Protected areas in Europe and their importance for conservation

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Introduction

The most effective and efficient way of conserving biodiversity is to prevent the conversion or degradation of habitat to begin with. The measures must be complemented by a wide array of techniques to conserve individual species, populations and genes (MILLER *et al.* 1995). Maintenance of plant and animal genetic material in the wild (*in situ*) and outside their natural habitats, *e.g.* in plantations, seed storages, gene or pollen banks (*ex situ*) is essential of managing the human use of genetic diversity. These two strategies are defined and discussed in the Article 2 of the Convention on Biological Diversity (ANONYMOUS 1992a). *In situ* conservation maintains not only the genetic diversity of a population but also the evolutionary interactions that allow it to adapt continually to shifting environmental conditions, such as changes in pest populations or climate[1]. Of all the various categories for conservation of forest areas, 'Genetic Reserve Forests', 'National Parks', and 'Strict Forest Reserves' provide a high status for *in situ* conservation of forest genetic resources. This paper addresses protected areas in forests and their importance for scientific research with special focus on biodiversity and genetic conservation. Different categories of protection will be discussed in their international context – distinguishing between unmanaged and managed protected areas. Minimum standards that are briefly described for the design of reserves are needed to ensure international comparisons.

[1] World Resources Institute http://www.igc.org/wri/biodiv/in-situ.html

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Protected forest areas

At the Fourth 'World Congress on National Parks and Protected Areas', held in Caracas, Venezuela, in 1992, protected areas were defined as *'areas of land or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means'* (IUCN 1994). Protected areas are important reservoirs for biodiversity and ensure that other benefits, such as soil and watershed protection, research and education, are secured. The long-term importance of protected areas is dependent on how they are chosen and managed.

The aims, definition, size and approaches to management of protected areas are becoming far more flexible. This broadening of scope means that land managers can use protected areas in a broader context than it was previously the case. Some of the uses of protected forests go beyond traditional conservation priorities and can include, for example watershed protection, soil protection and protection of all categories of biodiversity, *i.e.* also including the genetic level. The focus of protected area management is also shifting from individual protected areas towards protected area networks as part of a landscape or bioregional approach to planning.

Changing priorities have contributed to general confusion about the definition and purpose of protected areas. To address this, the World Commission on Protected Areas (WCPA) has drawn up a modified set of six IUCN (International Union of Conservation Networks) 'Protected Area Management Categories'. These were officially adopted by the IUCN in 1994.

To give greater coherence to the role and scope of protected areas within conservation planning and sustainable land use, the IUCN and its WCPA have expanded on this basic definition and developed the following categories of protected area:

- *Category Ia*: Strict nature reserve/wilderness protection area managed mainly for science or wilderness protection; an area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.
- *Category Ib*: Wilderness area; protected area managed mainly for wilderness protection; large area of unmodified or slightly modified land and/or sea, retaining its natural characteristics and influence, without permanent or significant habitation, which is protected and managed to preserve its natural condition.
- *Category II*: National park; protected area managed mainly for ecosystem protection and recreation; natural area of land and/or sea designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

- *Category III*: Natural monument; protected area managed mainly for conservation of specific natural features; area containing specific natural or natural/cultural feature(s) of outstanding or unique value because of their inherent rarity, representativeness or aesthetic qualities or cultural significance.
- *Category IV*: Habitat/species management area; protected area managed mainly for conservation through management intervention; area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats to meet the requirements of specific species;
- *Category V*: Protected landscape/seascape; protected area managed mainly for landscape/seascape conservation or recreation; area of land, with coast or sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.
- *Category VI*: Managed resource protected area; protected area managed mainly for the sustainable use of natural resources; area containing predominantly unmodified natural systems, managed to ensure long-term protection and maintenance of biological diversity, while also providing a sustainable flow of natural products and services to meet community needs.

All six types of protected areas, as categorised by IUCN, provide distinct land management systems with the potential to conserve biodiversity while at the same time meeting other objectives. By this relatively universal approach, the Strict Reserve or Wilderness Area, for example, is employed where objectives focus upon the maintenance of relatively wild habitats and ecosystems, *e.g.* forest types or mountain ranges (MILLER *et al.* 1995).

In general, the maintenance of genetic diversity is possible in all these categories. However, specifically for *in situ* conservation of genetic resources, the categories I, II, IV and VI are most important. Category III (natural monument) includes mostly small landscape elements with aesthetic qualities which are generally too small for genetic conservation. Category V includes intensively used landscape with important cultural values, but which may show changes in the naturalness of the vegetation communities and taxa. Furthermore the main goals of ´Protected Landscapes´ are different to the ones of genetic reserves. In protection of these genetic values, there is a clear distinction between 'protected forests without forest management' and 'protected forests with forest management'. A major advantage of *in situ* genetic conservation is that the genetic reserves are an inherent part of the forest, rather than requiring additional time and expense to establish.

Categories I and II from the IUCN definitions include semi-natural and virgin forests as well as forests in National Parks, which are relatively unmanaged. A common protection status of natural forests in Europe, being the basis for research, is the 'Strict Forest Reserve' (SFR) (SCHUCK *et al.* 1994, PARVIAINEN *et al.* 2000, EC 2000). This category is similar to the IUCN category I 'Strict Nature Reserve' and 'Wilderness Area'.

