Conservation of the wild relatives of European cultivated plants: conclusions

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Preamble

In attempting to draw major conclusions regarding the conservation of the wild relatives of cultivated plants from the large number of papers, working groups and discussions held during the three workshops on which this volume is based, it is important, as already noted in the introduction, to view them in the light of several major developments that have had an influence on our attitudes to biodiversity in general and to the conservation of genetic diversity in particular. In addition to the Convention on Biological Diversity and the Leipzig Conference mentioned in the Introduction, there are two pieces of European legislation that concern us here.

The first is the Bern Convention on the Conservation of European Wildlife and Habitats that came into effect in 1982. Appendix I (Strictly Protected Plant Species) of the Convention lists about 500 species, including some of the wild relatives of European cultivated plants. It is now being extended and in December 1996, a further 107 Central and Eastern European species were added. In addition, the Standing Committee decided to implement a recommendation to create a network (called the 'Emerald Network') that is similar to the EU Natura 2000 network and is intended to cover the whole of Europe. The Group of experts on the conservation of plants of the Bern Convention is also encouraging the preparation of Action Plans for threatened species.

The second is the EU Habitats Directive which was adopted in June 1992 and makes provisions for the conservation of habitats and species (other than birds). Under the Directive, member states are required to create special areas for conservation (SACs) to conserve the sites of a given list of threatened species and of threatened habitat types.

Together with national legislation, these agreements provide a background against which the issues discussed in this volume have to be viewed. In addition, we must not lose sight of the more general context of the continuing loss or fragmentation of habitats as a result of human activities in most parts of Europe, including areas that have been designated as reserves or sites of special scientific or conservation interest. The landscapes, vegetation and flora of Europe have been subjected for thousands of years to change on a scale not yet seen on any other continent. Deforestation, transhumance, grazing, agriculture, fire, plantation forestry, introduction of exotic species, urban and industrial development, tourism and population growth and movements have dramatically altered the face of the continent whose biomes are now made up of remnants of natural and semi-natural vegetation in a mosaic of agricultural land, planted forests, wasteland, roads, industrial landscapes and urbanizations. Recent developments have included changes in agriculture towards large-scale operations, merging of farms into larger units, loss of hedgerows and other boundaries with a consequent loss of biodiversity; movement away from the land to the towns and cities; an increase in the spread of alien and invasive species; and the devastating effects of agricultural, industrial and urban pollution. Yet most of Europe's plant species have managed to survive, albeit some of them in small populations, although their habitats — most of our natural biotopes — have been dramatically reduced in area or modified. Nonetheless the continuing pressures on these habitats makes the survival and management of remaining populations of many of our plant wild relatives a complex and demanding task.

The mandate of the group that was set up by the Council of Europe was to review the present situation of the large number of wild progenitors of the cultivated plants native to Europe, to identify research priorities, and develop procedures for basic and efficient research to achieve the effective conservation of this genetic heritage.

Although the three workshops covered a different range of topics, inevitably there were overlaps and some themes were revisited several times. Some of the topics discussed were controversial and agreement was difficult to reach. In what follows, I have attempted to highlight some of the major conclusions as well as draw attention to points of particular interest or significance.

Conclusions

General. The conservation of wild relatives of crop species is a largely neglected field and has only recently come into prominence. The reason for this neglect, as Gómez Campo notes, stems from the obvious fact that they are wild species and that consequently the approaches needed for their study and conservation are very different from those that have been applied to the cultivars or landraces of agricultural crops. Much experience has been gained by agricultural genetic resource agencies and seed banks in undertaking ecogeographical surveys, formulating collecting and sampling strategies, seed storage, establishment and maintenance of field gene banks, clonal collections, tissue and cell culture, cryopreservation and germination studies, but we have little experience so far of applying or adapting this for wild species. Conservation agencies and organizations, for their part, acquired great experience of setting up and managing protected area systems and in identifying rare and endangered wild species but have paid little heed to the genetic conservation and gene banking on the one hand or to conserving target species within protected areas on the other. What this series of workshops marks is a convergence of interest between the agricultural (and forestry) genetic resource sector and the conservation sector.

