For example, you may wish to pursue genetic studies if you suspect there are hybridization problems, if the species looks different in different locations, if one or more populations of the species has distinct ecology from the majority of populations, or if it is difficult to distinguish this species from a congener. You may also wish to conduct genetic studies if you know or suspect that your species has variable ploidy (/taxonomy/term/137) levels across populations (Kramer et al. 2018). Conducting a molecular genetics study can help elucidate the mating system (/taxonomy/term/103); the degree of natural inbreeding (/taxonomy/term/90); the level of genetic divergence among collection sites or subpopulations; area of seed and pollen dispersal; the degree of genetic relationship or co-ancestry between adult plants in natural conditions; and the neighborhood within which adults are genetically related (Crossa and Venkovsky 2011). (See Part 3, "Genetic Guidelines for Acquiring, Maintaining, and Using a Conservation Collection." (/node/519)) Often, it will be necessary to work with local geneticists at botanic gardens, universities and/or government facilities to do the genetic studies. Although costs for genetic analysis are becoming more reasonable with technological advances, be aware that adequate funding will be required for proper genetic work. Complementary to genetic studies are hand-pollination studies, common garden (/taxonomy/term/24) experiments, or reciprocal transplant (/taxonomy/term/151) studies. The latter will allow researchers to understand the performance of the species for a particular source in a new setting. Each has advantages and disadvantages.

When are genetic studies needed?

- Ascertain whether genetic studies are needed before conducting the reintroduction and, if possible, conduct studies to measure genetic structure (/taxonomy/term/76) of the focal species (Neale 2012).
- A genetic assessment of wild populations is advised before conducting a reintroduction if the species meets any of the following criteria in the box “When Are Genetic Studies Needed?”
- Once genetic data is available, review compatible management options (Ottewell et al. 2016).
- In the absence of genetic data, it is valuable to utilize information on species life-history traits, such as habit and breeding system (/taxonomy/term/22), to inform reintroduction decisions (Neale 2012).

Use a genetically diverse founding population.

- Use a large genetically diverse founding population to improve chances of establishing a self-sustaining population (Guerrant 1996).
- To compensate for propagule losses due to mortality during reintroduction, start with an estimate of desired numbers of individuals surviving to reproduction in a new founding population. Then, account for expected losses during establishment. Some of these calculated losses can be mitigated by maintaining backup clonal (/taxonomy/term/23) material.
- When growing the material for purposes of a reintroduction or other reintroductions, keep in mind the reproductive biology of the species. (See Part 3, “Genetic Guidelines for Acquiring, Maintaining, and Using a Conservation Collection.” (/node/519)) For example, obtaining 10 female plants of a dioecious species may require planting twice as many seeds as the expected germinant count if the sex ratio is 50:50.

Questions to Ask

When are Genetic Studies Needed?

Assessing the genetic diversity (/taxonomy/term/72) of wild populations can reveal insights about the biology of the species, however genetic studies can be expensive and may not always be necessary. They can include either molecular work (genotyping, sequencing (/taxonomy/term/168), genome (/taxonomy/term/77) or ploidy (/taxonomy/term/137) analysis) or common garden (/taxonomy/term/24) studies. These types of studies are advisable before collecting a rare species or before conducting a reintroduction if the wild populations have any of the following characteristics:

Within-population (/taxonomy/term/142) issues

1. Population has fewer than 50 individuals flowering and setting fruit.
2. The species is clonal (/taxonomy/term/23).
3. Little or no viable seed is being set.
4. There are potential taxonomic concerns (taxonomic ambiguity (/taxonomy/term/175), potential hybrids, or variation in ploidy).

Issues across the species' range

5. The species is declining and little is known about the biology or life history of the species.
6. The species has highly fragmented and isolated populations.
7. The species looks different in different locations.
8. One or more populations of the species has distinct ecology from the majority of populations.

(Maschinski, Albrecht et al. 2012)

Use founders with evenly represented family lines.

- Collect and maintain seeds from each maternal line separately. In this way, it is possible to know and intentionally control even representation of the different founders.
- Minimize ‘‘unconscious’’ or artificial selection (/taxonomy/term/11) during seed increases or augmentation of natural populations. Note that variation in germination (/taxonomy/term/81) and growth of maternal lines (/taxonomy/term/101) should be expected. Resist the temptation to over-represent the winners—those abundantly available, vigorously growing maternal lines that may skew the diversity of the population (/taxonomy/term/142)—but rather consciously maintain even family line representation (Guerrant et al. 2004; McKay et al. 2005).

Questions to Ask

About Wild Populations

1. What is the genetic structure (/taxonomy/term/76) of the wild populations?
2. What is the dispersal capability of the species?
3. If hybridization (/taxonomy/term/85) is a concern, what are the ploidy (/taxonomy/term/137) levels of the wild populations (McKay et al. 2005)?
4. Does the species suffer symptoms of inbreeding (/taxonomy/term/90) depression?
5. Is there evidence of outbreeding (/taxonomy/term/127) depression?
6. Based upon special ecology, unique morphology (that is, ecotypes (/taxonomy/term/55)) or spatial disconnection from other populations, do you suspect that a population (/taxonomy/term/142) has local adaptation?
7. Based upon the presence of a congener in the wild population (/taxonomy/term/187) and/or variable morphology, do you suspect that the species is hybridizing with a congener?

(McKay et al. 2005; Neale 2012)

Choose founders from a single source or mixed populations.

- Sometimes it may be appropriate to use a single-source population (/taxonomy/term/142), while other times it may be appropriate to mix populations for the founders.
- The decision of whether to mix source populations or keep them separate should consider several factors: condition and context of the wild population (/taxonomy/term/187)(s), mating system (/taxonomy/term/103), dispersal mode, ploidy (/taxonomy/term/137) level, and genetic structure (/taxonomy/term/76). (See box "Questions to Ask Related to Wild Populations," Fig. 3.2, "Summary of Collecting Recommendations for Numbers of Populations to Sample (/node/521#fig-3.2)," and Figure 3.3, "Summary of Collecting Recommendations for Numbers of Individuals to Sample within a Population (/node/521#fig-3.3).")
- Traditionally, it is recommended to use founders from only a single wild population that is ecologically similar to the recipient site in order to preserve locally adapted genes. For example, if the species is an obligate outcrosser (/taxonomy/term/124) and is locally adapted to a site at very fine scale, then mixing populations may cause outbreeding

(/taxonomy/term/127) depression (Neale 2012). This is especially true if there are known genetic differences between existing populations or if populations have more than 100 individuals, have distinct ecology, and have been separated for more than 20 generations (Frankham et al. 2011).