Protected forests without forest management: Strict Forest Reserves (SFRs)

The importance of nature conservation in forests has increased because of the impact of sustainability and forest certification issues. The Forest Steward Council (FSC) Certification process for example, defines in the principle 6.2 and 6.3, that protection areas should be established to protect threatened and endangered species and habitats. The ecological functions and values of certified forests should be maintained intact, enhanced, or restored, including (1) forest regeneration, (2) genetic, species, and ecosystem diversity and (3) the natural cycles that affect the productivity of the forest ecosystem.

SFRs are important protection sites in their own right and they provide the necessary reference data for nature-based silviculture in production forests. The term 'Strict Forest Reserve' is used very differently in Europe (PARVIAINEN *et al.* 1999). In many countries, wildlife control, fire suppression, and removal of invasive exotic species are permitted. The strict concept of no intervention is not realistic in all European forests. In these cases, 'Strict Forest Reserves' are best regarded as 'minimum intervention forests' with the details of intervention dictated by national legislation and other requirements (BÜCKING *et al.* 2000). The 'COST[2] Action E4 'Forest Reserves Research Network' stated, that the only feasible common requirement for SFR status is that no silvicultural intervention takes place[3]. A detailed comparison of SFRs and comparable categories in Europe is given by the European Commission (EC 2000, Appendix 1). The Austrian definition for 'Strict Forest Reserves' is as follows:

'Strict Forest Reserves are forest lands which are left for free development of the forest ecosystem where no direct human intervention takes place. Strict Forest Reserves are a contribution to the conservation of biological diversity. They are used for research, training and instruction purposes' (BMLF 1995).

There is some commonality but not complete coincidence between SFRs and *in situ* genetic reserves. The harvesting of seed, seedlings, saplings or grafts for commercial or regeneration purpose in SFRs is generally forbidden. There are two exceptions (1) needed for research and (2) where rare species or sub-populations are driven close to extinction (FRANK 1998). A useful combination of SFRs and genetic conservation is to use the close-to-nature managed buffer zones on the border of SFRs additionally as genetic reserves (see below). In contrast to the narrower focus of 'Genetic Reserve Forests', SFRs are oriented to maintain the all biodiversity of forest ecosystems and they are left to free development without silvicultural intervention (FRANK & KOCH 1999).

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[2] COST (European Cooperation in the Field of Science and Technical Research) http://cost.cordis.lu/src/home.cfm

[3] http://www.efi.fi/Database _Gateway/FRRN/ frrnintro.html

Protected forests without forest management: National Parks

The interpretation of the term 'National Park' is even more confusing than that of SFRs. However, National Parks as interpreted by the IUCN (1994) generally include large landscape units and, in addition to forests, may include other natural formations or land-use categories. Some National Parks or parts of them are dedicated to scientific research, and this category is an important pool of forest areas where natural processes are not intentionally interrupted. Most large-scale reserves, such National Parks, are not dedicated entirely to maintaining natural processes, but include smaller, strictly protected 'non-intervention areas'. This is particularly true in the case of central Europe. Central areas in National Parks are effectively SFRs surrounded by managed protection areas, and therefore, well suited to protecting natural processes (BÜCKING *et al.* 2000). This is the case in many European countries (*e.g.*, Austria, France, Finland, Germany, Greece, Ireland, Norway, Portugal, Slovenia, Spain, Sweden). It is notable that in some countries, National Parks are considered to be of higher quality than SFRs. National Parks are legally protected by nature conservation acts and managed by 'State Forest Service' or 'State Nature Conservation Administrations'. In Austria, however, National Park legislation distinguishes between core area and peripheral zones. Any form of utilization is prohibited in the core area, whereas agricultural and silvicultural activities are generally allowed in most peripheral zones. Harvesting of seed, seedlings or saplings for research or commercial use is permitted in peripheral zones.

In addition to their conventional function, unmanaged protected areas support the survival of indigenous species and maintenance of ecosystems as well as habitat protection for endangered fauna and flora. Thus, they serve not only for conservation of within-species genetic diversity, but species-level biodiversity.

Recognising that forest management practices may have positive or negative impacts on genetic diversity and population viability (see p. 437 ff. and p. 651 ff., this volume), a research emphasis on the consequences of forest management practices is recom-mended (cf. MÜLLER-STARCK 1996, MÜLLER-STARCK *et al.* 2000, ROGERS 2000). Reference populations at long-term ecological research sites, 'model forests', and research natural areas for studies on effects of forest management are required.

Protected forests without forest management: Genetic Reserve Forests (GRFs)

