

Chapter **48**

**Supporting *In Situ*
Conservation:**

*The Berry Botanic Garden, an
ex situ regional resource in an
integrated conservation community*



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Summary

To effectively support plant conservation *in situ*, *ex situ* providers must not only provide reliable, high quality *ex situ* services, but also apply them creatively and adaptively to local circumstances. In so doing, *ex situ* resource providers must take the initiative to actively seek out, educate, and work cooperatively with *in situ* partners. These points will be illustrated by using the work of the Berry Botanic Garden Seed Bank as one example of how they can be applied in practice.

Role, Value and Limits of *Ex Situ* Conservation

The very notion of *ex situ* plant conservation is something of a paradox. Conserving biodiversity, or our failure to do so, will ultimately occur in the world at large, and not in *ex situ* facilities. Nevertheless, *ex situ* samples can make the difference between extinction and survival of rare and endangered species in their natural habitats. The resolution to the paradox of removing genetically representative samples of such species for off-site storage in order to enhance their survival prospects in the wild can be found in a clear understanding of the role, value and limits that *ex situ* methods play in plant conservation efforts more generally.

Ex situ methods can serve a variety of different roles, depending on the sorts of plants that are of concern and the purposes for which they are being stored. The roles played by collections of agriculturally important crop plants and their wild relatives (e.g., breeding purposes) may not be the same as for collections of threatened native species. In this chapter, the focus is on the manner in which seed banks can support *in situ* native plant conservation efforts.

Ex situ collections of threatened species are *a means to an end* – enhanced survival prospects of both the sampled populations and the species in the wild. Thus, their basic role is one of support for *in situ* plant conservation efforts. Viewed this way, *ex situ* collections are an integral *part of a larger whole* in which comprehensive efforts involving any and all available and appropriate means are used to enhance the survival prospects of rare and endangered plants. This marriage of *ex situ*, *in situ*, social, legal and other means have been referred to as integrated conservation strategies (Falk, 1987; 1990). In the end, if there is neither suitable habitat left for a species, nor any reasonable prospect of restoring any, then *ex situ* samples are unlikely to leave any self-sustaining descendants for future generations to enjoy.

The value of *ex situ* samples and methods is varied. First and most basic is that the mere existence of the living samples themselves, appropriately maintained away from the sampled population, reduces the risk of extinction. If a sampled population suffers a drastic reduction in size or is extirpated, the genetic information is not lost to the world. This can be thought of as the ‘insurance policy’ value of the samples. For the ultimate conservation value of the samples to be realised, however, they need to be used to restore diversity. Thus, the second primary value of *ex situ* samples is to provide additional options for restoration efforts. Even the most enlightened on-site management efforts are not always successful and it is wise to maintain a “restoration toolbox” with as many options as possible. Other values served by *ex situ* collections include providing material for scientific research and public education (e.g., garden displays and interpretation), without having to collect additional material from wild populations. Additionally, they provide the opportunity for performing research to obtain horticultural and biological information that will ultimately aid in reintroduction efforts.

Despite their potentially pivotal value, *ex situ* methods should not be viewed as a panacea that could save all biodiversity given sufficient effort. *Ex situ* methods have limited spheres of application, and the collections themselves come with both biological and other resource costs. For *ex situ* methods to be most effective, not only must the role and value be appreciated, but also their limitations. Both must be recognised and factored into the overall conservation strategy. First, *ex situ* methods are necessarily population and species based, and thus can be applied to only a small fraction of the biota of a sampled location. Furthermore, not all taxa are equally amenable to *ex situ* storage, limiting the scope of applicability of these tools. *In situ* and *ex situ* methods are not alternative ways to conserve biodiversity, they are complementary, with *ex situ* playing a support role for *in situ* efforts. Based on the erroneous premise that the two approaches are alternatives, some land managers fear that *ex situ* samples might detract from *in situ* efforts, and thus do not use them. Again, based on this same erroneous premise, a more insidious danger is that the ignorant or unscrupulous can misuse *ex situ* methods to justify habitat destruction. Some have argued that off-site collections reduce or eliminate the need for preserving wild populations or habitat. *Ex situ* providers need to understand this potential danger, and embrace the ethical imperative not to let their facilities be used in a way that facilitates habitat destruction. The mere existence of *ex situ* samples should not provide a false sense of security, which may lead to complacency in the face of deteriorating conditions in the wild populations.

Obtaining *ex situ* collections is not a risk-free activity. The removal of seeds or other plant parts increases the short-term risk of loss to a sampled population. The size of the risk will depend on the strategy adopted by the seed collectors. Proper strategies will only marginally increase the risk. In addition, inattentive collectors can cause physical damage to some fragile environments in which rare plants occur.

With appropriate use, including a wary eye on the limitations described above, *ex situ* methods can play a very positive role in native plant conservation. *Ex situ* methods are often fairly simple and straightforward. The cost of obtaining and maintaining *ex situ* plant collections is low and a limited amount of technology is needed. This is particularly so when compared to animal conservation methods.

