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Critical global review of existing guidelines and methodologies and other relevant literature on *in situ* conservation of target plant species and of current activities in this area being undertaken by national and international agencies

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Global review of *in situ* conservation of target plant species

Executive Summary

1. A critical global review has been undertaken of current activities on species-based *in situ* conservation being undertaken by national and international agencies and of existing guidelines and methodologies and other relevant literature in this area.

2. Conservation *in situ* is seen to be a poorly understood concept and covers a range of different situations that involve wild population and species, domesticates, ecosystems, agroecosystems, landscapes and bioregions:
   - Conservation of natural or semi-natural ecosystems in various types of Protected Area
   - Conservation of agricultural biodiversity, including entire agroecosystems and the maintenance of domesticates
   - Conservation and maintenance of target species in their natural or semi-natural habitats
   - Recovery programmes
   - Habitat restoration

3. Conservation *in situ* of target species in natural or semi-natural habitats should be seen as just one component of an overall conservation strategy, along with *ex situ* and other conservation approaches.

4. The review shows that effective *in situ* conservation of target species is a complex, multidisciplinary, time-consuming and expensive process, involving many different stakeholders and agencies.

5. The international mandate for *in situ* conservation of species and populations is examined and the role of the *Convention on Biological Diversity* (CBD) and the *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture* (GPA) in advocating *in situ* conservation of species is discussed. There appears to have been little subsequent follow-up, either in clarifying or implementing the recommendations in these instruments as regards this specific topic and very few GEF-funded or other projects have addressed *in situ* species conservation..

6. Several UN agencies and other international conservation, genetic resource and related agencies, and NGOs include *in situ* conservation of target species in their mandate and have drawn attention to the need for appropriate action, emphasizing role of local communities. However, implementation has been limited largely to conservation action plans for certain groups of critically threatened species (e.g IUCN), as components of conservation and sustainable use projects for medicinal plant programmes (e.g. World Bank, WWF) and for selected forestry species of economic importance or crop wild relatives(e.g. FAO, IPGRI).

7. National mandates are also considered. With the exception of programmes for the identification, conservation and recovery of threatened species, some of which are extremely well developed and organized, most countries do not appear to have a

coherent strategy for *in situ* species conservation that includes all groups of plants such as those included in agriculture and forestry.

8. On the other hand there is greatly increased awareness of the need for *in situ* conservation of species following the publication of the CBD and the GPA, and in a growing number of countries some effort is going into determining which species are candidates for selection and undertaking ecogeographical surveys for some of these. Many countries, however, have no plans to take action in this area. Likewise, most conservation organizations have not given *in situ* conservation of species, other than those that are on Red Lists, much prominence.

9. Overall, the review finds that the goal of maintenance of viable populations of species in their natural surroundings, identified as a fundamental requirement for the conservation of biological diversity by the Convention on Biological Diversity, does not seem to be have been reflected in the conservation actions of many countries. It remains however a basic requirement if *in situ* conservation is to be effective. The target of '60 per cent of the world's threatened species conserved *in situ*' by 2010 proposed in the Global Strategy for Plant Conservation will need to be very carefully analyzed and represents a major challenge.

10. A key requirement for assessing the requirements for *in situ* conservation of plant species is clearly an adequate information base. This is not available for most countries and no global assessment that covers all groups of species has been made. While many countries have produced partial or complete lists of threatened species, few if any countries have developed priority lists of species of economic, scientific or cultural importance for *in situ* conservation.

11. The two main groups of species that have been the subject of most *in situ* conservation action to date are (1) nationally or locally threatened, rare or endangered (Red List) species and (2) forestry species. They have both attracted a large body of literature referring to theoretical and practical aspects of priority determination, selection, sampling, management and conservation strategies but those involved in each of these two areas have tended to pay little attention to each other's work. It is strongly recommended that each sector should take active steps to learn from the experience of the other. This review should provide an introduction to what is being done and what information, policies, strategies and conservation actions are available.

12. A review of the literature and discussions with experts reveals that the number of cases of effective practical *in situ* conservation of target species, is still small and mainly confined to developed countries in temperate and Mediterranean regions of the world such as the United States, most European states, Australia and New Zealand. *In situ* species conservation activities are being undertaken in some developing countries (such as Colombia, Ethiopia, Jordan, Kenya, Korea, Sri Lanka, Zambia), often with an emphasis on community-based conservation. Probably the number of species which are currently the subject of *in situ* conservation programmes or activities represents less than 0.5% of the total plant species (c.400 000), most of them being rare or endangered wild species identified by national Red List programmes. Species recovery programmes have been instituted for several hundred species worldwide,

mainly in temperate-climate countries. They are complex, time-consuming and expensive and it is too early to judge how successful they will be in the longer term.

13. The review reveals that three main groups of economically important target species have been the focus of *in situ* conservation: forestry tree species, wild crop relatives and medicinal and aromatic plants.

14. It is evident that some forms of *in situ* conservation of forest genetic resources, in natural or seminatural forests, are a long standing tradition and considerable practical experience has been gained during the past 50 years. This experience is largely unknown outside forestry and has been largely overlooked by other sectors involved in *in situ* species conservation. Similarly the very extensive theoretical and practical background gained in species recovery programmes is often overlooked by the agricultural and forestry sectors.

15. Globally, the number of potential candidate species for *in situ* conservation is very high (many tens of thousands). The use of priority mechanisms for selecting target species is therefore a critical process both nationally, regionally and globally, and the criteria adopted will depend on the group of species concerned, and on national, regional and global priorities and economic, social and environmental considerations.

16. Degree of threat or endangerment is widely adopted as a filter for all groups of target species, including those of economic importance and high priority is given to those that are also endemic. Although this is understandable, it does run the risk of excluding taking conservation measures for widespread species of major economic importance where the need to preserve particular values such as alleles, genotypes or ecotypes for present and future use, while they still exist, is urgent and important. It should also be recognized that information on which species are threatened and the nature of the threats is not available for most species that occur in tropical biomes.

17. The main elements involved in developing a strategy for the conservation of target species *in situ* are described, including the kinds of baseline information needed and the criteria for the selection of target species, selection of sites and sampling of genetic variation.

18. The role of protected areas and their managers in conserving species *in situ* is reviewed. Most protected areas were not set up with conservation of particular plant species or groups of species in mind and even the presence of what may be identified as target species will not be known in many cases. Floristic inventories of protected areas should be given priority as part of national strategies for *in situ* species-orientated conservation.

19. Nonetheless, protected areas will play a major role in the *in situ* conservation of species of economic importance as habitats where many of them will be found to occur. However, recorded presence in a protected area is not on its own a criterion for effective *in situ* species conservation. At the least it would have to be established what is the minimum viable population number needed to ensure the maintenance, survival

and continued evolution of a significant part of the genetic variability of the species concerned.

20. The so-called ‘hands off’ or laissez faire approach whereby it is assumed that species which are known to occur in protected areas are afforded long-term protection without human intervention is unlikely to be effective for many species, even assuming that the populations represented have been shown to constitute an adequate sample of the genetic variation in the species concerned. Such passive conservation leaves the populations liable to unobserved genetic erosion or population decrease due to stochastic factors and possible eventual extinction. For threatened species, action to monitor, control or remove the factors that cause the threat(s) will require active management interventions.

21. Even if the wild populations of target species selected for *in situ* conservation need little management, the processes involved in the assessment of their distribution, ecology, demography, reproductive biology, and genetic variation and in the selection of number and size of populations and sites to be conserved is still onerous.

22. It is recommended that protected area managers should consider the possibility of enhancing the level of protection to afforded to the populations of species of economic importance that are found to occur, through modifying the management of the area. Although this would fall far short of effective *in situ* conservation of such species, it would contribute to the overall goal.

23. In addition to the different categories of protected areas recognized by IUCN, a wide range of specialized types of protected areas for genetic conservation exist and much more work needs to be undertaken to establish their effectiveness.

24. The role of local people and other stakeholders in the management and protection of the areas on which the target species occur is stressed. In the case of species of economic importance that are directly harvested or consumed (such as medicinal plants or fruits), *in situ* conservation needs to be closely integrated into the overall framework of sustainable resource management and a participatory approach which involves the local community and recognizes the importance of the resource to local people, needs to be adopted whenever possible. This will involve for example, consideration of indigenous knowledge systems, land tenure systems, control of access to plant resources and links with on-farm conservation approaches.

25. The *in situ* conservation of species outside protected areas, where the majority of them occur, is a subject that deserves much further consideration by conservation agencies. While the very act of taking steps to protect, manage or conserve species populations in such areas effectively brings them under the umbrella of protection, there are other indirect means, such as easements, whereby some degree of protection to the species can be afforded by agreements to reduce the level of exploitation or to contain threats.

26. A review has been made of the available guidelines for various aspects of *in situ* species conservation. These range from the very general to the highly specific and

from cursory lists to detailed handbooks. What is clear is that no overall set of guidelines is applicable to all groups of species and that while there are some widely applicable considerations and practical models for genetic resource conservation have been proposed, development of a conservation strategy has to be tailored to the particular species and the economic, social, legal, conservation and other circumstances.

27. Because of the restricted resources and finance available, effective *in situ* conservation is only likely to be applied to a small minority of species, even for those that are threatened. Consequently, for the majority of potential target species, no formal conservation *in situ* conservation action is possible and for these alternative solutions must be sought. A set of proposals is made for tackling this situation.

28. A multi-level strategy will be need to be adopted to afford some degree of protection to those species that cannot be covered by structured *in situ* conservation programmes. A number of different situations will be found to occur, depending on whether the species is known to be threatened or not, whether or not it occurs in a protected area, whether it is of economic importance or not. Thus:

- for **widespread** species which are **not currently known to be threatened** and **of no known particular economic importance**, a minimum goal is identification and monitoring of the populations of the species concerned and effective management of any protected area(s) in which they occur; or monitoring their presence and the habitat conditions if they occur outside any protected areas .

- for species of **known economic importance** that are **not threatened**, ecogeographical surveying should be undertaken to establish the amount and distribution of genetic variation and how much of it is represented in protected areas, and an assessment of conservation and monitoring needs undertaken.

- for **threatened species**, whether **of known economic importance or not**, which occur **in protected areas**, ecogeographical surveying should be undertaken, the extent of the genetic representation in the protected area assessed and further areas for eventual protection identified to ensure that an adequate representation of the diversity is covered; then action taken to control or remove the factors that cause the threats and **if the species is considered of sufficient priority** any necessary further conservation action that is needed, such as detailed management or recovery, should be planned and implemented.

- The development and implementation of multi-species as opposed to single-species conservation or recovery plans is an option provided the different species face the same or similar threats although experience suggests that for many such plans this is not the case and in any event their effectiveness is in proportion to the amount of time and money that is devoted to the individual species.

29. Attention is drawn to the potential effects of global change (demographic, land use and disturbance regimes, climatic) on *in situ* conservation programmes. While these are difficult to predict, it seems likely that in some areas not only individual species

but the ecosystems in which they are conserved *in situ* will be put at risk. This emphasizes the need for a holistic view to be taken of conservation strategies.

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'The potential conservation utility of these [*in situ*] *programs has not been realized and may not be for many years'* US National Research Council (1991)

'The main problem in achieving [*in situ*] *conservation goals is, at present, the lack of institutional and political frameworks under which adequate land use and operational management choices, fair to all stakeholders, can be considered and efficiently implemented in the short as well as in the long term.'* FAO (2002)

I. The concept of *in situ* conservation

Introduction

This review has been prepared by a DIVERSITAS consultant at the request of FAO as part of the UNEP GEF PDFB project **'Design, Testing and Evaluation of Best Practices for *in situ* Conservation of Economically Important Wild Species'**. The terms of reference of this survey and assessment are to provide a 'Critical global review of existing guidelines and methodologies and other relevant literature on *in situ* conservation of target species and of current activities in this area being undertaken by national and international agencies' (see Annex 1).

It is clear from reviewing the literature of biodiversity and genetic conservation that the concept of *in situ* conservation focused on species, as opposed to the ecosystems in which they occur, is ambiguous and has been subject to a wide range of interpretations by different interest groups.

The ambiguities concerning *in situ* conservation of species reflect the long-standing dichotomy in ecological and conservation thinking between ecosystem- and species-based approaches. There has been a tendency to dichotomize nature into species and ecosystems[2]. For the last 30-40 years, ecosystem and population ecology have ploughed their own independent furrows and developed their own paradigms, approaches and questions[3]. The emphasis in the Convention on Biological Diversity on the so-called 'ecosystem approach' has had the unfortunate consequence of appearing to reinforce this distinction although that was not the intent[4].

In the fields of crop genetic resources and agricultural biodiversity in general, little attention has been paid to species conservation *in situ* although there has been a revival of interest in the past decade in conservation of landraces 'on-farm'. Yet the principles of *in situ* conservation of genetic resources have been well established for some years[5]. On the other hand, forestry in North America and Europe, for example, has long been based on empirical approaches to management of natural resources, including target species, and a

[2] Soulé & Mills (1992).
[3] Lawton and Jones (1993).
[4] The ecosystem approach is in practice an integrated or holistic approach to biodiversity conservation and would be more appropriately so-described.
[5] e.g. Wilcox (1984); Ingram (1984); FAO (1989).

theoretical basis has been recognized in recent years. It is noteworthy that Aldo Leopold's essay 'The conservation ethic' was published in the *Journal of Forestry*[6].

On the other hand, in a review by the US National Research Council of managing genetic resources of forest trees, in the section on *in situ* conservation and referring to the number of reserves and sampling strategies, it is stated that[7]:

> 'Although much of the literature is couched in terms of conserving particular populations, in situ conservation in reality involves preserving whole communities. The number of populations and species that require some protective measure in the wild is so large that it is impractical to design in situ conservation programs on the basis of individual species and their populations'.

While it is clearly unrealistic with the limited resources available to envisage wholesale programmes of *in situ* conservation of all those species for which a case could be made, it is clear that a much greater effort needs to be made to conserve *in situ* a substantial number of target species of priority importance, whether forestry species or not, using a variety of approaches.

The issue of whether or not to include a wide range of species in *in situ* conservation has been addressed in a thoughtful review 'Genetics and the Future of Forests'[8] (see discussion in Section II. Forestry Species). The author notes that even for the relatively small number of forestry species which have a recognized current commercial value, the amount of genetic management is limited and that 'only very meagre funding is available for any but the most important commercial species in industrialized forestry'. As the vast majority of forest plant species have little known or potential commercial value or function that is not served by other species, the only management objective is likely to be ensuring the continued existence of a sample of such populations or species, most likely *in situ* in protected areas such as reserves or parks. Even this may be difficult to achieve in view of the lack of information available on the precise distribution and ecology of the species concerned, not to mention their demography, reproductive biology and other key attributes.

The above considerations reflects the current situation in forestry[9] whereby (1) commercial timber is increasingly obtained from intensively managed plantations of a small number of species, and (2) a relatively small forest area is devoted to enterprises such as agroforestry and urban forestry which play a small role commercially in global terms but are important nationally in poverty alleviation, in the provision of fuel wood, fruit trees, medicinal plants and other useful products, while (3) the vast bulk of forest is wild, natural or semi-natural and not managed. It follows that *in situ* conservation of all but a small number of target species is not likely to be undertaken by forest authorities. As the values that would be derived from any genetic management of those species (the vast majority) that are either of

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[6] Leopold (1933); see also Aplet & al. (1992).
[7] National Research Council (1991)
[8] Namkoong (1986)
[9] From literature and discussions with Pierre Sigaud (FAO)

marginal utilitarian value or have little or no commercial value are of such generalized and long-term interest, it is the general public that would be the primary beneficiaries. It has been suggested, therefore, that for the vast majority of species of no direct use we would have to look to international agencies such as IUCN for investment in *in situ* conservation programmes[10] although it would be unrealistic to expect any direct financial support from such quarters.

The view has been expressed[11] that *in situ* genetic conservation techniques are still in their infancy and that we are not methodologically well equipped to proceed with the genetic conservation of plant diversity in its natural surroundings. While this is to some extent true, this review will show that much information does exist which could be applied and it is widespread ignorance of what has been achieved for different groups of plants that is largely responsible for our present poor record of species-based *in situ* conservation.

In situ conservation of individual target species, whether of economic importance or not, of necessity involves various levels of biodiversity, from genes and alleles to populations, ecotypes, species, and ecosystems, landscapes and ecoregions. It requires a broad perspective and cooperation between specialists of many different disciplines and between many different agencies and is largely dependent on the close and active cooperation and participation of local stakeholders.

It needs to be emphasized that *in situ* conservation of target species in protected areas should be seen as one aspect of an overall strategy that may be required for the successful maintenance of the species and its genetic variability. It is increasingly recognized that biodiversity conservation whether of genes, species or ecosystems should be viewed in the context of a mosaic of land use options[12], each of which will require its own range of management options. Thus the conservation of target species may be undertaken in nature reserves and other protected areas; private and publicly owned natural forests and plantations and other types of habitat; as trees, shrubs and herbs in agroforestry systems of various types including home gardens; in homesteads; and along rivers and roads.

Various forms of *ex situ* conservation may also be needed to supplement the *in situ* action, such as conservation collections in arboreta and botanic gardens, properly sampled accessions seeds banks, clone banks, field trials and seed production areas[13].

Methodology

During the preparation of this review, contact has been made with international organizations, national organizations and individuals in many countries around the world (see Annex 1). A literature review was undertaken, including the country and regional reports prepared as part of the preparation of the FAO International Technical Conference on Plant Genetic Resources (Leipzig 1996) and the National Reports prepared by Parties to the Convention on Biological Diversity (under Article 6), and an Internet search was made of relevant information. Visits were made to FAO Rome, IPGRI Rome, the University of Córdoba Botanic Garden, Spain, and the University of Leiden Institute of Cultural and Social Studies Ethnosystems and Development Programme (LEAD), the Netherlands.

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[10] Namkoong (1986)
[11] Hawkes (1991); see also Maxted & al. (1997)
[12] Wilcox (1990, 1995)
[13] Palmberg-Lerche (2002)

It is emphasized that the perspective is global and that no attempt has been made to focus on the special requirements of the four countries, Egypt, Lebanon, Morocco and Turkey which are partners in the GEF PDF B project. On the other hand, it is hoped that the issues, examples, methodologies and guidelines referred to in the review will be of value to them in formulating their own policies. What is quite clear from the review is that the circumstances and requirements in each case of target species *in situ* conservation is unique and that there is no single set of procedures which can be applied.

Definition of *in situ* conservation

It is evident that a great amount of misunderstanding exists in the literature about what is meant by *in situ* conservation. It is defined by the Convention on Biological Diversity[14] as:

> **…the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties** **CBD (1992)**

In fact, the notion of *in situ* conservation, sometimes referred to as 'dynamic conservation', applies to a range of different situations:

1. **Conservation of natural or semi-natural ecosystems in various types of Protected Area,** with various management aims such as: maintaining ecosystem diversity; biodiversity in general; special landscapes; providing habitat for target species such as megavertebrates, birds, forest species, medicinal plants; concentrations of endemic species; etc.

2. **Conservation of agricultural biodiversity** (defined as 'the maintenance of the diversity present in and among populations of the many species used directly in agriculture, or used as sources of genes, in habitats where such diversity arose and continues to grow'[15]. This includes:

a. **Entire agroecosystems**, including immediately useful species (such as food crops, forages, and agro-forestry species), [as well as their wild and weedy relatives that may be growing in nearby areas– see 3].

b. **Maintenance of domesticates** such as landraces or local crop varieties in farmers' fields (often referred to as 'on-farm' conservation[16] or *in agro*[17] or *inter situ*[18])

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[14] CBD (1992) 2. Use of terms "*In-situ conservation*"
[15] Brown (1999)
[16] Maxted & al. (2002)
[17] Chauvet (1994)
[18] Blixt (1994); the term should be, correctly, *inter situs* (between sites); in fact the term *situs* (fourth declension masculine), according to Stearn (1973) means 'position occupied by an organ' while site in the sense of place is *locus* (second declension masculine) but the terms *in situ* and *ex situ* are entrenched in the literature.