From the above, another general conclusion can be drawn – the need for an integrated multidisciplinary approach to solving these problems. The range of disciplines involved is remarkably wide, including genetics, plant breeding, population biology, population genetics, demography, phytochemistry, molecular biology, taxonomy, ecology, sociology, legislation, seed physiology, gene bank management, protected area management, and conservation biology.

Another, perhaps unexpected, general conclusion is that the conservation of wild relatives of tree species is quite different in many respects from that of agricultural and horticultural crop species. This is very evident from several of the papers, especially those in Section VII (Protection of genetic variability in forest tree populations). The *in situ/ex situ* separation that plagues other areas of conservation breaks down here and the sampling and conservation methods (and even the terminology) are special.

Following on from this last point, another general conclusion made by several papers is that the situations described in so many of the groups and species dealt with in this volume are so complex, and as we have seen, multidisciplinary, that an integrated approach to conservation is required in which *in situ*, *ex situ*, *in vitro*, static, dynamic, reintroduction or whatever approaches are appropriate are applied. Undue stress on any one approach for political reasons should be avoided.

Sampling and surveying populations. A basic first step is to establish the distribution of the target species concerned and investigate the way in which the genetic variability they contain is distributed. Ecogeographical survey techniques provide such a methodology and require the co-operative effort of workers from a range of disciplines, including taxonomists, ecologists, conservationists, statisticians and geneticists.

In surveys, the need for information and making what does exist readily accessible are important, especially in the pre-survey phase when literature searches and surveys have to be made. The role of taxonomists is critical here and it was suggested that taxonomists need to become more closely involved in genetic resource conservation work, especially in the case of wild relatives. Three main areas were identified:

- making the information accumulated in Floras, monographs, herbarium specimen labels, catalogues and similar sources, over the last centuries, more readily available to plant genetic resource users, especially in database form;
- ensuring that the services and products of taxonomy are better adapted to the needs of consumers such as plant genetic resource (pgr) users and population geneticists analyzing genetic variation in wild relatives: the design of Floras, handbooks, keys and databases need special consideration;
- enlisting the co-operation of taxonomists in recording appropriate information for pgr purposes during their collecting missions, including specialists from other disciplines in their field teams, seeking briefings from pgr experts before setting out so that a lookout for particular target groups can be made, and in appropriate cases actually collecting germplasm samples.

Collaboration between the different organizations involved (conservation agencies, herbaria, botanic gardens, research groups) should be increased.

There is no agreement between the authors on what constitutes a population which in not surprising when one considers the difference between, for example, stands of wide-ranging wind-pollinated trees such as *Pinus sylvestris* (see the paper by Puglisi), and highly localized populations of *Brassica* on islands and cliffs (see papers by Gustaffson & Lannér and Raimondo).

Decisions on the size of samples, how much genetic variation we should attempt to capture, and for what intended use, lead to considerations of how we assess genetic variation in populations and how far existing sampling methods (and these are developing all the time) are able to detect what is 'essential variation', the variation in factors such as ecophysiological tolerance that is not identifiable by isozyme analysis and other analytical techniques. Detailed and thorough studies such as those carried out on *Brassica* and *Dactylis* (see paper by Lumaret) are an urgent requirement for species representing different situations (inbreeders, outbreeders, annuals, perennials, clonally propagated etc.).

Sampling populations is not just a question of how much but where. The need to assess genetic variability throughout the range of a species, not just in the area or country concerned nor just in the populations that occur in particular reserve areas, is stressed by Zohary. Pérez de la Vega considers the lessons about sampling that geneticists might give conservation managers — for example that genetic variability is commonly organized in the form of multilocus associations and that the distribution of variation in populations may be highly uneven. Sampling heterogeneous areas is likely to lead to large samples of genetic variability (or is it?).