- Mixing source material may be necessary if there is no appropriate ecological (/taxonomy/term/53) recipient site that matches extant population site, if the available source material is limited, or if there is evidence of low genetic diversity (/taxonomy/term/72) or inbreeding (/taxonomy/term/90) depression in the source population (Dalrymple et al. 2012; Neale 2012). We recommend mixing source material if the taxon (/taxonomy/term/174) has extant populations of less than 100 individuals with no chromosomal differences, no distinct ecological differences, and if populations have been separated less than 500 years (Frankham et al. 2011).
- If mixing sources, keep track of each individual source through collection, production, and reintroduction to allow for rapid response should any issues arise.

Consider genetic rescue (/taxonomy/term/75).

- When the wild or reintroduced population has low genetic diversity and signs of inbreeding depression, consider genetic rescue (Frankham 2015).
- Infusing new genetic stock into a wild or reintroduced population (genetic rescue) may be necessary to overcome detrimental effects of inbreeding (Frankham 2015). Introducing new individuals or genes (from pollen) could increase genetic diversity and fitness of a small, inbred population (DeMauro 1993; White et al. 2018).
- Aim to release equal numbers of individuals from each source population early in the reintroduction to promote balanced admixture (/taxonomy/term/6) in the descendant population (Havens et al. 2004; White et al. 2018).
- For species critically imperiled by threats that are genetically linked, genetic rescue may also comprise insertion of advantageous genes as is being done in crop development (Rinaldo and Ayliffe 2015).

Source Material and Horticulture

The source material used for any reintroduction may determine its fate. To give the new population the best chance to persist against future stochastic or catastrophic events, it is important to use plants that are adapted to site conditions, have adequate genetic diversity and good health (Falk et al. 1996; Guerrant 1996; USFWS (/taxonomy/term/179) 2000; Guerrant et al. 2004; Neale 2012). Review and account for genetic concerns of source material from collection through propagation in the nursery to outplanting (/taxonomy/term/130) in field. This requires that you simultaneously evaluate and match recipient site characteristics (see “Choose a suitable recipient site” and “Create a sustainable population”) to genetic stock available for the reintroduction.

Review the US Fish and Wildlife Service Policies.

- Review the USFWS Policy Regarding Controlled Propagation of Species Listed under the Endangered Species Act (USFWS 2000) (https://www.fws.gov/endangered///laws-policies/policy-controlled-propagation.html).

Plan the source material.

- Review and plan the source material that will be appropriate to introduce to a particular site (Basey et al. 2015).
- Identify the potential source material(s) available for reintroduction. Note collection site ecological conditions, community structure, and proximity to the proposed recipient site (Maschinski, Falk et al. 2012).
- Collect or retrieve from a seed bank the source material whose location has similar climatic and environmental conditions to the recipient site(s). This is particularly important if the species has distinctly different appearance (or ecotypes (/taxonomy/term/55)) within wild population sites. Detailed information recorded on accession (/taxonomy/term/2) forms at time of the collection is essential for this evaluation.
- The extent of gene (/taxonomy/term/70) flow between populations varies by species. Some may have isolated, locally adapted patches within a small area, whereas others may have great gene flow over great distances. Therefore, there isn’t a simple relationship between distance and genetic relatedness (Richards et al. 2016).
- Use genetically heterogeneous founders to improve the ability to cope with varying conditions (Falk et al. 1996; Guerrant et al. 2004; Neale 2012). Theoretically, high levels of genetic diversity will equip the new population with adaptive (/taxonomy/term/4) potential needed to withstand stochastic and deterministic events including climate change, and can defend against potential genetic pitfalls of small populations such as founders effect and inbreeding depression. (See “Using a single-source population versus mixing populations.”)
- Genetic rescues may use targeted genotypes to restore fitness at a recipient site rather than focus specifically on maximizing genetic diversity in the founder population. (See “Consider genetic rescue.”)

Questions to Ask

Regarding the Genetics of Source Material

1. From which wild population (/taxonomy/term/187)(s) should the material be collected for use in the reintroduction?
2. What is the basis for collecting source material from a particular location?
3. How will the source material be sampled?
4. What is the genetic composition of the material reintroduced?
5. Should material come from an ex situ (/taxonomy/term/58) source, only one wild source population (/taxonomy/term/142), or mixed population sources?

(Falk et al. 1996; Vallee et al. 2004; Maschinski, Albrecht et al. 2012)

Propagating adequate numbers of plants is an important prerequisite to rare plant reintroduction. *Amorpha georgiana* (Georgia indigobush) seedlings are growing at North Carolina Botanical Garden to support a reintroduction on Fort Bragg, a Department of Defense Army Installation in NC. **Photo credit:** Mike Kunz.

Use ex situ (/taxonomy/term/58) source material.

- CPC recommends using *ex situ* source material before collecting new material from the wild (Guerrant et al. 2004).

- Using ex situ propagules will minimize adverse impacts on wild populations (Guerrant et al. 2004). Over several years it may be beneficial to add fresh stock to increase diversity and age structure (Guerrant et al. 2004) and improve the chances for successful establishment of the reintroduced population (/taxonomy/term/142) (Duquesnel et al. 2017).
- Compelling reasons not to use ex situ propagules include: a) the collection site is ecologically very different from the recipient site, b) there is a more appropriate source population that can withstand collection, or c) the ex situ propagules you have available are not genetically diverse.
- Bulking up ex situ collections through vegetative reproduction or seed bulking is often very feasible. When producing propagules for reintroduction, be aware of potential selection and genetic bottlenecks that may occur (Basey et al. 2015).
- If ex situ material is not available, collect no more than 10% of seed produced in any year from wild populations to avoid harm to the wild populations with >50 plants. Collect from all individuals within the population if there are < 50 plants. Capturing broad genetic diversity (/taxonomy/term/72) may require collecting in different years and across the range of the fruiting season. (See Guerrant et al. (2004) for specific guidance regarding ex situ collection and management and Part 1B, "Collecting Seeds from Wild Rare Plant Populations." (/node/24))

Choose the best propagule type.