3. **Conservation and maintenance of target species** in their natural habitats/ ecosystems through action or management plans. This is also known in the case of species of economic importance as 'genetic conservation' or 'genetic reserve conservation'[19] which has been defined as 'the location, management and monitoring of genetic diversity in natural wild populations within defined areas designated for active, long-term conservation'[20].

4. **Recovery programmes** for nationally or subnationally threatened, rare or endangered wild species (of economic importance or not)

5. **Habitat restoration**

The main concern of the GEF Project is on *in situ* conservation and maintenance of target species but with special emphasis on those of economic importance such as wild relatives of crops, medicinal and aromatic plants, forage species, timber trees, ornamentals, and species needed for restoration of populations or habitats.

The terms **genetic conservation or gene conservation** are sometimes applied to the conservation of crop or forest genetic resources and includes *in situ* gene conservation.[21]

In situ conservation thus covers a wide range of different activities and goals. The clear distinction between *in situ* and *ex situ* conservation traditionally recognized by conservationists (exemplified by protected areas and botanic gardens respectively) breaks down when applied to crop and forest genetic resources where a range of situations occurs, reflecting the complete spectrum between wild and completely domesticated species[22]. It has been suggested[23] that it would be better to distinguish between the different approaches according to their specific objectives. Thus it has been suggested that the term 'static conservation' could be used to substitute for *ex situ* conservation and 'dynamic conservation' for *in situ* conservation[24]. Another dimension that can be used is the extent of deliberate intervention needed to achieve a specific conservation objective[25].

Similarly, the distinction between species conservation *in situ* and ecosystem conservation is by no means clear cut as the two are interdependent. For example, the term '*circa situm*'[26] has been used, to refer to a type of conservation that emphasises the role of regenerating saplings in vegetation remnants in heavily modified or fragmented landscapes such as those of traditional agroforestry and farming systems[27]. Thus in the south of

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[19] The areas are also known as gene or genetic reserve management units, gene management zones, gene/genetic sanctuaries, and crop reservations (see pp.).
[20] Maxted & al. (1997b).
[21] Yanchuk (1997)
[22] Heywood (1999)
[23] See Bretting & Duvick (1997) for an extensive review of dynamic conservation of plant genetic resources. The term is however ambiguous in that it covers both the conservation of wild relatives of crops in their natural habitats and the creation of artificial populations that are grown on a large scale in farmers' fields or in experimental areas, which allow the various ongoing human and natural selection pressures to operate on them (Chauvet 1994)
[24] Bretting & Duvick (1997)
[25] T. Hodgkin (personal communication). See also Lleras (1991)
[26] Also referred to as *circum situm* and incorrectly as '*circum situ*'or '*circa situ*'. Cf. Footnote 15.
[27] Cooper & al. (1992); Barrance (1997, 1999)

Honduras, small farmers manage naturally regenerated trees of *Cordia alliodora*, *Gliciridia sepium* and *Leucaena salvadorensis* in their fields, pruning them as necessary to reduce competition with their local crops[28] . Trees may also be transplanted from native habitats and managed within an *in situ* on-farm system using traditional sylvicultural techniques. The material is effectively managed within traditional farming systems by local farmers. *Circa situm* has also been termed 'conservation though use'[29]

A focus on species conservation is readily comprehensible since most people find it easy to empathize with biodiversity immanent in species, especially if they are charismatic or flagship species. Moreover, such a focus may well serve both the interests of conservation and those who exploit species[30]. On the other hand, there is an increasing tendency to shift the focus away from species and view biodiversity conservation and sustainable use through the lens of the ecosystem with an emphasis on maintaining the healthy functioning of the system. In any event, it is obvious that effective conservation of target species cannot be achieved without protection of the habitats/ecosystems in which they occur.

In recent years, it has been increasingly recognized that because of the limitations of both species-based and ecosystem-based approaches and taking into account the dynamics of species and ecosystems and the effects of human action, **integrative** (holistic/complementary) methods for deciding conservation strategies should be adopted. Essentially this recognizes that one should adopt whatever scientific and social techniques or approaches, such as *in situ*, *ex situ*, *inter situs*, reintroduction, population reinforcement, that are judged appropriate to a particular case and circumstances. This approach has been endorsed by the CBD in its promotion of the 'Ecosystem Approach'[31] (see Box 1) in which what is essentially a holistic approach is adopted. Key distinguishing features of the Ecosystem Approach are[32]:

- it is designed to balance the three CBD objectives of conservation, sustainable use and equitable sharing of benefits
- it places people at the centre of biodiversity management
- it extends biodiversity management beyond protected areas while recognizing that
- they are also vital for delivery of the objectives of the CBD
- it engages the widest range of sectoral interests

Box 1: An Ecosystem approach

The ecosystem approach is a strategy for integrated management of land, water and living resources that promotes conservation and sustainable use of these resources in an equitable way –

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[28] Barrance (1997)
[29] Stewart (2001)
[30] Hutton & Leader-Williams (2003)
[31] the consistent use by the CBD of the formulation 'The ecosystem approach' is misleading as the Convention recognizes that there is no single way to implement it, depending on local, provincial, national, regional or global conditions. Moreover is also states that 'there are many ways in which ecosystem approaches may be used as the framework for delivering the objectives if the Convention in practice' (CBD/COP Decision V/6).
[32] Smith & Maltby (2003)

UNEP/CBD. This ultimate goal is to ensure that wildland diversity and ecosystems are maintained and will survive as biologically intact and functional as possible for generations to come. An ecosystem approach broadly evaluates how people's use of an ecosystem affects its functioning and productivity. Implementation of an ecosystem approach will require a new look at ways of integrating human activities with conservation goals. National Parks and Protected Areas will have fit within an overall strategy of landscape management that includes compatible human activities. An ecosystem approach has the following characteristics:

- *It is an integrated approach.* It considers the entire range of possible goods and services and attempts to optimize the mix of benefits for a given ecosystem and also across ecosystems.

- *An ecosystem approach reorients the boundaries that traditionally have defined our management of ecosystems.* It emphasizes a systemic approach, recognizing that ecosystems function as whole entities and need to be managed as such, not in pieces.

- *An ecosystem approach takes the long view.* It respects ecosystem processes at the micro level, but sees them in the larger frame of landscapes and decades, working across a variety of scales and time dimensions.

- *An ecosystem approach includes people.* It explicitly links human needs to the biological capacity of ecosystems to fulfil those needs. Although it is attentive to ecosystem processes and biological thresholds, it acknowledges an appropriate place for human modification of ecosystems.

- *An ecosystem approach maintains the productive potential of ecosystems.* An ecosystem approach is not focused on production alone but views production of goods and services as the natural product of a healthy ecosystem, not as an end in itself.

It presupposes that we know what values and functions we wish to maintain them in them. This poses a challenge since both ecosystems and their component species are dynamic and will change over time due to the processes of evolution which is indeed the raison d'être for their conservation.

Partly based on *World Resources 2000-2001. People and Ecosystems*, WRI. 2000

The ecosystem approach, although widely advocated, does have its critics[33], and there may be circumstances in which its adoption may not be fully compatible with particular conservation aims such as, specifically, the conservation and sustainable use of a target species. As a recent paper notes[34] '…the potential for future conflicts around sustainable use is alarming when, within an ecosystem approach it is quite possible to use a species sustainably within its biological limits, but for this to be deemed unsustainable in terms of ecosystem structure or function…'. This concern is highlighted when it comes to considering what management approach to adopt.

In a review of the ecosystem approach and biosphere reserves prepared by UNESCO[35], it is pointed out that an ecosystem approach does not preclude other management or conservation approaches such as single-species conservation programmes but could in fact integrate them.

[33] Hutton & Leader-Williams (2003)
[34] Hutton & Leader-Williams (2003)
[35] UNESCO (2000).

The distinction between an ecosystem approach and *in situ* approaches to conservation are[36]:

- there may be more human interventions in *in situ* approaches than in ecosystem approaches to conservation
- ecosystem approaches are more process- or function-orientated approaches than *in situ* approaches
- *in situ* conservation may be more species-specific and species-centred than ecosystem approaches
- *in situ* approaches are geographically more restricted than ecosystem-based approaches
- *ecosystems* approaches primarily conserve habitats, often with little if any knowledge of the genetic resources present in these habitats, whereas *in situ* approaches often target specific genetic resources

Target species

As already indicated, species conservation necessarily involves a selection process. This review is largely concerned with those plant species, that have been selected (targeted) for particular conservation attention or action and commonly known as target species (also known as candidate species).

The great bulk of the detailed literature that has been published on *in situ* conservation of species refers to nationally rare or endangered native species, irrespective of their actual or potential use, and extensive experience of conserving such species has been acquired in many countries. This target group is defined by solely by being threatened or endangered although as discussed below, this involves a complex series of selection procedures. This group of species constitutes by far the largest number of those for which *in situ* conservation projects or recovery plans have been planned or implemented.

On the other hand, most of the work on species of economic interest refers to three groups of target species: crop wild relatives, forestry tree species, and medicinal and aromatic plants As explained below, many factors can be taken into account in deciding on which of these species to select as targets (p.__).

Aims and purpose of *in situ* conservation of target species

The main general aim and long-term goal of *in situ* conservation of target species is to protect, manage and monitor the selected populations in their natural habitats so that the natural evolutionary processes can be maintained, thus allowing new variation to be generated in the gene pool that will allow the species to adapt to changing environmental conditions such as global warming, changed rainfall patterns, acid rain or habitat loss.

As noted below, the amount and type of phenotypic, chemical and genetic variation and the number of populations selected for *in situ* conservation will depend on the nature of the species and the objectives of gene conservation in any particular case. It is widely accepted

[36] Poulson (2001)

that it is desirable to conserve as wide a range of genetic and other variation as possible so as to ensure the maintenance and functioning of viable populations of the species concerned even in a changed environment, i.e. genetic adaptability.

On the other hand, many of the species that may be targeted for *in situ* conservation because of their economic use, are subject to exploitation and it should not be assumed that the conservation objective is simply to maintain the species so that they continue to evolve as natural viable populations. It may be that the emphasis will be more on sustaining the use itself for the benefit of the various stakeholders[37] and this will affect the management objectives. As a recent review of sustainable use and incentive-driven conservation notes[38], these could be the conservation of the species (or its populations), the ecosystem in which they occur, or the livelihoods that depend on the exploitation. The complexities involved in devising management systems for exploited species can be illustrated by a recent study of the palm açaí (*Euterpe oleracea* Mart.) harvested commercially for its palm hearts in the Amazon basin largely from natural stands.[39] Natural stands may be managed sustainably so as to maintain a steady supply of palm heart or to allow the fruit to be harvested as well as palm heart extraction but these have cost implications for the processes of extraction, processing and distribution which may not be acceptable. Different management practices will also affect biodiversity adversely to different degrees.

In situ conservation requires a focus on the biodiversity, dynamics and conservation of all components of the ecosystem and a recent review[40] warns that 'As long as genetic conservation and crop improvement are directly linked, any form of conservation will be judged by its short-term benefits to breeders, and in situ methods will attract considerable opposition. *However, on-site conservation is more plausible if these two goals are decoupled*, making biodiversity conservation an end in its own right'[my emphasis]. On the other hand, the same author reminds us that to fulfil their objectives, *in situ* conservation projects should be politically viable and share broad national development goals such as increased farm income. The involvement and acceptance by the local inhabitants, farmers, officials and other interested parties is crucial for the successful implementation of in situ conservation projects in most cases[41]. Setting aside large areas of land for the conservation of species whose economic potential is uncertain or cannot be easily perceived is difficult to justify and can be a serious constraint when selecting target species.

Other more practical or specific aims of *in situ* conservation that have been identified include:

- Ensuring continued access to these populations for research and availability of germplasm. For example, native tree species may be important plantation species within the country or elsewhere and thus *in situ* conservation will allow access to these forest genetic resources in the future if needed[42]

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[37] Freese (1997)
[38] Hutton & Leader-Williams (2003)
[39] Clay (1997)
[40] Damania (1994)
[41] Damania (1996)
[42] Rogers (2002)

- Ensuring continuing access to or availability of material of the target species populations that are exploited by local people, as in the case of medicinal plants, extractivism (e.g. rubber, palm hearts), fuel wood
- Selection for yield potential, i.e. genetic potential that confers desirable phenotypic traits[43], for example in forest trees, fruit or nut-producing trees[44]
- Conserving species which cannot be established or regenerated outside their natural habitats such as: species that are members of complex ecosystems e.g. tropical forests, where there is a high degree interdependency between species; species with recalcitrant seeds or with fugacious germination; or species with highly specialized breeding systems, dependent on e.g. specific pollinators which in turn depend on other ecosystem components [45]
- Enabling some degree of conservation of associated species which may or may not be of known economic value and which may be of importance in maintaining the healthy functioning of the ecosystem. This may provide additional justification for single-species conservation programmes

The international mandate

Global Plan of Action

The *Global Plan of Action* (GPA)[46] sets out a global strategy for the conservation and sustainable use of plant genetic resources for food and agriculture with an emphasis on productivity, sustainability and equity[47]. It complements the CBD (see below). It contains a specific recognition of the need to promote *in situ* conservation of wild crop relatives and wild plants for food production (Priority Activity Area 4: **Promoting *in situ* conservation of wild crop relatives and wild plants for food production**). The assessment it makes of this area is given in Box 2. Partly as a result of this there is now much more focus by many countries on the need to conserve target species of economic importance *in situ* as opposed to on-farm conservation of landraces with which *in situ* conservation was frequently identified by the genetic resources sector in the past.

Box 2: Assessment of *in situ* conservation of wild crop relatives and wild plants for food production)

Natural ecosystems hold important plant genetic resources for food and agriculture, including endemic and threatened wild crop relatives and wild plants for food production.

- Many are not managed sustainably.
- This genetic diversity, because of interactions which generate new biodiversity, is potentially an economically important component of natural ecosystems and cannot be maintained *ex situ*.
- Unique and particularly diverse populations of these genetic resources must be protected in situ when they are under threat.

[43] Hattemer (1997)
[44] Reid (1990)
[45] FAO (1989)
[46] Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. Adopted by the International Technical Conference on Plant Genetic Resources, Leipzig, Germany 17-23 June 1996. 1996. FAO, Rome.
[47]

- Most of the world's 8500 national parks and other protected areas, however, were established with little specific concern for the conservation of wild crop relatives and wild plants for food production.
- Management plans for protected and other areas are not usually broad enough to conserve genetic diversity for these species to complement other conservation approaches.

Source: FAO (1996)

The Convention on Biological Diversity

The *Convention on Biological Diversity* (CBD) treats *in situ* conservation of species upfront in the Preamble[48] and the relevant Article 8 of the CBD that refers to *in situ* conservation of species reads: [Each contracting Party shall, as far as possible and as appropriate:] '(d) Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings', yet curiously little attention appears to have been paid subsequently by SBSTTA or COP to the part referring to 'maintenance of viable populations of species in natural surroundings'

The Handbook of the CBD[49] in its consideration of Article 8(d) by the Conference of the Parties notes: 'Most consideration of this issue is implicitly included in the discussion of protected areas above [consideration of articles 8(a-c) by the COP]' but there is no mention specifically of species or populations there.

It is only recently that countries have been faced with a specific call to take action through the *Global Strategy for Plant Conservation*(GSPC)[50] which includes as Target 7: '60 per cent of the world's threatened species conserved *in situ*', to be achieved by 2010.

The rationale behind this is given as:

> '*Conserved in situ* is here understood to mean that populations of the species are effectively maintained in at least one protected area or through other in situ management measures. In some countries this figure has already been met, but it would require additional efforts in many countries. The target should be seen as a step towards the effective in situ conservation of all threatened species'. (CBD 2002)

It is clear from this and subsequent GSPC discussion documents[51] that the target requires considerable clarification and that perhaps too much emphasis has been given to the role of protected areas in meeting the target[52] and not enough to the actual mechanisms and

[48] '*Noting* that the fundamental requirement for the conservation of biological diversity is the *in-situ* conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings'.

[49] CBD Secretariat (2001).

[50] agreed by the CBD (CBD/COP Decision VI/9 2003)

[51] CBD (2002, a,b,c; 2003)

[52] The first published UK response to the GSPC, for example, includes under Target 7 the following statement: 'Many threatened species already occur on protected areas. It follows therefore that protected areas and habitat initiatives [described under targets 5 and 6] will help many species, but some will require more specific management'.

procedures of *in situ* conservation of species populations. An exception is the review of the scope, terminology, base-line information, technical and scientific rationale of the draft targets[53] which recognized for Target 7 that, amongst other requirements:

> '*in situ* information on these threatened species is needed. Few protected areas can produce a reliable inventory of either all plant species within the area, or just the threatened ones, and even less often information on numbers, genetic variability, population trends, and threats posed to these species. A concerted effort on producing this information is needed if threatened species are to be conserved *in situ*. Key information includes number and size of populations, the spatial distribution of populations, identification of important associates such as pollinators and seed dispersers, critical habitat identification, and trend information that can be related to environmental changes and patterns of disturbance'.

Target 7 also overlaps substantially with the second component of Target 8: '…10% of [threatened plants] included in recovery and restoration programmes', which necessarily deals with the population-related information mentioned above. The Target 8 Stakeholder Consultation Report notes that 'Through the implementation of coordinated restoration and recovery programmes, Target 8 can make a significant contribution to the implementation of Target 7'[54], although proposed actions for this target focus mostly on *ex situ* conservation[55].

There is also an overlap with Target 3: *Development of models with protocols for plant conservation and sustainable use, based on research and practical experience*, which is extraordinarily wide-ranging.

Apart from these considerations, the implementation of Target 7 hinges to a large extent on an interpretation of 'effectively maintained'. As a recent discussion of this Target, with reference to the United Kingdom[56], points out, we need to define what is meant by 'effectively maintained' and it suggests that 'in reality the successful protection of a threatened species in "at least one protected area" should represent the barest minimum that we should strive for. Instead, we should use this milestone as the starting point for a fuller programme of species recovery, so that Britain's rarest species are not confined to just a handful of reserves, but again becoming features of working landscapes'. But even this is questionable as *occurrence* within a Protected Area is by no means the same as *successful protection* and moreover, effective conservation *of a species* would require a proper ecogeographical survey to be undertaken and a survey of the extent and pattern of genetic variation within the species and its populations to allow an informed decision to be made about the number of individuals and the number of populations to be included to achieve this. It is therefore, perhaps misleading, as has been claimed, to suggest that the target is met by the UK (and other countries in a similarly fortunate situation of having a restricted flora but ample human and financial resources) and the first published UK response to the GSPC (JNCC 2004) in fact lists a series of ongoing actions, and high, medium and low priority additional work that is needed to meet the target.

[53] CBD (2002d)
[54] BGCI (2003)
[55] CBD (2003)
[56] Byfield (2003)

Furthermore, as is pointed out below, many protected areas, especially in developing countries, are not adequately managed or even secure. These issues are discussed further below (p.__)

It has been suggested by WRI[57] that for a national protected area system to effectively conserve biodiversity it must include:

- two or more large samples of each of the nation's ecosystem types (biogeographic provinces, Holdridge Life Zones, or other ecological classification systems);
- habitats containing viable populations of economically important genetic resources (wild relatives of industrial crops, vegetables, fruits, pharmaceutical plants, and traditional medicines, etc.);
- transition zones (ecotones) in all major ecosystem types across altitudinal, moisture, salinity, and other gradients in the landscape (mountain slopes, wet to dry ridges and valleys, marsh and estuary sites, coastal zones, etc.);
- a matrix of protected areas, corridors, and private land that ensures the survival of keystone species in the ecosystem; and,
- sites containing locally endemic species.

but the reality is very different, certainly as regards the criterion of containing viable populations of economically important genetic resources.