Finally, the problems need to be addressed of the differences between sampling cultivars and land races of cultivated species and populations of wild species. Most of our genetic resource experience comes from crop cultivars (or from forest trees) which, while instructive, addresses a different set of problems. It is a question of comparing very intensive sampling in a small number of species with less intensive sampling of a wide range of species.

Demography. Demographic factors, including the special problems of small populations, minimum viable populations and extinction proneness, are also of critical importance alongside population genetics in conservation planning. It should be noted that small populations are not necessarily prone to extinction through loss of genetic variability: stochastic environmental factors are much more likely to represent such a threat. Some populations are naturally small and really endangered populations are those that are not capable of reproducing themselves as Pérez de la Vega points out. Marginal populations whose composition is often quite different or more heterogeneous than that of more central populations may be of particular value for survival under special conditions of stress, for example. Attention was also drawn to the non-randomness and demographic instability of local populations.

Reproductive biology. The different flowering and fruiting strategies, seed germination, breeding systems, soil seed banks, etc. which can be considered under the general heading of reproductive biology, affect not only the way in which genetic variation is partitioned in populations but also the way in which populations are adapted for growth and survival and therefore affect the ways in which we plan our conservation strategies. Again, as Gómez Campo pointed out, there is no point in collecting and storing seed samples and distributing these if they cannot be germinated because of dormancy mechanisms that have not yet been studied. The importance of the seed bank in the soil is a key, but largely neglected, factor in the survival of some species (especially annuals). Here is an area where further research is an urgent requirement. For example, in species with seeds that have longer or shorter dormancy, as in the case of *Lens*, sampling is difficult because only part of the populations appears each year.

Pattern of gene flow. The pattern of gene flow that occurs within species and its importance for the cohesion of species is a subject that needs to be studied in more detailed. The methods of measuring gene flow need to be looked at carefully: den Nijs &

Oostermeijer note that there is evidence to suggest that current techniques of measurement may underestimate the actual level of gene flow in some species although we do not know how significant this is. Fragmentation of habitats is, as we have seen, increasingly the pattern in many parts of Europe so that questions of the degree of gene flow between populations of the same species that occur in these fragments are critical in assessing the effectiveness of corridors and series of vegetation patches in conservation planning. This is an area we do not yet understand very well. Another aspect of gene flow that is of current concern is the effects of transgenic plants: the introduction of genetically modified *Brassica napus* could endanger the wild forms of *B. campestris* by introgression and the risk of genetic pollution of cultivars and the production of weedy plants with new genes conferring fitness is a worrying prospect and could put wild *B. campestris* at risk. Concern has also been expressed about the potential dangers of genetic pollution occurring as a result of introducing populations or reinforcing existing populations by introducing genetic material from similar ecological niches as a conservation technique.

Somewhat related is the question of metapopulations and ways of overcoming the problem of the isolation of stored germplasm from its environment through 'dynamic management' as described by Pham. This consists of allowing composite metapopulations, of wheat in the case described, to evolve in different environments. The contrast between static *ex situ* and dynamic *in situ* conservation is thus being further eroded.

Interactions. A topic that is often overlooked is the various kinds of interactions amongst and between organisms. Zohary reminds us that crop plants are the result of a long and complex series of interactions, selection and coevolution: domestication is a kind of mutualism. *In situ* conservation has to do with these various relationships — mutualism (including plant-pollinator relationships), commensalism, allelopathy, parasite-host relationships, plants and their pathogens. Some of these relationships change rapidly which reminds us of the need for active management of populations.