GRFs as well as other conservation units play an important role for *in situ* conservation. There is a fundamental difference between the two strategies of *ex situ* and *in situ* genetic conservation. While *ex situ* conservation involves the sampling, transfer and storage of target taxa from target areas (see p. 567 ff., this volume), the *in situ* strategy involves the designation, management and monitoring of target taxa where they are encountered (MAXTED *et al.* 1997b, see p. 535 ff., this volume). *In situ* species conservation measures usually emphasize the protection and management of ecosystems and communities to avoid the loss of resident species. The key characteristic of *in situ* conservation is its dynamic nature allowing for continuous evolution. While in agriculture *in situ* conservation may include 'On-Farm Conservation' or 'Home Garden Conservation', in forestry this conservation is commonly restricted to naturally regenerated forests of certain genetic value (ERIKSSON & EKBERG 2001, *loc. cit.* chapter 10). Generally, GRFs aim to preserve the genetic diversity of forest tree species in order to sustain the adaptive potential of forest tree populations, and thus to guarantee the long-term survival of tree species (LEFÉVRE 2000, FINKELDEY *et al.* 2000). Some of the advantages of this technique are to allow a dynamic conservation in relation to environmental changes, pests and diseases, to provide easy access for evolutionary and genetic studies and to permit multiple taxon conservation in a single reserve (MAXTED *et al.* 1997b). In Europe the definition of GRFs is a natural or semi-natural unit of conservation stands or populations where genetic conservation of forest trees is implemented. The forest has to be large enough to encompass sufficient genetic diversity, permit adequate internal pollination, and to allow the existence of several age classes (KOSKI *et al.* 1997, see p. 413 ff., this volume). To achieve genetic conservation objectives, such activities as facilitating natural regeneration, protection of individual trees, regulation of competition, *etc.*, are generally permitted, or even required, in genetic reserves. All management activities - including, for instance, collecting, regeneration - ensure the continuous existence, evolution and availability of genetic resources. The network of GRFs supplements the network of unmanaged protected areas, because in this unmanaged reserves active measures for genetic conservation may be limited or even prohibited (MÜLLER 2000). General guidelines for selecting and maintaining GFRs are as follows (MÜLLER 1993a, 1993b, KOSKI *et al.* 1997, FINKELDEY *et al.* 2000, see also p. 535 ff., this volume):

- The number of individual genotypes must be high enough to include most of the gene pool;
- The tree species in genetic conservation forests should be autochthonous. Exotic tree species are not desirable;
- Plantations of undesired origins should be removed;
- Natural regeneration must be possible;
- Areas of large clearcuts or other uses which reduce natural genetic variation are not allowed;
- The minimum size of genetic reserves should be at least 30 to 100 hectares, depending on the forest type. Smaller areas are accepted only for rare tree species and for small scale azonal forest types on specific sites.

The selection of *in situ* populations as genetic resources continues to be one of the problematic features. Different approaches based on an ecological approach, on fitness relevant traits, and on different types of genetic markers are reviewed in GEBUREK (2000). Like other requirements, the minimum size has changed over time. In Austria, for example, approximately 8,700 hectares are declared as GFRs. Most reserves are smaller than 30 hectares and 25 GFRs are even smaller than 3 hectares (Fig. 1).

A great potential for *in situ* conservation resides in protected areas set aside to conserve species that are difficult to be preserved *ex situ*. In addition, *in situ* conservation of forest species maintains not only the target species, but secure also a number of other species that share the same habitat. KEMP *et al.* (1993) point out that

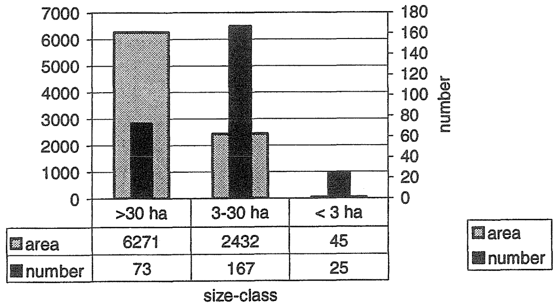

Figure 1. Number and area of Genetic Reserve Forests in Austria [from GEBUREK & MÜLLER, in press].

even when the objective is the conservation of a particular target species or population thereof, this objective may require the protection or management of whole communities – at least until there is a better understanding of the complexities and interactions between ecosystems and target species or populations. Even if they were more widely implemented, *in situ* programmes would not always be available or sufficient to maintain the diversity of species, populations and genetic resources. While *in situ* programmes are nearly always preferable when there is a choice, *ex situ* technologies have become increasingly useful as an adjunct to on-side conservation and restoration efforts (MILLER *et al.* 1995).

Protected forests with forest management: Biosphere Reserves

UNESCO has developed the concept of 'Biosphere Reserves' and defines them as a protected area including a core, a buffer and a transition zone (UNESCO 1995).

The idea of co-ordinating studies of natural systems at national, regional and international levels was inherent in the setting up of the International Biosphere Reserve Network, the backbone of the UNESCO's Man and Biosphere Program (EuroMAB 1993, Fig. 2). Biosphere Reserves are alternative types of protected areas with a combination of functions including *in situ* conservation of natural and semi-natural areas, sustainable management of natural resources, scientific research and monitoring, and environmental education and training (STORK & SAMWAYS 1995).

In combining the functions – conservation, socio-culturally and ecologically sustainable development, support for demonstration projects, support environmental education and training, research and monitoring – Biosphere Reserves should strive to be sites of excellence to explore and demonstrate approaches to conservation and sustainable development on a regional scale (UNESCO 2001).

Given the dual function of Biosphere Reserves, a system of zoning was developed to designate various levels of protection within the designated territory. Although the configuration may vary from the concentric rings envisioned by the original concept, Biosphere Reserves typically have three types of land-use zones:

(1) core zone: a strictly protected area where little human influence is permitted; this area is used to monitor natural changes in representative ecosystems and serve as conservation areas for biodiversity;

(2) buffer zone: an area surrounding the core zone where only low-impact activities are allowed, such as research, environmental education, and recreation;

Figure 2. Location of Biosphere Reserves in Europe [map compiled from data (dated 2004) from MABnet Web page http://www.unesco.org/mab].