The reference to threatened species in the GSPC target 7 should be noted. The relevant article in the Convention does not restrict itself in this way but such a narrow focus is in line with most of the work on species conservation *in situ* that is undertaken by many countries, especially in the more developed ones, as is discussed below (Conservation of Endangered Species). The reference to threatened species echoes the emphasis given by many countries to preparing Red Books and Lists of threatened species and giving protection to these through various forms of action including habitat and species action, management or recovery plans.

In fact the target as a whole is far from clear: unlike the WRI criteria mentioned above (p.), it makes no mention of which kinds of species are to be included, such as those of economic importance, although the CBD itself does make reference in Article 7 (Identification and Monitoring) to the indicative list of categories given in Annex 1 which refers to: species which are threatened; crop wild relatives; species of social, economic, or cultural importance; or species of importance for the conservation and sustainable use of biological diversity, such as indicator species. Target 7 of the GSPC should therefore be interpreted in this context and its implementation should include species of economic importance.

Target 9 of the GSPC is that 70 percent of the genetic diversity of crops and other major socio-economically valuable plant species be conserved and associated indigenous and local knowledge maintained. It is clear that this will include *in situ* approaches so that close liaison with the activities envisaged under Target 7 will be needed.

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[57] http://www.wri.org/biodiv/b27-gbs.html

Convergence between the CBD and the GPA

A significant development that followed from the CBD and the GPA was the convergence of interest between bodies such as FAO and IPGRI and conservation and development organizations and agencies such UNESCO-MAB, IUCN, WWF and ITDG[58]. One the one hand, the CBD recognized that agricultural biodiversity is a focal area in view of its social and economic relevance and the prospects offered by sustainable agriculture for reducing the negative impacts of biological diversity, enhancing the value of biological diversity and linking conservation efforts with social and economic benefits. The COP has welcomed the GPA and the contribution that it makes to the implementation of the CBD. On the other hand, it is recognized by FAO and IPGRI that the Global Plan of Action covers a number of multidisciplinary areas such as *in situ* conservation of wild plants and crop relatives in natural ecosystems that extend the traditional activities of sustainable agriculture and plant genetic resource conservation and that successful implementation will require the development of new partnerships with a range of intergovernmental and non-governmental organizations as well as with indigenous and local communities.

Much of the CBD's work on agricultural biodiversity has been undertaken in cooperation with by FAO which plays a key role in the implementation of the CBD's **Decision III/11: Conservation and sustainable use of agricultural biological diversity** and its work programme by the Parties.

Regional and national mandates

In addition to the obligations that signatory countries have acquired under the CBD and GPA, in Europe there are regional mandates that include the protection of wild species and their habitats under the Bern Convention and the Habitats Directive of the European Union. The Council of Europe's Bern Convention[59] has a threefold objective: to conserve wild flora and fauna and their natural habitats; to promote co-operation between states; to give particular emphasis to endangered and vulnerable species, including endangered and vulnerable migratory species. It is also responsible for the European Network of Biogenetic Reserves, the Emerald Network, and the proposed Pan-European Ecological Network. 45 European (and some African States) as well as the European Community are parties to the convention while a number of other states, including Algeria, Belarus, Bosnia-Herzegovina, Cape Verde, the Holy See, San Marino and Russia attend the Standing Committee meetings as observers. The EU Habitats Directive[60] establishes a common framework for the conservation of natural habitats and of wild fauna and flora species and provides for the creation of a network of Special Areas of Conservation (SAC) called 'Natura 2000' to 'maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest'. The European Plant Conservation Strategy (EPCS)[61] developed by Planta Europa and the Council of Europe is intended to

[58] Heywood (2003)
[59] The Convention on the Conservation of European Wildlife and Natural Habitats, adopted in Bern on 19 September 1979 at the 3rd European Ministerial Conference on the Environment, came into force on 1 June 1982
[60] European Union Council Directive 92/43/EEC of 21 May 1992
[61] Planta Europa (2002)

provide a framework for wild plant conservation in Europe and contribute to the development of the CBD Global Strategy for Plant Conservation.

The role of UN and other International Agencies

In situ conservation of target species is included in the mandate of a number of UN and other international agencies or organizations:

Food and Agricultural Organization of the United Nations (FAO)

The Food and Agricultural Organization of the United Nations (FAO) provides a global, neutral forum for debate and discussion of all issues related to food, agriculture, forestry and fisheries. In the field of forest genetic resources, FAO provides technical and scientific support to countries, covering all aspects of the conservation, sustainable use and development of forest genetic resources; and facilitates the free exchange of information and know-how between nations. FAO's work falls into two broad categories: the Regular Programme, covering normative work, policy and planning, advice to member nations and internal operation; and the Field Programme, mainly consisting of projects, through which assistance is provided to member countries'.

- **FAO Agriculture**

In situ conservation of target species of economic importance has not been a major concern to FAO Agriculture although several initiatives have drawn attention to the need for such actions, such as the International Undertaking and the Commission on Plant Genetic Resources:

International Treaty on Plant Genetic Resources for Food and Agriculture. An International Undertaking on Plant Genetic Resources was adopted by the 22nd FAO Conference in October 1983. It recognized *in situ* conservation of plant genetic resources as an important component of its work. It also provided for the establishment of an FAO Commission on Plant Genetic Resources. Very little work in the area of *in situ* conservation resulted. After more than 10 years of negotiation, the Undertaking was replaced in November 2001 by the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA)[62]. The objectives of the Treaty are: the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of benefits derived from their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security[63].

The relevant activities of the IT PGRFA are (Article 5 – Conservation, Exploration, Collection, Characterization, Evaluation and Documentation of Plant Genetic Resources for Food and Agriculture):

[62] The Treaty will enter into force on 29 June 2004.
[63] ftp://ext-ftp.fao.org/ag/cgrfa/it/ITPGRe.pdf

(a) Survey and inventory plant genetic resources for food and agriculture, taking into account the status and degree of variation in existing populations, including those that are of potential use and, as feasible, assess any threats to them;

(d) Promote *in situ* conservation of wild crop relatives and wild plants for food production, including in protected areas, by supporting, *inter alia*, the efforts of indigenous and local communities;

(f) Monitor the maintenance of the viability, degree of variation, and the genetic integrity of collections of plant genetic resources for food and agriculture.

Commission on Genetic Resources for Food and Agriculture (CGRFA). The CGRFA reviews and advises FAO on policy, programmes and activities related to the conservation, sustainable use and equitable sharing of benefits derived from the utilisation of genetic resources of relevance to food and agriculture[64].

When dealing with the issue of *in situ* conservation, the FAO Commission on Plant Genetic Resources (later the Commission on Genetic Resources) expressed its concern at the lack of effort in this area and proposed a strengthening of work in the area. However, the Commission's work has been focused largely on *ex situ* conservation of crop plants and the only *in situ* conservation activities have been on the conservation of primitive cultivars/landraces on-farm.

The role of FAO in developing awareness of the need for *in situ* conservation of wild species (other than forestry) has been largely through the work undertaken and commissioned for the report on the State of the World's Plant Genetic Resources for Food and Agriculture prepared for the International Technical Conference[65] (Leipzig 1996). The preparatory process was country-driven and the Country and Regional Reports were major inputs into the process. An expanded version of the report was subsequently peer-reviewed and published by FAO in 1998[66]. Chapter 2 is entitled 'The state of *in situ* management'. A Second Report is under preparation and one of the studies being undertaken in preparation is on the conservation of crop wild relatives which will build on the GEF UNEP/IPGRI project on the conservation of wild crop relatives.

The Ecosystem Conservation Group (ECG) ad hoc Working Group on *in situ* Conservation of Plant Genetic Resources. The ECG established in 1974 brings together United Nations agencies such as UNESCO, UNEP, FAO, secretariats of biodiversity-related conventions and non-United Nations international institutions such as IPGRI and IUCN to advise its member organizations on the development and implementation of relevant ecosystems and genetic resources conservation activities and promote thematic joint programming. It established an *ad hoc* Working Group on *in situ* Conservation of Plant Genetic Resources which at its first meeting in 1986 reviewed on *in situ* conservation activities and needs, especially in the context of the FAO Commission on Plant Genetic Resources, the UNESCO Action Plan on Biosphere Reserves and the IUCN Bali Action

[64] http://www.fao.org/ag/cgrfa/default.htm
[65] FAO (1996)
[66] FAO (1998)

Plan. Its work plan included the preparation of an information document on *in situ* conservation and this was published in 1989[67]

A recent FAO document on International Plant Genetic Resources Networks[68] notes that *in situ* conservation is addressed by regional PGR networks and by the *in situ*-oriented networks such as the MAB world-wide network of Biosphere Reserves. It comments that in general linkages between such networks for *in situ* conservation are not obvious. It draws attention to the document *Progress Report on the development of a network of* in situ *conservation areas*[69] which reviews the Commission's considerations on *in situ* conservation.

- **FAO Forestry**

The FAO Forestry Department has played a major advocacy role over the past 25 years in developing awareness of the need for conservation of forest genetic resources *in situ* and has commissioned a series of reports on the subject[70] As early as 1980 it held an expert consultation jointly with UNEP on the *in situ* conservation of forest genetic resources[71].

For this review, the relevant FAO activities in various aspects of forest genetic resources under the Regular Programme are:

Conservation of genetic resources. FAO's policy on the conservation of forest genetic resources covers both in *situ* and *ex situ* (i.e. in conservation stands, genebanks, arboreta, botanic gardens etc.) and it has actively contributed to the elaboration of methodologies for both approaches. Since the early 1980s, *in situ* conservation has been emphasized. Collaboration with national institutes has continued in research and pilot activities, and in studies underpinning genetic conservation. Countries involved have included, among others, Bangladesh, Brazil, India, Mexico, Morocco, Myanmar, Peru, Senegal, Sri Lanka and Thailand. In collaboration with IPGRI, the DFSC (DANIDA Forest Seed Centre, Denmark) and other partners FAO is developing a practical guide on conservation of forest genetic resources, which will complement earlier documents related to conservation[72].

Gathering and dissemination of information. FAO publishes an annual bulletin *Forest Genetic Resources* (formerly Forest Genetic Resources information) in English, French and Spanish with a global distribution, also available on the Internet. In addition, FAO has continued developing the World-wide Information System on Forest Genetic Resources, REFORGEN , in close collaboration with national institutes and relevant international organizations. The system, which stores data on species and institutions, is intended to support policy and technical decisions for genetic conservation at national, regional and international levels.

[67] FAO (1989)
[68] FAO CGRFA-9/02/12; Kalaugher & Visser (2002).
[69] FAO CGRFA-9/02/13
[70] FAO/UNEP (1981, 1985, 1987), (1987, FAO (1968–1988;1985, 1987)
[71] FAO/UNEP (1981)
[72] FAO, DFSC, IPGRI (1991)

Integrated Strategies and Action plans. At the request of the 13th Session of the Committee on Forestry (1997), FAO is supporting country-driven processes for the elaboration of strategies and action-oriented plans on forest genetic resources at sub-regional and regional level. FAO joins forces with national and international partners to help organize regional workshops on the conservation, management, sustainable utilization and enhancement of forest genetic resources, aiming at reviewing the status and trends of the genetic resources of major and important tree and shrub species, and elaborating relevant programmes amenable to regional cooperation. The first of these workshops targeted the Sahelian sub-region of Africa and was held in Ouagadougou, Burkina Faso, in September 1998[73]. Similar workshops have been held in South Pacific Islands (Apia, Samoa 1999)[74] and Eastern and Southern Africa (SADC countries) in Arusha, Tanzania, June 2000[75], Central America (2002)[76] and Central Africa (Pointe Noire, Central African Republic, 2003).

Strategy. Following a recommendation of the 13th Session of the Committee of Forestry in 1997, and under the guidance of the FAO Panel of Experts on Forest Gene Resources, action has been taken to facilitate a series of regional forest genetic resources workshops, as a first step towards the development of regional plans of action. The overall goal of such sub-regional and regional action plans is to help countries ensure that forest genetic resources are conserved and sustainably utilized as a basis for local and national development, including economic and social advancement, food security, poverty alleviation, environmental conservation, and the maintenance of cultural and spiritual values. The immediate objective of the workshops is to help countries and regions to define priorities and requirements in the conservation, management and sustainable utilization of forest genetic resources. Regional Workshops have been held in Sahelian Africa, the Pacific Islands and Eastern and Southern Africa, Central America and Central Africa.

UNESCO

The main involvement of UNESCO in *in situ* conservation is through its programme on **Man and the Biosphere (MAB)**[77] and its system of **Biosphere Reserves**[78]. Since its inception in the early 1970s the conservation of natural areas and the genetic material they contain has been one of the component project areas of MAB. Several of the individual reserves are concerned with the conservation of target species *in situ* such as the Arganeraie MAB Biosphere Reserve, the Souss Valley, region of Agadir, Morocco where the endemic Argan tree (*Argania spinosa*) is of main conservation interest, and the Sierra de Manantlán, Biosphere Reserve, Mexico which houses a maize wild relative (*Zea diploperennis*) which is endemic to the area of the reserve. It was the discovery of the species in the mid-1970s that was a major stimulus to the subsequent denomination and designation in 1987 of Sierra de Manantlán as a biosphere reserve.

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[73] see FAO 2001a,b
[74] Sigaud & al. (1999); FAO 2001c.
[75] See FAO (2003a)
[76] See FAO (2003b)
[77] http://www.unesco.org/mab/about.htm
[78] http://www.unesco.org/mab/wnbr.htm, UNESCO (1992)

Other biosphere reserves that conserve target species include the Fenglin Biosphere Reserve in China which houses *Pinus koraiensis*, or the various biosphere reserves in the Russian Federation and Central Europe which conserve wild fruit-trees.

The Biosphere Reserve model with its emphasis on sustainable use and conservation of biological diversity, and for the improvement of the relationship between people and their environment is an important one to take into account when planning *in situ* conservation programmes. The operation of Biosphere Reserves is detailed in the *Seville Strategy for Biosphere Reserves*[79] which identifies the specific role of biosphere reserves in developing a new vision of the relationship between conservation and development.

UNESCO is a key player in the WWF-UNESCO-Kew **People and Plants Initiative**[80] which publishes the *The People and Plants Handbook*, a source of information on applying ethnobotany to conservation and community development (Issue No. 7 is *Growing Biodiversity: People and Plant Genetic Resources*).

The World Bank

The World Bank is involved in *in situ* conservation through various projects on medicinal plants (see below) and implicitly in its Forest Strategy[81]. As the Strategy notes, 'Bank client governments do not, by and large, wish to borrow funds for forest protection. The reality, therefore, is that, unless significant additional funds at highly concessional or grant terms blended from multiple sources can be made available for protection, or effective markets for the ecosystem values of forests developed, the problem is likely to worsen'.

The World Bank and WWF through the World Bank/WWF Alliance for sustainable forest conservation and use, are working together with governments, the private sector and civil society to achieve three targets by the year 2005: 125 million acres of new forest protected areas, 125 million acres of existing but highly threatened forest protected area to be secured under effective management, and 500 million hectares of the world's production forests under independently certified sustainable management.

Through the Critical Ecosystem Partnership Fund, another major effort is underway to support the protection and management of particularly important areas of biodiversity.
However, as it notes in the Bank's Forest Strategy 'if these efforts are to lead to protection across the board in remaining natural forests, and not only in selected areas, perceptions of Protected Areas that would give high priority to setting aside discrete wilderness areas and biodiversity reserves and excluding them from all forms of human use will have to evolve. There are signs that this change in perception is happening. It is now widely recognized that local communities and forest-fringe farmers can play a key role in biodiversity preservation. There is a trend towards a wider definition of Protected Areas that embraces the concepts of IUCN Category V[82]'.

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[79] http://www.unesco.org/mab/docs/Strategy.pdf
[80] http://www.rbgkew.org.uk/peopleplants/pdf/h7.pdf
[81] World Bank (2002).
[82] Phillips (2002)

IPGRI

The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization, operating under the aegis of the Consultative Group on International Agricultural Research (CGIAR). IPGRI's mandate is to advance the conservation and use of genetic diversity for the well-being of present and future generations. IPGRI's global goal to encourage conservation of natural ecosystems is long standing, but *in situ* conservation is a relatively new area for IPGRI.

Much of the past work of IPGRI has been on the conservation of crop genetic resources through *ex situ* techniques. As regards *in situ* conservation, the work of IPGRI has focused mainly on:

- Developing strategies and techniques such as ecogeographical surveying[83] and guidelines for collecting plant diversity[84]
- Strengthening the scientific basis of on-farm conservation of local landraces
- Conservation of useful wild species such as rattan and bamboo (with CIFOR)
- *In situ* conservation of forest genetic resources and management strategies

Recently it has expanded its scope into crop wild relatives and medicinal plants. Specific activities on crop wild relatives include:

- implementing a UNEP/GEF PDFB project '*In Situ* Conservation of Crop Wild Relatives Through Enhanced Information Management and Field Application'
- Producing an inventory of wild relatives of crop species in Bolivia, Sichuan and Paraguay
- Compiling internationally available information sources for the development of *in situ* conservation strategies for wild species useful for food and agriculture[85]
- Understanding the population structure, dynamics and genetic variability within and between populations
- Management of natural ecosystem including establishment of genetic reserves, ecological restoration and species recovery plans

In 1991, the CGIAR expanded its mandate to include forestry and agroforestry, with IPGRI's role covering forest ecosystems and genetic resources. Over the years, IPGRI, in close collaboration with relevant partners, has developed the basis for a comprehensive and coordinated research programme in this area.

The specific goal of IPGRI's FGR programme is to ensure the continuous availability of forest genetic resources for present and future use, through *in situ* and *ex situ* measures that allow species' adaptation and evolution to changing environments.

IPGRI's Forest Genetic Resources programme focuses on two major areas:

[83] IBPGR (1985)
[84] Guarino & al. (1955)
[85] Thormann & al. (1999)

- Strengthening institutional frameworks and contributing to international collaboration and policy making in conservation and use of forest genetic resources, and
- Generating knowledge and developing appropriate methods and tools for conservation and use of forest genetic resources

A major element of IPGRI's programme is increasing international collaboration through networking (see Annex 4). In most cases their programmes of activities do not at present involve *in situ* species conservation, although some involve on-farm conservation, but some of them recognize the need for such work. The EUFORGEN networks do address issues of forest genetic resource conservation including *in situ* strategies and some of the CIWANA networks also address conservation of wild species medicinal and aromatic plants. *In situ* conservation is the specific concern of the the ECP/GR *In situ* and On-farm Conservation Network which was established and became operational in May 2000 with a joint meeting, held in Isola Polvese, Italy, of two Task Forces for 'Wild Species Conservation in Genetic Reserves' and for 'On-farm Conservation and Management[86].

IUFRO

The international Union of Forest Research Organizations (IUFRO) is a non-profit, non-governmental and non-political body that unites more than 15 000 cooperating member scientists in over 700 member institutions in over 100 countries. Its mandate is to promote the coordination of and the international cooperation in scientific studies embracing the whole field of research related to forests and trees, and includes a

Task Force on Management and Conservation of Forest Gene Resources (FGR) whose terms of reference include the gathering and synthesis of scientific information on:

- scientific knowledge necessary for the conservation of FGRs: management of base and breeding populations, maintenance of representative diversity, including rare populations
- case studies on *in* and *ex situ* conservation
- interaction between human activity and integrity of FRGs: silviculture, forest operations, agroforestry, forest and landscape management, others
- effect of environmental factors on the integrity of FGRs: insect pests, diseases, air pollution.