Stress. As McNeilly reminded us, stress is a universal phenomenon, the most obvious case being those plants that are exploited as food by animals. The need to keep grazing intensity and grass productivity in balance has clear implications for the management regimes of wild relatives that occur in agroecosystems. Humphreys draws attention to the fact that forage grasses are often close to being wild and that wild relatives may, therefore include different ecotypes of the same species as well as other related species. His paper illustrates the importance of wild relatives in extending the gene pool in grass breeding in response to future demands of European agriculture and also the ability to cope with the possible effect of climatic change.

Forest trees. The special nature of forests and forest trees in a conservation and genetic resource context is referred to frequently in this volume. How far *are* they a special case? Müller-Starck and Hattemer both stress the peculiarities of forest trees and note that their average heterozygosity exceeds that of all other organisms. Their heterogeneity in space and time is also special although some other organisms may also show as much heterogeneity in time and other groups may be as long-lived (e.g. some chasmophytes and chamaephytes although perhaps not as long lived as some trees such as oaks). Approaches to forest tree conservation also differ considerably from those of crop plants or wild species, involving gene reserves (a sample of a natural population that is intensively managed and can be utilized under certain conditions), seed orchards and 'dynamic conservation' both *in situ* and *ex situ* (as mentioned above). It is not clear how far are production forests different from other agroecosystems — certainly they may be less managed but they are not *un*managed.

Few tree species are grown in forestry and they are usually scarcely domesticated, with little selection or breeding (except perhaps in ornamentals which are not specifically considered in this volume). We need to explore how far these differences in approach and even terminology are the result of separate traditions and training and how far they reflect real differences from other kinds of plants.

Habitat conservation. The normal paradigm for the conservation of wild organisms is through maintenance of the habitats in which they occur, i.e. *in situ* conservation. This is, however, a subject that is open to a great deal of confusion and misunderstanding and although it sounds straightforward there are many complicating factors. Protected areas (reserves, national parks, natural parks, biosphere reserves, etc.) do not of themselves ensure either the protection of the ecosystem/biotope nor of the populations of the species contained therein. We must beware of the myth of 'benign neglect' — the seductively simple idea that species diversity can be conserved simply by setting aside areas under some form of protection. Of course many species will survive under such a hands off approach but since the ecosystems are dynamic and constantly changing in response to a series of environmental factors, and since the populations of the species that comprise the ecosystems are also dynamic and constantly changing in composition, even from one year to another, there can be no guarantee that any particular target species with its present day demography, distribution and genetic variability will be maintained in an acceptable manner. Protected areas need to be managed, as Safriel makes clear, but managed for a purpose or set of purposes: protection must have specific and attainable goal. The appropriate level of management or intervention — from simple monitoring to intensive management or habitat farming — needs to be determined. This is no easy task: there is nothing intuitive about management, as Safriel observes.

We have to distinguish between the conservation of an area and the protection and maintenance of the populations of species that occur within the area. Both are in situ but the focus is different and the management needed will often be different and the needs of the one may conflict with the other.

Conservation situations. In practice, actual conservation situations are very diverse. In *Populus nigra*, for example, Cagelli notes that *in situ* conservation is confined mainly to river bank habitats so that these pioneer habitats need to be maintained. *Ex situ* conservation of this species is quite, either grown in stands or in botanic gardens, whereas seed collections are made in narrow valleys in the Alps and the Pyrenees where there is little risk of genetic pollution. The conservation of wild relatives of cereals *in situ* is difficult because of the weedy habitats in which they occur. Brassicas may, on the other hand, present problems because of their rupicolous nature as in Sicily where they are difficult to sample (and populations difficult to define), collect, conserve and monitor.

Integrated conservation strategies. The conservation or protection of habitats is not always possible and other complementary measures may have to be taken. The conservation of wild relatives may be achieved effectively *in situ* but this may only cover part of their populations and genetic variability in the case of species that are widespread or with disjunct populations. Or the habitats may be suffering progressive change that cannot be overcome by management intervention, or the populations reduced to small inviable populations through fragmentation or loss of habit. In such cases *ex situ* conservation of samples of the genetic variability should be made. Or the populations may need reinforcement which requires the use of both *in situ* and *ex situ* techniques. The use of whatever conservation approaches that are appropriate to the situation is termed integrated/complementary or holistic conservation and good examples may be found in the work of the Conservatoires Botaniques Nationaux in France, as described by Olivier and Dalmas & al.

