Conservation of conifer genetic resources
Selection of *in situ* gene conservation units (gene reserves) of conifers

Csaba Mátyás
Sopron, Hungary

General introduction: aims and principles

Genetic resources are elements of genetic variability which are (or might be) used to meet human needs and objectives. In forestry, the term covers naturally occurring populations and individuals, as well artificial plantations and collections, which carry actually or potentially valuable genetic information. Their protection is considered necessary from the point of view of economics, ecology, conservation, and/or even human culture or aesthetics.
Gene conservation forms part of the strategy of conservation of biodiversity, and more generally of nature conservation. The general aim of conserving the genetic resources of forest trees is to safeguard adaptability, and in the long run their evolutionary ability, which requires the conservation of genetic diversity.

A basic concept for conservation is the *minimum viable population* (*MVP*); the total number of individuals necessary for the long-term survival of a population. It has to be large enough to conserve genetic diversity and to safeguard evolutionary ability. To assess the probability of loss of low-frequency alleles is the most appropriate way to estimate MVP size (Table 1).

Table 1. *Estimation of minimum viable population (MVP) size based on probabilities of allele loss (P) (from Krusche and Geburek, in Mátyás 2004)*

P	***q***	**Population size**			
		***M* = 1**	***M* = 10**	***M* = 100**	***M* = 1000**
0.01	0.05	90	135	180	225
	0.01	459	687	916	1 146
	0.005	919	1 378	1 837	2 296
0.005	0.05	104	149	193	238
	0.01	528	757	986	1 243
	0.005	1 058	1 516	1 976	2 435

The table gives estimates for three allele frequencies (*q*) and different numbers of rare alleles (*M*). The calculation is based on the assumption that all genotypes are homozygotes. If the population is in Hardy–Weinberg equilibrium, the numbers should be halved.

Table 1. shows that MVP should include at least 100 or so individuals, if there is only one rare allele. *The numbers refer to effective population sizes, so in reality MVP has to be at least one order of magnitude larger;* i.e. for one allele a minimum of 1000 individuals for outcrossing, widely occurring wind-pollinated species, such as most conifers. *MVP* size may vary widely according to species, depending on diversity and mating conditions, on dispersion, density and on evolutionary status (natural population sizes).

Why specific forest gene conservation strategy is needed

Although nature conservation areas protect valuable genetic resources, they are not sufficient because:

- the areas do not necessarily represent ecological conditions typical and important for silviculture
- there may be legal obstacles to interventions in protected areas (regeneration, seed collection, etc.)

A strategy of forest gene conservation and the selection of conservation units should be based on some knowledge of past and present human influence, mating conditions, and the size of *MVP* and of adaptively homogenous areas (*AHA*s, Mátyás 2004).

Methods of gene resource conservation

Dynamic *in situ* conservation of natural or naturalized populations is the optimal solution. Although natural forest dynamics should be preferred in most cases, unavoidable human intervention to regulate succession or density, and even to artificially regenerate (with authentic material) is acceptable. The species-oriented protection of evolutionary potential is best served by a network of gene reserves, covering the area of distribution of the species.

In *ex situ* conservation, reproductive material is brought to units outside the natural habitat. Gene banks include seed, pollen and tissue banks, as well as field collections (clonal archives, stool beds, etc.). *Ex situ* conservation stands (progeny stands) may be established with evacuated populations where the original site is threatened, or with plantations of valuable selected populations or exotic species. In what follows, only *in situ* gene reserves are considered.

General requirements for gene reserves

Gene reserves represent forest areas specifically selected, registered and managed in order to maintain and promote genetic diversity. The following requirements apply:

- There has to be a legal basis for conserving the genetic resource.
- The area must have identifiable, defined boundaries and must be properly registered and marked in the field.
- The forest owner and/or manager is required to maintain the area and density of the population, or to extend it.
- The introduction of reproductive material of the target species from outside the gene reserve is not acceptable.

Both unmanaged and managed forests qualify for *in situ* conservation, but active gene conservation is mainly implemented in managed forests by adopting specific silvicultural measures to safeguard gene conservation. Genetic conservation is theoretically possible also in national and nature parks, nature reserves and wilderness areas. The prerequisite is the accessibility of the genetic material (e.g. seed harvesting, sampling for genetic analysis) and the fulfilment of all further requirements described below. A nature conservation area is unsuitable for genetic conservation in the strict sense if interventions that are potentially necessary for active conservation (e.g. regulating succession processes) cannot be carried out. Seed stands *per se* do not qualify either, as their perpetuation and proper regeneration with the same material is generally not prescribed.