IUCN – The World Conservation Union (IUCN)

The mission of IUCN is 'to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural

[86] Laliberté & al. (2000); further information on the network can be found at http://www.ecpgr.cgiar.org/Networks/Insitu_onfarm/insitu_onfarm.htm

resources is equitable and ecologically sustainable.'[87] As a union of states, Government agencies and NGO's, it undertakes a wide range of activities through its secretariat, commissions and regional offices. The parts of the Union that are most concerned with the topics of this review are summarized :

The **Species Survival Commission (SSC), w**ith more than 7000 members, advises the Union on the technical aspects of species conservation, and mobilizes action by the conservation community for conservation of species threatened with extinction and those important for human welfare (See Box 3). It has proposed a Plant Conservation Strategy 2000-2005 (see Annex 4) which includes *in situ* conservation activities. Relevant activities include:

Output 1.2: The SSC Plants Programme participates in projects on specific conservation issues, such as the conservation of wild plants of importance for food and agriculture and other selected economic plants, and the study and mitigation of major threats by providing inputs to the development and implementation of these projects.

Activity 6: The SSC Plants Programme collaborates in reviews and analyses of existing guidelines for *in situ* conservation of plants and their further development, utilising the experience gained from *in situ* research and management.

Activity 7: The SSC Plants Programme collaborates in projects on the conservation of wild relatives of crop plants, for example, in the development of a catalogue of wild relatives and the distribution and use of protected areas for their *in situ* conservation.

Activity 19: The SSC Plants Programme participates through the Medicinal Plants Specialist Group in inter-agency collaboration on the conservation and use of medicinal plants with particular reference to sustainable production, benefit sharing and community participation

Box 3: IUCN Species Survival Commission

The Species Survival Commission (SSC) of IUCN - The World Conservation Union is a science-based organisation, comprising 7,000 volunteer experts from a variety of fields. SSC offers to the conservation and development communities the knowledge and tools needed for sound decisions regarding ecosystems and the people who depend on them. SSC is a knowledge network of volunteer members who work in 179 countries around the world, through more than 110 Specialist Groups. On a volunteer basis, members convene workshops; undertake field projects; raise funds for and carry out research; publish Action Plans for the conservation of groups of species; provide scientific advice and services to conservation organisations, government agencies, and IUCN members; and support implementation of international treaties.

Source: http://www.iucn.org/themes/ssc/index.htm

The members of the 34 SSC Plant Specialist Groups cover a wide range of plants groups and geographical areas and undertake extensive work on the conservation of rare and endangered species. Several of these have produced Action Plans that include conservation strategies such as: palms[88], cycads[89], cacti and succulents[90], orchids[91] and conifers[92]

[87] http://www.iucn.org/about/index.htm#do
[88] Johnson (1996)
[89] Donaldson (2003)

The **IUCN World Commission on Protected Areas (WCPA)** consists of a global network of protected area specialists. Its objectives include:

- helping governments and others plan protected areas and integrate them into all sectors, through provision of strategic advice to policy makers;
- strengthening capacity and effectiveness of protected areas managers, through provision of guidance, tools and information and a vehicle for networking

It has set up a **Task Force on Management Effectiveness which is addressing two issues:** 1. the management of existing protected areas (are the existing protected areas effectively managed?); and 2. the location and design of new protected areas (will the protected area network represent and effectively retain regional and national biodiversity?).

It produces a series of **Best Practice Protected Area Guidelines**[93] and jointly with the IUCN/WWF/GTZ Forest Innovations Project I it held an international Workshop on Management Effectiveness of Protected Areas, June 14-16 1999 at CATIE, Turrialba, Costa Rica. A summary is given in a special issue of *Arborvitae* on 'Management Effectiveness of Protected Areas'[94] (2000).

The IUCN Commission Ecosystem Management (CEM) as part of a joint working group with the Society for Ecological Restoration International (SERI) has prepared a joint rationale on why ecological restoration is a critical tool for biodiversity conservation and sustainable development[95].

The IUCN Forest Conservation Programme (IUCN-FCP) has as its goal the maintenance and, where necessary, restoration of forest ecosystems to promote conservation and sustainable management of forests, and equitable distribution of a wide range of forest goods and services[96].

World Wide Fund for Nature (WWF)

The mission of WWF is threefold – conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable and promoting the reduction of pollution and wasteful consumption. Its endangered species programme does not have an *in situ* component and like its flagship species project is heavily biased towards animals. The International Plant Conservation Unit[97] is the main focus of plant conservation activities. Much of its work on plant species comes under the People and Plants Programme, a joint initiative of WWF-UK, UNESCO, and the Royal Botanic Gardens, Kew, aimed at promoting the sustainable use of plant resources, and the reconciliation of conservation and development, by focusing on the interface between people and the world of plants.

Management of forests for biodiversity conservation is included in its forest programme, and in its Mediterranean and European programmes.

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[90] Oldfield (1997)
[91] Hágsater & Dumont (1996)
[92] Farjon & Page (1999)
[93] http://www.iucn.org/bookstore/pro-areas-2.htm
[94] http://www.nrsm.uq.edu.au/wcpa/metf/docs/Arborvitae.pdf
[95] http://www.iucn.org/themes/cem/work/restoration/rest.htm#2
[96] http://www.iucn.org/themes/fcp/about/guide.html
[97] http://www.wwf.org.uk/filelibrary/pdf/plant_conservation_and_wwf.pdf

The WWF is an international network and runs more than 280 projects which contribute to plant conservation worldwide. Many of these are concerned with the conservation of habitats rich in plant diversity, rather than with the conservation of individual plant species. WWF-India and WWF-South Africa are among the WWF national organisations that are most involved in plant conservation.

Other GEF projects that involve *in situ* conservation of target species

Central America and Caribbean: Biodiversity Conservation and Integration of Traditional Knowledge on Medicinal Plants in National Primary Health Care Policy in Central America and Caribbean.

The project will contribute to the conservation and management of medicinal plants in globally significant ecoregions of Central America and the Caribbean. The primary focus of this project will be on forest ecosystems and indigenous and local knowledge. It aims to support the conservation and sustainable use of forest ecosystems in the region by identifying conservation and management needs of medicinal plants within key forest ecosystems, and integrating these issues into the broader management of selected forest ecosystems. Specific objectives are:

- to assess the conservation status and management needs of medicinal plants;
- to work with indigenous and local communities to develop appropriate management strategies; and
- to work with research institutions, NGO s, and national government agencies to integrate conservation and management of medicinal plants with rational use of traditional remedies in primary health care (PHC).

Egypt, Sinai: Conservation and Sustainable Use of Medicinal Plants in Arid and Semi-arid Ecosystems.

This will focus on the medicinal plants used by the Bedouin who live in St Catherine's Protectorate in Sinai, Egypt, and who have developed over the centuries, extensive knowledge of their uses. The project will include *in situ* conservation of target species, introduce small-scale community-based cultivation, processing and marketing to relieve pressure on wild sources, and protect community intellectual property rights[98].

Turkey: In situ *Conservation of Genetic Diversity in Turkey*

A major project on *in situ* conservation of agrobiodiversity in Turkey was initiated in 1993. The project was supported by the Global Environmental Facility (GEF) and conducted in collaboration with the Ministries of Agriculture and Rural Affairs, Forestry, and Environment of the Republic of Turkey. The goal of the project was to develop *in situ* gene

[98] Participatory approaches to biodiversity management and conservation in this region based on Bedouins' technologiesis included as one of the goals of the Sinai subglobal assessment of the Millennium Ecosystem Assessment (http://www.millenniumassessment.org/2/subglobal.sinai.aspx)

conservation programmes for target plant species selected from wild relatives of crop, fruit tree and globally important forest tree species in selected pilot sites[99].

Regional: Wild Relatives

GEF/UNEP Project 'In situ Conservation of Crop Wild Relatives through Improved Information Management & Field Application'. This PDFB project involving Armenia, Bolivia, Madagascar, Sri Lanka and Uzbekistan was successfully completed and the full project has been approved by the GEF Council and implementation arrangements are in hand (April 2004).

Ethiopia: Conservation and Sustainable Use of Medicinal Plants.

The project will include *in situ* conservation activities in the Bale Mountains massif, one of the most important conservation areas in Ethiopia

Regional: Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Syria and the Palestinian Authority

This project will promote the conservation of wild relatives and land races of important agricultural species in the Fertile Crescent (Near East region), by introducing and testing *in situ* and on-farm mechanisms and techniques to conserve and sustainably use agrobiodiversity. The project is divided into a regional component and four national components, one for each of the four participating countries: Jordan, Lebanon, the Palestinian Authority and Syria.

Jordan: Conservation of Medicinal and Herbal Plants Project.

This medicinal and herbal plant conservation project will support Jordan's capacity to sustainably manage the wild genetic resource base of these plants, diminish threats to the species, and identify and protect key biodiversity areas. The project will also establish an operational database, gene pool and monitoring system, improve the livelihood of rural communities, promote public awareness and environmental education on medicinal/herbal plants, and engage local communities in conservation, management and income generating programs. *In situ* conservation of these plants will take place at three pilot sites in Jordan. In addition, the project will establish a long-term plan for conserving and managing these plants, while strengthening the capacity of local and national institutions to meet the objectives of the conservation plan. An important element of this project will be the participation of women from local communities, who play a key role in conserving these ecosystems and in identifying curative and healing characteristics of plants.

Central Asia: 1. GEF/World Bank. Central Asia Transboundary Biodiversity Project in Kazakhstan, the Kyrgyz Republic, and Uzbekistan

This project will improve habitat management and species protection in the Protected Area Network of the West Tien Shan a mountain range shared by the three countries located on the western edge of the Himalayan Mountain system that includes wild relatives of horticultural, agricultural, and medicinal plants.

[99] Tan & Tan (2002)

2. *In Situ*/On-farm Conservation of Agrobiodiversity (Horticultural Crops and Wild Fruit Species) in Central Asia

Many wild fruit species grow in the forests of this region. They are valuable genetic resources for food crops because of their resistance to insects, disease and their wild adaptation. Examples are pistachio (*Pistacia vera*) and walnut (*Juglans regia*) which are valuable not only as a source of fruit genetic resources but provide food for local people. Wild apple (*Malus* spp.), wild pear (*Pyrus* spp), wild plum (*Prunus* spp.), wild almond (*Amygdalus* spp), wild pomegranate (*Punica granatum*), wild grape (*Vitis* sp.) and other relatives of fruit trees are also found in forests in the region. Most of these wild relatives are utilized as rootstocks. There are also relatives of other fruits like wild hawthorn (*Crataegus* spp.) and wild barberry (*Berberis vulgaris*).

To counter the genetic erosion of this wild genetic diversity of native fruit species that has taken place over the years, Central Asian states have established about 15 forest reserves where wild fruit species are preserved in accordance with State legislation.

Peru. *In-Situ* Conservation of Native Cultivars and Their Wild Relatives

This project will target 11 important crop species, including several local varieties and wild relatives, for conservation of their genetic diversity within functioning agroecosystems.

Genetically important areas (micro gene centres) or ‘hot spots’ based on the following criteria were selected according to the following criteria:
a) Presence of a significantly large number of native varieties of one or more of the 11 target species.
b) Species endemism.
c) Existence of conservation-oriented farmers or communities that manage a number of species and varieties.
d) Presence of traditional agricultural systems.
e) Include diverse agroecological zones.
f) Some traditional form of seed exchange through ‘seed routes’.

Sri Lanka. Conservation and Sustainable Use of Medicinal Plants.

The Project will design and implement a medicinal plants conservation program. For five botanical reserves where medicinal plants are collected from the wild, it will support baseline research, monitoring, conservation planning, community organizing, enrichment plantings, research on traditional medicinal plant knowledge, sustainable economic activities relating to medicinal plants or taking pressures off wild resources, improved marketing of such plants, and education.

Vietnam. *In-situ* Conservation of Native Landraces and their Wild Relatives in Vietnam.

The project covers conservation of six important crop groups (rice, taro, tea, litchi-longan, citrus and ride bean) including native landraces and wild relatives in three local ecogeographical areas: the northern mountains, the northern midlands, and the north-west mountains of Vietnam.

Zimbabwe: Conservation and Sustainable Use of Traditional Medicinal Plants in Zimbabwe

The Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) is an approach to development and conservation in Zimbabwe[100]. The essence of the CAMPFIRE approach is that it gives the some ownership, control and benefits of wildlife to the local community rather than central control. The concept includes all natural resources, although the focus has been upon wildlife management in communal areas, particularly those adjacent to National Parks, where people have to live with the costs of having wildlife in the area. Under the GEF project, it will be adapted to the conservation of medicinal plants in four districts where CAMPFIRE is already operational. Floristic surveys will be conducted to establish the distribution of endemic medicinal plant species and degree of threat in the pilot areas. Local communities, through their traditional leaders, will be encouraged to map out no-use zones, corridors, and buffer zones in areas that are rich in the threatened medicinal plants, using physical barriers, and to formulate local bye-laws that regulate the use of the areas where endangered medicinal plants are particularly over-exploited. In these areas, sites may be chosen for enrichment planting of appropriate medicinal plants by the local people, using seed from non-degraded areas. This component will also promote the adoption of a benefit sharing mechanism for plants on common property (through CAMPFIRE principles). The adoption of a CAMPFIRE approach to benefit sharing will ensure that local communities are sufficiently motivated to participate in the activities.

II. A global survey of current *in situ* conservation activities, projects and programmes

Introduction

A survey of the extensive literature on *in situ* conservation of species, of the data collected in the process of country reporting during preparations for the International Technical Conference on Plant Genetic Resources, and reviewed in the *State of the World's Plant Genetic Resources for Food and Agriculture*[101], and the National Biodiversity Actions Plans and Strategies and National Reports prepared by Parties to the Convention on Biological Diversity (under Article 6) has revealed that:

- Only a small number of countries have active programmes that address the conservation of selected groups of target species such as forest tree species, medicinal and aromatic plants, fruit trees or crop wild relatives.

[100] See the Wildlife and Development series of articles at: http://wildnetafrica.co.za/bushcraft/articles/document_campfire1.html
[101] FAO (1998)

- Another larger group of countries have undertaken preliminary steps such as inventory, ecogeographical surveying of some target species[102] but have not yet implemented conservation actions.

- In many countries, *in situ* conservation activities are largely concerned with ecosystem conservation and protected areas, and only exceptionally with target species. For example, in East Africa, to quote from the Sub-Regional Synthesis Report for the FAO International Technical Conference on Plant Genetic Resources[103],

  ‘the conservation of genetic resources in situ has been primarily in the form of habitats and ecosytems conservation (Appendix 8). The in situ conservation and related programmes, projects and activities are diverse in nature and they include indigenous forest conservation and management programmes e.g. COMIFOR and KIFCON in Kenya; inventories of threatened habitats, in situ conservation sites and species e.g. in Kenya and Uganda; establishment and management of national parks and protected areas (Uganda, Ethiopia, Rwanda and Burundi); in situ conservation education and awareness creation (Uganda, Kenya, Ethiopia, Rwanda) and in situ conservation of wetlands plant species (Kenya, Uganda, Sudan). Many of these projects have benefited from financial and technical support from such international NGOs as IUCN, WWF, African Wildlife Foundation (AWF)and World Conservation International (WCI). There are also a number of programmes for in-situ conservation in the National Forestry Action plans in Kenya and Ethiopia. Natural forests management and conservation programmes and projects exist in all the countries in the region’.

- Many countries recognize the importance of *in situ* conservation and have identified the kinds of actions that are needed as in the case of Vietnam[104]; others have no specific plans to take action. For example, the USA Country Report to the FAO International Technical Conference on Plant Genetic Resources notes ‘At the present time, *in situ* conservation of wild crop relatives occurs fortuitously, for the most part, on protected lands and other wilderness areas. … Greater efforts need to be made to promote *in situ* conservation of native crop genetic resources within the USA. The land management agencies in the USA should be alerted to the presence of wild crop genetic resources on their lands so that management of these lands can preserve these resources’. A report on neglected and underutilized species of Cyprus notes that ‘Wild relatives of crops such as *Hordeum* spp., *Aegilops* spp., *Vicia* spp., *Avena* spp., *Lathyrus* spp. and others are found in abundance in Cyprus. However, no direct measures have been taken yet for protecting them in their natural habitats…’[105]

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[102] For example, in the case of *in situ*-related work on wild potato relatives in the USA, undertaken by the USDA Agricultural Research Service, for the past decade, ‘the approach has been to begin with thorough documentation and sampling of the existing populations, trying to understand their genetic structure, reproduction and what might threaten their diversity in the wild and genebank. We have taken no active steps for protection, although we have thought a lot about what factors would make a site high priority for such work’ (John Bamberg to VHH, 27 May 2003 by email).
[103] FAO (1995)
[104] Ngyyen Hoang Nghia (2003)
[105] Della (1999)

- Frequently in the literature, attention is drawn to the need for *in situ* conservation of particular target species but action is planned for the future (cf. the important medicinal rhizomatous herb *Podophyllum hexandrum* from Garhwal Himalaya, India which reported to be in need of immediate action[106]; *Prinsepia utilis* Royle, a wild edible shrub of the higher Himalayas, India[107]; and ecotypes of grasses and fodder crops and some fruit trees in Czechoslovakia[108]

- Some countries draw attention to the lack of understanding of the principles and methodology of *in situ* conservation, especially of target species, and on issues such as effective population sizes, recommended sizes and areas of *in situ* sites[109]

- Many countries do not recognize *in situ* conservation as an issue and make no reference to it in National Reports

- On the other hand, many countries, especially in the developed world, have devoted very considerable efforts to the management, maintenance and recovery of rare or endangered species (see below)

- As far as can be determined no single country has an integrated policy for *in situ* conservation of wild species that covers rare and endangered (Red List) species and those of importance in agriculture and forestry, although the Institute of Biodiversity Conservation and Research in Ethiopia[110], covers plant genetic resources (including field crops, pasture and forage, horticultural crops, medicinal plants and forest genetic resources), ecosystem conservation and ethnobiology Even for those countries that do have a range of ongoing species-orientated conservation programmes, none of them has a mechanism that covers all groups of species

- A major constraint that affects the prosecution of species-orientated *in situ* activities is the range of disciplines involved, requiring a considerable amount of inter-agency cooperation. Even agencies within the same Ministries often do not have mechanisms for such joint action or it may be difficult to reach agreement because of their different mandates. Cooperation between ministries can be even more difficult and these are issues that have to be addressed at a national planning level. Even planning to work within Protected Areas can lead to problems or lack of full cooperation

- The literature review and consultations make it quite clear that most effort on *in situ* conservation has been focused on two main groups of plants – (1) **rare and**

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[106] Bhadula & al. (1996)
[107] Maikhuri & al. (1994)
[108] 'Also "*in situ*" conservation in few valuable selected localities is planned, on the base of systematic mapping of the Czech territory. Ecotypes of grasses and fodder crops as well as some fruit trees will be the target materials. In some cases these genetic resources are located in protected areas and "*in situ* " conservation is actually provided by existing national authorities (e.g. in the national parks Sumava or Krkonose)', Dotlacil (2001)
[109] FAO (1995)
[110] http://www.telecom.net.et/~ibcr/index.htm

endangered wild species and (2) **forest trees**. In addition, substantial work has been initiated recently on crop wild relatives and on medicinal and aromatic plants. Also, there is a body of work on fruit trees and shrubs and on various types of plants of economic importance including coffee, rattans, potatoes, multipurpose trees, onions, ornamentals, forages, etc.

Regional level activities

As regards forest trees, the European Forest Genetic Resources Programme (EUFORGEN) was established in 1994 following the recommendation of the Ministerial Conference on the Protection of Forests in Europe in Helsinki (1993). The main tasks of EUFORGEN are to coordinate and promote the *in situ* and *ex situ* conservation of forest genetic resources in Europe and the exchange of expertise and information. The Programme is coordinated by IPGRI.