Ex Situ Support for In Situ Plant Conservation:

The Berry Botanic Garden, a Case Study

1. Introduction

The general approach of providing high quality service, adapting to local circumstances and educating potential clients seems simple enough. However, there is no one-size-fits-all formula for how *ex situ* facilities can best support *in situ* efforts to conserve biodiversity. Indeed, one of the greatest challenges is defining the most effective application of the various *ex situ* methods to local circumstances. In the United States, for example, different participating institutions of the Center for Plant Conservation (CPC) vary greatly in the severity of the problems they face, the sorts of plants with which they must deal, and also in the patterns of land use, ownership and management. The resources available to different institutions also vary greatly. All of these factors influence how each institute must operate. On a global scale, differences among institutions are much greater. *Ex situ* providers must therefore tailor their efforts accordingly. The sheer quantity of highly threatened species and levels of endangerment facing Hawaiian colleagues are very different than those faced by their counterparts in the northeast corner of the United States. The New England Wildflower Society's Garden in the Woods conservation programme operates in a part of the country in which the land is overwhelmingly in private ownership. This is in stark contrast with the situation faced by the Berry Botanic Garden, where over half the land in the State of Oregon is publicly owned or managed, mostly by agencies of the US Federal Government. Rather than attempt to describe a universally applicable set of guidelines about how *ex situ* facilities can best support *in situ* efforts, a description of The Berry Botanic Garden and its plant conservation programme is offered as an example of how effort and resources can be matched to support *in situ*.

The Berry Botanic Garden is a private, non-profit organisation located in the city of Portland, Oregon, USA. Conservation of rare and endangered plants of the Pacific Northwest region of the USA is one of its core institutional missions. Toward that end, in 1983 the *Seed Bank for Rare and Endangered Plants of the Pacific Northwest* was established. In 1984, the Garden became a charter

participating institution of the Center for Plant Conservation. Its effectiveness has been greatly enhanced by participation in this larger community of like-minded organisations. Work in partnership with local, regional and national land management and regulatory agencies, as well as private landowners interested in conserving rare and endangered plants, is actively sought. To increase the value of its seed bank work, associated scientific research is conducted on seed germination and storability, propagation, and complementary fieldwork, such as monitoring studies and reintroduction of native plants to the wild.

For an *ex situ* resource to provide high quality support to *in situ* efforts, several basic tasks must be performed. The process begins with the collection of genetically representative samples, which are large enough to meet “housekeeping” and users needs throughout long-term storage and the rigours of reintroduction. The samples must then be maintained in good condition for very long periods of time. As with any bank, it is necessary to know how best to recover the treasures within so they become of use. Consequently, we must also learn to germinate and propagate the taxa. Finally, it is necessary to know how to use the samples to create a new population or enhance an existing one, if the need should arise.

2. Collecting and Maintaining Samples

To meet the goal of providing the best possible regional *ex situ* conservation resource, the collection of genetically representative samples from the most threatened populations and taxa is paramount. Obtaining and properly maintaining genetically representative samples for *ex situ* storage are not so much events, as ongoing processes

In an attempt to provide the best possible *ex situ* conservation resource for the region, Berry Botanic Gardens has actively sought to work in partnership with the major land management agencies. These are most notably the US Department of Interior Bureau of Land Management (BLM), the US Department of Agriculture Forest Service (USFS), and the US Department of Interior Fish and Wildlife Service (USFWS), which administers the Endangered Species Act. Today, much, if not most of the collection work is performed either in cooperation with, or by, federal botanists. Much of this work is in the form of Challenge Cost Share projects in which Berry and a federal agency share the cost of collection, and at least initial storage. Other seed collection partners include the US Fish and Wildlife Service, which administers the Endangered Species Act, the U.S. military, state and local government offices and agencies, private organisations such as The Nature Conservancy, businesses, and private individuals. In other words, Berry Botanic Gardens seeks to work with those with whom a common cause is shared.

The extensive on-going partnerships with these agencies are mutually beneficial and multifaceted. The Seed Bank's first curator, Ms. Julie Kierstead Nelson, established the pattern of working closely with both agency botanists in the field, as well as higher level personnel. The Seed Bank benefits from the partnership by having the services of many more seed collectors than could otherwise be put out in the field. It also benefits from their local knowledge of the rare plant populations and, perhaps as important, any new or serious threats to those populations. In turn, the land management agencies benefit by having an 'insurance policy' with respect to sampled populations and species. The agencies have legal responsibilities to maintain viable populations of many rare plants, but no matter how enlightened or diligent management actions are, bad things can happen. Collaboration with Berry to store seed of their most vulnerable plant charges results in the populations becoming more protected from extirpation. If a population should decline in size, or be destroyed catastrophically, stored seed can be used to reintroduce it.