(3) transitional zone: the outer zone where sustainable use of resources by local communities is encouraged and these impacts can be compared to zones of greater protection.

Many Biosphere Reserves simultaneously belong to other national systems of protected areas (*e.g.*, where the 'core' is a National Park). Generally, Biosphere Reserves are similar to National Parks in size, and may contain different protection zones (*i.e.*, from totally unmanaged areas separated from areas with a history of management). In contrast to the natural conditions within National Parks, areas that have been anthropogenically influenced often require some ongoing management.

The legal status of Biosphere Reserves is not clear and interpretations of the protection status vary from country to country. In some countries (*e.g.*, Germany), Biosphere Reserves do have a legal status, but in others this status may be absent or contingent on other factors or conditions (KLAFFL *et al.* 1999). Generally speaking, Biosphere Reserves are suitable for the maintenance of genetic diversity. But, the management history – particularly any practices that could have influenced the native gene pool – should be reviewed in order to qualify the area also as a genetic reserve.

Not all managed protected areas can serve as a genetic reserves (depending on the national definition of the categories 'protected landscape' or 'nature reserve'). However, in those cases where Biosphere Reserves do qualify, there are some advantages:

- All relevant forest types can be selected. This is not always possible for legally protected areas, because many of them are established to specifically protect rare and endangered habitats;
- The preconditions are not as stringent as for unmanaged protected areas;
- Close-to-nature harvests are allowed.

Network of forest protection areas

Many institutions and governments have launched initiatives to slow down the depletion of the world's forests. Forest genetic resources networks, either operating on a regional level or focusing on a single forest tree species bring together partners with different interests and backgrounds. The European Forest Genetic Resources Programme [4] (EUFORGEN), coordinated by the International Plant Genetic Resources Institute, promotes both *in situ* and *ex situ* conservation, facilitates the exchange of reproductive material and information, and seeks to increase public awareness (see p. 63 ff., this volume).

The European 'Forest Reserves Research Network' is another good example for cooperation in research and capacity building (EC 2000). This programme was established in 1995 to promote the research of 'natural' forests. The objectives were to create a European network of forest reserves, to survey ongoing research, to standardise research methodology and to create an accessible central data bank. Results are important for the application of ecologically-oriented silviculture and for forest protection network planning. There are nearly 2.6 million hectares of 'natural' forests (*i.e.*, approximately 1.6 % of the total forest area) residing in 3,500 'Strict Forest Reserves' and other protection categories in Europe (PARVIAINEN *et al.* 1999). Most of these reserves are located in areas protected by law.

The goals of this network are as follows:

- Representativeness of all European forest types: A network of 'Strict Forest Reserves' should be established with complete representation of forest types in the different countries. The forest types should follow a classification at an international rather than national scale, and possibly to be linked to EU Habitats and Species Directives (ANONYMOUS 1979, ANONYMOUS 1992b).
- Each country should be responsible for establishing representative forest reserves.
- To qualify for a protected status, forests should be adequate in size, have minimal

[4] http://www.euforgen.org

border impacts, and have sufficient buffer zones.

Forest reserves are generally selected on the basis of their condition (*i.e.*, natural status) and type. Criteria to assess the representativeness are mostly based on forest vegetation types, but may include site types (*i.e.*, in Germany) and percentage of forest cover (*i.e.*, in Norway). Nature conservation aspects are often considered, and old forests are particularly preferred (for instance in Austria, France or Italy). However, forests affected by management may be included (BÜCKING *et al.* 2000). In Austria, there is special emphasis on the representativeness of reserves covering all forest communities in all forest eco-regions (Fig. 3). A network of standardised observation plots provides the basis for long-term documentation of natural development and of human impacts.

In addition to represent a range of forest types another selection criterion is the minimum percentage of the forest areas (FRANK & KOCH 1999). This percentage of protected forests recommended varies widely in the literature from 1 % to 30 % of the total forest area.

In general, legal protection is a requirement to assure long-term natural succession and undisturbed evolutionary processes, although currently a substantial and increasing proportion of non-classified protection areas are left unmanaged in Europe. 'Strict Forest Reserves' and 'Genetic Reserve Forests' may be protected by legislation. In some European countries (*e.g.*, Austria, France, Germany, Denmark, Italy, Netherlands, United Kingdom), the forest reserves are protected by administrative regulations or ministerial edicts. These include, without further differentiation, private contracts. There are also unmanaged areas without legal protection in various ownership categories, but these cannot be regarded as 'strictly protected'.