IPGRI has developed a series of networks in different regions of the world and some of these engage in *in situ* conservation activities[111] (see Annex 3). In these and other such networks, the focus is often almost entirely on plantation forestry or agroforestry while management of genetic resources in natural forests has received little networking attention. The ECP/GR In situ and On-farm Conservation Network, mentioned above deals specifically with the preparation of guidelines for the *in situ* conservation of plant genetic resources.

In the South Pacific Region, a forestry network exists for a number of island states, namely South Pacific Regional Initiative on Forest Genetic Resources (SPRIG). Funded by the Australian Agency for International Development (AusAID), the network with practical aspects of forest and tree management and an important goal is to develop strategies for the conservation and sustainable management of priority species[112]. Ten priority indigenous trees have been selected for conservation strategies, three of which have already been prepared (*Agathis silbae* and *Endospermum medullosum* in Vanuatu and *Dacrydium nausoriense* in Fiji). A strategic plan for Heilala (*Garcinia sessilis*), the national tree of Tonga has also been prepared.

National level activities

At a national level, the level of activity that involves *in situ* conservation of species varies enormously from country to country. With the exception of work on medicinal plants reported elsewhere in this review, there is little organized or structured *in situ* conservation activity targeted at plant species in most developing countries. On the other hand, a great amount of activity and projects are reported in the more developed countries. The following examples are by way of illustration and are chosen because of the range of activities involved:

[111] http://www.ipgri.cgiar.org/catalogue/theme.asp?theme=5
[112] Thomson (1998)

Australia: the conservation of threatened plant (and animal) species *in situ* is covered by the Australian *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides for:

- identification and listing of Threatened Species and Threatened Ecological Communities;
- development of Recovery Plans for listed species and ecological communities;
- recognition of Key Threatening Processes; and where appropriate
- reducing these processes through Threat Abatement Plans.

All States have had involvement in the preparation and implementation of recovery plans, often in cooperation with the Commonwealth's Endangered Species Program.

Several hundred species are included in recovery plans that have been adopted, are under review or in preparation[113]. These include a wide range of species – herbs, shrubs, and trees – and ecological communities such as threatened species-rich shrublands. There are 39 plant species with management, monitoring or recovery plans in South Australia (as at September 2000)[114].

The Australian Network for Plant Conservation (ANPC) has as its major aim the integration of all approaches to plant conservation. Membership of the Network includes botanic gardens, conservation agencies, mining companies, community groups (Landcare, Society for Growing Australian Plants), researchers, local government, power authorities and farmers. The conservation of agricultural and forestry species is undertaken by the CSIRO which also has a programme of work that concentrates in the main issued described in the goals of the National Strategy for the Conservation of Australia's Biodiversity.

USA: the conservation of endangered species is dealt with by a number of Federal programmes such as the US Fish & Wildlife Service, the Endangered Species Act and the Bureau of Land Management, and by a large number of programmes at State level (see below). In addition, The Nature Conservancy[115], whose mission is to 'preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive', plays a major role in the long-term conservation of biodiversity in the United States through land acquisition, public land management and conservation funding (including debt for nature swaps).

The Plant Conservation Alliance (PCA) is a consortium of ten federal government Member agencies and over 145 non-federal Cooperators representing various disciplines within the conservation field: biologists, botanists, habitat preservationists, horticulturists, resources management consultants, soil scientists, special interest clubs, non-profit organizations, concerned citizens, nature lovers, and gardeners who work collectively to solve the problems of native plant extinction and native habitat restoration, ensuring the preservation of the ecosystems of the USA (see discussion below).

[113] a list can be found at http://www.deh.gov.au/biodiversity/threatened/recovery/index.html
[114] see: http://www.environment.sa.gov.au/reporting/biodiversity/pdfs/recovery_plans.pdf
[115] see http://nature.org/

There are 28 State Wild Flower Societies which undertake a wide range of conservation or conservation-related activities.

The Center for Plant Conservation[116] also plays a key role in conserving and recovering endangered native species through research, germplasm conservation and restoration of threatened species though its network of 34 botanic gardens, arboreta and other centres. It holds a national collection of endangered plants part of which is maintained by the USDA's National Center for Genetic Resources Preservation. Several CPC member institutions are also involved in restoration projects, and efforts are being made to stabilize current populations of threatened plants and reintroduce new populations into appropriate habitats.

Responsibility for the collection and preservation of genetic resources of crop species and their wild relatives is the responsibility of the U.S Department of Agriculture through its various agencies and stations while forest genetic resources are the responsibility of the USDA's Forest Service and State Programs although the country does not have an overall strategy for the conservation of forest genetic resources or a national program for long-term conservation of forest germplasm *ex situ*.

France: Based on preliminary work undertaken by INRA, CEMAGREF and ONF, the Ministry of Agriculture initiated a national policy for *in situ* conservation of main forest trees in 1991.

The *Bureau des Ressources Génétiques*[117] (BRG) is a governmental organisation created to develop and conduct national policy on animal, plant and micro-organisms genetic resources, allowing the various stakeholders involved to consult each other and for collecting the expertise needed in this field at the national and international level.

It combines within one scientific body the following organisations: the Ministry for Research, the Ministry of Industry, the Ministry of Agriculture, the Ministry of the Environment, the Ministry Overseas Territories, the Ministry of Cooperation, the *Institut National de la Recherche Agronomique* (INRA), the *Muséum National d'Histoire Naturelle* (MNHN), the *Centre National de la Recherche Scientifique* (CNRS), the *Institut de Recherche pour le Développement* (IRD), the *Centre de Coopération Internationale en Recherche Agronomique pour le Développement* (CIRAD) and the *Groupe d'Etude et de Contrôle des Variétés et des Semences* (GEVES).

Work on *in situ* conservation of plant genetic resources includes crop wild relatives and forest genetic resources.

Conservatoires Botaniques nationaux. A novel approach has been taken by the French Ministry of the Environment to the conservation of rare and endangered plants through the creation since 1988 of a system of Conservatoires Botaniques Nationaux[118]. There are eight in mainland France and one in the island of Réunion.

The Conservatoires have an agreement with the Ministry under which they are responsible for:

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116 http://www.mobot.org/CPC/
117 http://www.brg.prd.fr/brg/ecrans/vegetalesPi_An.htm
118 http://www.mnhn.fr/mnhn/chm/fr/3cons/acteurs/CBN.htm

1. Obtaining detailed knowledge of the local flora and habitats of the region for which they are responsible;

2. Conservation by all appropriate means of the species identified as threatened – in their natural habitats (*in situ*) and by cultivating them or building up stocks of seed (*ex situ*);

3. Developing information systems and public education to encourage respect for the country's plant heritage

Rare and endangered species programmes

Globally, a large part of the effort that has gone into *in situ* conservation of species has been directed at rare and endangered species through rescue or recovery programmes and a very considerable literature on theoretical and methodological considerations has been published, much of it under the heading 'conservation biology'[119]. Most of these species are not of known economic importance and the main criterion that led to their selection was their state of endangerment, most of them occurring in national, regional or local Red Lists or Red Data Books or similar documents. On the other hand it should be noted that it has been suggested that a majority of rare US plant taxa are congeners of species of economic significance in agriculture, forestry, industry, pharmaceutics or horticulture[120]. An example is *Zizania texana* a near relative of commercial wild rice which was once a troublesome weed of irrigation ditches and now reduced to a single population and the subject of a recovery plan[121].

Many countries have produced National Red Lists or Red Data Books although they are more common in temperate zones – most European countries, for example, have produced Red Data Books – and they are usually a valuable source of information for *in situ* conservation, containing distributional and ecological data and information of the degree and nature of the threats.

Lists of endangered species are critical foci of conservation attention and receive special attention in priority-devising systems for conservation, whether at national or international level. The various editions of the *IUCN Red List of Threatened Species* [122] constitute the only available global factual summary of threatened species, although seriously incomplete in their coverage, and serve as an indicator of likely species' loss.

At a national level, inclusion on an endangered list can have important consequences as in the United States where the Endangered Species Act (ESA) affords immediate protection to areas known to hold populations of endangered species (see below).

In the United States, the management and conservation of rare and endangered species is enormously complex with responsibilities and legislation at both Federal and State level. In

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[119] e.g. Falk & Holsinger (1991); Soulé (1986, 1987); Fiedler & al. (1992); numerous articles in *Conservation Biology* and *Biological Conservation*

[120] Falk (1991)

[121] U.S. Fish and Wildlife Service (1995); see also the corresponding CPC Plant Profile: http://ridgwaydb.mobot.org/cpcweb/CPC_ViewProfile.asp?CPCNum=4456

[122] IUCN (2002); see also http://www.iucn.org/themes/ssc/redlists/rlindex.htm

California, for example, the management of the State's rare plants has been described as under 'a tangled web of laws, regulations, policies and agencies'[123]. Thus lands under federal management, or projects under federal control, are subject to laws that include the Federal Clean Water Act, National Forest Management Act, the National Environmental Policy Act and the Federal Endangered Species Act. The landmark Endangered Species Act is also complex and controversial and a useful summary has recently been published in *Plant Talk*[124]

The *USA Bureau of Land Management*'s (BLM) Threatened and Endangered Species Management Activity addresses the conservation and protection of plants and animals that are listed, proposed for listing, or candidates for listing under the Endangered Species Act (ESA), as well as species designated by the BLM as 'sensitive'.

BLM public lands support at least 306 Federally listed species (171 Federal endangered, 114 Federal threatened, 13 proposed endangered, and 8 proposed threatened), 59 Federal candidate species, and an additional 1,500 BLM sensitive species. Collectively termed special status species, these occur over significant portions of the 264 million acres of public land managed by the BLM.

The BLM carries out programmes for threatened, endangered, proposed, and candidate species and the ecosystems upon which they depend with the ultimate goal of bringing these species and their habitats to a point where the protective provisions of the ESA are no longer necessary. Section 102(a)(8) of the Federal Land Policy and Management Act requires the BLM to manage the public lands in a manner that protects resource values (such as scientific, historical, ecological, and scenic) while allowing appropriate land uses. This Activity funds inventory and monitoring of special status species populations; development of recovery plans (see below p.__) and conservation strategies; implementation of recovery plan actions and conservation strategies; and restoration.

Under Section 4 of the US Federal Endangered Species Act, the Fish & Wildlife Service is directed to develop recovery plans for all listed species. Several hundred of the Listed Species and Populations have Recovery Plans as of 5 May 2003[125] but there is no legal requirement that the plans be implemented. In fact shortage of budgetary resources means that for many species, the recovery plans often gather dust[126]. These should not be confused with Habitat Conservation Plans which are tools to resolve conflicts between land developers and species conservation. They are 'regulatory and legal documents, not biological documents'[127] and have been the subject of considerable controversy since their introduction (see p.).

Numerous programmes exist for the *in situ* conservation of rare and endangered species in various countries in Europe. These programmes may be at a national or subnational level, an example of the latter being the United Kingdom, where there are separate arrangements for England, Scotland, Northern Ireland and Wales.

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[123] Roberson (2001)
[124] Villa-Lobos (2003)
[125] http://ecos.fws.gov/tess_public/TESSWebpageRecovery?sort=1#Q
[126] Roberson (2001)
[127] Moser (2000)

In Spain responsibility has been devolved to the autonomous governments (autonomías) and programmes for the conservation of threatened species are well developed. For example, in the Autonomous Community of Andalucía where a large part of the threatened flora is officially protected[128], recovery plans or programmes have been made for 50 endangered or vulnerable species. In the Autonomous Community of Valencia, an extensive series of programmes are in place for the conservation of the flora including *in situ* actions such as a network of microreserves[129] (see p.); a similar situation obtains in the Balearic Islands[130], and in the Canary Islands where over 20 species are the subject of recovery plans within the well developed protected area system[131]. The *in situ* activities form part of integrated conservation programmes in which botanic gardens such as those of Córdoba, Las Palmas, Sóller, and Valencia play a major role.

At a regional European level, the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention)[132] is a binding international legal instrument. Its aims are to conserve wild flora and fauna especially, endangered and vulnerable species, and their natural habitats and to promote European co-operation in that field. In Recommendation n° 30 (1991) on conservation of species in Appendix I to the Convention, paragraph No. 4 reads 'as a matter of urgency, formulate and implement conservation or recovery plans for endangered and, if necessary, vulnerable species listed in Appendix I, giving priority to *in situ* conservation action'.

The Habitats Directive of the European Union[133] has as its central aim conservation of biodiversity across the area of the Community. Under the Directive, Member States have a responsibility to preserve habitats and species of Community interest and to identify and designate, as Special Areas of Conservation (SAC), sites which are important for the protection of the species and habitats covered by the Directive.

In addition, the European Union recognizes 'priority species of Community interest' (Council Directive 92/43/EEC, Annex II) and an example of a conservation action programme, under the Life-Nature Project LIFE99 NAT/IT/006217, is 'EOLIFE99' which addresses the conservation of such priority plant species in the Aeolian Islands (Sicily, Italy)[134]: *Cytisus aeolicus* Guss. (*Fabaceae*), a small tree endemic of the Aeolian Islands; *Bassia saxicola* (Guss.) A.J. Scott (*Chenopodiaceae*), whose known populations occur only in three small islands in the Thyrrhenian Sea; *Silene hicesiae* Brullo & Signorello (*Caryophyllaceae*) described on plants from Panarea and recently reported for Alicudi and one site in Sicily; *Ophrys lunulata* Parl. (*Orchidaceae*), an endemic orchid occurring in Sicily too. All of them have numerically small populations with very narrow distributions and high biological value, whose loss would cause (in one case at least) the global extinction of the species. The project aims at ensuring the survival of the four target species through *in situ* (gathering field data) and *ex situ* actions (establishment of seed banks, propagation with the aid of biotechnology, cultivation), and 'pilot' re-introductions to re-enforce natural populations, reducing the risks linked to direct or indirect human activities.

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128 Hernández Bermejo & Clemente Muñoz (2001)
129 Laguna (2001a)
130 Gradaille (2001)
131 Bañares & al. (2001);Garcia (2001)
132 http://www.nature.coe.int/english/cadres/bern.htm
133 EU Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora.
134 http://web.tiscali.it/no-redirect-tiscali/ecogestioni/eolife/summauk.html

On the whole, they are complementary actions external to the sites where the target populations occur; all of these sites were proposed as 'SCI' (Sites of Community Interest) and most of them are included in Protected Areas (Regional Natural Reserves).

Medicinal and aromatic plants (MAPs)

Since the publication of the Chiang Mai Declaration[135], issued by the WHO/IUCN/WWF Consultation on the Conservation of Medicinal Plants, drawing the attention of the United Nations, its agencies and Member States, other international agencies and their members and non-governmental organisations to the vital importance of medicinal plants in health care and of the need to take the necessary steps to ensure their continuing availability, there has been a considerable increase in initiatives aimed at the conservation of medicinal and aromatic plants both *in situ* and *ex situ*. The International Council for Medicinal and Aromatic Plants (ICMAP)[136] which is a scientific activity of IUBS was established in 1993 with the general objective as promoting international understanding and cooperation between national and international organizations on the role of medicinal and aromatic plants in science, medicine and industry, and to improve the exchange of information between them. Its activities include the promotion of conservation of genetic resources both *in situ* and *ex situ* of medicinal and aromatic plants species. The Species Survival Commission of IUCN created in 1994 a Medicinal Plants Specialist Group (MPSG)[137] which is a global network of experts contributing within their own institutions and in their own regions to the conservation and sustainable use of medicinal plants. Its programme includes the following objectives:

- To identify priority medicinal plant taxa and habitats threatened by non-sustainable harvest, high levels of trade, environmental degradation, and other factors contributing to loss of species and genetic diversity;

- To work with local, regional, national, and global partners to design and implement conservation action plans for priority medicinal plant taxa and habitats;

- To support the development of tools and methods needed for a coordinated effort on medicinal plant conservation at all relevant levels, such as data management systems, research methods and guidelines, and basic research, monitoring, and networking tools (bibliographies, directories, etc.).

Examples of programmes or projects that have been instituted at a national level are the following:

USA: To address growing concerns for medicinal plant conservation the US Fish & Wildlife Service helped to establish the *Medicinal Plant Working Group* (PCA-MPWG) under the auspices of the *Plant Conservation Alliance* (PCA); one of its aims is to promote appropriate conservation measures for native medicinal plants.

Indonesia: An example is the FAO/IBPGR/UNEP project on 'The Conservation of Biodiversity of Medicinal Plants by Partnerships Approach in Meru Betiri National Park, East Java, Indonesia'. This included: an inventory of biodiversity of medicinal plant,

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[135] See Akerele & al. (1991) p.xix
[136] http://www.icmap.org
[137] http://iucn.org/themes/ssc/sgs/mpsg/

research on active chemical contents, study on marketing, study on ecology of species priority, study on cultivation techniques, study on harvesting technique from nature, and study socio-economic condition of the community living around the National Park. More than 25 formula folk medicine and health drinks have been developed with women, local people and the local health division, to produce folk medicine for hypertension, reduction of blood lipids, diabetes, etc. Starting in 1999, medicinal plants have been cultivated as an agroforestry system in partnership with the local people (c. 1500 persons/families) in an area of 2000 ha (rehabilitation land of Meru Betiri National Park). Now, the local Government, especially Ministry of Health, has decided to use of folk medicine for the Centre of Village Health in Jember district.

Sri Lanka: The 'Sri Lanka Conservation & Sustainable Use of Medicinal Plants Project'[138] was the first approved by the World Bank that is focused exclusively on the conservation and sustainable management of medicinal plants. Originally to be implemented between 1998 and 2002, it has now been extended to 2004. It is being financed by a grant of US$4.57 million from the Global Environment Facility Trust Fund and a contribution of US$0.5 million from the government of Sri Lanka. The World Bank is the implementing agency for the fund (see Box 4).

Box 4: The Sri Lanka Medicinal Plants Project.

The objective of the project is to secure the active conservation of globally and nationally significant medicinal plants, their habitats, species and genomes, and promote their sustainable use through three initiatives to:
– Establish five medicinal plant conservation areas (MPCAs) where plant collection from the wild is particularly intensive and develop a conservation strategy for each; implement village action plans to reduce dependency on harvesting from the wild; collect basic socioeconomic and botanical data; and promote extension and education on medicinal properties of species within these conservation areas.
– Increase nursery capacity to develop the cultivation potential of select species and support research on propagation and field planting techniques
– Collect and organize existing information on plant species and their use and promote an appropriate legal framework through production of draft regulations to ensure the protection of intellectual property rights.

This project is expected to yield important environmental and social benefits. It will help conserve more than 1,400 medicinal plant species used in Sri Lanka, of which 189 are found only there and at least 79 are threatened. It will spread knowledge about sustainable growth, crop yields, biological cycles, and the danger of depleting plant resources; maintain critical habitats for medicinal plants; and increase the diversity and quantity of threatened species. The project will also preserve indigenous knowledge about medicinal plants and their use, promote policy and legal reforms, involve tribal people and local communities in efforts to reduce dependency on wild resources, and generate alternative income opportunities for the rural population.

Source: World Bank *Medicinal Plants: Local Heritage with Global Importance.*
The World Bank Group. http://www.worldbank.org/html/extdr/offrep/sas/ruralbrf/medplant.htm

India: *The Kerala Forestry Project.* The conservation of medicinal plants is a key objective of biodiversity conservation components in several forestry projects in India being assisted by the International Development Association (IDA), the World Bank's

[138] http://www.medicinalplantsrilanka.slt.lk/mainpage.htm

concessionary lending arm. The Kerala Forestry Project, recently approved by IDA's board, is supporting a pilot program that involves tribal and other forest- dependent communities in the inventory, conservation, and sustainable development of medicinal plants. The four-year project, expected to cost US$47.0 million, is being financed with a US$39.0 million IDA credit and contributions totalling US$8.0 million from the state of Kerala and project beneficiaries. Project activities related to medicinal plants will cost US$0.2 million, or 0.4 percent of the total. The project supports technological improvements for artificial propagation of endangered plant species; research and training in better harvesting and processing techniques; community management of plant propagation, harvesting, and marketing; analysis of marketing policies; establishment of community-managed, forest-based enterprises for in five villages that are economically highly dependent on medicinal plants.