- Choose the best propagule type and size of founders based upon the species' life history, recipient site characteristics, and logistics.
- It is possible to use seeds or whole plants for any reintroduction, however there are advantages and disadvantages of each (Table 4.1).
- Seeds may be an easily collected, bulked in the nursery setting, and provide a rich source of genetic diversity for use in reintroductions. If seeds are orthodox, they are relatively inexpensive, easily and compactly stored prior to use. When seeds germinate at the recipient site, they are a bioindicator that germination (/taxonomy/term/81) is possible there. However, typically only a small percentage of seeds (1–10%) germinate in wild conditions and a small percentage of reintroductions have established with seeds (Albrecht and Maschinski 2012, Dalrymple et al. 2012, Guerrant 2012). Therefore, founder population size for seeds will require thousands to tens of thousands of seeds. Further, the time required to mature to reproductive stage from a seed varies with species' life history. For most species, the most vulnerable life stages to mortality factors are the seed and seedling stages (Grubb 1977). The longer the seed or seedling stage remains in the wild, the more mortality should be expected.

- To improve the likelihood of success of a seed reintroduction, use thousands, employ dormancy-breaking treatments if appropriate, protect seeds and seedlings from herbivory, and irrigate for months as is the practice for perennial (/taxonomy/term/132) whole plants (Bainbridge 2007, Maschinski et al. 2017).
- For annual and short-lived species, seeds are often the best choice. Transplanting annual plants as seedlings or adults to the field is fraught with perils, as plants would not survive well or would require extreme care and watering on a daily basis if natural rainfall did not occur daily.
- For species with intermediate lifespans (usually herbaceous perennials), whole plants have been shown to be most successful. Grow plants as large as is feasible to manage for transport to the reintroduction site and planting. Using physically large founders increases the likelihood of establishing a persistent population (Guerrant et al. 2004; Albrecht and Maschinski 2012). An exception to this is if habitats, such as rock outcrops, do not allow digging or transplanting whole plants. If this is the case, then seeds would be the best choice.
- If the species is long-lived, reintroduce plants of varying size and life-stage to account for variable success of stages in different microsites (Albrecht and Maschinski 2012). Using different-stage plants will result in a more diverse population structure in the present and future and will increase the probability of finding the optimal conditions for the whole population to grow. For example, use juveniles and reproductive plants in the reintroduction. Sometimes, the two will have different microsite requirements (Wendelberger and Maschinski 2016). Generally, the largest plants one can manage to transplant will have greatest survival, as was the case with *Amorpha herbacea* var. *crenulata* (Wendelberger et al. 2008).
- To improve the likelihood of success of a whole plant reintroduction, use large numbers, protect new transplants from herbivory, and provide irrigation aftercare for months.
- For many trees, foresters have found the best survival and most cost effective size for transplanting thousands of trees is a long-rooted seedling (in a container that forces deep root growth). The best timing for planting is when trees are dormant (/taxonomy/term/50) for temperate species (North Carolina Division of Forest Resources 2009), while for tropical species planting in the rainy season is advised. Tree roots are best established from the seedling or small container size, as they tend to get root-bound and suffer from circular root patterns in containers. Palm trees are an exception. Large *Pseudophoenix sargentii* juveniles in 3–10 gallon containers reintroduced to the Florida Keys had higher survival than seedlings (Maschinski and Duquesnel 2007).

TABLE 4.1. Advantages and Disadvantages of Using Seeds or Whole Plants for a Reintroduction

Qualities	Seeds		Whole Plants	
	Advantages	Disadvantages	Advantages	Disadvantages
Acquisition and Quantities Required	Easily collected and easily sown	1000s to 10,000s required; ease of installation and care is misunderstood. "They'll take care of themselves" is not necessarily true.	In comparison to seeds, fewer individuals can comprise the founder population and they will have overcome the perils that seedlings face in the wild.	In comparison to seeds, fewer individuals can comprise the founder population, hence there may be less genetic diversity represented.
Propagation	Easily bulked to produce next generation in nursery	Nursery produced seeds may be adapted to nursery rather than wild conditions.	Plants can be propagated from seeds or cuttings.	Propagation requires adequate space.
Genetic Diversity	Rich source of diversity	Survival of seeds and seedlings in wild may be quite low.	Survival and maturation is good in nursery and in wild. Controlled propagation can provided more control over genetic structure of founder population.	Generally, because of space constraints, the total diversity represented in a whole plant collection will be less than that of seeds.
Cost	Relatively inexpensive	Many seeds and/or seedlings will not survive long in the wild, therefore there is a resource cost.	High survival is expected in the greenhouse. One hundred seeds may yield 95 plants if germinated in a greenhouse, while only a single seedling may emerge in the field.	Time to achieve appropriate size for planting in wild has labor and resources cost.
Maturation Time	Annuals and short-lived species can grow to reproductive maturity in the first year or two.	Maturation time from seed to adult may be lengthy for long-lived species. The longer the seed or seedling stage remains in the wild, the greater chance of mortality.	Growing plants in a nursery setting can accelerate growth to maturity.	Plants with large root systems may be challenging to transplant in the field.
Ex Situ Space Requirements	Easily and compactly stored prior to use, if the species has orthodox seeds	If the species has desiccation or freezing intolerant seeds, storage requirements are specialized or the seeds must be used immediately.		Whole plants require much more space for production than seeds.
***Bioindicators* of Appropriate Recipient Site**	When they germinate at the recipient site, they are a bioindicator that germination can happen at the recipient site.	Typically, only a small percentage of seeds (1%–10%) germinate in wild conditions and a smaller percentage establish.	Large plants tend to have good survival at the recipient site.	The location where a transplant is placed may not be optimal for next generation seed to germinate.