The long-term commitment to such a specialised (reserve) use of forests is normally restricted to public forests. The ownership pattern of SFRs and GRFs varies

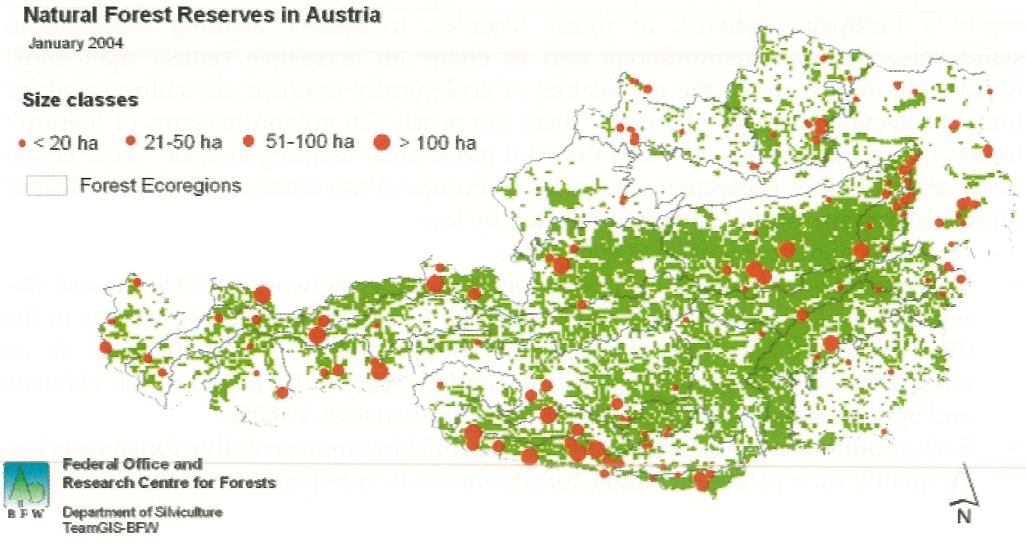

Figure 3. Location of 'Strict Forest Reserves' in Austria (dated 2004) .

considerably. In most countries, state authorities probably own the largest proportion of reserves.

Socio-economic and political factors affecting reserve networks

With the change of property rights a decrease of income is often observed. If reserves are established by law, preference could be given to forest types that have little current or potential economic value, thus neglecting some important (economically valuable) forest types in the reserve network.

Nature conservation by contract could provide an alternative providing a compensation for the income loss to forest owners. The establishment of SFRs and GRFs may be done on an individual and voluntary basis. However, to ensure the maintenance of biodiversity, certain standards have to be accepted.

Protected areas often result in a decreased public use of the forest. However, public education – as long as it does not directly or indirectly impact the reserve (*e.g.*, by tourism) – can be useful in garnering support for forest reserves and decreasing conflicts that could limit their establishment or security.

Research recommendations

Management of biodiversity and forest genetic resources can be effective only to the extent that it is supported by information and knowledge. A research and monitoring programme is an essential component of management and administration (MILLER *et al.* 1995). Protected forests serve as an important basis for close-to-nature silvicultural research, for evolutionary studies, and for providing a basis for 'naturalness inventories' (MAYER *et al.* 1987, GRABHERR *et al.* 1998, KOCH *et al.* 1999). Research in 'Strict Forest Reserves' requires sound conditions (minimum size, legal protection, time frame of protection) in order to fulfil long-term requirements. Multidisciplinary research should be promoted to understand natural forest ecosystems and their functions (EC 2000). Research activities in GFR should focus on the genetic structure of natural populations, the mating systems, and evolutionary processes including co-adaptation. These research subjects will gain increased importance also in view of a climate change (GREGORIUS & GEBUREK 1998). Results should be integrated into practical forest management through national and international training programmes and workshops. More interaction between interested and relevant stakeholders is required and a better dissemination of the results of research and monitoring is needed (PARVIAINEN *et al.* 2000).

Monitoring programmes should be established in as many forest reserves and protected areas as is required to determine changes in ecosystem condition from whatever source. Long-term monitoring and research should be co-ordinated at a national level, with EU and international linkage. There are many common linkages between European research projects and further tasks could be developed in collaboration. Some examples for research or technical programmes are:

- EUFORGEN[5] (European Forest Genetic Resources Programme) operates through networks in which forest geneticists and other forestry specialists meet and work together to analyse needs, exchange experiences and develop conservation methods for selected species. Activities of the networks focus on inventories of genetic resources, development of joint databases and lists of descriptors, identification of common research needs, efforts to submit joint project proposals, development of joint conservation strategies, and promotion of the establishment of national genetic reserve forests.
- BEAR (Indicators for forest biodiversity in Europe) is a European Concerted Action, which aims to develop a system of forest biodiversity indicators (LARSSON 2001).
- EFERN[6] (European Forest Ecosystem Research Network) has established an European forest ecology network and a comprehensive report containing current European forest ecosystem research requirements (ANDERSSON *et al.* 2000).
- PROFOR[7] (Protected Forest Areas) describes, analyses, and harmonises the wide-range of 'Protected Forest Areas'.

Socio-economic research should be integrated in conservation strategies (see , p. 13 ff. and p. 89 ff., this volume). Broader knowledge on biodiversity is needed in order to enhance the understanding of local and indigenous use of forest resources. Thus studies can teach us whether resources are being used sustainably and can help to identify incentives for conservation (OUEDRAOGO & RAYMOND 1996).

Design of reserves

The design of protected areas plays an important role not only in achieving the conservation objectives, but in allowing comparability of research results across reserves. A considerable body of literature related to reserve design is available but less has been written concerning *in situ* plant genetic resources conservation (BATISSE 1986, KOSKI *et al.* 1997, MAXTED *et al.* 1997a).