Also in India, the *in situ* conservation group of the Foundation for Revitalisation of Local Health Traditions (FRLHT)[139] has been co-ordinating a pioneering medicinal plant conservation programme 'Strengthening the medicinal Plants Resource Base in India in the context of Primary Health Care' that has been implemented by the state forest departments of Tamil Nadu, Kerala and Karnataka since 1993, and Andhra Pradesh and Maharashtra since 1999. The project, supported by DANIDA focused on the conservation of medicinal plants both *in situ* and *ex situ*.

This *in situ* conservation initiative has resulted in the setting up of a network of 54 Medicinal Plant Conservation Areas (MPCA) across different forest types and altitude zones in these five states of peninsular India. For all the MPCA sites, detailed floristic information on medicinal plant diversity including the threatened, traded and endemic plants is documented. The network of 54 Medicinal Plants Conservation Areas captures around 2000 medicinal plant species. These represent 50% of the medicinal plant diversity of the five states, and it significantly includes over 75% of the Red Listed species of the States.

Particular emphasis has been given to the so-called Maharastra initiative which involves

- Identification of 10 Medicinal Plants Conservation Areas (MPCAs) in the state of Maharashtra. Each site is on average 250-300 ha.
- Detailed floristic studies of the 13 MPCAs
- Prioritizing medicinal plants for focused conservation action by undertaking rapid threat assessment following the International Union for Conservation of Nature (IUCN) guidelines.
- Developing action plans for specific recovery and enrichment programmes in MPCAs for critically endangered and economically valuable species.
- Involving local communities in conservation of medicinal plants while ensuring community benefits through innovative schemes for sustainable utilization of medicinal plants.

[139] http://www.frlht-india.org/html/is.htm

Brazil: A recent report[140] notes that 'In the last decade, serious efforts to collect and preserve the genetic variability of medicinal plants have been initiated in Brazil. The National Centre for Genetic Resources and Biotechnology (CENARGEN), in collaboration with other research centres of Embrapa (Brazilian Agricultural Research Corporation), and several universities, has a program to establish germplasm banks for medicinal and aromatic species'. **'**Most *in situ* conservation has focused in forest species, with some medicinal species included, such as *Pilocarpus microphyllus* and *Aniba roseodora*. The establishment of genetic reserves in Brazil has relied on National Parks and conservation areas established by the environmental protection agency of Brazil, Ibama.'

31 species of medicinal and aromatic species with high priority for germplasm collection and conservation in Brazil have been identified, of which 12 are conserved *in situ*[141].

Ethiopia: A World Bank-supported project, Conservation and Sustainable Use of Medicinal Plants, includes as one of its aims, '(vi) support in-situ conservation and management and initiate ex-situ cultivation of medicinal plants'[142].

Egypt, Sinai: A major GEF-supported project has recently been initiated on the 'Conservation and sustainable use of medicinal plants in arid and semi-arid ecosystems'. This will focus on the medicinal plants used by the Bedouin who live in St Catherine's Protectorate in Sinai, Egypt, and who have developed over the centuries, extensive knowledge of their uses. The project will introduce small-scale community-based cultivation, processing and marketing to relieve pressure on wild sources, and protect community intellectual property rights.

Africa: *Prunus africana*: a great deal of attention has been paid to this well known medicinal plant species and much research carried out into its distribution, local use, harvesting, genetic variation, trade and protection but only a limited amount of *in situ* conservation of this tree has been carried out[143]. It occurs in scattered populations in Afromontane forest islands in mainland Africa and in outlying islands such as Madagascar, and an extract from its bark is used for the treatment of benign prostatic hyperplasia, with a substantial international trade. It is subject to heavy exploitation in some parts of its area, notably in Camerooon where a plan for community involvement in its management is being implemented[144].

Forestry species

Conservation of genetic resources of forest trees has followed a different approach from that employed for other groups of species[145]. It is often suggested that the conservation of genetic resources of forest trees is a special case and various forms of *in situ* conservation have traditionally been practised although in a wider sense than adopted for other groups of plants[146]. Thus it covers not only the setting aside of areas of natural forest habitat as

[140] Vieira (1999)
[141] Vieira (1999:Table 2)
[142] http://www.dgmarket.com/eproc/project?activity_id=118842
[143] Cunningham (1996); Dawson & al. (2000); Dawson & Powell (1999); Ewusi & al. (1997); Jaenicke & al. (2002).
[144] Gabriel (2000)
[145] Hattemer (1997)
[146] Palmberg-Lerche (1993)

reserves but also the regeneration or rehabilitation of forests that have been affected by logging or depleted through other causes, both stochastic and human-induced. The conservation of forest genetic resources has been described as at the interface between the conservation of the genetic resources of cultivated species and conservation of sites[147].

Forest tree genetic resources are defined in a recent feasibility study on the state of forest genetic resources in the world[148] as ‘the set of trees having an actual or potential value as a pool (reservoir) of genetic diversity’ while forest genetic diversity is defined by IUFRO-FAO in the following manner ‘The genetic variability within a population or a species is an aspect of biological diversity. Genetic diversity can be assessed at three levels: (a) diversity within breeding populations; (b) diversity between breeding populations; and (c) diversity within the species’[149].

Forest trees have special characteristics, such as:

- They often contain higher genetic diversity than other species[150]
- There may be poor differentiation with respect to nuclear markers
- There is generally high differentiation among populations for adaptive traits
- The longevity of the individuals

In a review of genetics and forests of the future[151], a distinction is made between three groups of forestry plant species in terms of the kind of the genetic management required:

1. Species of current socio-economic importance and management for commercial development;
2. Species with clear potential or future value and management for potential commercial use;
3. Species of unknown value given present knowledge and technology and management of non-commercial populations

With regards the third group, it points out that ‘The vast majority of forest plant species have little recognized current or future commercial value, or no function that is not otherwise served by other species’.

A considerable number of forest tree species have been the subject of *in situ* conservation/management action. Many examples are found in the review of forest genetic resources management published by FAO/DFSC/IPGRI[152] and the EUFORGEN Networks[153] also deal with a range of species for which management guidelines are produced.

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[147] Lefèvre (2000)
[148] Bariteau (2003)
[149] IUFRO
[150] Müller-Starck (1995, 1997)
[151] Namkoong (1986)
[152] FAO, DFSC, IPGRI (2001)
[153] http://www.ipgri.cgiar.org/networks/euforgen/

The South Pacific Regional Initiative on Forest Genetic Resources (SPRIG) includes as one of its aims the preparation of management strategies for priority tree species of the region[154].

In Korea, 33 natural forest stands have been set aside for in situ conservation if forest genetic resources of 19 species[155].

In Zambia, the Dry Forest Management Project initiated in 1987 under the Forest Research Division gives the best example of *in situ* activities carried out in the country. The project was located within the teak production forests of Western province in Sesheke district[156]. A complete list of species included and their respective uses
is given in Box 5.

Box 5: Species included for *in situ* conservation in the Dry Forest Management Project, Zambia

Botanical Name	Major Uses
1.*Baikiaea plurijuga*	Timber,general construction, mining timber, parquet, etc.
2.*Pterocarpus angolensis*	Timber, handcraft, dyes, medicines
3.*Guibourtia coleosperma*	Timber, handcraft, edible seeds
4.*Afzelia quanzensis*	Timber, handcrafts,
5.*Entandrophragma caudatum*	Timber, tannin constructing, veers, etc.
6.*Erythophleum africanum*	Timber, general construction
7.*Albizia versicolor*	Timber, parquet construction etc.
8.*Ricinodendron rautanenii*	Handcrafts, canoes, pulp and edible fat from seed
9.*Burkea africana*	Joinery, mining timber construction, etc.
10.*Brachystegia speciformis*	Timber, veneers, handcrafts, boat building, etc
11.*Julbernardia*	Timber, handicrafts & implements

Source: Malaya (1990)

A programme for the provision of practical advice on *in situ* gene conservation stands of forest tree species to assist countries in the planning and implementation of conservation
Of genetic resources of forest tree species was initiated in 1996/97 by FAO, Danida Forest Seed Centre (DFSC) and relevant national institutions. It was agreed that conservation plans for four tropical tree species would be developed, focusing on *in situ* conservation. One of the case studies is Zambezi teak (*Baikiaea plurijuga*) in Zambia, a major timber tree; the others are teak (*Tectona grandis*), *Pinus merkusii* and *Acacia senegal*. The conservation plans for Zambezi teak in Zambia[157], for *Pinus merkusii* Thailand[158]and for teak (*Tectona grandis*) in Thailand[159] have been published

[154] Thomson (1998)
[155] Lee (2002)
[156] Table 4.1 in http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPS/Pgrfa/pdf/zambia.pdf
[157] Theilade & al. (2002)
[158] DFSC (2000)
[159] Graudal (1999).

Pinus merkusii is afforded legal protection at most of its remaining natural sites and the eastern populations are conserved in the Khong Chiam *in situ* Gene Conservation Forest (GCF), located in Ubon Ratchathani Province in north-east Thailand – one of the few areas in South-East Asia which has been set aside specifically for conservation of forest genetic resources. In 1983, an area of about 700 ha was reserved with the objective of protecting the genetic resources of local tree species, especially the lowland form of *Pinus merkusii*. Other important tree species conserved in the Khong Chiam include *Anisoptera costata, Dalbergia cochinchinensis,Dipterocarpus costatus, Ivingia malayana, Peltophorum dasyrachis, Pterocarpus macrocarpus* and *Schima wallichi*[160].

Wild relatives of crops

Wild relatives of crops are group of target species that has attracted considerable interest in recent years. A series of workshops on the conservation of wild relatives of European cultivated plants was held under the aegis of the Council of Europe and the Proceedings published[161] as well as a catalogue of the species involved[162]. A survey of work on crop relatives was commissioned by IPGRI as part of a GEF project[163].

An example of work on the *in situ* conservation of genetic diversity in crop wild relatives is the series of studies produced by the Bureau des Ressources Génétiques, France, on *Beta vulgaris*, *Brassica insularis*, *B. oleracea* and *Olea europaea*[164].

The landmark studies on the *in situ* of wild relatives of cereal crops in the Near East are those known as the Ammiad Project on wild emmer wheat (*Triticum turgidum* var. *dicoccoides*) although the work has focused on research into the genetic changes in the populations and the Ammiad site is not a conservation area and not likely to become one[165].

A wide range of crop wild relatives was selected as target species for *in situ* conservation in a major project on conservation of genetic diversity in Turkey[166] (Box 6).

Extensive work on the genetics and demography of wild bean populations has been undertaken on *Phaseolus* by IPGRI, the University of Gembloux and the University of Costa Rica. This has given some insight about two critical aspects when contemplating in *situ* conservation: the genetic identity and distinction of populations and the minimum size of populations for keeping a certain amount of genetic diversity and thus potential for further evolution[167].

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[160] Granhof (1998); Isager & al. (2002)
[161] Valdés & al (1997)
[162] Heywood & Zohary (1995)
[163] Meilleur (2001); Meilleur & Hodgkin (2004)
[164] Soupizet (2002)
[165] Safriel & al. (1997)
[166] Firat & Tan (1997); Tan (1998); Tan &Tan (2002)
[167] D. Debouck (personal communication to vhh, 25 June 2003). See Zoro & al. (2003) and references therein.

A worldwide survey of *in situ* conservation of wild relatives of *Lathyrus* has been undertaken[168].

Box 6: Target species of wild relatives for *in situ* conservation in Turkey

Aegilops speltoides	*Vicia johannes*
Triticum tauschii	*Castanea sativa*
Triticum boeoticum	*Prunus divaricata*
Triticum tricoccoides	*Abies equitrojana*
Lems ervoides	*Abies cilicica*
Lens orientalis	*Pinus brutia*
Pisum sativum sensu lato	*Pinus nigra*
Vicia sativa sensu lato	

Source: Tan & Tan (2002)

Pilot projects in *situ* for the wild relatives of various native crops have been initiated by the US National Germplasm System:

Vitis rupestris Scheele, *V. shuttleworthii* House, *V. monticola* Buckl.[169]

Allium columbianum, A geyeri, A. fibrillum[170]

Lathyrus grimesii R.C.Barneby[171]

Carya floridana, C. myristiciformis[172]

Capsicum annuum var. *aviculare* (Dierbach) D'Arcy & Esbaugh[173]

Solanum jamesii, S. fendleri[174]

A celebrated case of the study of wild relatives is the work undertaken on the conservation of *Zea diploperennis*¸a wild relative of maize, in the Sierra de Manantlán Biosphere Reserve (see Box 12).

Fruit germplasm. There is growing interest in the *in situ* conservation of germplasm and wild relatives of fruit trees and shrubs. For example, the Fruit Network established by the ECP/GR in 1999 includes in its activities discussions on establishing uniform standards for

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168 Maxted & al. (2003).
169 Pavek et al. (2001, 2003)
170 Hannan & Hellier in Pavek & Garvey (1999); Hellier (2000)
171 Hannan & Hellier in Pavek & Garvey (1999)
172 Grauke in Pavek & Garvey (1999; verbal comm. 4 June 2003 to vhh)
173 Tewskbury et al. (1999)
174 Bamberg in Pavek & Garvey (1999)

the conservation of fruit germplasm and of the most appropriate methods for fruit tree conservation (such as cryopreservation, *in vitro* growth, *in situ*, *ex situ*, etc.)[175].

A series of case studies on the collection, utilization and preservation of fruit crop germplasm was presented at the 96th American Society for Horticultural Science (ASHS) includes *Prunus*, *Vaccinium*, *Fragaria*, *Malus* and *Rubus*[176].

Strategies for *ex situ* and *in situ* conservation of wild *Malus* germplasm in Kazakstan have been proposed.[177] Several countries have initiated *in situ* conservation activities for *Citrus* wild relatives.

In India, there is an *in situ* gene sanctuary for citrus in the Garo Hills located in Nokrek National Park in the northeast of the state of Assam. The 10 000 ha sanctuary was set up to safeguard populations of the wild orange (*Citrus indica*)[178]. This was apparently the first reserve set up specifically for the purpose of genetic conservation of a tropical shrub[179].

In Vietnam *Citrus* spp. are included in six gene management zones[180]

Ornamentals

'The genetic conservation of ornamental plant species, whether in situ or ex situ has been poorly served. Genetic materials for ornamental plants are not centrally collected and maintained anywhere in the world', J.Metzger, 1996.

Very few attempts have been made to conserve ornamentals *in situ*[181]: the orchid sanctuary maintained by the Botanic Garden, Orchid Research and Development Centre, Tippi, Arunachal Pradesh, India, is an exception and there are other such orchid sanctuaries in the country. For rare and endangered species, gene sanctuaries or microreserves are sometimes established but their viability is still untested. The *in situ* conservation of target ornamental species within ecosystems is still in its infancy and should be combined with *ex situ* approaches as part of an integrated conservation strategy.

Miscellaneous

Examples of other groups of target species which have been the subject of *in situ* conservation include:

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[175] http://www.ecpgr.cgiar.org/Networks/Fruit/fruit.htm
[176] Hokanson (2001)
[177] Hokanson & al. (1997)
[178] Singh (1981)
[179] Smith & al. (1992)
[180] UNDP In situ conservation of native landraces and their wild relatives in Vietnam. VIE/01/G35. http://www.undp.org.vn/projects/vie01g35/gmz.htm
[181] Heywood (2003)

Incense: *Boswellia sacra* (Frankincense)[182]: a project is underway to make a protected area of Wadi Doka (Dhofar), with the aim of preserving and restoring the natural habitat of the frankincense tree, *Boswellia sacra*, where approximately 1200 trees grow.

Work on Bamboo and Rattan[183]: A project to conduct studies on population genetics, evolution and systematics of the species of *Johannesteijsmannia* H.E. Moore (*Palmae*) to provide information necessary to effectively manage the conservation as well as sustainable exploitation of the species is being undertaken by the Department of Biological Sciences The National University of Singapore Department of Biological Sciences, The National University of Singapore, Forest Research Institute, Malaysia and Royal Botanic Gardens Kew. Work is in progress on the genetic diversity of *Johannesteijsmannia altifrons* and this will be extended for all four species in the genus for all known and accessible populations in East and West Malaysia, and Southern Thailand. So far no conservation management has been undertaken[184].

IPGRI's work programme on the conservation of genetic resources includes[185] work on bamboo and rattan species.

Coffea spp.: a project to assess of extent of variability present in wild *Coffea* taxa in the Mascarene islands (Mauritius and Reunion) at the genetic and taxonomic level using molecular and morphometric tools has been carried out as a basis to develop a sound conservation strategy. The project also an in depth ecogeographical study of coffee species and examined the effectiveness of protected areas in conserving genetic diversity of coffee[186].

Another project, funded by BMZ (Germany), on conservation and use of wild populations of *Coffea arabica* in the montane rainforest of Ethiopia, aims to assess the diversity and the economic value of the Ethiopian coffee gene pool and to develop concepts of a model for conservation and use of the genetic resources of *Coffea arabica* in its centre of diversity in Ethiopia, based on the conservation of the montane rain forests as the natural habitat of the wild coffee populations, and the traditional use of the wild coffee populations in the forest coffee systems [187].

IPGRI has also developed a project on conservation of coffee genetic resources. The goal of the project is to conserve genetic diversity of coffee genetic resources as a basis for improving coffee quality and livelihoods of small scale farmers in sub-Saharan Africa and protecting their natural forest environment. The project seeks to develop a complementary conservation strategy for the conservation of coffee genetic resources in sub-Saharan Africa, using both *in situ* and *ex situ* conservation methods and help establish better documentation and information system on the status of coffee genetic resource in region.

III. The components of a conservation strategy

[182] Raffaelli & al. (2003)
[183] Rao & Ramantha Rao (2000); http://www.ipgri.cgiar.org/regions/apo/inbar.html
[184] Hugh Tan Tiang Wah (pers.comm. to vhh 22 July 2003).
[185] Hong & al. (2001)
[186] Dulloo & al. (1998), Dullooo & al. (1999).
[187] Denich & al (2002); see also Gole & al. (2002)

Conservation strategies for target species range from complex documents running to hundreds of pages and involving a range of activities to simple pragmatic actions, depending on the species concerned and its characteristics, genetic variation and distribution, the habitat(s) occupied, economic importance, the degree of urgency and the resources available. The main elements involved in developing a strategy for the conservation of target species *in situ* can be:

1. Establishment of a knowledge baseline
2. Determining selection criteria for target species
3. Target area selection
4. Ecogeographical surveying within the target areas
5. Estimating the amount and pattern of genetic diversity
6. Selection of precise sites and identification of populations to be conserved
7. Planning and establishing a genetic reserve or conservation management area
8. Setting up an information management system
9. Involving local and other relevant stakeholders
10. Informing the public
11. Incorporating the conservation strategy into the national biodiversity strategy and action plans

The order in which they are applied may vary and not all components are essential.

Although a model has been proposed as suitable for widespread application and is being tested in several projects around the world[188], a point that comes out clearly in this review is that there is no simple single strategy for genetic conservation of target species that is appropriate to all situations or even generally applicable.

