Promoting Gene Conservation through Seed and Plant Procurement[1]

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Abstract: Genetic conservation is the protection and preservation of the genetic raw materials of adaptation and evolution. The need to account for genetic conservation, coupled with the significant increase in demand for a plethora of native species, presents new challenges to the nursery industry. General seed and plant procurement guidelines are provided for conservation of genetic resources on public and private lands. The genetic implications of seed and plant procurement are discussed, and current and needed information is identified. Guidelines for the propagation of species of known genetic architecture, species of unknown genetic architecture, narrowly endemic species, and rare and endangered species are presented. The guidelines are intended to assist land managers in making informed decisions about genetic conservation.

Retrieval Terms: **genetics, conservation, land management**

Introduction to Genetic Conservation Guidelines

Biodiversity exists at many levels, including the gene, individual, population, ecotype or geographic variant level, and also the species, community or ecosystem level. Accounting for biodiversity in plantings presents a unique challenge; however, ignoring the conservation of biodiversity can have disastrous ecological consequences. A critical focus in the conservation of biodiversity involves the genetic diversity of species being managed. While diligently planting species, irreplaceable genetic resources are capable of being destroyed. Species and ecosystems, relying on the evolutionary process for long-term survival, depend on appropriate genetic diversity. Plants, unlike *Homosapiens,* cannot move from or modify their environments and must contend with all physical and biological factors. For some species this means for decades, even centuries. Plants accomplish this by accumulating genetic variations that are appropriate to the environments in which their ancestors evolved. Therefore, an enormous diversity of adapted genesis necessary to counter successfully the inevitable environmental hardships over the lifetime of the plant.

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Decades of research, primarily in commercial forest species, has provided several insights into the importance of genetic variation and local adaptation. Research has demonstrated that the use of genotypes that are not locally adapted can result in immediate mortality, delayed mortality, and poor growth and reproduction performance. Genetic contamination propagates outward from non-local genotypes, moving undetected and irreversibly into wild populations. If stock originates from a few closely-related parents, inbreeding may result, at a cost to growth performance and the genetic integrity of the gene pool.

Forestry research has also taught us that species are genetically structured. In most cases, their genetic structure is hierarchical. The total genetic variation is organized as: variation among physiographic regions within the species, variation among populations within region, variation among stands within populations, variation among famflies within stands, and variation among siblings within families. The arrangement of genetic variation differs with each species and knowledge of its structure is useful in defining plant procurement requirements that account for genetic conservation.

Historically, plantings and management of natural ecosystems favored particular species or species-groups to the exclusion of others. The nursery industry was able to keep up with the demand for these plants, and account for the genetic architecture of the many forest species. Recently however, plantings in natural areas include a broader range of native species to meet ecological restoration goals, creating unique and difficult demands on the nursery industry. A native plant nursery might need to inventory as many as 300-400 native species, for which little or no propagation information is available, to meet restoration demands in their bioregion. The large number of restoration projects requiring site collections requires redoubling ofeffort for commonly used species. Ecological restoration is the process of intentionally altering a site to establish a defined, indigenous, historic ecosystem. The goal of restoration is to emulate the structure, function, diversity and dynamics of the specified ecosystem. Restoration should assist nature in restoring natural processes including natural regeneration, succession and co-evolution. Ecological restoration in the state of California alone potentially deals withover 7,000 species. Because insufficient knowledge is available about the genetic architecture and horticultural requirements of these non-commercial species, genetic conservation programs for each species are virtually impossible to provide. In response to the need for genetic guidelines, the author has prepared seed and plant collection guidelines that integrate genetic conservation principles.

Due to an increased awareness, managers are beginning to emphasize an ecosystem orientation to land management. Thus, plants and animals are considered in the context of dynamic interactions with their physical and biotic environments, and as continually evolving systems. Ideally, these natural processes would proceed unimpeded, but because lands have been modified and natural processes interrupted, managers often choose to actively intervene and restore, where possible, ecological integrity altered by human activity. The genetic conservation guidelines presented here assume that resource management goals focus on not merely random collections of plants and animals, but interconnected associations of communities and processes. Managers should recognize that genetic resources are affected through changes in ecological conditions, such as plant diversity and reproduction regimes. Fundamental to the dynamic communities and processes are the genetic components of the ecosystem.