For the sake of brevity, discussion will be focused here on work with the BLM. Equally the USFS could have been used, for many similar projects exist with them. Extensive contacts are maintained with the on-the-ground botanists at the local levels throughout Oregon, Washington and Idaho, and parts of California. The latter three are neighbouring States. In some cases, Berry enters into Challenge Cost Share agreements with individual BLM Districts, to collect and store seeds of mutually agreed upon plants. The Challenge Cost Share program is set up to help the public share the costs of projects in which both public and private partners have a common interest. These projects are often just one component of larger management plans to conserve particular taxa. In addition to district-level work, cooperative agreements exist with the BLM State Office to provide information about the taxa and populations represented in Berry's Seed Bank and supporting scientific information generated, such as seed germination protocols. These agreements allow organisations to pool respective resources and areas of expertise to more effectively protect and learn about imperiled taxa.

In 2001, the seed bank was storing over 9,200 accessions of a total of 309 taxa (Figure 48.1) from the region. The graphical representation of how the seed bank holdings have grown illustrates how an attempt has been made to assemble a genetically representative collection of the region's most threatened species. Strategically assembling a collection such as this is a complex and never-ending exercise in weighing the needs of particular taxa with what exists in the collection, and using the resources in the most efficient manner possible to increase the value of the collection. Notice in Figure 48.1, how the rate at which new species have been added to the collection increased rapidly at first, but has slowed over time. Conversely, the rate at which new accessions of these taxa have been added to the collection has steadily increased over time.

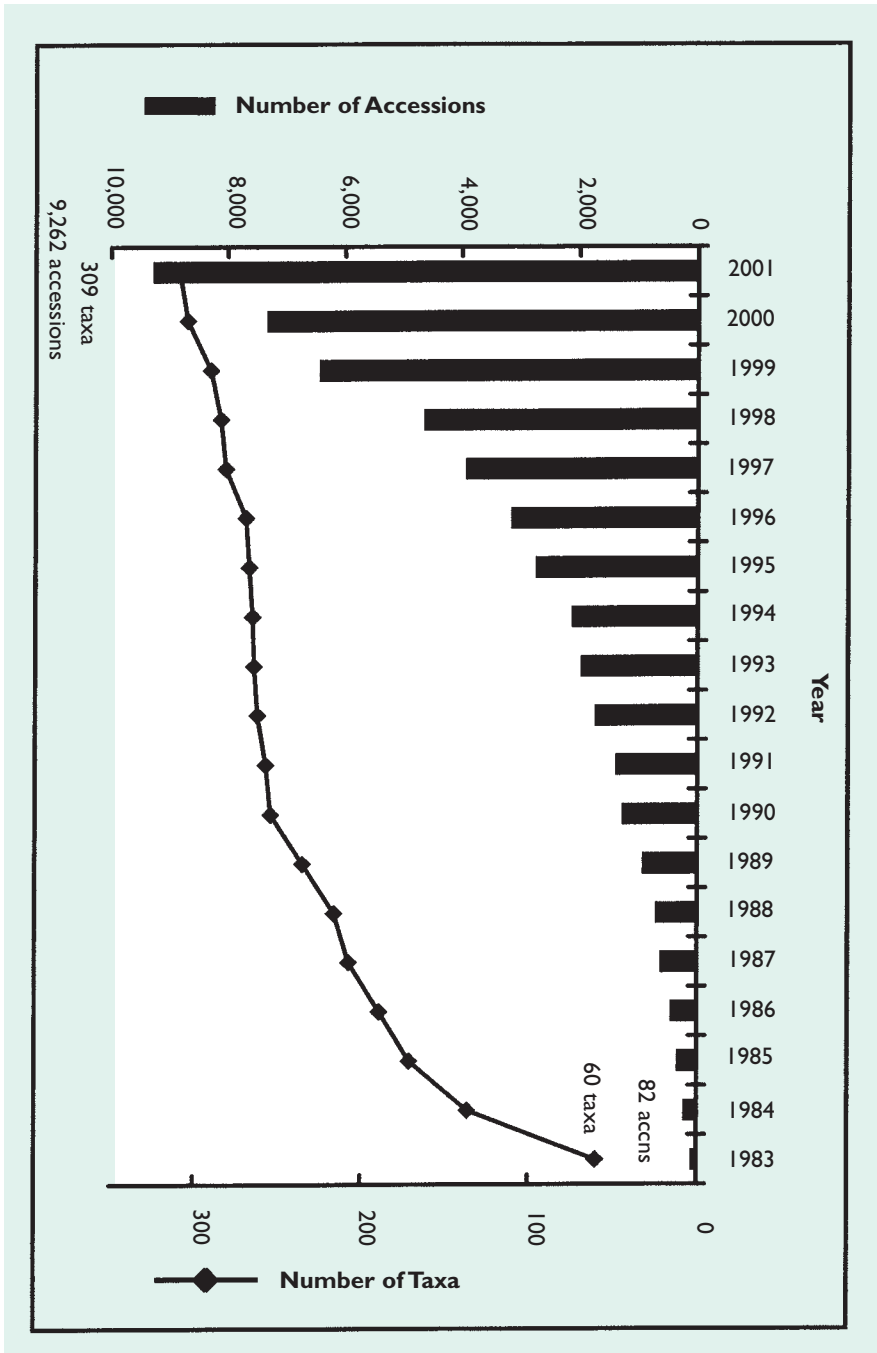


Figure 48.1 Growth in the number of taxa (line) and accessions (histogram) in Berry's seed bank as a function of time, since it was established in 1983. See text for discussion.