Confirm that successful propagation is possible.

- Confirm that the species can be successfully propagated and that adequate numbers of high quality, healthy, genetically diverse source material is available.
- A critical step to accomplish prior to reintroduction is mastering the art of propagating large quantities of the species, acclimatizing them, and growing them ex situ

(/taxonomy/term/58). A declining species that has not been propagated such that large numbers exist in ex situ nursery stock is simply not a good candidate for reintroduction.

- Acknowledge that you are not ready to proceed if you have not mastered this step.

Allow enough time to generate the source material.

- Allow enough time to generate adequate numbers of source material prior to initiating the reintroduction. Depending on the species, this may take several months to several years.

Keep detailed documentation on all source material used.

- Keep detailed documentation on all source material used to restore populations. This documentation should be linked to permanent plant labels/ID tags attached to the reintroduced plants. Store these data in multiple locations.

Don’t use all material for the reintroduction.

- Keep some material in reserve.
- Genetically diverse source material should be safely backed up in an ex situ location so that regardless of whether reintroduction succeeds or fails there is still germplasm (/taxonomy/term/82) conserved.

Use good horticultural practice.

- Acclimate plants to novel conditions (Haskins and Pence 2012). Transitions from culture medium to soil and from greenhouse to outdoors will require a period of adjustment to reduce the chance of shock.
- Take phytosanitary precautions to insure that diseases will not be inadvertently transmitted.
- Use native soils from the wild site (if possible) during nursery production. Native soils may require augmentation with sterile perlite or vermiculite to achieve consistency necessary to be container-grown. The benefit of native soils is that they potentially contain beneficial microbes; however, pathogens may also be transferred with native soil. Follow good nursery hygiene practices accordingly. We advise separating plants with native soil from the rest of the nursery in quarantine.
- Weed pots containing plants destined for the reintroduction to reduce the chance of introducing weeds to reintroduction site.
- If using propagules that were derived from tissue culture (/taxonomy/term/177), acclimatization will be important. We recommend gradually decreasing humidity, while subjecting cultures to ventilation or air exchanges before transfer to soil. Alternatively,

methods could include increasing ambient CO_2, decreasing sugar levels in the cultures, or treating with growth regulators to increase stress tolerance. (Haskins and Pence 2012)

- Grow in controlled nursery conditions to maximize plant health and grow to appropriate size prior to moving to the reintroduction site.

Questions to Ask

Related to Planning for Population (/taxonomy/term/142) Growth

1. What founder population size will be used?
2. What size and stage structure of plants will be used?
3. How will the founding population be spatially configured to favor demographic persistence and stability?
4. What is known about population growth, recruitment, and survivorship in wild habitats and what environmental or community factors are correlated with population growth rates?
5. How will population growth, recruitment, and survivorship be monitored in the reintroduced population? And by whom?

(Falk et al. 1996; Vallee et al. 2004; Maschinski, Albrecht et al. 2012)

Planning for Population (/taxonomy/term/142) Growth

Use as many founding individuals as is feasible.

- Use as many founding individuals as is feasible (50+ individual plants or thousands of seeds) to bolster population growth (Guerrant 1996; Albrecht and Maschinski 2012). Increasing the numbers of reproductive adults early in population establishment increases the chances of next generation recruitment (Albrecht et al. 2018).
- Develop a demographic model for the species to determine the optimum founder size (Knight 2012).

- When working with perennial (/taxonomy/term/132) herbs and sites in highly competitive environments like grasslands, founder population sizes will need to be larger than 50. Introduce enough individuals (seeds or juveniles) to be able to break through demographic and environmental stochasticity of low populations to achieve a viable population (Knight 2012). Planting higher numbers of individuals increases the probability that the population will persist and perhaps spread (Reichard et al. 2012). This may occur because of higher numbers of total seeds produced or perhaps because, even with some mortality after planting, sufficient numbers of individuals remain to reproduce.
- Multiple outplantings over many years may be required to build up a population structure and size that sustains population growth over the long-term.
- Use seed bulking at the nursery to generate enough seed for a reintroduction. This provides an opportunity to document F1 characteristics, such as variation in timing of germination (/taxonomy/term/81), which can be compared to the wild population (/taxonomy/term/187).

Create experimental conditions to improve germination.

- Seek or create conditions experimentally with the intention of improving germination and the establishment and survival of next generation seedlings (Albrecht and Maschinski 2012).
- Although used in large-scale restoration projects, to date there have been few published or reported reintroductions using seeds that have incorporated experimental designs with techniques to improve success of field seed germination and establishment, such as microcatchments (/taxonomy/term/107) (for example, Bainbridge 2007). Similarly, there are few reports of manipulating site conditions for the next generation seedlings. As this is a critical part of establishing a sustainable population, more attention should be placed on this step in the reintroduction process.

Have a question or info about Rare Plant Reintroduction?

POST TO FORUM (/node/add/answers-question?edit[field_category][und][192]=192)

Suggested Citation

Sam Wright, Fairchild Tropical Botanic Garden, plants *Lantana canescens*. **Photo credit:** Joyce Maschinski.

Summary

- Good logistical preparation will make installation day run smoothly.
- Ensure that the plants or seed plots are labeled, mapped, and recorded in such a way that they can be monitored for many years into the future.
- Implementation day is a great day to involve the public. Be sure to demonstrate planting or sowing techniques to safeguard the rare species.

The logistics of the reintroduction day often entail coordinating many details and people. It can be a time of great celebration as a high point in the steps towards a species' recovery. Particularly when involving volunteers or inexperienced personnel, coordinating logistics well can result in an extremely satisfying event.

Plan how the reintroduction will be implemented.

Plan timing, materials, personnel, and logistics needed to implement the reintroduction. (See the "Questions to Ask Regarding Logistics for Implementation.")

Improve site conditions for the reintroduced species.