The genetic conservation guidelines provided here are intended to assist land managers and growers in procuring plant materials. The genetic conservation implications, and current and needed information, are discussed. Guidelines are then presented for species of unknown genetic architecture, species of known genetic architecture, narrowly endemic species, and rare and endangered species. Narrowly endemic species are defined as plants with very limited geographic range or of highly specific habitat characteristics. The procurement guidelines provided forspecies of unknown genetic architecture are most appropriate to out crossing species. Because of their limited genetic base and vulnerability to extirpation, rare and endangered species are recognized as a special case, even if the genetic architecture is known or the species is a narrow endemic. Therefore, implications, needed information, and guidelines, are presented separately for rare and endangered species.

a. Genetic Conservation Implications

Revegetation projects relyon techniques that encourage natural regeneration or use more intensive methods such asplanting, seeding, transplanting, and salvaging. The speciesselected in a planting program, and the source of seed and plants, have tremendous genetic implications. The genotype of plants or seeds in the planting program should be assessed. Non-local planting stock, especially of native species, can introduce novel, undesirable normal adapted genotypes into the ecosystem. Use of non-local stock may result in mortality in the short-term, delayed death, or problems with growth and reproduction. If planting stock originates from a few related parents, inbreeding in subsequent generations may result in inbreeding depression and population decline. Thus, both the source location of the planting stock and the number of parents that contribute to the planting stock influence genetic structure.

b. Current and Needed Information

1. What species are native to, and compatible with, the ecological and genetic requirements of the revegetation site? What populations are native to the local gene pools of the revegetation site? How have Euro american influences changed species composition, distribution, and regeneration patterns?

2. Evaluate or infer the genetic architecture of those species that maybe considered for inclusion in the revegetation program. Of the populations of native species present, are these populations genetically distinct and vulnerable to genetic contamination? Are there populations of genetic significance that need a recovery program? Are there populations that have reduced genetic vigor due to human activities? To increase the genetic vigor of these populations, is revegetation with stock from outside of the project area warranted?

3. What native species or genetic populations have been extirpated or substantially diminished from the project area by Euroamerican influences? What was the reason for the species/population disappearance, and would this reason make the reintroduction of this species unsuccessful? Do subspecies exist in or near the project area that approximate the depleted species; are the two populations genetically similar?

4. Are genetically unique populations, or plant species that provide critical resources for rare and endangered wildlife, either a component of the revegetation projector likely to be affected by it?

5. For those species being considered for revegetation, several elements should be considered. What is the preferred method of revegetation, (L e., seed, cuttings, poles, whips, container plants, bare root stock, transplants, or site manipulations that encourage natural regeneration), and what are the genetic consequences for each species? How are the species currently regenerating? How amenable are these species to custom collections or site manipulations? Are the species early or late successional? Are the species long- or short-lived?

6.Once the taxa for revegetation are determined, the source of plant materials must be identified. If custom collections are prescribed, the range from which to collect plant propagules should be defined. Can the collections and revegetation sites be matched for soils, elevation, aspect, slope, rainfall, annual temperature patterns, frost dates and associated vegetation? Are there comparable sites slated for destruction, from which stock can be salvaged? What is the genetic condition of donor plants and their populations? Are donor plants growing in isolation or near genetic exotics?

7.Donor stands should be evaluated for their ability to provide sufficient numbers within the criteria set forth in the guidelines.

8.Are seed or hedge orchards necessary and feasible to provide sufficient propagules for revegetation? Who will provide the horticultural expertise in establishment and manage ment of the orchard?

9. What steps are necessary to ensure plant and seed materials are available on schedule?

I O. W hat state-of-the-art revegetation techniques are applicable to the proposed revegetation in the project area? Is there a need to test available techniques or experiment with others? Is there sufficient time to include a pilot project in the phasing of the revegetation program?

11 .Can a pilot project be structured to accommodate the need for expansion of plant propagules by establishment of seed or hedge orchards?

Genetic Guidelines for Species of Unknown Genetic Architecture

a. General

1.Revegetation in natural zones should be accomplished using seeds, cuttings, or transplants of species and gene pools that are native to the revegetation site. This does not mean that collections should be restricted to project boundaries. Manmade boundaries, such as project or county lines, are not ecological boundaries.