This growth pattern is not random, but reflects ongoing evaluations of the holdings against the conservation purpose. The collections are evaluated at two levels. One is how well a sample represents the population from which it was taken, and the other is how well the populations in our collection represent the geographic and ecological distribution of the species. The collection protocols used are based on the Center for Plant Conservation's Genetic Sampling Guidelines for Conservation Collections of Endangered Plants (CPC, 1991). Adaptations are made to the Guidelines on a case-by-case basis. The CPC guidelines are organised around a hierarchical series of four questions that must be considered before a final judgement is made. They are:

- Which species to collect?
- How many (and which) populations should be sampled?
- How many individuals should be sampled in each population? and
- How many propagules should be collected from each individual?

The answers to these questions will determine the focus and desired intensity of seed collection. If the final judgement identifies a suitable collection programme that places on the population too high a burden for one year, collection must be spread over two or more years.

Species are prioritised for collection based on a number of criteria, beginning with their global rarity and threat. In order to better serve *in situ* conservation partners, priority is also given to species and populations based on more regional and local concerns. Even though one particular species might not be as globally rare or threatened as another, a BLM district or National Forest might hold significant populations that are at the periphery of a species' range, or there might be particular threats known to the agency botanists that would warrant extra protection through seed collection. We believe that decisions on the prioritisation of species and populations to be sampled are best made by combining input from organisations with broad views with that from organisations with greater local knowledge.

Over time, the larger issue of how well the populations we have sampled represent the species distribution has begun to be addressed. Berry is fortunate in its part of the world to have a series of state Natural Heritage Programs, originally established by The Nature Conservancy, which maintain extensive databases of the size and status of all known populations of rare taxa. For each taxon in the collection, data can be combined on the distribution of wild populations with data on seed collection sites (Figures 48.2 and 48.3). In this way, how well the sampled populations represent each taxon's geographic distribution can be evaluated. For some taxa, coverage is reasonably comprehensive (Figure 48.2), whereas for others, holdings are far from thorough (Figure 48.3).

Seeds from each maternal plant are maintained separately at the Berry Botanic Garden Seed Bank, because its work is with rare and endangered species, often