Establishment of a knowledge baseline

The first step in any *in situ* conservation programme for target species is to establish a baseline of available information (knowledge database)[189] before other activities are initiated. This is central to all issues of conservation and is a key requirement[190]. It will include, for example:

- bringing together information on:
    - the correct identity
    - distribution
    - reproductive biology
    - breeding system
    - demography and
    - conservation status

  of the main wild species of economic use in the country or region

[188] Maxted & al. (1997b)
[189] This is sometimes referred to as an ecogeographical survey or study (N. Maxted, personal communication) ; cf. Maxted & al. (1995)
[190] Ouédraogo (1997)

- gathering information on how they are used, including local traditional knowledge
- gather information on the nature and extent of trade in these species
- gather information on the extent to which (if relevant) they are harvested from the wild and the consequences of this on the viability of wild populations
- gather information on their cultivation and propagation
- gather information on their agronomy if cultivated
- establish which of them occur in Protected Areas
- gather information on the availability of germplasm and authenticated stock for cultivation
- gather information of what (if any) other conservation activities (including *ex situ*, ecogeographical surveys) on the species exist

A word of caution, however, is needed. The USDA *in situ* conservation guidelines for crop wild relatives comments[191] 'Get as much information as possible as you can from as many sources as possible, then do not necessarily believe any of it … In western Texas, we were told that we would not be able to find any wild potatoes because all the appropriate habitat is privately owned, and the cowboys there are so afraid of the Endangered Species Act that they shoot first and ask questions later–but we found beautiful populations in public roadside picnic areas'.

Once the knowledge baseline is established this will allow gaps in knowledge to be identified and inform the implementation of the next steps.

The role of taxonomy

Correct identification of the target species is an essential step in any conservation strategy as it provides not only the key to the associated literature but establishes the basis for repeatability[192]. The correct naming of the plant material sampled is also essential and a prerequisite for their proper use and conservation. It is reported that the forestry sector in the Amazon region does not currently have the capacity to identify many trees to the level of species. Yet correct scientific identification is essential for obtaining available information on species properties. Great caution should be exercised in using common names to identify material: common names, which are often locally specific but not unique over larger areas, are often inaccurately associated with scientific names[193].

However, when dealing with species conservation, the choice of which units of biological diversity should be adopted is a matter of considerable debate[194]. In most cases, the species is used as the basic unit but the conservation focus may be more on infraspecific units or populations within the species targeted. Conventionally plant species are defined in taxonomic terms i.e. based on morphological or phenetic discontinuities that are believed to reflect breeding discontinuities, although the question of species concepts is still highly contentious and there are currently seven or eight different species concepts in use (phenetic, biological, recognition, ecological, cladistic, pluralistic, phylogenetic and

[191] USDA (1999)
[192] Miller & al. (1989)
[193] Kanashiro & al. (2002)
[194] Bruford (2002)

evolutionary) and no agreement between the different practitioners on how to develop a coherent theory of systematics at the species level[195]. In addition, species concepts differ from group to group and there are often national or regional differences in the way in which the species category is deployed[196] which make comparisons difficult.

The methods used to determine the distinctiveness of species and other biological units will in turn determine whether or not they are selected for conservation action or legal protection[197]. There is growing evidence to suggest that the use conventionally defined species (taxonomic or biological) may not lead to the adequate conservation of the diversity needed with future evolutionary potential. Increasingly in conservation studies, mainly of animal groups such as birds, the concept of Evolutionarily Significant Units (ESU) rather than species, subspecies or ecotypes is being employed as the basic unit for conservation management and establishing priorities[198]. For plants of agriculture whose genetics and breeding relationships have been well studied, there may be serious discrepancies between conventional taxonomic treatments and classifications that reflect primary, secondary and tertiary genepools or similar systems based on degree of gene exchange such as the ecosystem/ecospecies/coenospecies/comparium hierarchy which is often used in biosystematic or genecological classifications[199].

It is likely that in the majority if cases, however, a taxonomic species concept will be employed for identifying target species and in practical terms, the Standard Flora(s)[200] of the country should be used for their identification and the nomenclature used therein should be followed unless it is possible to determine the correct name (if different) through other sources. For Europe[201] and the Mediterranean Region[202] and for the combined Euro-Mediterranean region[203] lists of Standard Floras exist, as do regional treatments – *Flora Europaea*[204] and *Med-Checklist*[205] – and a comprehensive taxonomic database and information system for the combined region is in an advanced state of preparation[206]. If a monographic treatment exists, this should be followed.

While it is likely that in the case of known rare and endangered wild species few problems of identification will arise, for widespread species which occur in more than one country, care should be taken, however, as the same species may occur under different names in different Floras in the different countries and in the absence of any agreed nomenclator,

[195] Heywood (1998)
[196] Gentry (1990); Heywood (1991)
[197] Olfelt & al. (2001)
[198] Ryder (1986); Waples (1995, 1998)
[199] Spooner & al. (2003)
[200] The term Standard Flora refers to works that are the most generally acknowledged by botanists in the country or region concerned as the most reliable source of information on the plants that occur there. In some cases there is more than one Standard Flora for a country or region.
[201] See Tutin, Heywood & al. (1964–1988); Tutin & al. (1993)
[202] Heywood (2003)
[203] Euro+Med PlantBase A guide for contributors of initial taxonomic accounts Version 2.0 July 5, 2002. http://www.euromed.org.uk/d_ocuments/5.7.02_revision_guidelines.pdf
[204] Tutin, Heywood & al. (1964–1988); Tutin & al. (1993);
[205] Greuter & al. (1984-1989)
[206] Euro+Med PlantBase http://www.euromed.org.uk

specialist taxonomic advice should be sought. This is not a trivial issue as incorrect identification will have serious consequences.

Infraspecific variants such as subspecies, ecotypes or chemical races or individual populations[207] rather than species may be the focus of attention. Increasingly, molecular methods are being used to identify or characterize populations

The role of the herbarium

The examination of herbarium specimens may be an important source of information[208] and is an important step in preparing an ecogeographical survey[209]. In a recent study on American wild potatoes[210], a survey of available herbarium material was undertaken to help determine the location and distribution of the species and collection potential sites; information was also obtained from local botanists.

Herbaria should also be used to help determine or verify the identity of material sampled.

Selection criteria for target (candidate) species

Even within the main groups of target species of economic importance (wild relatives, forest tree species, medicinal and aromatic plants), the number of species to consider is greatly in excess of any reasonable expectation of conservation possibilities. In the case of wild relatives, it has been suggested that the number of candidate species is presumably at least an order of magnitude higher than the crops to which they are related[211]and it has even been suggested that 'for practical purposes, this group alone, if fully investigated, represents more than can be attempted in the foreseeable future'[212]. If a conservation strategy depends, as it will do in many cases, on the results of ecogeographic surveys and analyses of genetic and biological variation, all of which require considerable investments of time money and expertise, quite apart from any management interventions and monitoring, then even for such programmes as those for endangered species of the Center for Plant Conservation in the USA would not be possible for most of the species identified[213]. It follows that the selection of target (candidate) species is a key element of any *in situ* programme. A useful review of the principles of priority setting in species conservation, although in an ornithological context, is included in a recent volume on conserving bird biodiversity[214]. The priority setting systems applied most widely in the USA are those developed by The Nature Conservancy and the US Fish and Wildlife Service[215].

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[207] Yanchuk (1997)
[208] Pearce & Bytebier (2002)
[209] Maxted & al. (1995)
[210] Bamberg & al. (2003)
[211] Brown & Brubaker (2001)
[212] Holden & al. (1993)
[213] Holsinger & Gottlieb (1991)
[214] Mace & Collar (2002)
[215] See Elzinga & al. (1998a: 29 seq.)

Some general principles for the selection of target species are widely applied[216] (see Box 7) but in addition there are special factors that may have to be taken into account in particular cases or types of plant and consequently affect the selection or may be applicable only at a later stage, such as the degree of management needed.

Box 7: General criteria for selecting target species

– **Actual or potential economic use**
- Crop relative
- Medicinal or aromatic herb, shrub, tree
- Forest timber tree
- Fruit tree or shrub
- Ornamental herb tree, shrub
- Agroforestry species
- Forage species
- Species used for habitat restoration or rehabilitation
- Other

– **Current conservation status: the degree and nature of threats**
– **Endemism**
– **Restricted range**
– **Recent rate of decline**
– **Rarity**
– **Threat of genetic erosion**
– **Ecogeographical distinctiveness**
– **Biological characteristics and importance**
– **Cultural importance or of high social demand**
– **Occurrence and frequency in current Protected Areas**
– **Status of protection**
– **Ethical considerations**
– **Taxonomic or phyletic uniqueness or isolation**
– **Focal or keystone status/ecosystem role**
- Indicator species
- Umbrella species
- Keystone
- Flagship

Modified and amplified from Maxted & al. (1997), Maxted & Hawkes (1997), Mace & Collar (2002) and other sources

For example:

- Degree of coverage (percentage of the total cover) occupied by the species
- Occurrence in marginal habitats
- General distribution pattern (widespread, disjunct populations, narrow localized species, metapopulations) – will affect the genetic architecture and the amount of variation[217]
- Existence of ecotypic (genecological) variation

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[216] Maxted & al. (1997c)
[217] e.g. Millar & Libby (1991) who discuss strategies for conserving variation in widespread species such as Northern Hemispshere Conifers.

- Existence of chemical variation
- Existence of clinal variation
- How far the populations and even individuals have been mapped, their population structure and variation patterns known
- Competitive ability which may affect degree of management intervention required
- Special desirable features such as chemical variation[218] that needs to be covered in the populations selected
- Genetic integrity at risk
- Genetic contamination in native stands
- Capacity for natural regeneration
- Whether it forms part of provenance and breeding programmes

Pragmatic considerations may also have to be taken into account such as:

- likelihood of conservation success and sustainability
- relative monetary costs of conservation actions
- taxonomically well known and unambiguously delimited
- readily available and easy to locate and sample
- biological characteristics (e.g. breeding system) well known

For **forestry species**, there is no general forum for discussing and deciding on which species to select and which can be safely neglected[219] although the FAO statutory body the Panel of Experts on Forest Gene Resources, whose role is to help plan and coordinate FAO's efforts to explore, utilize and conserve the gene resources of forest trees, includes in its recommendations lists of priority species by region, species and operation. In assessing priority species, degree of threat is not the basis of selection but rather a balance of socioeconomic, environmental and cultural values[220].

The FAO Draft Technical Guidelines for Identification and Definition of National Priorities prepared for use in regional workshops on forest genetic resources[221], include a detailed discussion on the identification of target species according to perceived value and attributes/uses, present management and occurrence, and level of security and threats[222].

For **medicinal plants**, the following criteria have been proposed[223] to define priority: (1) species with proven medicinal value including those containing known active substance(s) or precursor(s) used in the chemical–pharmaceutical industry with proven pharmacological action, or at least demonstrating pre-clinical and toxicological results; (2) species with ethnopharmacological information widely used in traditional medicine; and which are threatened or vulnerable to extinction; (3) species with chemotaxonomical affinity to botanical groups which produce specific natural products.

[218] Heywood (2002)
[219] Namkoong (1986)
[220] Palmberg-Lerche (2001)
[221] FAO (1999)
[222] See also Koshy & al. (2002); Namkoong (1987, 1999); Namkoong & Koshy (1997).
[223] Vieira & Skorupa (1993)

What is clear that there is no single factor that can be applied unequivocally to all situations or groups of species. When different variables are recognized, some kind of decision support system such as the application of qualitative or numerical values to the factors chosen and the use of a matrix so as to determine priorities may be employed[224].

The endangerment filter

Endangered species are a widely accepted focus for conservation attention both nationally and globally and are frequently afforded high priority. Lists of endangered species are compiled with little regard to the economic, social or scientific importance or the biology of the species involved; it has been pointed out that in the United States, many ‘endangered’ species are peripheral (and often not viable) populations if the whole range of the species is taken into account[225] and this may well be true of other countries. If however the species are endemic to the country concerned then there is much greater justification to chose them as targets for conservation.

An emphasis on threatened species is not just confined to national species recovery programmes for Red List species. Although endangerment is but one of many criteria that may be employed to determine conservation priorities, it is often employed as a filter after other factors are applied. Thus in a review of work on collecting and research on wild potatoes (*Solanum* spp.) of the southwest USA[226], it is considered that future *in situ* research should involve precise documentation of the locations of living populations so as to provide ‘an essential platform for in situ projects to identify which populations are most valuable, and which are endanger of extinction or are otherwise threatened’.

Presence in a Centre of Plant Diversity or hotspot

The presence of a target species in a recognized Centre of Plant Diversity or ‘hotspot’[227] may be considered beneficial in that by definition these locations contain concentrations of endemic species and so the effective conservation of the habitat as a whole will be more likely (although by no means guaranteed). The IUCN/WWF 3-volume *Centres of Plant Diversity*[228] is a major source of information.

Narrow-range versus widespread species

While many of the species targeted for *in situ* conservation are restricted in distribution, if not rare, attention has also been focused in some cases on species which are widespread and of economic importance such as major forest trees[229]. Sampling and conservation strategies for such species may involve including genetic core areas, important ranges of diversity, particular ecotypes or ranges of clinal variation, outlier or marginal populations.

Multiple species strategies

[224] Yanchuk (1997)
[225] Peterson (2001); Godown & Peterson (2000)
[226] Bamberg & al (2003) (in press)
[227] Myers & al. (2000)
[228] Davis & al. (1994–1997)
[229] Millar & Libby (1991)

Most of the above considerations apply to single target species but in some cases an alternative strategy is to design a strategy that conserves the target species jointly with other species in the same ecosystem as has been proposed for example in the case of Ash (*Fraxinus* spp.)[230] This is not the same as the incidental protection of other species which as a by-product of the conservation of a target species – in such a case, any conservation of the bycatch species is 'hands off' and no specific strategy for them is involved.

The multi-species approach is suggested in the US National Research Council review of managing genetic resources of forest trees when it says that 'There may exist well-correlated sets of co-occurrences of species that can for immediate conservation purposes be considered to be distinct assemblages, if not communities'[231] but as it goes on to say, in areas where several species are being conserved at the same time in a reserve, it is a problem to ensure that the number and distribution of the populations of the species concerned are adequate for maintaining genetic variability in either single or multiple reserves. Not only this, but joint species conservation strategies need to be based on the same principles as single target species, and in the case of *Fraxinus* spp. 'should be dynamic, evolutionary oriented, and based on multiple breeding system (MPBS)[232].

On the other hand, multi-species recovery plans for endangered species have been proposed by several countries such as Australia, Canada, the United Kingdom and the United States where recovery plans under the US Endangered Species Act include some in which several species have been grouped together under the same plan (see also Section IV). The advantages of a local, multi-species or regional approach are 'that it can focus efforts on specific populations of animals and plants and can develop local community campaigns to help implement the necessary recovery actions. Further benefits include the avoidance of duplication, greater efficiency and cost-effectiveness, and the ability to bring together a broader range of interested groups and individuals'[233]. It should be noted, however, that a recent review indicates that the decisions on which species to include have not been influenced by the similarity of threats to which they are exposed but rather by their taxonomic relatedness or geographic proximity[234] and suggests that multi-species plans are less effective than single-species plans, probably because less time and money is spent per species[235] Criteria for deciding whether single-species or multi-species are more appropriate are proposed in the South Florida Multi-Species Recovery Plan[236]

Target Area Selection

Once basic information on the geographical distribution of the target species has been obtained, a decision has to be made on which areas should be chosen for detailed survey

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[230] Pliûra (2003)
[231] NRC (1991)
[232] Pliûra (2003); the multiple population breeding system (MPBS) as applied to joint breeding and conservation strategies by Namkoong (1983, 1989) that the populations selected would consist of small subpopulations over range of environments (see p.).
[233] Boyes (2001)
[234] Clark & al. (2002)
[235] Boersma & al. (2001)
[236] Jewell (2000)

and sampling. This in turn will allow a decision to be made on how many and which populations at which precise sites should be identified for potential inclusion in the genetic reserves.

Apart from technical considerations, priority may well be given to sites that are protected areas or centres of plant or are centres of crop origins or diversification. In practical terms, the size of the sites in which the target species occur in also an important consideration as this may well determine population size.

Ecogeographical surveying

The concept of ecogeographical surveying gained wide currency after the publication of a booklet 'Ecogeographical Surveying and *In Situ* Conservation of Crop Relatives' by IBPGR (later IPGRI) in 1985. The term applies to various systems of gathering and collating information on the taxonomy, geographical distribution, ecological characteristics, genetic diversity, ethnobiology of the target species, as well as the geography, climate and the human setting of the regions under study.[237]

Much of the initial work involved in undertaking an ecogeographical survey is desk-based and this then needs to be complemented by field work. As noted above (p.), the term ecogeographical survey is now sometimes used more for the desk-based rather than the field components.

With certain exceptions, the patterns of distribution and abundance of species and their populations is poorly known, especially in the tropics[238]. A recent review of ten years of collecting and research on wild potatoes of the SW USA concluded that finding and precisely documenting locations of living potato populations in the USA provides an essential platform for *in situ* research projects to identify which populations are most valuable, and which are in danger of extinction or are otherwise threatened[239].

Geographical Information Systems (GIS) are increasingly used in ecogeographical surveys of target species. GIS can be defined as a 'database management system that can simultaneously handle data representing spatial objects and their attribute data'[240] Examples include e.g. FloraMap (see Box 8) which was developed at CIAT [241] and DIVA-GIS[242]. A recent review surveys the use of spatial analysis of georeferenced data generated during the various processes involved in the conservation and use of genetic resources[243] and a list of references on spatial analysis and GIS applied to genetic resources management has been compiled by IPGRI[244].

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[237] Guarino & al. (2002)
[238] Gentry (1992)
[239] Bamberg & al. (2003)
[240] Jones & al. (1997)
[241] Jones & Gladkov (1999); Jones & al. (2002)
[242] Hijmans & al. (2001)
[243] Guarino & al. (2002)
[244] Plant genetic resources in the Americas: http://www.ipgri.cgiar.org/regions/Americas/programmes/gisreferences.htm

The maps can be used for prospecting and for identifying *in situ* conservation sites. A Power Point on Mapping the distribution of five species of *Passiflora* in Andean countries is available[245].

Box 8: FloraMap – A software tool for predicting the distribution of plants and other organisms in the wild.

FloraMap, is the product of more than 20 years of research at CIAT. The program makes precise, detailed maps that eliminate much of the guesswork from the slow, expensive process of finding and recovering wild species. It was developed for predicting the distribution of organisms in the wild when little is known of the physiology of the species concerned.

With its user-friendly software linked to agroclimatic and other databases, biodiversity specialists can create maps showing the most likely distribution of wild species in nature. Such maps are extremely valuable for tasks such as planning collection expeditions and deciding where to locate programs for in situ conservation.

Early versions of the program have been used successfully to guide plant collecting, to study the taxonomic and genetic variation of particular species, and to map the distribution of crop pests and their natural enemies. The pre-release version was thoroughly evaluated by a select panel of genetic resources experts.

An example of its use is in mapping the probability distribution for each of the 68 wild species of *Arachis* across their geographical range in the whole of central South America to help determine conservation status and assess conservation priorities[246].

Source CIAT: http://www.floramap-ciat.org/ and Jarvis & al. 2003.

GIS has been used in developing medicinal plants conservation parks in India[247].

Estimating the amount and pattern of genetic diversity

A detailed understanding of the structure of genetic variation in a species and its populations is needed if a strategy that captures a desired level of genetic variation is to be adopted. The pattern and way that the variation is organized will determine the conservation strategy in terms of which and how many populations are selected for inclusion in which areas. It would be misleading, however, to suggest that such information is likely to become available for a large number of species in the foreseeable future. As has been pointed out[248] 'A total survey of the genetic variation of all species identified for genetic resource conservation is neither practical nor economically possible. The study of genetic variation in adaptive traits requires in general that the species should be tested for long periods and at many sites. A survey based on the use of ecological data in combination with biochemical markers and data from already established field trials is probably a possible way to approach the problem for many species within a realistic time span. Such surveys are, however, not possible for all species. For the time being, the required number and the optimal geographic distribution of the conservation stands must be decided by other means'. And as has been commented recently[249], 'Considering the thousands of tropical tree species, we dare say that for more than 99.9% of the potentially

245 http://www.floramap-ciat.org/ing/poster-ppt.htm
246 Jarvis & al. (2003)
247 Use of GIS in Medicinal Plants Conservation Parks http://www.gisdevelopment.net/applicationm/health/planning/healthp0009b.htm
248 Graudal & al. (1997)
249 Kjær & Graudel (2000)

important tree species we have nothing but qualified guesses about their genetic structure. One can say that the dilemma is that an urgent need for conservation is recognised without really knowing what to conserve!'