2.If a species was extirpated or substantially diminished as a direct or indirect result of human activities, the manager should strive to restore the native species, where possible, if adequate habitat to support the species exists or can be reasonably recreated, and if other sensitive or high priority taxa will not disturbed. The genetic source used in the revegetation should most nearly approximate the extirpated subspecies, race or ecotype.

3.Native plants should be introduced from populations as closely related genetically and ecologically as possible to the project area populations, except in the rare cases where the management goal is to increase the variability of the local gene pool to mitigate for past human-induced loss of genetic variability. Such introductions should only be done with guidance from a population geneticist. Managers are cautioned against introducing new genetic strains or land races to natural populations.

4.The need to maintain adequate genetic diversity should guide decisions concerning management of isolated populations or enhancement of populations of sensitive species. All resource management actions involving planting or relocating species, subspecies or varieties, should be guided by knowledge of local adaptations, ranges, and habitat requirements, and detailed knowledge of the ecological history of the site.

5.Every effort should be made to extend the lives of specimen trees dating from the historic period. An individual tree of historic value that poses a safety hazard or is diseased beyond recovery should be removed and replaced, preferably by its own progeny. Where unique trees or shrubs are still healthy, plans should be made to eventually replace them with their own progeny grown from seeds or propagated vegetatively.

b.Plant Palette

1.The plant palette lists those species included in the revegetation program and their propagule type (seeds, cuttings, poles, whips, container plants, bare root stock and transplants). The manager should include genetic criteria in the development of a plant palette.

2.The plant palette does not necessarily include all plant species in the community. Emphasis should be on species amenable to genetically appropriate propagule collections and other genetic conservation considerations. Plantings should represent species and gene pools that are native to the revegetation site and compatible with the ecological and genetic requirements of the site. Expansion of certain species can be accomplished by site manipulations that favor regeneration, while revegetation efforts concentrate on establishing genetically appropriate stock from species critical to habitat values.

3.Anyspecies that have special regeneration requirements should receive special consideration. Some species already established in the project area may be extended by simple management activities such as exotic eradication, clearing, or tillage.

4.The plant palette should reflect not only currently existing native species, but potential vegetation of the plant association represented in the revegetation area.

5.Although emphasis should be placed on using genetically local stock, site circumstances and revegetation goals may justify inclusion of non-local species. Species native to the general region, but not local to the project area maybe assumed to be the closest living relative of a extirpated species, and justifiable for inclusion. If no populations of a species occur in the project area, introductions should be from a region most ecologically similar to the project area. Self-pollinating species, native to the region but not the project area, also cannot contaminate local stands and may be desirable to include in the plant palette.

6.Any planting or seeding included in erosion control repairs should also meet genetic criteria.

7. In ornamental landscaping around historic cultural areas, non-natives maybe used if they are non-invasive. Non-invasive exotics are favored to non-local natives that may contaminate wild populations. All non-local plantings should be evaluated for their potential negative impacts, as pests or contaminants to the genetic composition of neighboring plant communities.

c. Seed and Plant Procurement

1.Revegetation in natural zones should use species and gene pools native to the revegetation site. This does not mean that collections should be restricted to project boundaries. Manmade boundaries, such as project or county lines, are not ecological boundaries. The overriding criteria *are* *genetic diversity* safeguarded by minimum number of widely-spaced donors, and *local adaptations* maintained by matching site characteristics of project and donor sites and collecting propagules in the project vicinity. If sufficient numbers of widely-spaced donor plants are not available on the project site, collections should be made beyond the project boundaries, while matching donor and collection site characteristics.

2.If a commercial operation collects the plants for revegetation, requirements for procedures, labeling and record-keeping should be clearly specified. The sampling and handling procedures, and compliance monitoring should be prescribed. Both the appropriate range of collection sites and the propagule type should be determined for each species in the plant palette. Since significant variation can occur over short distances, guidelines based on geographic distance are not reliable. Collections in the near vicinity of the revegetation site are preferred. When adequate numbers of widely-spaced donors are not available on site, additional collection sites should be identified. Genetically appropriate sites will supply the revegetation program with genetically local stock.

3.If the breeding range of stands is known or can be inferred, it can be useful in designing collections. Collection within the same local watershed as the project site, even for distances up and downstream, are preferred to jumping to adjacent watersheds, where gene flow with the project site is unlikely.