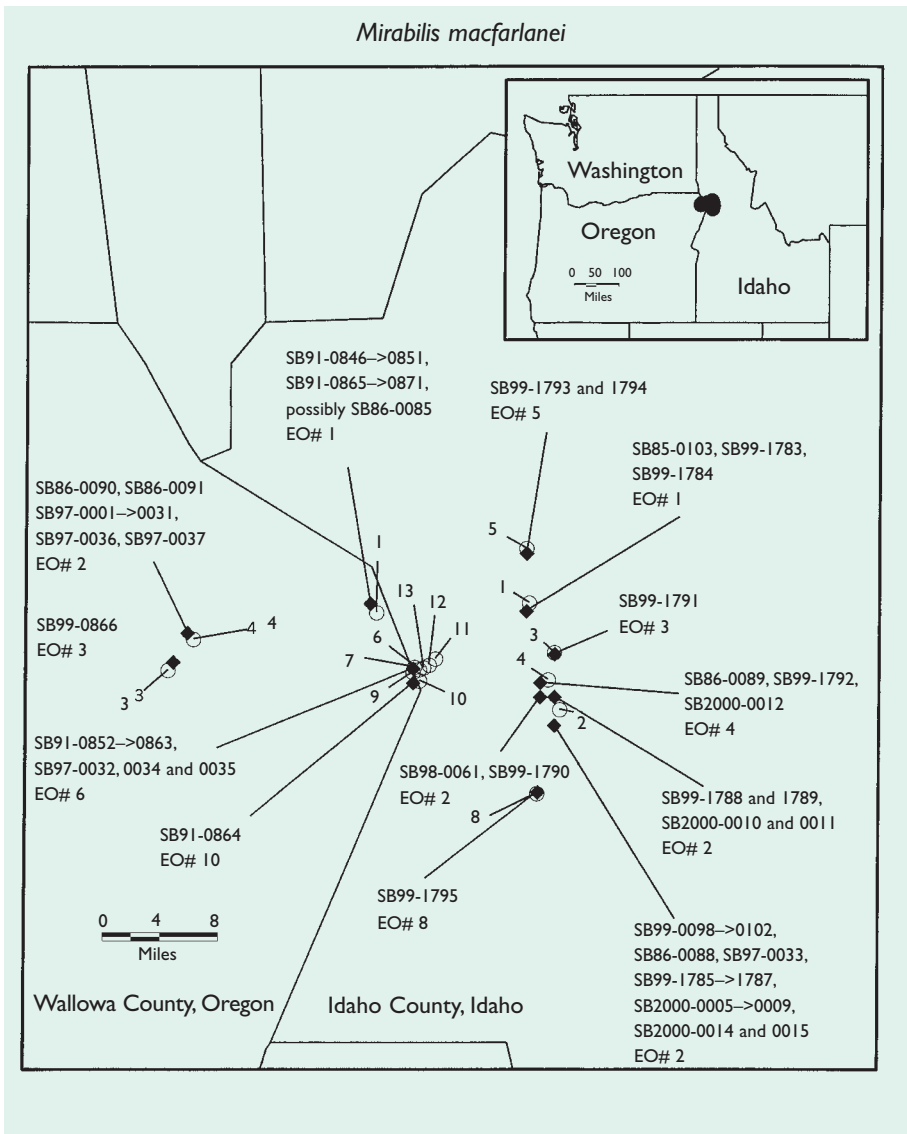


Figure 48.2 Geographic distribution of all populations of *Mirabilis macfarlanei* (open circles) known to the Oregon Heritage Program and the Idaho Conservation Data Center, and of all seed accessions in Berry's Seed Bank (solid diamonds).

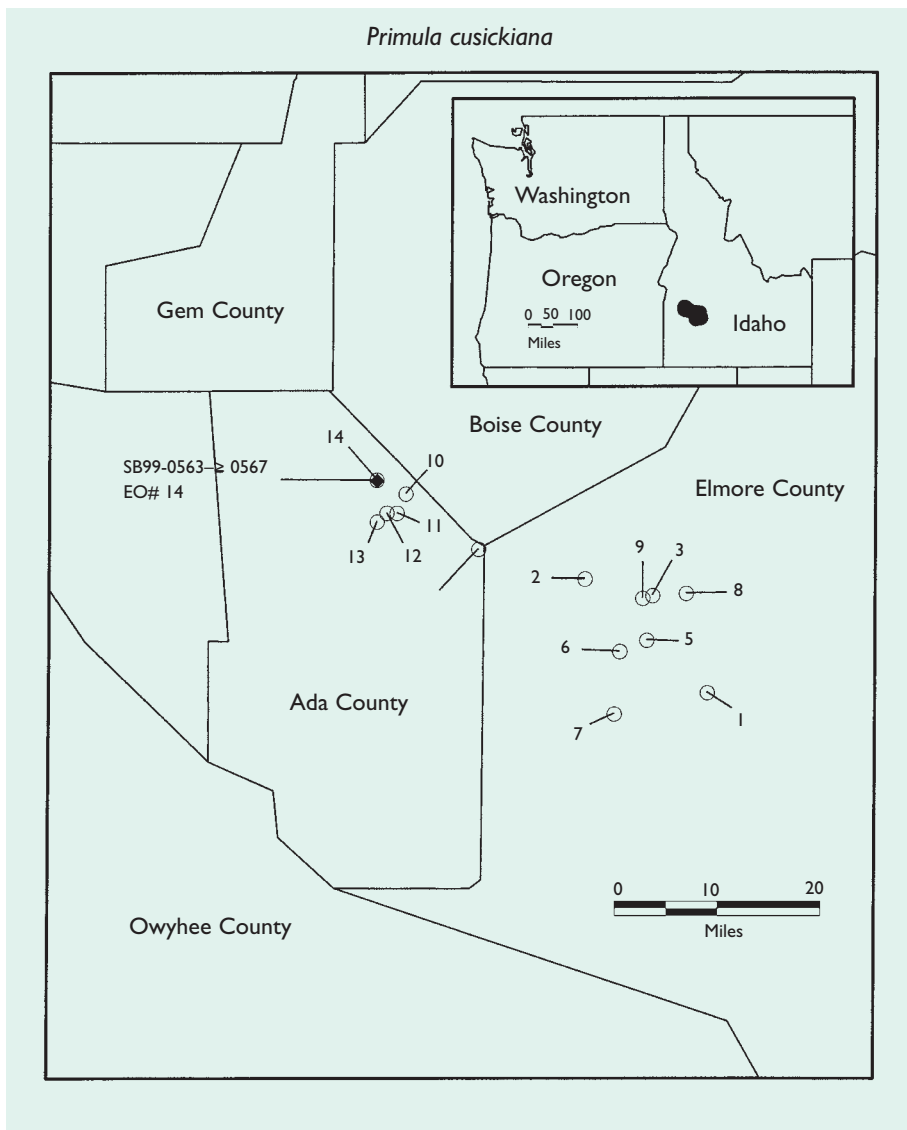


Figure 48.3 Geographic distribution of all populations of *Primula cusickiana* (open circles) known to the Idaho Conservation Data Center, and of all seed accessions in Berry's Seed Bank (solid diamonds).