- If necessary, remove invasive species or thin canopy to improve site conditions for the reintroduced species.
- Often it will be easiest to prepare the site prior to and on a different day than the reintroduction. If site preparation increases the potential risk of invasion by undesirable species or exotics, the site should be monitored for several months and outplantings should be delayed until the risk of invasion is considered low.
- Multiple site preparation treatments may be required to ensure ideal conditions for reintroduced plants.

Use a system, such as color coding, to easily distinguish plants in different experimental treatments.

- Select durable, long-lasting tags for labeling plants.
- Particularly if you have a large number of plants and a large number of people helping with the installation of the reintroduction, it is important to be able to distinguish plants from different treatments. For example, if you are testing plants that had mycorrhizal inoculum (/taxonomy/term/117) versus those that did not, clearly mark plants before moving to the field and clearly mark the location at the site where plants of each group should be planted.

North Carolina Botanical Garden gathered many staff and volunteers to assist with endangered *Ptilimnium nodosum* reintroduction. **Photo credit:** Johnny Randall, NCBG.

Questions to Ask

Regarding Logistics for Implementation

1. What is the best season to transplant or sow seeds? Keep in mind that best season for rainfall may also be the hottest time of the year and plants may require more attention.
2. Have you invited participation from enough staff, volunteers, community members, agency and landowners, or land managers to execute the reintroduction?
3. Have permits been acquired and are they up-to-date?
4. How will you ensure that plants will be able to be tracked for many years in the future? Are plants tagged and positions recorded with GPS?
5. How will you transport plants to the recipient site? Do you have necessary off-road equipment for transport away from roadways?
6. What is the planting layout design?
7. How are you going to water plants?
8. Have you notified the press or have you arranged for photos to be taken of the event? (Note that there may be circumstances when the exact location of the conservation translocation (/taxonomy/term/31) must not be publicized to prevent unauthorized collection of the taxon (/taxonomy/term/174); however, good conservation news with general descriptions of the reintroduction can be used to engender public enthusiasm for plant conservation. If you are uncertain, talk to your regulatory agency prior to notifying the press.)

(Vallee et al. 2004)

Select microsites carefully.

- Select microsites carefully or conduct an experiment to test different microsites.
- Even when there is reasonably good information about the environmental attributes associated with the species occurrence, test plantings can show which microhabitat conditions are optimal for growth and survival and long-term population (/taxonomy/term/142) growth (Maschinski, Falk et al. 2012).
- Note aspects of the landscape topography, ecosystem dynamics, and patterns that may help determine the locations with greatest likelihood of sustaining a reintroduced population

(Maschinski, Falk et al. 2012).

Tracking seed germination (/taxonomy/term/81) in the field can help us understand a critical part of rare plant biology. Kristie Wendelberger labeled seedlings of endangered *Amorpha herbacea* var. *crenulata* and measured ecological (/taxonomy/term/53) variables to assess conditions needed for seedling survival. **Photo credit:** Kristie Wendelberger.

Plant in a spatial pattern that will promote effective pollination, seed production, and recruitment.

- Plant density strongly influences variation in outcrossing (/taxonomy/term/129) (or selfing (/taxonomy/term/165)) among plants; therefore, plant in a spatial pattern that will encourage the appropriate breeding system (/taxonomy/term/22) of your species (Monks et al. 2012). Planting individuals in small clusters throughout the population (/taxonomy/term/142), instead of fewer larger clusters, may lead to increased spread in the population (Reichard et al. 2012). Keep spatial design in mind in any experimental design.
- Understanding a target species' tolerance for competition (/taxonomy/term/25) and disturbance, as well as habitat composition and structure, can help inform spatial and temporal placement of any reintroduction (Maschinski, Falk et al. 2012; Maschinski, Wright et al., 2012). For example, if the target species is not a good competitor, planting into open spaces with few other species present is beneficial.

Ensure that you have enough help to treat the site and/or install plants.

- This is a wonderful opportunity for student and citizen volunteers of all ages.

- Ensure that individuals installing plants are provided with adequate training and supervision.
- Bring snacks and water.

Consider pretreating reintroduced seeds.

- If using seeds, consider pretreating seeds to release them from dormancy and sow into permanently marked plots or (Maschinski et al. 2017).

Have a question or info about Rare Plant Reintroduction?

POST TO FORUM (/node/add/answers-question?edit[field_category][und][192]=192)

Suggested Citation

Center for Plant Conservation. Implementing the Rare Plant Reintroduction in *CPC Best Plant Conservation Practices to Support Species Survival in the Wild.* Web Version. https://plantnucleus.com/best-practices/implementing-rare-plant-reintroduction (https://plantnucleus.com/best-practices/implementing-rare-plant-reintroduction) Accessed: 08/11/2020 - 5:59pm

Related Videos

Sometimes reintroduced plants require caging and irrigation to thrive. **Photo credit:** Joyce Maschinski.

Summary

- A reintroduction will have a higher chance of successful establishment if it receives water and weeding after installation.
- Keeping land managers apprised of the performance of the rare species and engaging them in active site management is critical for long-term population (/taxonomy/term/142) persistence.
- Developing and implementing a long-term monitoring plan is needed to document the success of the reintroduction.

After the time-intensive process of preparing for the reintroduction and installing it, practitioners often breathe a sigh of relief when the plants or seeds are finally in the ground. However, it is important to realize that the work is not over at this step. Survival and population persistence of the reintroduction depends upon aftercare and no one will be able to learn about the reintroduction unless it is monitored long-term and findings are reported back to the conservation community. The great thing is that aftercare is likely to improve successful establishment and reduce the species' risk of extinction. Monitoring helps document this success, so it is worth it!

Conduct Aftercare of the Restored Population

Water plants and seeds until established.

- Account for the amount of effort and time required to transport water for supplemental watering.
- It is possible to set up drip irrigation systems that can be watered from tanks installed on site or transported in pick up trucks.

Periodically weed until plants are well-established.

Ongoing site management is important.