4.Under unusual circumstances, mature specimen trees or shrubs maybe transplanted. For example, mature plants may be transplanted to revegetation sites when an immediate revegetation is needed for a sensitive species. Although such a program is costly, it maybe required as mitigation for habitat impacts. Other situations may call for the removal and mitigation of a specimen tree. Depending upon mitigation requirements, it is feasible that transplanting the specimen is less expensive than guaranteeing the survival of multiple seedlings to maturity. Transplantation to an appropriate site protects genetic integrity and may in some instances cost less than other revegetation scenarios.

5. In addition to seed collected from donor plants, seed banks in the soil are an important source of viable propagules (top soil salvaged from the donor site is spread over the revegetation site). The composition of the seed bank should be confirmed, since seeds of exotic species may remain in soil for decades. Species composition maybe determined by testing germination at several locations. This method can also be used to conserve the genetic resources of an area designated for construction.

6. In addition to ensuring geographic proximity, the revegetation and donor sites should be matched for soil, elevation, aspect, slope, rainfall, annual temperature patterns, frost dates and associated vegetation.

7. Where necessary, collections should be done in a way that protects the vigor of the donor plants and their ability to regenerate. Although many species (such as Populus spp. and Sal ix spp.) readily provide many cuttings (pruning stimulates them to grow), care must still be taken to prevent excessive harvesting of all species. When seed banks are salvaged from topsoil, the donor site should be protected from excessive depletion.

8. Donor plants growing in isolation, or near genetic exotics (such as highway plantings, ornamental landscapes or gardens) should be avoided.

9.To maintain an equal representation of the donor genes, collections should sample equally among the donor plants. An effort should be made to collect from donor plants spaced equally throughout the collection range and at sampling distances appropriate to the genecology of the species. Generally, donors should be in large natural populations and donor individuals sampled with adequate spacing between them. A minimum spacing of 100 meters between donors maybe used as a guide i n the absence of genecology information. If feasible, wider spacing should be employed. Collection should be designed to locate donors throughout the entire collection area.

I O.The number of donor plants sampled depends on the scale of the revegetation project and the species being revegetated. In general, the number of donors should be large (e.g., 50-100), with the range depending on the genecology of each species. If insufficient donor plants are found on site, adjacent sites with genetically similar populations should be used. In the event only a limited number of local donor plants are available, wider-ranging donors maybe accepted after consideration of the consequences. The criteria for matching ecological conditions of the collection site to the revegetation site apply strictly. Different criteria apply for the establishment of seed and hedge orchards.

11 .Seed and hedge orchards provide propagules for revegetating large areas or for longtime periods. The number of donor genotypes in the orchards depends on the scale of the revegetation program. Establishment of seed and hedge or chards requires the expertise of a population geneticist in selecting donor materials and the expertise of a horticulturalist in managing the orchard for propagule production. Correct establishment and use of these seed and hedge orchards is vital, as incorrect establishment and usage can adversely affect genetic integrity.

12.The genetic origin of propagules should be safe-guarded with conscientious labeling, storage and handling. Labels should record the species, date of collection, and donor location.

13. If propagules of known origin cannot be used, the manager should seriously consider removing the species from the plant palette. As a last resort, if plants or seeds of unknown origin are used, the manager should purchase from several suppliers in an attempt to increase genetic variation. In addition, accurate records should document the non-local origin of the plants.

d.Recordkeeping

1.The genetic origins of the propagules should be safeguarded with conscientious labeling, storage, and handling. Labels should record the species, collector, date of collection, and donor location.

2. Information about the genetic make-up of a revegetation project should be documented and archived. The geographic origin of the stock should be documented, and nurseries and suppliers should be encouraged to track the origin of all collections. All plants and seeds purchased should be stock certified by the supplier to originate from the appropriate region to the project area. As no centralized archive for genetic information currently exists, records of genetic origin should be stored by the manager and with an appropriate agency. An example of a standard form for recording information on genetic resources is provided herein.

Genetic Guidelines for Species of Known Genetic Architecture

a. General

1.If the genetic architecture of a species is known the manager will be able to tailor a procurement program to that species, while accounting for genetic conservation. The genetic architecture of many of the conifers is known, such as Douglas fir, Monterey pine, Torrey pine, ponderosa pine and Jeffery' pine. Some managers may base a collection program on inferences made about genetic structure, although the expertise of a population geneticist should be included in such decisions. Inferences made about the distribution of genetic variation should be made in part based on correlation work of Hamrick and Godt (1990) from 449 species. Managers are cautioned that numerous exceptions exist to these correlations.