those having only very small populations. This is a bit more labour intensive than combining the seeds from all the plants into a single bulk collection, but the potential rewards are great if they are needed for reintroduction, as it allows maternal contributions to be both maximised and equalised (Guerrant, 1996a; Guerrant and Pavlik, 1997). Collection of seeds from 50 individuals per population is generally attempted to ensure that representative genetic diversity is obtained. The number of individuals to be sampled is adjusted based on the number of individuals present in a given population, the percentage of mature reproductive individuals, threats to the population and other factors. No more than 10% of annual production is gathered in order not to overly impact on the survival prospects of the sampled population. The Center for Plant Conservation (1991) recommends 1–20 propagules be collected from each maternal plant sampled. It is difficult to generalise because the number of seeds produced per plant per season varies so greatly, from a very few to many thousands. Because of the geographic area of operations, and the focus on rare and endangered plants, much of the work is with small herbaceous perennials that produce relatively few seeds in a season, compared with, for example, larger woody perennial shrubs and trees. The CPC (1991) genetic sampling guidelines feature a summary table in which a wide variety of key considerations and factors are described, which aid in deciding whether sample sizes should be adjusted up or down.

Once collected, the next step in the process is to prepare the seeds (dry, hand clean, hand count, weigh and package) and place them in long-term frozen storage. A great majority of the taxa in north-west USA appear to have seeds with orthodox seed storage behaviour, and which are amenable to long-term storage through drying and freezing. Although Berry operates at a vastly smaller scale, the seed storage facilities are structurally similar to the Royal Botanic Gardens, Kew's Millennium Seed Bank (see Linington, 2003 – Chapter 33). As soon as possible after collection, each and every seed lot is assigned an accession number, and is dried in our Seed Vault to prepare the seeds for their eventual long-term frozen storage. The Seed Vault consists of a heavily insulated room (8 feet by 10 feet, approx. 2.4 m by 3 m), which is encased in a steel reinforced 8-inch (approx. 0.2 m) thick concrete 'bunker', the entrance of which is protected by a steel, 3-hour fire door. The interior space is maintained at a constant temperature of 15°C and a relative humidity of c. 22% (Vertucci and Roos, 1990).

Once seeds are properly dried, cleaned and counted, they are placed in heat-sealed, metal foil packages, and stored in a modified residential-type chest freezer, which is maintained at -18°C. This freezer, which is the Seed Bank proper, remains secure through its location inside the Seed Vault described above. For additional protection, the freezer's compressor has been moved to outside of the fire-proof concrete shell.

3. Germination and Propagation Protocols

For the assets of any bank to be useful to depositors, there must be a way to withdraw them when needed. In order that the samples serve their ultimate conservation purpose of supplying propagules for reintroduction back into the wild, it is necessary to know how to germinate and propagate them. Such knowledge is also required to be able to monitor the viability of a sample over time. Even though samples can potentially remain viable and in good condition for decades or even centuries, seeds do die, and so they must be monitored over time.

Before successive germination tests can be used to monitor the changes in viability, a reliable germination protocol for each taxon must be developed. Currently Berry is engaged in a preliminary survey of the more than 300 taxa represented in the collection. Later it will focus on the more troublesome species. In the absence of any knowledge of a particular taxon, a small number of seeds (usually five seeds for each treatment) is typically subject to the following four standard germination conditions:

- direct placement into a 20°C chamber with an 8 h light and 16 h dark cycle,
- direct placement into a chamber with alternating temperatures: 20°C during the light portion of the cycle (8 h) and 10°C during the dark portion (16 h),
- eight weeks of cold stratification followed by placement into the 20°C chamber (with the same light/dark cycle),
- eight weeks of cold stratification followed by placement into the chamber with alternating 10/20°C temperatures.

Small sample sizes are used to avoid depleting the number of seeds in storage. After moistening, seeds are examined and germination data is recorded on a weekly basis for a minimum period of four months. Germination is defined as emergence of the radicle (root tip).

Figure 48.4 shows the results of recent germination surveys. The x-axis indicates the maximum germination observed in any of the four treatments for a given taxon. It was anticipated that there would be difficulties germinating many species, as rare plants have a reputation for being “fussy.” To our surprise, 50% germination or higher was obtained for the majority of the 180 taxa tested (165 trials out of 226 total, or 73%). One hundred percent germination was obtained in at least one of the four treatments in 96 trials (nearly half of the trials). Low germination rates (defined here as fewer than 20% of seed germinating in the best of the four treatments) were observed in only 38 trials out of 226 total (17% of the trials). Of these, it was impossible to germinate any seeds in 25 trials (11% of the 226 trials). In the future, it is hoped that time will be devoted to examining seeds of the more challenging taxa in greater detail.