- Collaborators committed to long-term site management should review the status of the site periodically to ascertain whether management is needed. **FAQ - Should I manipulate my planting site after the reintroduction? (/node/198)**
- Control invasive weeds and competing vegetation.
- Control overabundant herbivores. Cage plants, if necessary.
- Restore historical disturbance regimes such as fire.
- Periodically review the site surveys to detect unforeseen issues (for example, trampling, theft, herbivory, pest insects, vandalism, or maintenance personnel abuse of plants.)

Threats to vernal pool habitats come from many factions. Careful monitoring allows practitioners to understand the impact of the threat on the rare plant population (/taxonomy/term/142). **Photo credit:** Stacy Anderson.

Questions to Ask

Regarding Post Planting

1. What aftercare will be needed and how frequently will this require attention?
2. What habitat management and threat abatement is needed? How frequently?
3. Has a monitoring plan been prepared and reviewed?
4. How will success be measured?
5. Are sufficient funds available for aftercare?
6. Do permits cover aftercare activities?

(Vallee et al. 2004)

Design Appropriate Monitoring Plans

A well-designed monitoring plan is an essential component of any reintroduction program. To ensure the long-term persistence of a species in the face of environmental change, a long-term monitoring plan is necessary to evaluate how reintroduced populations respond to infrequent events (for example, drought) and to detect changes in the population (/taxonomy/term/142) that might take years to express (for example, inbreeding (/taxonomy/term/90) depression in long-lived perennials or replenishing of the soil seed bank). Our goal is not to provide an exhaustive review of how to monitor plant populations, but rather to provide standards for the minimum amount of information needed to evaluate the long-term fate of reintroduced populations. A long-term monitoring strategy will depend upon a number of factors including the trajectory of population growth, the life-history of the focal species, monitoring resources available, and the goals and objectives of the experimental components of the project.

Use the reintroduction to learn more about the species.

- Use the reintroduction as an opportunity to learn more about the species, its habitat requirements, and its biotic (/taxonomy/term/20) interactions.
- Incorporate the factors of interest into monitoring plan. Note conditions at the time of installation.

- Document how pollinators and other animals interact with translocated species to improve understanding of the community function in the ecosystem.

Develop a monitoring plan.

- Although all monitoring plans must be tailored to individual projects in order to obtain data relevant to the experimental design and objectives, all reintroduction monitoring plans include basic components needed to provide information relevant to species' biology and techniques for managing rare plant populations (Table 4.2).
- A well-designed monitoring plan with clear objectives provides information on the species' biology and techniques for managing rare plant populations. It should be easily understood by your successors, therefore record details as if you are writing for institutional memory.
- If any changes are made to the monitoring plan, then document changes in detail.

Gather demographic data.

- Gather demographic data on the reintroduced population, unless it is not appropriate for the life-history of the target species (Morris and Doak 2002).
- Demographic monitoring of individuals is the method of choice for achieving the central objectives of most rare plant reintroduction projects.
- Specifically, we recommend measuring survival, growth, and reproduction on each plant preferably over multiple generations (Monks et al. 2012).
- For demographic modeling and tracking the success of the reintroduction, determine life history stages (typically seedlings, juveniles, non-reproductive adults and reproductive adults) and note when benchmarks are achieved (See Figure 4.2). **FAQ - How will I know if the reintroduction is a success? (/node/190)**
- Count the number of seedlings, juveniles, non-reproductive adults, and reproductive adults in your reintroduced population.
- If you plan to develop and compare population dynamic models for the reintroduced population and natural populations, then the frequency of monitoring will need to be at a rate that accurately charts movement of an individual from one life stage to another. **FAQ - How often/how long should I monitor my reintroduction? (/node/192)**
- Define how large an area you will need to search for recruits.

TABLE 4.2. List of actions essential to monitoring plans for reintroduced plant populations. These are the minimum items to consider when establishing a monitoring plan.

Action	Description

1) Develop clear monitoring objects.	Take into account the life history of the focal species, propagule stage(s) planted, biological and project goals (Pavlik 1996).
2) Define sample (/taxonomy/term/160) units.	Use individuals or transplants for demographic monitoring or plot/transect based methods for monitoring demographic structure. All transplants and plots permanently marked and mapped, preferably with GPS.
3) Determine appropriate monitoring frequency.	Monitoring period should match key phenological (/taxonomy/term/133) phases (e.g., peak fruiting and flowering) and life-history of the focal species.
4) Monitor vital rates (/taxonomy/term/182).	Follow the fates (survival, growth, fecundity (/taxonomy/term/64), and recruitment) of transplanted individuals and their progeny or quantitatively track abundance of stage classes (seedling, juvenile, non-reproductive adult, reproductive adult).
5) Evaluate fecundity.	Measure seed production by counting the number of fruits per plant and estimate the number of seeds per fruit through sub-sampling (/taxonomy/term/161). Compare results to reference or natural populations.
6) Survey new habitat patches for dispersal and spread.	Search for seedlings at each census both near and far from sample units. Add new recruits to demographic studies, subsample if recruitment densities are large. Conduct searches for the focal species in suitable habitat patches within and beyond the initial planting site. Establish new sample units to monitor the growth and development of new patches/populations.
7) Monitor wild reference populations (/taxonomy/term/154).	Simultaneously monitor reintroduced and natural populations to gain insight into key factors that underlie restoration success. Natural populations should be monitored across several sites and during the same years to capture variation in vital rates for comparison to reintroduced populations.

8) Monitor threats.	Document evidence of changes in: exotic species distribution and abundance, successional patterns, hydrology, disturbance regimes, land management, herbivores, predators, and disease.
9) Prepare backup plan to relocate lost sample units.	Document all sites and plots with GPS and supplement with precise directions that includes compass directions and measured distance from permanent visible landmarks (Elzinga et al. 1998). Produce GIS layers and maps if possible.
10) Archive monitoring data and provide metadata.	Enter, store, and backup all monitoring data in digital files. A minimum of two copies of raw data sheets should be kept on paper file, preferably in separate locations. One copy should be accessible to take into the field during subsequent monitoring events. Metadata should be assembled during the project and continually updated.