2.Revegetation in natural zones should use species and gene pools native to the revegetation site. This does not mean that collections should be restricted to project boundaries. Manmade boundaries, such as project or county lines, are not ecological boundaries. The overriding criteria *are: genetic diversity* safeguarded by minimum number of donors, *and local adaptations* maintained by matching site characteristics of project and donor sites, and collecting propagules in the project vicinity. If sufficient numbers of widely-spaced donor plants are not available on the project site, collections should be made beyond the project boundaries, while matching donor and collection site characteristics.

3.The guidelines for species of unknown genetic architecture are appropriate to species of known architecture, except that locations of donor plants can be better defined to match the structure of genetic variation. Collection design depends on the purpose of the revegetation program. Several examples of situations that maybe encountered are provided below.

b. Specific Examples of Collection Design

1.Ifamong-population genetic variation is high and stand variation is low, the manager may collect more freely throughout the population. Collections should be stratified throughout the population to capture the genetic diversity. Collections should remain within the same population(s) as the project. In a small revegetation project, one population maybe collected. In a large revegetation project, several populations may be collected.

2. If among-stand genetic variation is high and population variation is low, the manager must identify and respect the stands, by collecting from only those stands where planting will occur. Collections should be spread throughout the stand(s) to capture the genetic diversity. In a small revegetation project, one stand maybe collected. In a large revegetation project, several stands maybe collected.

3.If sampling an entire population, the manager should identify the stands and strive to sample stands equally. Priority should be given to stands in the central range; stands at the extremes should be collected if feasible.

4. If the breeding range of stands is known or can be inferred, it can be useful in designing collections. Collection within the same local watershed as the project site, even for distances up and downstream, are preferred to jumping to adjacent watersheds, where gene flow with the project site is unlikely.

5.The collection guidelines discussed up to this point are primarily appropriate to revegetation projects, however, nurseries may procure plants to meet the demand for plants in their bioregion. Managers should not sample a single stand thinking it is representative of the entire population. If stand variation is high, the collection will not represent the population and will be missing a significant amount of variation available in the other stands. If population variation is high, the collection could be depauperate in variation because that variation must he captured throughout the population.

6. If sampling an entire species, managers should identify the populations and stands and strive to sample equally. A greater priority is given to populations and stands in the central range than those occurring at extremes. In order to capture the population and stand variation, sampling should be stratified.

7. Where there is less genetic variation, higher sampling numbers are required. Managers should design collections according to population and stand structure. Hamrick and Godt correlations show that higher species diversity is associated with higher among-stand genetic variation, and lower species diversity is associated with higher among-population genetic variation.

c. Record keeping

I. The genetic origins of the propagules should be safeguarded with conscientious labeling, storage, and handling. Labels should record the species, date of collection, and donor location.

2.Information about the genetic make-up of a revegetation project should be documented and archived. The geographic origin of the stock should be documented, and suppliers should be encouraged to track the origin of all collections. All plants and seed purchased should be stock certified by the supplier to originate from the appropriate region to the project area. As no centralized archive for genetic information currently exists, records of genetic origin should be stored by the manager and with an appropriate agency. An example of a standard form for recording information on genetic resources is provided herein.

Genetic Guidelines for Narrowly Endemic Species

a. General

].Narrowly endemic species are frequently found growing in unusual or adverse site conditions. Unusual soils (such as serpentine), and specific topographic or climatic circumstances are known to contribute to narrow endemism in plants. Ecotypic variation in these species is the result of adaptation to specific site conditions. The genetic structure of ecotypes of the same species should be expected to be very different from ecotypes growing indifferent conditions.

2.Narrowly endemic species maybe indicators of similarly unusual and site-specific plant communities. Managers should he aware if endemic plant species of interest are members of such communities, and should design collection and plantings that reflect this level of endemism.

b. Seed and Plant Procurement

1. When procuring narrow endemics for restoration, managers should recognize that physical distance does not equal ecological distance. The overriding criteria should emphasize matching project and donor sites for soil, elevation, aspect, slope, rainfall, annual temperature patterns, frost dates and associated vegetation.

2. Where the causes of endemism are identifiable (or where specific landscape features are highly correlated with endemism of a species), priority should be given to those features in selecting suitable donor sites. This overriding criteria can be integrated into the guidelines for species of unknown genetic architecture.