The first current consensus view of a reserve design is based on the Man and Biosphere programme (UNESCO) or on the guidelines for the establishment of strict forest reserves as discussed by MEYER *et al.* (2001) and HOCHBICHLER *et al.* (2000). All these design concepts include a central core area surrounded by a buffer zone. Standardised data collection procedures can enable comparisons of research data among reserves, provide comprehensive regional information and improve availability of information on distribution of tree species, dynamic of forest change under different conditions and effects of different environmental influences on tree species (KOCH & WALLNÖFER 1997). In particular, data collection procedures should describe the forest stand structure, shrub layer, regeneration layer and ground

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5 http://www.euforgen.org

6 http://ifff.boku.ac.at/efern/

7 http://www.efi.fi/projects/coste27/Introduction.html

vegetation to be able to repeat the measurements, and therefore to analyse regeneration and stand structure through time (PROJEKTGRUPPE NATURWALDRESERVATE 1993).

The forest vegetation type determines the physical structure of the forest, and has a critical influence on the energy balance and food chain within the forest ecosystem. The dynamics of the forest ecosystem are driven by the processes of regeneration, competition between individuals and senescence of tree species. In addition to the tree and shrub flora, the ground vegetation is also an important indicator of the forest condition. The condition can indicate the degree of human influence (GRABHERR *et al.* 1998) and regional patterns of variation. Furthermore, it is recognised that forest stand structure and vegetation are in close interaction with other components of the forest ecosystem.

Reserve size

Various recommendations are given for the minimum size for protected forest areas. The debate is often centred on the relative advantage of a single large versus several small reserves, the so-called SLOSS debate (HAWKES *et al.* 1997). The current consensus is that the optimal number and size of reserves depend on the characteristics of the target species or habitats. A common criterion for the size is the 'minimum structural area'. Defined by the area necessary for a certain forest community to be ecologically sustainable, this area determines the minimum size of a reserve. The minimum structural area varies with the forest type (KORPEĽ 1995). In Austria, the minimum size for a SFR should be 20–60 ha, depending on the forest community (FRANK & KOCH 1999). Other countries have also established minimum areas depending on the ecoregion and the forest type (*e.g.*, 30 ha in lowland areas and 50 ha in mountain areas). The size required for *in situ* genetic conservation will vary widely – depending on the species, its genetic structure, its density, *etc.* (*e.g.*, KOSKI *et al.* 1997, FINKELDEY *et al.* 2000). In some cases, the ideal reserve size for an *in situ* genetic reserve may be considerably larger than that estimated for a SFR. Such areas with more than 50 ha may be difficult to find or designate. An important question related to the minimum size of a reserve is, if the minimal or ideal number of individuals of the target taxon is sufficient for a viable population. Precise estimates of the minimum viable population (MVP) size varies and depends on the tree species, the lifeform, the breeding systems, the environmental factors and catastrophes (*e.g.*, fire, drought, pests) (LAWRENCE & MARSHALL 1997).

To be ecologically sustainable, the size of reserves should secure the diversity of the tree species, genetic diversity within the species, and the processes and conditions necessary for perpetual natural regeneration. The size and shape of a reserve should minimise the biotic and a-biotic disturbances (*e.g.*, windbreak, snowbreak) from outside (*e.g.*, NOSS & COOPERRIDER 1994). These disturbances potentially may be due to wildlife, livestock, pests and diseases and alien species. Problems are common in small size reserves, their location within commercial forests, or proximity to urban areas or tourism centres.

Buffer zones

Buffer zones around reserves can minimise unwanted impacts by providing habitats and safe passage for old-growth species. In Europe in many cases reserves are sheltered by buffer zones treated as non-intervention or are managed in a perpetually mature state (PETERKEN 1996). A refinement of the buffer concept was proposed by HARRIS (1984), who proposed the 'island archipelago approach' in order to improve the viability of Pacific Northwest old-growth reserves as wildlife habitat. The design of buffer zones is also intensively discussed by BATISSE (1986) based on the Man and Biosphere programme. He defines the buffer zone as an area, where research, educational activities, traditional subsistence activities and tourism are emphasized. Within selected conservation areas, designation of various zones can segregate management objectives and uses that may be incompatible and identify management activities by area. Areas of key significance for their genetic materials may well be zoned out of human visitation. Scientific research sites may warrant special protection (MILLER *et al.* 1995).

As forest conservation areas (SFRs, GRFs, Biosphere Reserves) are often 'islands' within larger commercial forests, it is important to establish buffer zones around the core – or strictly protected – area. Buffer zones should have a width of at least 1 to 3 times the height of the tree canopy from the border of the reserve (FRANK & KOCH 1999, Fig. 4).

Sample plot design

Sampling of vegetation and of plant populations are mainly done according to the plot method. Plot sampling involves observations at the sampling point within areas of standard size, usually called quadrats (MAXTED *et al.* 1997c). Most monitoring in GFR and in SFR will involve the sampling of temporary or permanent sample plots.

For SFR in Europe, HOCHBICHLER *et al.* (2000) recommended establishing a permanent network of sample plots and to supplement this with a number core areas, in which complete inventories should be made (Fig. 5). Two different levels of inventory within forest reserves are suggested: (1) a representative description of the entire SFR, and (2) a more detailed description of selected parts of the forest. The general description of the reserve should include:

(1) name and number of the reserve;
(2) area of forest;
(3) protection status;
(4) date of initial description;
(5) location, latitude /longitude, geographic-al region, *etc.*;
(6) mapping of forest vegetation communities (scale 1:5,000/10,000);
(7) mapping of site characteristics (scale 1:5,000/10,000).