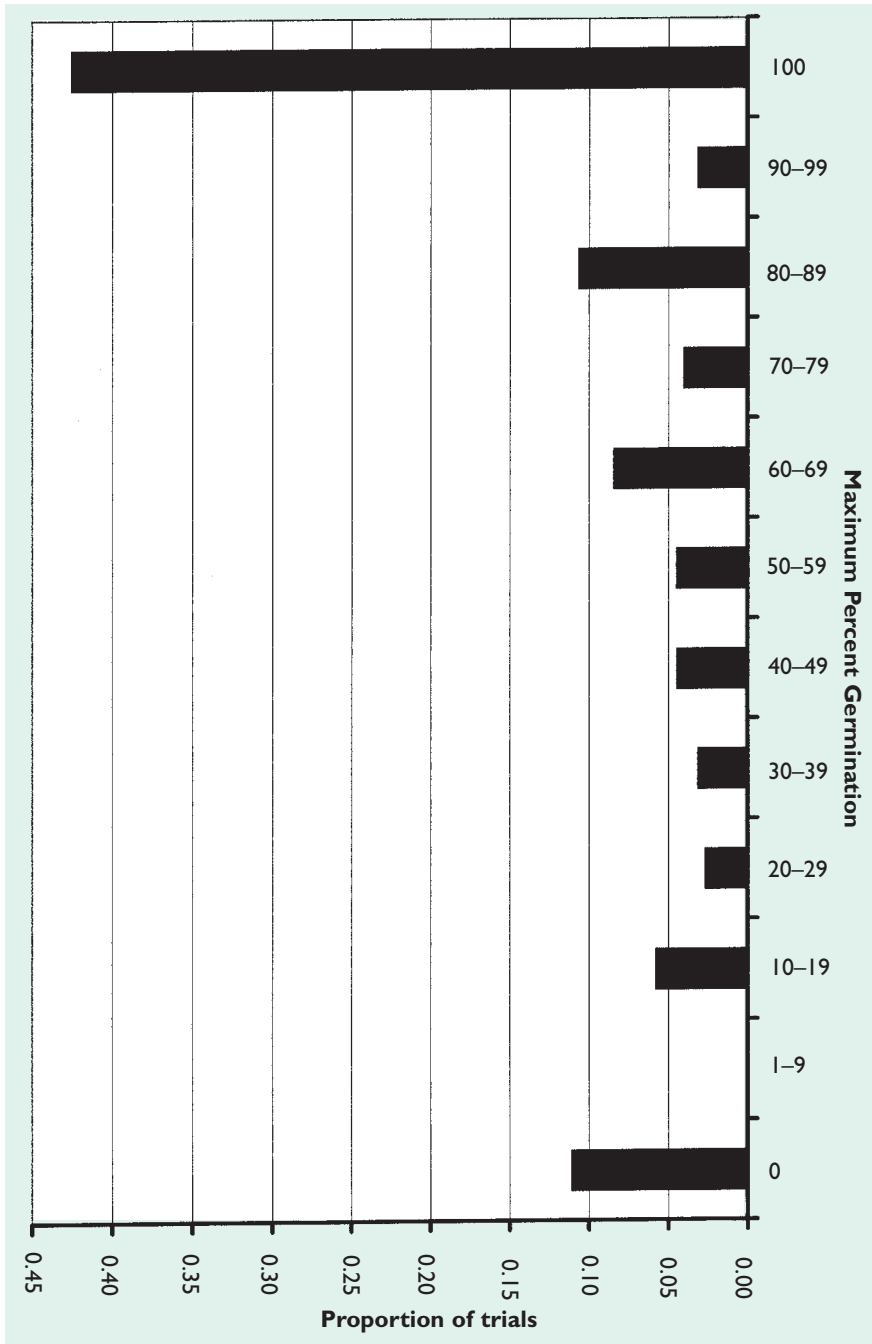


Figure 48.4 Histogram of maximum germination percentage in any of four standard germination treatments, based on a total of 226 trials (i.e., a battery of the four treatments) of c. 180 taxa.

Seedlings that emerge from the trials are handed on to the garden's horticultural staff in order to learn how to propagate them, as well as to display them. To support these displays and as part of Berry's mission to increase public awareness of rare plant issues, a variety of interpretive materials are provided. These summarise rare plant biology, perceived threats to species and ongoing research for those who visit the Garden or its website.

4. Formal Recovery Plans and Reintroductions

The final task that brings *ex situ* conservation efforts to bear in support of *in situ* efforts is using the stored seeds as founders in the reintroduction of plants to their native habitats (Falk *et al.*, 1996). To prepare for this possibility, the USFWS has specified with increasing frequency that seeds be stored in the garden's seed bank as part of the formal recovery planning process that follows a species' listing as Threatened or Endangered. Examples include *Lilium occidentale* (USFWS, 1998a), *Sidalcea nelsoniana* (USFWS, 1998b) and *Castilleja levisecta* (USFWS, 2000).