3.Many species in the vicinity of a narrow endemic species may closely associated with it, forming a particular plant community. The distribution of the community may also be of very limited range or explained by particular environmental features (for instance, soil type). The association of plant species observed in natural settings will probably have the greatest success growing together in planted situations, rather than growing with species not part of the natural plant community.

4.Manycommon species in the vicinity may actually be excluded from growing in close association with the narrow endemic species, such as by a sharp boundary between soil types. These species should not be part of the plant palette if the site to be planted has environmental characteristics that match those of the endemic plant site.

5.Knowledgeable individuals familiar with the distribution and identification of the endemic species and its close relatives should be consulted before collections are made. Man y narrow endemic species have very narrow ranges of distribution, yet appear very similar to closely related species, subspecies or ecotypes growing nearby. Hybridization may not occur in nature. Care must be taken not to mix closely-related species, subspecies or ecotypes, which would result in potentially damaging genetic contamination.

Genetic Guidelines for Rare and Endangered Species

a. Genetic Conservation Implications

The special case of rare and endangered species is considered separately. Because of their narrow distribution, rare and endangered plants are often quite vulnerable to stochastic (random) events. Small populations may suffer from past bottleneck effects and ongoing genetic drift or inbreeding. Species distributed in only a few populations are vulnerable to catastrophic events (fire, insects or disease) that may significantly reduce genetic diversity if one or more whole populations is eliminated. In addition, certain populations of widespread or sensitive species not listed as rare or endangered may merit protection similar to that given to listed species because of their threatened genetic structure. Recovery programs designed to restore genetic diversity must be specific to the species, the population, and the threat they face.

b.Seed and Plant Procurement

Any procurement of rare or endangered species should be conducted under the supervision of the state and federal agencies with jurisdiction over the species, as stated in the federal and state endangered species acts. In propagating rare and endangered species, several factors must be considered. Conservation collections are only as good as the diversity they contain. Only a small portion of seeds or cuttings of the species may be viable. The appropriate horticultural and storage techniques maybe unknown. Geographically isolated populations may, in fact, be fragmentary remains of the original breeding gene pools, and treating each site as a population may enshrine an unnatural distribution of the species, although a large sample size can avert intensification of founder and drift effects. Large collection sizes are preferable to the risk of missing components important to the genetic vigor of the species, since under-representation of genetic diversity can severely cripple the vigor of the species. Species are not static entities and collections are important in so far as they further the maintenance of natural populations exposed to ecological and evolutionary forces.

c. Current and Needed Information

1. What is the location of all rare and endangered species (RES) populations? What is the total geographic range of the RES within the project area? Are the populations within the area near the limits of their range? What is the distribution of the populations: several lone individuals, a few small groups, or one large group?

2. What are the ecological requirements of the RES? These requirements include slope, aspect, soil, elevation, rainfall, annual temperature pattern, frost dates, and associated vegetation.

3. What is the age structure of the populations, and the species as a whole? Are the populations, and the RES as a whole, successfully reproducing? If the RES is not reproducing, is the reason for this inability known? Are methods to encourage reproduction known? For example, is fire necessary to the RES's reproductive cycle?

4. What are the threats to the genetic diversity of the RES? These include impacts that increase inbreeding, decrease gene flow, or increase genetic contamination, as well as threats to population stability, e.g., excessive herbivory, human impacts (trails, structures, fences, leaching from mine tailings), disease, insect infestation, or habitat fragmentation and destruction.

5. Evaluate the genetic architecture of any rare, endangered, or keystone species growing in the project area. Of the populations of native species present, are these populations genetically distinct and vulnerable to genetic contamination? Are there populations of genetic significance that need a recovery program? Are there populations that have reduced genetic vigor due to human activities? To increase the genetic vigor of these populations, is revegetation with stock from outside of the project area warranted?

6.Are there species within the project area which, although not listed by federal or state agencies as rare, threatened or endangered, will be considered for listing if their populations continue to decline'?

d. Genetic Conservation Guidelines

1. When inventories are made of RES, data should include aspects relevant to genetic diversity, such as population size and demography, flowering conditions, hemiparasitic associations, plant community structure, etc. Many RES species cannot be successfully recovered without including hemiparasites. Management and revegetation plans should specifically address means of improving and maintaining genetic diversity.