The inventory should be designed to ensure that the range of present vegetation

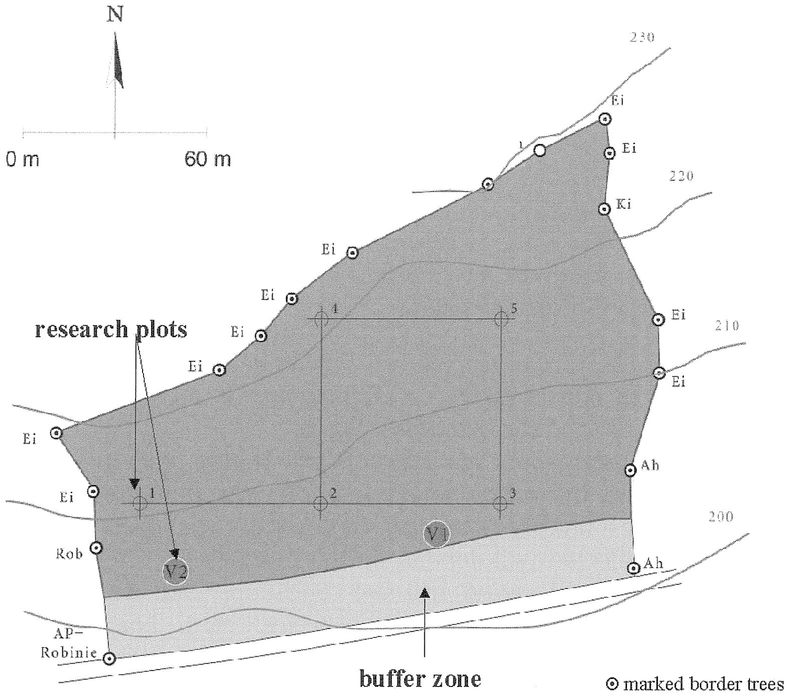

Figure 4. Buffer zone along the border of a 'Strict Forest Reserve' and grid of research plots.

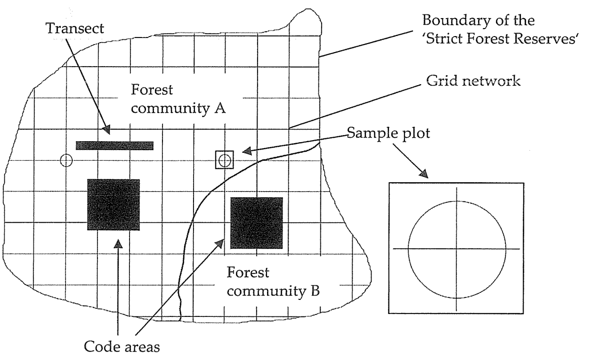

Figure 5. An example of a sample inventory design for 'Strict Forest Reserves' (HOCHBICHLER *et al.* 2000).

types are sampled, while taking into consideration the amount of funding and time available for the research. The basis of the recommended inventory design is the establishment of a systematic grid, which covers the entire forest reserve, and which is permanently marked out on the ground (Fig. 6). This is a fundamental element of the inventory design, and it ensures repeatability of the research. A recommended minimum sample plot density is 1 plot per hectare, with a plot size of 500–1,000 m². The density of sample plots on the grid can be increased within that particular area, to adequately sample the range of variation. In some cases, it may be necessary to choose smaller plots, for example, 250–300 m², on a denser grid,

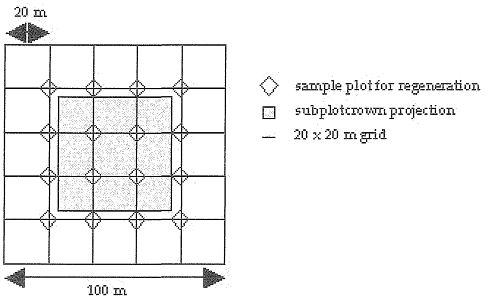

Figure 6. An example of a design of 'core area' in a German forest reserves (MEYER *et al.* 2001).

to gain representative samples. In contrast, for large, homogeneous areas, it may be possible to locate sample plots on the grid through a process of random selection.

For more intensive study of stand characteristics, including ecological or genetic studies, the establishment of core areas in selected parts of the reserve is recommended (KOOP 1991, MEYER *et al.* 2001). In general, squares are recommended over elongated transects. Inside the core areas the establishment of sub-plots is recommended for special investigations (*e.g.*, regeneration) (Fig. 6).

The purpose of permanent sample plots is to derive data on forest vegetation and stand structure over the entire forest reserve over time. A structured approach, describing each forest layer (*e.g.*, canopy, understorey) of vegetation, is recommended. The type of data collected will depend on the research but should minimally include plot characteristics (*e.g.*, location and site conditions) and description of each layer (species, height, diameter for woody species, *etc.*). For recording the forest regeneration or species diversity it is recommended to use permanently marked subplots. The size of sample plots and of subplots depends on stand density. Subplots may be circular plots or transects (Fig. 7). It is recognized that the research objectives will largely determine the design of sample plots. However, adoption of a minimum, standard dataset will facilitate the interpretation of results and the comparison of scientific data between different reserves or different countries. The process of management and monitoring is pivotal to the conservation of plant populations within a reserve. It is expensive in time and resources but is the only way to ensure that the target taxa or habitats are conserved effectively (MAXTED *et al.* 1997c).