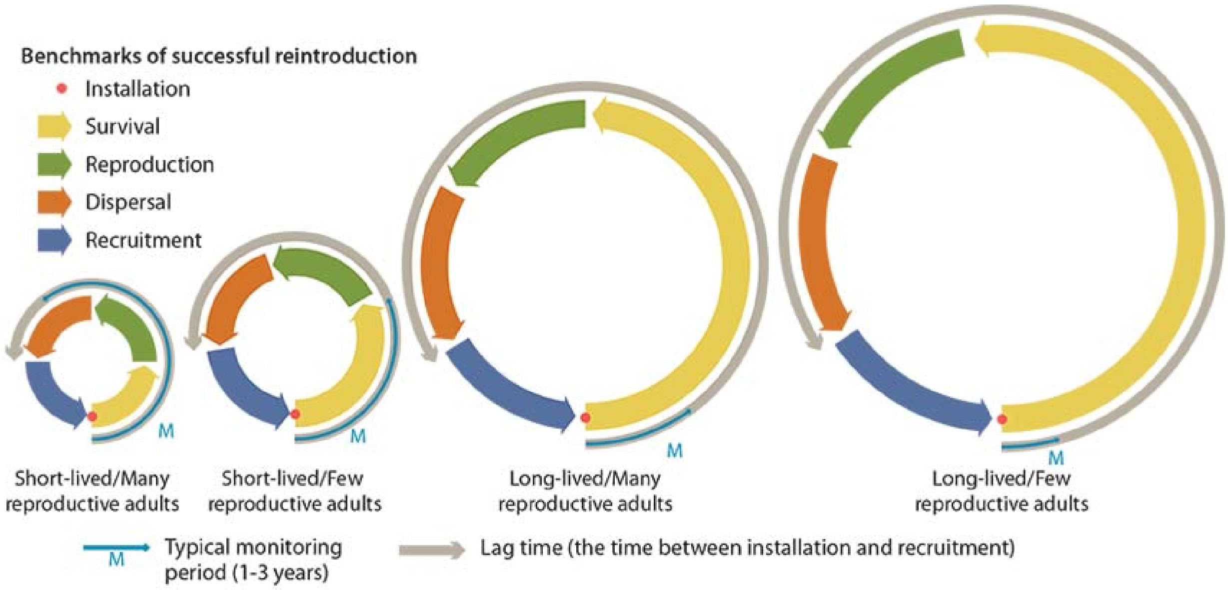

FIGURE 4.2 Benchmarks of successful reintroduction. Bars indicate the four benchmarks of a reintroduction: survival, reproduction, recruitment, and dispersal, where dispersal encompasses movement to a new location and establishment. For founders installed as whole plants, the first benchmark is survival, however if founders are seeds, there is an added step. The first benchmark is recruitment, followed by survival, reproductive maturity, next generation recruitment, and dispersal. Species life history and reproductive adult abundance influence duration of time needed to achieve benchmarks. The ability to detect success is constrained by a

typical monitoring period of 1-3 years versus the time required to detect recruitment. Turquoise blue arrows denote typical monitoring period, which may be brief and limited by project funding. Grey arrow around circumference of circle indicates lag time to next generation recruitment.

Monitor wild reference populations (/taxonomy/term/154).

- Whenever possible, monitor wild reference populations to compare to the reintroduced population (/taxonomy/term/142) (Bell et al. 2003; Colas et al. 2008; Menges 2008).
- Reference populations will give context for the reintroduced population's vital rates (/taxonomy/term/182) and aid in identifying the vital rates that are driving population trends (Morris and Doak 2002).
- In augmentations, the fate of augmented individuals and naturally occurring ones should be distinguished in demographic or quantitative censuses when possible to determine whether transplants are performing differently than naturally occurring individuals in the population.
- If available, multiple reference populations should be monitored to capture the full range of variation in vital rates possible across different sites and years.

Adopt an appropriate monitoring strategy.

- Adopt a monitoring strategy that is appropriate for the life history of your target species and the founding propagule used.

a) For long-lived perennial (/taxonomy/term/132) plants, monitoring plans will need to accommodate changes in population structure over time.

- Specifically note when transplants transition into larger size classes and sexually reproduce.
- Tag new seedlings as they recruit into the population.
- Searches beyond the transplant plots or transects (/taxonomy/term/178) will need to be conducted to document dispersal, seedling recruitment and metapopulation (/taxonomy/term/105) dynamics adequately.
- Most monitoring of perennial plants will need to be done at least annually to obtain annualized vital rates. More frequent visits may be necessary to quantify disparate parts of the life cycle such as survival, fecundity (/taxonomy/term/64), and seed germination (/taxonomy/term/81).
- For long-lived species (for example, trees), monitoring on an annual basis may not be necessary to detect changes in population trends.

b) For annuals and short-lived species, monitoring plans will need to accommodate temporal and spatial fluctuations in population size (Albrecht and Maschinski 2012; Dalrymple et al. 2012).

- Track counts of reproductive versus non-reproductive plants that emerge in permanently marked plots or transects across years.
- In annual species, dormancy and germination are often driven by climatic cues that vary from year to year, resulting in wide annual fluctuations in distribution and abundance.

c) The method used to monitor seeds will depend upon the sample (/taxonomy/term/160) unit.

- When sample sizes are small, seeds can be tracked individually. In most cases, however, sow seeds directly into plots so that cohorts can be followed.

d) If demographic monitoring of individuals is not possible, monitor stages or size classes that are most important in maintaining population growth.

- If the importance of the vital rates is known for your taxa, you can concentrate on the most important vital rate and note changes across years to understand population trends.
- If populations begin to decline, then monitoring individuals in all stage classes may be needed to understand mechanisms that are driving the decline and determine what management actions are needed to reverse the decline.

e) If demographic monitoring is difficult or impractical, we recommend doing census counts of all or key life-history stages to detect population trends (Menges and Gordon 1996). Examples of species characteristics that may challenge typical monitoring practice include clonal (/taxonomy/term/23) reproduction, seed or plant dormancy or other cryptic life-history stages (for example, tiny seedlings, corms, bulbs).

f) As subsequent generations disperse seed, restricting the census to the original sown plots would fail to capture local dispersal. It will be important to note which microsites are suitable for germination and survival.