2.Prior to any potentially deleterious activity, including site-specific development, trail or facilities construction or relocation, or prescribed bums, additional surveys for rare or endangered plants should be made during the appropriate flowering season in the areas that will be affected.

3.The need to maintain appropriate levels and natural structures of genetic diversity should guide decisions concerning the enhancement of a rare, threatened, or endangered species' population. All resource management actions involving planting or relocating species, subspecies, or varieties should he guided by knowledge of local adaptations, ranges and habitat requirements, and site-specific ecological histories. When the management goal is to increase the variability of the gene pool of a rare or endangered species, importation of propagules may be appropriate but should be carried out in consultation with a population geneticist who would evaluate the compatibility of the foreign genotypes.

4.Collections of rare and endangered species should receive the approval of the state and federal agencies with jurisdiction over the species. Collection of rare and endangered plant material may require a state or federal permit, or a Memorandum of Understanding.

5.Collections of rare, threatened and endangered species should be carefully monitored and restricted, to prevent damaging local populations or donor plants. Ensure that propagule collection does not interfere with the donorsite's reproductive abilities. The level of appropriate collection should be determined by a trained ecologist, population biologist, or demographer. Collectors should be carefully trained to protect against damage to donor plants. If the collectors are not trained by the regulating agency, they should be required to provide qualifications.

6.Consult collection guidelines for rare and endangered species, such as those provided by the Center for Plant Conservation. Sample size within each sample population varies with relevant life history characteristics, population history, the degree of endangerment, potential consequences of introducing an artificial founder effect and prospects for the revegetation site to be used as a seed or hedge orchard for future projects. All of these reasons may require a larger collection. If no such considerations apply, the Center for Plant Conservation recommends sampling 10-50 individuals within each population, following a stratified sampling regime.

7.An adequate number of propagules should be collected from each individual to insure that at least one representative of each genotype remains after normal attrition. Inn the absence of other information, the Center for Plant Conservation suggests predicting 10% survival. The reproductive characteristics of the species should also be taken into account: self incompatible species, for example, require a doubling of the sample size to achieve the minimum effective breeding population size.

8. If a population is threatened with extirpation, e.g., due to fire suppression, pending sale and development of the property, or other reasons, that population should be included in the collection sample.

9. Where possible and appropriate, back-up collections of germplasm (ex-situ collections) should be made from a large sample (or all) of the RES. Seed or pollen banks, or plantations of live plants (including contributions to botanical gardens) should be established and documented.

1O. Record keeping should follow agency requirements. A documentation form is provided herein, if needed. (See Figures One and Two.)

DOCUMENTATION OF GENETIC RESOURCES

PROJECT NAME					
LOCATION (GENERAL DESCRIPTION)					
TOWNSHIP		RANGE		SECTION	
LAT.		LONG.		UTM	
SIZE	ac.	USGS QUAD			
DATE OF RESTORATION		HABITAT TYPE(S)			
LANDOWNER/MANAGER (NAME, ADDRESS, PHONE)			RESTORATION DESIGN MANAGER (NAME, ADDRESS, PHONE)		
SITE OWNERSHIP			MONITORING PROGRAM MANAGER (NAME, ADDRESS, PHONE)		
PUBLIC					
PRIVATE					
NON-PROFIT					
LAND USE					
LEAD AGENCY					
EVALUATION OF PLANT'S GENETIC INTEGRITY PRIOR TO RESTORATION					
NATIVE TO SITE		EXOTIC TO SITE		NATIVE BUT PLANTED OR SEEDED	
CERTAINTY OF EVALUATION					
PLANT MATERIALS COLLECTED FROM GENETICALLY LOCAL STOCK?	YES		NO		
FINAL PLANTING PLAN ATTACHED?	YES		NO		
GENETIC INTEGRITY OF PLANT MATERIALS SPECIFIED ON PLAN?	YES		NO		
OTHER ATTACHMENTS					

Figure One

GENETIC INTEGRITY OF COLLECTION SOURCE

SPECIES	PROPAGULE SOURCE LOCATION	INTEGRITY (local, non-local, or uncertain)

NOTES (Include information on genetic integrity of ornamental landscaping adjacent to restoration site, approximate spacing of donor plants, number of plants sampled in collection, estimated number of plants sampled in collection)

Figure Two