Visitors' access

Four categories of people may use forest reserves: the local population (land-owners, local farmers, local communities), the general public, reserve visitors and the scientific community. If the access to the reserve is not restricted, the specific usage of visitors group must be considered when designing and managing the reserve (HAWKES *et al.* 1997).

If unmanaged forest reserves are to remain close to nature, direct and indirect impacts of visitors and other users must be minimized (PETERKEN 1996). In addition to scientific and educational activities there may often be some 'eco' (limited) tourism. In this case it is important that local use or visits by the public should be managed and controlled to ensure that there is no conflict with the goals of the reserve. Usually 'rights of access' are conceded, meaning that people may use a

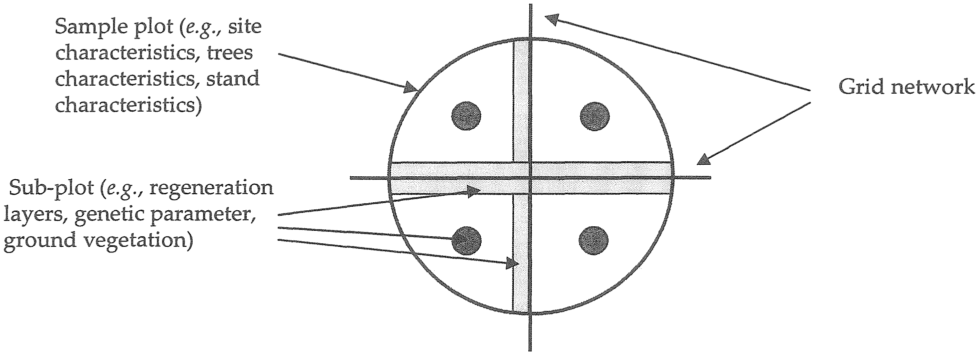

Figure 7. An example of a sample plot with supplementary subplots (HOCHBICHLER *et al.* 2000).

footpath/trail/way/forest road, but must stay on them. Unhindered access throughout the reserve is not encouraged, although this may be in conflict with the privilege to move freely in the countryside (*e.g.*, 'the right of common access' in the Nordic countries).

SFR offer a rare opportunity to observe structures and processes characteristic of natural forests. The support of a broad range of visitors is probably good for the long-term protection of strict forest areas. The modern conservation approach in densely populated countries is to restrict unlimited access and to route visitors by carefully designed trails (BÜCKING *et al.* 2000, CEBALLOS-LASCURAIN 1996).

Conclusions

Both strict protected forests and commercial forests have potential to maintain biodiversity. In both cases, a minimum size of forest areas, natural stand structures and adequate population sizes are required. The focus of genetic conservation is to maintain or enhance genetic diversity in defined target taxa.

The networks of 'Genetic Reserve Forests' and strictly protected areas (legally or voluntary protected) could complement one another and 'Strict Forest Reserves' can be useful in maintaining forest genetic resources (FRANK & KOCH 1999). If such reserves are selected considering also appropriate genetic criteria, it is possible to maintain tree species of the climax vegetation with adequate levels of genetic variation. Both categories of protected forests support the dynamic development of forest stands, either with a genetic or a forest community focus. When for genetic conservation a certain management is needed to maintain resource populations, conflicts with objective of nature protection may be envisaged (*e.g.*, SCHMIDT 1993, SCHMITT 1993). However, in many cases goals of nature protection and genetic conservation overlap considerably.

In general, additional effort has to be given to genetic monitoring, which is essential to follow the changes in a GFR (see p. 499 ff., this volume). Silvicultural management is particularly needed for rare tree species and pioneer tree species. Therefore, this type of tree species will be best maintained in managed protected areas (*e.g.*, genetic reserves, buffer zones of National Parks, NATURA 2000 areas and Biosphere Reserves – depending on their legal status in each country).

Protected areas are particularly important for genetic research and monitoring evolutionary processes. In order to effectively manage protected areas to fulfil also genetic requirements, comprehensive information on the intraspecific (=genetic level) of biodiversity are required. There is still a deficit of such information. Despite aforementioned limitations, managed as well as unmanaged protected areas offer many possibilities for the maintenance of forest genetic resources. Silviculture, forest genetic conservation and nature conservation differ to some extant in their objectives but all are based, in the long-term, on maintenance of the gene pool. Enhanced co-operation and co-ordination among professionals in these fields, as well as the recognition of all potential genetic conservation areas, are recommended for realising a long-term conservation of forest biodiversity.

´We must make every effort to preserve, conserve, and manage biodiversity. Protected areas, from large wilderness reserves to small sites for particular species, and reserves for controlled uses, will all be part of this process. Such systems of protected areas must be managed to take account of a range of ecological and human-induced changes. This is no small task; yet humans must be equal to this challenge, or risk becoming irrelevant´ (Peter Bridgewater, National Parks and Wildlife Service, Australia)[8].

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8 http://www.wri.org/biodiv/gbs-viii.html

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