- Regular counts of individuals within grids or belt transects that cover broad areas within the habitat may be needed to fully capture changes in the spatial distribution and abundance over the longer-term and to assess population trends effectively (Young et al. 2008).

Estimating percent cover of native and non-native plants in plots with restoration plantings can be used as a baseline for detecting change. **Photo credit:** Joyce Maschinski

Monitor for at least 3 years and if possible for 10 plus years.

- Long-term monitoring provides information necessary to evaluate how reintroduced populations respond to rare events (for example, drought) that were infrequent or nonexistent during the early phase of population (/taxonomy/term/142) establishment. It can reveal genetic issues that might play out only after multiple generations (for example, inbreeding (/taxonomy/term/90)). (Falk et al. 1996; Dalrymple et al. 2012.)
- Ultimately, long-term monitoring is needed to predict the fate of the reintroduced population and determine the mechanisms driving population viability (/taxonomy/term/180) (Albrecht et al. 2011). To develop population viability models and predict population trajectories, a minimum of 3 years of monitoring data are required. To predict long-term trends (10–100 years) and determine whether reintroduced population is potentially self-sustaining under current environmental conditions, extended periods of monitoring are necessary, see Figure 4.2.

- Demographic data will be needed to provide population size estimates for reintroduction plans whose objective is to achieve a specific population size or stage structure.
- A long-term monitoring strategy will depend upon a number of factors including the trajectory of population growth, the life-history of the focal species, monitoring resources available, and the goals and objectives of the experimental components of the project. (See Elzinga et al. 1998 for more details.)
- Enlist the help of public volunteers to accomplish long-term monitoring (Maschinski, Wright et al. 2012). Whenever possible, include land managers in monitoring to foster a close connection with the reintroduced population.

Use redundancy to mark individuals and plots. Assume that some sample (/taxonomy/term/160) units will be lost over time.

- Although an essential element in all reintroduction plans, long-term monitoring of reintroduced populations can pose formidable challenges. Over time, natural or anthropogenic disturbances can impede access to sites or complicate relocating sample units. For example, plots and transect boundaries or demographic markers can be lost due to fire, flood, downfalls, burial, vandalism, animal impacts, etc.
- Losses can be mitigated with a good insurance plan, which can be used to re-establish or re-locate the boundaries of sample units or tagged individuals when necessary. Whether using plot-based methods or monitoring individuals demographically, there are several ways to ensure the accurate relocation of lost plot markers, transects (/taxonomy/term/178), and tagged individuals. (See pages 190–191 in Elzinga et al. (1998) for more details.) Submeter GPS points are also helpful.

Determine how success will be measured and have realistic goals.

- Expand definition of success. Identify short-, mid- and long-term success that pertain to the target species and its habitat.
- Remember to think about project success and biological success (Pavlik 1996).
- Comparative mating system (/taxonomy/term/103) studies combined with pollination biology can be carried out over relatively short timeframes (one or two flowering seasons) and can be used to give vital clues to potential recruitment and reproductive success in subsequent generations (Monks et al. 2012).
- Use molecular markers to assess key population processes such as mating system variation and genetic variation in reintroduced populations and, where possible, compare to wild populations to predict reintroduction success (Monks et al. 2012).

Monitoring intensity may change over time.

- As short-term goals are achieved in a reintroduction program, monitoring intensity may change from experimental to observational.
- For example, when reintroducing the perennial (/taxonomy/term/132) forb *Helenium viriginicum* to sinkhole ponds in the Ozarks, Rimer and McCue (2005) initially set out to determine how planting position and maternal lines (/taxonomy/term/101) affected establishment rates of transplants over a 2-year period. Individuals of the species were grown ex situ (/taxonomy/term/58), transplanted in a replicated experimental design, and then the fates of transplants were followed demographically. After completing the initial goals of the reintroduction, the populations grew rapidly due to vegetative reproduction and successful seedling recruitment, making it impractical to differentiate transplants and new recruits in subsequent censuses. Because the short-term goals of the experimental design were accomplished, the populations grew rapidly, and the species was capable of completing its life cycle in this location, the monitoring protocol switched to count estimates and surveys for new threats rather than full-scale demographic monitoring of individuals. Likewise, transitioning to observational monitoring may lead to less frequent data collection (for example, annual rather than quarterly) than was needed during the more intense experimental stage.

Analyze data and report results in a timely fashion.

- Report results through publishing or publicizing via social media, newsletters, and websites.


Florida Parks biologist Janice Duquesnel has dependably monitored the reintroduction of Florida endangered *Pseudophoenix sargentii* for more than two decades. **Photo credit:** Joyce Maschinski.

Questions to Ask

Documentation Needed to Justify and Decide Whether to Conduct a Reintroduction

1. Survey and status updates are complete. Status includes degree of protection, threats, and management options for the extant populations.
2. Specific information on the number of populations has been collated within the last 18 months.
3. Counts or estimates of the number of individuals in each population (/taxonomy/term/142) have been done.
4. The age structure of the populations is known.
5. The relationship of populations in a metapopulation (/taxonomy/term/105) context is compiled.
6. Surveys identifying suitable habitat are complete.

7. Suitable recipient sites have been assessed and ranked.
8. Long-term protection and management plans are documented for suitable recipient sites.
9. Sufficient money is secured to conduct the reintroduction.

(Falk et al. 1996; Vallee et al. 2004; Maschinski, Albrecht et al. 2012)

Documentation

Documentation is an essential component of reintroduction, and we encourage practitioners to regard their reintroductions not only as activities done for the preservation of species, but as experiments. To this end, we encourage careful documentation so that the reintroduction is justified, that good decisions can be made about preparedness prior to the reintroduction event, that appropriate monitoring can be implemented, and that the data can be analyzed to determine project success. These steps are important to represent accurately the reintroduction from a legal and scientific perspective. (See Dalrymple et al. 2012). (See Part 5 “Documentation and Data Sharing” (/node/529) and North Carolina Reintroduction Documentation Form (http://ncbg.unc.edu/uploads/files/Reintroductionguidelines.pdf))

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