At least for federally listed species, the decision to initiate a rare plant reintroduction in our part of the world, especially on federal land, lies with the land management and regulatory agencies. Reintroductions of federally listed threatened and endangered species are conducted in consultation with the US Fish and Wildlife Service. To assist with this type of work, *ex situ* providers are well positioned to supply not only the propagules necessary to establish a new population, but also horticultural and other expertise to increase the probability of success of reintroduction attempts. This is a natural extension of seed bank work, and Berry works closely with those agencies in need of propagules for reintroduction.

The Berry Botanic Garden has been directly involved in experimental reintroductions of three taxa and indirectly in another three. The first reintroduction attempt with which Berry was involved was to supply 1,000 seedlings to the BLM and USFWS in their pioneering reintroduction of the endangered annual *Stephanomeria malheurensis* (*Asteraceae*) (Parenti and Guerrant, 1990; Guerrant 1996b; Guerrant and Pavlik, 1997). Berry staff subsequently became more involved, designing and executing an experimental reintroduction of the endangered western lily, *Lilium occidentale* (*Liliaceae*). This project, which was sanctioned in the USFWS Recovery Plan for western lily (USFWS, 1998a), has been funded each year since 1994 by a series of Challenge Cost Share agreements between Berry and the Coos Bay District of the BLM. The third and most recent reintroduction, of *Arabis koehleri* var. *koehleri* (*Brassicaceae*), is technically an augmentation because we used propagules taken from the site of one wild population. Both seeds and young plants have been placed at the site and are currently being monitored for their survival.

In all three cases, either the USFWS initiated the project as part of a formal recovery plan for the species or the need for reintroduction was proposed by the local BLM botanist most knowledgeable about the taxon, its status and current threats. In all three cases, Berry was able to supply the propagules for the reintroduction. For work with *Stephanomeria*, Berry was able to obtain seed from L. D. Gottlieb, who had described the species originally, and provide the seedlings called for by the USFWS and BLM, who designed and executed the project. Ultimately, Berry was called on to analyse more than 10 years of data on the reintroduction, evaluate the original experimental design and the success of this long-term reintroduction effort, and provide recommendations for future research (Raven, 2001). In part because Berry had appropriate seed available and an interest, as well as experience in conducting reintroductions, the BLM approached Berry for the two other reintroduction projects.

In the other three cases, Berry supplied seed to the State of Oregon Department of Agriculture for preliminary laboratory and greenhouse trials in preparation for their own reintroduction attempts. These efforts were for the annual *Plagiobothrys hirtus* ssp. *hirtus* (*Boraginaceae*), and the herbaceous perennials *Astragalus applegatii* (*Fabaceae*) and *Abronia umbellata* ssp. *breviflora* (*Nyctaginaceae*). The bank's holdings made it possible for the State to get an earlier start than they would have otherwise and, in return, they replenished the bank's holdings for each taxon by collecting additional seeds during their field reintroduction attempts.

5. Funding

Funding the ongoing operation of the Seed Bank and associated research is a continuing challenge. Again, partnerships with a variety of organisations and individuals have proven to be invaluable. For instance, the Center for Plant Conservation recognised the long-term commitment represented by *ex situ* collections, and so established a species endowment programme to help defray the costs of maintaining samples. An individual or organisation can donate a sum (up to \$10,000 per taxon) that goes into an interest-bearing account, the proceeds of which are used to support that taxon at a specific institution. Additional funding sources include income generated from The Berry Botanic Garden's endowment, garden member donations and government grants.

Many of the cooperative projects with the BLM and other organisations mentioned above explicitly include funds to support long-term storage, and these help to support on-going Seed Bank operating costs, as well as focused research, including experimental plant reintroductions. Berry has annual contracts with both the State Office of the BLM and Regional Office of the USFS. For each of those contracts, Berry provides detailed annual reports to the agencies of our holdings of taxa of interest to them on their lands as well as any associated information that has been gained from studying them, including germination research and field studies.

What began as individual relationships with the on-the-ground level personnel has come full circle. Now the sum of these many individual contributions are reviewed annually from a regional perspective. In this way, the conservation value of Berry's seed bank holdings continues to increase, because gaps in the protection of a given species through seed storage can be remedied quickly. With the information gained from this research, the agencies are better able to make sound, large-scale plans for conserving imperiled species on their lands and the conservation community, as a whole, benefits.

Conclusions

For *ex situ* service providers to best support *in situ* conservation efforts, we need to accomplish several basic tasks. First, and foremost is to provide high quality products (e.g., banked seed) and services (e.g., horticultural and reintroduction expertise). Next, because the situations facing each *ex situ* provider are unique in terms of the number and seed storage behaviour of local taxa, as well as what resources they can bring to bear, each facility must tailor its efforts to the local/regional context of *in situ* land management and legal regulatory circumstances. Finally, to best support *in situ*, *ex situ* facilities must take the initiative to educate the proper land management and regulatory authorities about the value and availability of the *ex situ* capability they provide. The effectiveness of our work is greatly enhanced through partnerships with a variety of individuals and organisations.

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