Ownership

Preference should be given to publicly owned forests, where long-term integrity of populations and access to genetic resources is most easily safeguarded. No potential change of land use should threaten the long-term existence of the population.

Size and stand characteristics

The minimum area for a suitable management unit should be greater than 10 ha (net or reduced area) or 2000 sexually mature individuals in a contiguous unit of larger size. The stand may include various admixed species as long as proper mating conditions for the target species are maintained. The optimum (although seldom reached) size would be 100 ha, with a minimum diameter of 300–400 m.

Selection of locations and number of sites

Selected locations should adequately represent the spatial genetic and ecological variation pattern of the species, but the consideration of adaptive variation pattern should have priority. Knowledge (or an educated guess) of within-species genetic patterns arising from within-species gene flow and genetic adaptation is therefore essential for the decision on *in situ* gene conservation units.

The balance of gene flow and adaptation forms adaptively homogenous areas (AHAs) within the species, which should serve as a basis for conservation planning. Within an AHA, adaptive behaviour and diversity of populations are roughly similar. As a result of gene flow, AHAs are considerably larger than selective environments where fitness value of genotypes is roughly uniform. Lacking detailed genetic information, at least distribution data should be checked in detail.

Usually biogeographical regions, such as forest regions, may be taken as convenient units for selection of at least one, preferably two representative reserves per region (if ecological variability, e.g. by altitude, is low). Spatial and temporal site variability (heterogeneity) promotes genetic diversity and should be therefore considered when selecting conservation areas. Locations extending over variable site conditions (water regime, altitude) are preferable to uniform sites.

Autochthonous populations

The conservation of autochthonous populations (those of local origin) should have priority. Special care must be taken to include populations outside the contiguous range, where selective forces might maintain specific alleles. The same applies to threatened occurrences (if conservation may be solved *in situ*, without expatriation or evacuation).

Nevertheless, the conservation of well-adapted allochthonous populations (landraces) can be also of interest, and should not be excluded. Information indicating the origin of the basic material should be recorded (e.g. historical evidence, genetic data, etc.). The unit may be formed from adjacent stands (subcompartments) of varying age and composition, but of uniform origin.

Isolation from undesired gene flow

Gene flow from stands of unknown or undesirable origin should be minimized through selection and establishment of large conservation areas and/or selection of relatively sheltered locations (e.g. valleys), or through the design of a buffer zone around a smaller central zone. The distance from undesired populations should be kept at 500 m or more.

Registration

For the registration of the gene reservation the following are required:

- The permanent status of the reserve must be safeguarded by an entry in the management plan and the local land register, or by any other suitable means, e.g. a contract.
- The responsible national authorities must keep a register of forest genetic conservation units.
- The units must be described according to a standard format.

Silvicultural requirements

All activities must be in line with conservation requirements. There are, however, no specific prescriptions regarding silvicultural treatment and utilization if they are in accordance with the general aim of the gene reserve; i.e. gene reserves need not be excluded from the production forest area.

General principles of management are described by Koski *et al.* (1997) and are not repeated in detail here. Special care has to be taken for (natural) regeneration, however. Ideally, good seed years over a longer regeneration period should be used for regeneration. Treatment should provide optimum conditions for widest possible mating (creation of regeneration in gaps). If necessary, site preparation, game regulation or protection (e.g. fencing) should be provided in order to guarantee regeneration success.

Artificial regeneration with reproductive material from the gene reserve itself should be applied only as an exception. Sowing is preferable to planting, if possible. Regardless of the method applied, it is important that the number of plantlets constituting the new stand be as high as possible.

References and further reading

Bonfils, P., A. Alexandrov and J. Gracan. 2001. In situ conservation of oaks. Pp. 43-47 *in* Report of the Third EUFORGEN Meeting on Social Broadleaves, 22-24 June 2000, Borovets, Bulgaria (S. Borelli, A. Kremer, T. Geburek, L. Paule, E. Lipman, compilers). International Plant Genetic Resources Institute, Rome, Italy.

Koski, V., T. Skrøppa, L. Paule, H. Wolf and J. Turok. 1997. Technical guidelines for genetic conservation of Norway spruce (*Picea abies* (L.) Karst.). International Plant Genetic Resources Institute, Rome, Italy.

Mátyás, Cs. 2004. Population, conservation and ecological genetics. *In*: Burley, J., J. Evans, J, Youngquist (eds.): *Encyclopedia of Forest Sciences*, Elsevier Major Reference Works, Oxford (in press)