The role of genetic resource managers. The role of the genetic resource manager varies according to the kind of facility involved. That of gene bank managers has changed because of a series of factors context such as the implementation of the Convention on Biological Diversity, technological progress, higher viability, more public recognition (and criticism) that have led to new activities being undertaken, including the cataloguing of biodiversity. Another tendency has been towards closer co-operation with the informal sector (e.g. botanic gardens, seed savers) and with the conservation sector. The number of accessions is impressive in some instances:

Gatersleben held more than 100 000 accessions at the end of 1993 and about 10 000 accessions of wild species obtained mainly through collecting missions. This latter figure, as a proportion of the total collections is high in comparison with other national gene banks.

The absence in most countries of an overall organization or centre responsible for the collection and storage of germplasm of wild species is noted. The role of seed banks in habitat conservation is still not well appreciated: the seed may be available for a variety of purposes, including the provision of material for reintroduction, population reinforcement, habitat restoration and rehabilitation.

Gene banks are not just seed banks: the term also covers clonal collections, field gene banks, botanic garden collections, *in vitro* storage, pollen storage, cryopreservation, that have a role to play in conservation.

Zohary makes the point that we will have to prepare for the time when many of our remaining habitats for wild species will have disappeared or changed due to human activities. We would be prudent, therefore, if in addition to planning our long-term habitat protection policies, we included storing samples of genetic variability of wild species as an insurance policy (and also to make material available for research and experiment).

This should apply not just to rare species — and many wild relatives are not rare — but to sampling and storing the variability within widespread species. The time to make germplasm collections when the range of genetic variability still exists, not when the species populations are reduced to endangered status.

The changed and complex and multifaceted role of the protected area manager is expounded by Safriel. Gone are the days when the aim of a protected area was to secure the 'balance of nature'.

It is now recognized that protected areas, as ecosystem samples, undergo nonequilibrium dynamics. The need, therefore, for setting clear and attainable goals is stressed and the importance of education and public awareness once the habitat is protected.

Neglected areas of research

Some areas of activity or research that are necessary for conservation projects were either omitted or dealt with only superficially in the three workshops and are therefore not adequately represented in this book. These include:

Monitoring. Although monitoring is frequently mentioned as an important component of conservation strategies, it is seldom practised. As Chauvet comments, it is a relatively new task so that no-one is really responsible for ensuring that it takes place. Cooperation is, therefore, needed between the different agencies involved in conservation if it is to be carried out. This is an good example of the difficulties of implementing integrated conservation strategies — they are interdisciplinary and therefore requires the co-operation of sectors that do not normally work together.

But monitoring for what? It could be the effectiveness of conservation action, e.g. setting aside land, protected areas, the viability of seeds in seed banks, or it could be change in ecosystems, in populations, in the distribution and patterns of genetic variability, and so on. But to be able to monitor we have to establish baselines — a topic that is scarcely mentioned.

Botanic gardens and arboreta. The role of botanic gardens and arboreta, apart from the French Conservatoires Botaniques Nationaux and the Royal Botanic Gardens, Kew Seed Bank at Wakehurst Place, UK, is scarcely covered in this book. Yet they play a considerable role today in many aspects of integrated conservation and many of them have adopted the IUCN/WWF Botanic Gardens Conservation Strategy.

The economics of conservation. We need to look into the economics of conservation. For seed banking, costs are estimated by Smith & Linington at £230 per collection (the year-on maintenance costs included) although both these and the capital costs will vary from institution and from country to country. We need to look more carefully at the relative costs of different techniques.