Moreover, it is often difficult to assess the significance of the genetic variation information uncovered. In a study of *Solanum* in the United States, the comment has been made that 'we are at a pitiable state of ignorance about which populations are most valuable. … geographic or environmental clues are usually not too helpful. Our recent unpublished data shows that the genetic distinction of some populations of *S. verrucosum* in Mexico is very well associated with proximity to other potato species. The two species are generally thought to not be very likely introgressors, but what if, in fact, the distinctive *S. verrucosum* populations are really so only because they have common bands from *S.hjertingii*? So, …, physical clues to the vigor of a population are not very reliable, especially in the southwest USA. Location and environmental distinctions are not very indicative either. So we test DNA variation directly, but that also can give misleading conclusions if we have inappropriately set the genetic pool of study to a set of populations'.[250]

The methods currently available for assessing the genetic variation in a species include studying morphological and metric features in the field and a range of biochemical and molecular markers in the laboratory. For example, in the case of wild grapes in the USA, the characterization of inter- and intra-population genetic variation by morphological and molecular analyses determined which populations were significant genetic resources[251]. Good accounts of the ways in which genetic diversity in species and below can be measured are included in recent texts on biodiversity[252] and conservation[253]. Molecular markers (RAPD, RFLP, AFLP, SSR) may be used for rapid surveys of genetic variation within and between populations[254] but as they do not identify of the distribution of adaptive traits, their value in guiding genetic conservation is limited[255]. A recent review concluded that genetic markers should be used with care unless combined with observations on quantitative traits such as growth and survival[256].

Ecogeographical variation and genecological zonation

It is possible to predict to some degree the patterns of genetic variation from ecogeographic variation. It is generally accepted that similarity in ecological conditions implies similarity of genetic constitution[257]. A comparison of a species' distribution with well-defined ecological zones may provide an indication of the genetic variation within the species. Although this assumption is often made, it is not true in some cases, for example in natural populations of wild lentils (*Lens* spp.)[258]

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[250] Bamberg (29 May 2003 in litt.)
[251] Pavek & al. (2001)
[252] Mallet (1996)
[253] Newbury & Ford-Lloyd (1997)
[254] Hamrick (1994)
[255] Theilade & al. (2002)
[256] Kjær & Graudel (2000)
[257] Theilade & al. (2000)
[258] Maxted & Ford-Lloyd (2003)

An area within which it is acceptable to assume that populations are genetically similar is sometimes termed a 'genecological zone'[259]. Genecological zonation is considered a practical tool for the selection of populations to be conserved[260] (Box 9). In the absence of genetic studies, ecogeographic studies have been used to outline genecological zones for conservation of genetic variation in Zambesi teak (*Baikiaea plurijuga*)[261].

Box 9: Genecological zonation

Genecological zonation is a practical tool in the selection of populations to be conserved. It consists of identifying areas with uniform ecological conditions and subject to none or limited gene flow from surrounding areas. Genecological zonation may be prepared as one common system for several species or as a specific system for one species. It is usually based on existing data on natural vegetation, topography, climate and soil. If available, information from provenance trials and genetic marker studies may be used to test the validity and adjust the zonation.

Compared to ecogeographic zones, genecological zones differ in at least one aspect. An ecogeographic zone may be composed of a group of ecologically similar but geographically separate areas. If the geographic separation constitutes barriers to gene flow, such areas should most likely be considered as different genecological zones. The close relationship between ecogeographic zones and genecological zones implies that the latter can be used as a starting point to develop genecological zones for Zambezi teak in Zambia. However, geographically separate areas included in the same ecogeographic or agro-ecological zone have to be considered different genecological zones.

Genecological zonation should ideally be specific for individual species, or at least for major groups of species. Different target species in a given gene resource conservation programme may diverge in several ways. They may vary in reproduction biology, they may react differently to environmental clines, and they may reflect entirely different life histories in terms of evolution, migration, hybridisation events, or human utilisation. Thus species with the same distribution may show entirely different pattern of genetic variation within that area. Species-specific zonation will require the same basic data as common zonation. For economic reasons, and due to lack of species-specific data, such specific systems will generally be limited to species of major economic importance.

Source: Theilade & al. (2002)

Selection of precise sites and identification of populations to be conserved

Once a decision has been made on which species to target for *in situ* conservation and the target areas in which they occur, the next set of questions concerns the numbers individuals, which populations and how many populations are to be conserved and their , size and proportions, how much genetic and other diversity they should contain, and their geographic distribution[262]. Choice of precise sites for conservation of target species is an essential component of a conservation strategy and involves goals, targets and scales[263].

With certain exceptions, mentioned below, selecting some populations and some individuals from these populations will have genetic and conservation consequences The number of individuals needed to maintain genetic diversity within populations has been the

[259] Graudal & al. (1997); Theilade & al. (2002)
[260] Theilade & al. (2002)
[261] Theilade & al. (2001)
[262] Hodgkin (1997)
[263] Balmford (2002)

subject of considerable work and a great body of literature exists on topics such as minimum viable population size, minimum effective population size, minimum available suitable habitat[264], sampling for alleles or heterozygosity. It would not be appropriate to try and review it here.

In any case, many of the 'rules' or guidelines suggested are only applicable in certain circumstances and the realities of the field situation often determine how many and how much. Although the generally accepted paradigm of *in situ* conservation of species is the maintenance in their natural habitats of viable populations that will allow the species to continue to maintain itself and evolve, in practice other factors can come into play. For example, the widely employed concept of **minimum viable population** (MVP) implies that within a given habitat there is a threshold of a minimum number of individuals below which survival or persistence of the population is not possible[265]. Unfortunately there is no agreed MVP for most species or even groups of species as this will vary according to factors such as the biology, life form and ecogeographical pattern of the species.

While the primary concern of *in situ* conservation is to ensure that the population sizes selected are large enough to allow the long-term maintenance and continuing evolution of the target populations and their genetic diversity and in the case of more widespread species to capture sufficient of the species so as to include the most significant variation, in the case of rare or endangered species, the number of populations and individuals is often so reduced that there are no options other than to try and save what is available rather than any theoretically recommended minimum viable population. Indeed, population reinforcement is often employed as an option to try and ensure the survival of the remnants of the species.

Examples of species with dramatically reduced population sizes are found especially in island floras such as that of Rodrigues in the Indian Ocean (See Box 10). Examples of critically endangered tree species being conserved in protected areas and the threats to which they are subjected, is given in a recent review of forest genetic resources[266]; these include *Hibiscadelphus woodii* of which fewer than 10 individuals remain in the Napali Coast State Park, Kaui, Hawaii, USA and *Maillardia pendula* which is known only from a few individuals on Grand Terre, in the Aldabra Strict Nature Reserve. Seychelles.

Box 10:The devastated flora of the island of Rodrigues.

Rodriques in the Indian Ocean was once covered with a rich and luxuriant evergreen forest but as a result of three centuries of human habitation all the original plant communities have gone and the island is today mainly barren hillsides, dotted with trees or covered with a usually monotypic shrub or thicket of introduced species; only a few areas of degraded native forest exist. According to the *Plant Red Data Book for Rodrigues*[267], at least 18 endemic plant species have become extinct and of the surviving 36-38 endemic flowering plants, 19-21 are Endangered, 7 Vulnerable and 8 Rare, with nine of these endangered species reduced to fewer than ten individuals and three known from only a single wild individual. If the combined floras of Rodrigues and the neighbouring island of Mauritius are considered, 120 taxa are known from either less than 20 individuals or just one or two

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[264] Hanski & al. (1996): the minimum available habitat is a relatively new concept which has with great potential in restoration.
[265] Menges (1991)
[266] Thomson & Theilade (2001) Table 4.1
[267] Strahm (1989)

populations, and 28 species are known from less than ten individuals in the wild[268]. Despite this apparently hopeless situation, the work of Strahm and others during the last 15–20 years has, through a programme of careful management, fenced-in areas, artificial propagation of both plants and animals, replantation, weeding and promotion of conservation awareness plus the designation of several areas as nature reserves, has enabled many of these species to be rescued from total extinction.

Source: Strahm (1989,1996); Heywood (1999)

Unlike Red List wild species, where the selection of sites is seldom an issue because of the restricted distribution of the species, in the case of species of economic importance which are subject to human exploitation to a greater or lesser degree, selection of sites so as to include populations which contain important genetic, chemical or phenotypic variants is an important consideration. Moreover, enhancement of the genetic variation populations may also be recommended and often a combination of both natural *in situ* conservation units and managed *in situ* conservation units will be desirable[269].

In the case of species that are fragmented and form metapopulations, rather than small, isolated stands, as in the case of *Populus nigra* in Europe, it is recommended that *in situ* conservation activities should not consider local sites or conservation units in isolation but should rather consider them as part of the complete network of inter-linked local populations[270]. In such cases networks of natural and managed *in situ* conservation units should be established, covering the most important genetic resources of the target species throughout its whole area of distribution.

Conservation targets

The number of populations needed to conserve the genetic diversity of a species will depend on the way that diversity is partitioned among the different populations as well as on the conservation aim. For *ex situ* conservation the five population standard proposed for rare species has been widely adopted[271] and for plant genetic resources the Marshall & Brown strategy of 50 populations is generally used but there is less agreement on the number of populations needed to conserve genetic diversity that should be selected specifically for *in situ* conservation.

A recent review[272] questions the effectiveness of current conservation targets and concludes that in the absence of genetic diversity data it is necessary to conserve 53-100% of sampled populations to meet the standard for common alleles.

Likewise, the so-called SLOSS debate over whether it is better to have one large reserve or several smaller ones is often inapplicable simply because of the lack of suitable habitats, as in the case of the Monterey pine where large contiguous genetic reserves are not possible for some or most populations[273].

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[268] Strahm (1996)
[269] Lefèvre & al. (2001)
[270] Lefèvre & al. (2001)
[271] Brown & Briggs (1991) who suggested that sampling five populations would be sufficient to have a 90-95% probability of capturing all common alleles for *ex situ* conservation; see also Falk (1991)
[272] Neel & Cummings (2003a)
[273] Rogers (2002)

Planning and establishing a genetic reserve

The planning and design of conservation reserves is an enormously complex issue about which a great deal has been written. The primary determinant of the design must be the purpose(s) for which they are being proposed. These include[274]:

- Conservation of large and significant parts of functioning ecosystems
- Conservation of biodiversity
- Conservation of target species or groups of species
- Protection of landscape values and resources
- Use by local indigenous communities (including cultural and religious values, e.g. sacred groves)
- Research

Design principles are of course closely linked to the question of the amount of genetic variability it is aimed to conserve, as discussed above. For conservation reserves the main design principles for ecological conservation reserves have been summarized in a recent review[275] and they are also discussed in various management plans. Although genetic diversity plays a significant role in the persistence of species and populations, most reserve selection and design efforts focus on ecological characteristics, species distribution patterns or on community level diversity[276]. It is widely assumed that the application of ecological approaches to species conservation will also allow the conservation of genetic diversity but it should be noted that according to a recent study, selecting populations according to ecological reserve guidelines did not capture more genetic diversity than selecting populations at random. What is important is the numbers of populations included in the reserves and the proportion of sites needed to capture all alleles may be substantially greater than the five that are currently recommended.

Genetic reserves (gene management zones/units) are a particular kind of reserve where the purpose is the long-term conservation of genetic diversity in wild populations of target species (see below p.). Principles of genetic reserve design have been proposed[277] but theory do not necessarily apply in particular cases, such as the Monterey pine (*Pinus radiata*) where there are too many habitat restrictions to allow their application[278].

A basic restraint is that reserves (of whatever type) are usually small parts or fragments of larger, more continuous ecosystem or landscape units with all the consequences that fragmentation brings with it, both for the ecosystem and the constituent species and their populations.

The role of Protected Areas in species conservation

[274] Meffe & Carroll (1994); Cavalcanti & al. (1999)
[275] Neel & Cummings (2003b)
[276] Neel & Cummings (2003b)
[277] Hawkes & al. (1997)
[278] Rogers (2002)

'…in the medium to long term, protected areas only work if they really are protected' WWF (2004)

The main approach to biodiversity conservation is the setting aside of as much land as possible as protected areas[279] and the establishment by countries of protected area systems is the major component of most national biodiversity conservation strategies. According to the 2003 United Nations List of Protected Areas[280] , globally there are more than 100 000 Protected Areas covering more than 11% of the earth's terrestrial surface.

Public protected areas are supplemented in some countries by extensive private reserves or other forms of protection. In the United States, for example, The Nature Conservancy currently owns and manages approximately 15 million acres of the national territory and globally protects more than 116 million acres of the most ecologically-important places in the United States and 28 other countries. Many of the populations of the target species selected for *in situ* conservation will be found to grow in one or more protected area and consequently benefit from some degree of protection (but see below). On the other hand, in some countries the extent to which natural ecosystems have been destroyed or modified makes it impossible to design a protected area system that will afford the conservation of many species. In Central America, for example, in southern Honduras the few remaining areas of continuous forest cover which have attracted conservation interest to date are highly dispersed and cumulatively represent only a very small proportion of the landscape within which they lie. The bulk of the germplasm of native tree species lies in the dominant 'agroecosystem' which surrounds and separates the forest fragments[281].

Yet the protected area approach often seems to be predicated on the belief that there is 'some pristine Garden-of-Eden like state for all, ecosystems, from which they have been disturbed by human actions[282].' Moreover, protected areas vary enormously in their characteristics and aims and as a recent review notes, '[i]n Amazonia and elsewhere, rural people are defending far bigger areas of tropical forest from unfettered deforestation and logging than are parks, thereby conserving the ecological services provided by these forests and the majority of their component plant and animal species'[283].

Ecosystems are continually changing and so the question of deciding what to conserve, what state of an ecosystem to conserve, is not a scientific question since there is no benchmark original state against which to measure it. The establishment by countries of protected area systems, however scientific one would like the selection of sites to be so as to cover the maximum complementarity of biodiversity in the minimum area, is ultimately a politically determined process moderated by aesthetic, ethical, social and other considerations. Moreover, we have tended to overlook the dynamics of the ecosystem, the landscape and, overarching all, global change. As has recently been observed[284], 'the

[279] As agreed at the Fourth World Congress on National Parks and Protected Areas in 1992 (IUCN 1994), a protected area is defined as 'An area of land and/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'.
[280] Chape & al. (2003)
[281] Barrance (1999).
[282] Lawton (1999)
[283] Schwartzman & al. (2000).
[284] Huntley (1999)

current paradigm of conservation management set against a static environment must be replaced by an approach that incorporates the realization of the dynamic character of the environment and of the species assemblages'.

There is in fact a triple dynamic: that of the environmental factors (climatic, edaphic, biotic) that affect the ecosystem itself and today involves a new factor – that of global change; (2) that of the ecosystem itself which may show considerable change over short periods of time; and (3) that of the populations of the species that make up the ecosystem that may fluctuate considerably in size, distribution, genetic and composition even from one year to another (Box 11).

The hands off approach. As we have seen, the potential number of candidate species for *in situ* conservation is vastly in excess of the resources or finances available for this purpose. The strategy of protecting enough habitat so as to ensure the presence of viable populations of all the native species of a region, as has been suggested, is a laudable aim but seldom possible and is fraught with difficulties. For most wild species the best that we can hope for is their presence in some form of protected area where, provided the area itself is not under threat and subject to the dynamics of the system and the extent of human pressures, some degree of protection may be afforded. This is known as the hands-off or benign neglect approach and is widely advocated: in the words of one recent study, '…for species which are not under threat of destruction, the most sensible and effective policy is to leave the material to conserve itself, in the wild…'[285]. It is also known as 'passive' conservation[286] in that the existence of particular species is coincidental and passive, and not the result of active conservation management, as opposed to 'active' conservation which requires positive action to promote the sustainability of the target taxa and the maintenance of the natural, semi-natural or artificial (e.g. agricultural) ecosystems which contain them, thereby implying the need for associated habitat monitoring.

In fact, the level of management in a large number of protected areas is minimal – indeed for many no management plan exists other than protection of the area as such – and this may in fact be deliberate policy.

If examined in detail, such a hands-off strategy is somewhat problematic and may frequently lead to the loss of those very species or assemblages whose conservation one wishes to ensure. The most obvious problem is that, even if not ostensibly under threat, many if not most protected areas are not effectively managed: as noted below, protected areas are very diverse as is their degree of management and a new report[287] commissioned by the the World Bank/World Wildlife Fund (WWF) Alliance and carried out by IUCN revealed that less than one quarter of declared national parks, wildlife refuges, and other protected areas in 10 key forested countries were well managed, and many had no management at all. This means that only one percent of these areas is secure from serious threats such as human settlement, agriculture, logging, hunting, mining, pollution, war, and tourism, among other pressures. A further report entitled '*How effective are protected*

[285] Holden & al. p. 92 (1993)
[286] Maxted & al. (1997)
[287] http://forests.org/recent/1999/resindno.htm

areas?'[288] undertaken by WWF provides a preliminary analysis of the management effectiveness of nearly 200 forest protected areas in 34 countries using a tracking tool developed by the World Bank and the IUCN World Commission on Protected Areas.

Even when good management plans are in place, protected areas may still be at risk as in the case of the Coto Doñana Biosphere Reserve, Spain which has been subjected to a series of major threats in recent years from chemical pollution, adjacent urbanization and agriculture, and the Sierra de Manantlán Biosphere Reserve where the main threats to the biodiversity of the area include illegal logging, excessive harvest of firewood for fuel, forest fires caused by agricultural burns especially during dry seasons, overgrazing and browsing in forests and poaching mammals and bird species to sell in the black market[289]

Thus, the focus shifts from the target species to the state of endangerment of the ecosystem, given that without securing the conservation of the habitat, there is little chance of maintaining the species they contain. The well documented large scale loss and fragmentation of forest and other habitats worldwide simply emphasizes the need to take action to extend the protected area systems as far as possible; and in deciding which additional areas to target, the conservation of genetic diversity of wild species should be given much greater prominence than hitherto[290]

Without effective management, the populations of target species in existing protected areas are at risk of change in size and genetic composition because of the dynamics involved. Moreover, as discussed below (p.), protected areas in some regions will be put at risk as a result of global change and as global change intensifies, more areas and the species they house will be placed at risk. The mere presence of target species in protected area is therefore no guarantee of its conservation. Frequently some form of intervention or management of the populations of the target species is needed to ensure its successful maintenance and continued evolutionary development.

Of course, many species that will be selected as targets do not occur in areas that are currently protected and the chances of setting up areas for them, even without proper species-orientated management, are as we have seen very limited.

It may be concluded that while there is no doubt that protected areas play a significant role in strategies aimed at protecting target species, the identification by the CBD of the maintenance of viable populations of species in their natural surroundings as a fundamental requirement for the conservation of biological diversity (Preamble and Article 8 (d)) appears to be very unlikely to be achieved in the short or medium term for most species. The target proposed in the Global Plant Conservation Strategy of '60 per cent of the world's threatened species conserved *in situ*' by 2010 will require a series of actions that are not currently being addressed by most protected area managers. For example, a recent WWF survey[291] notes that very few protected areas report having comprehensive monitoring and management programmes yet these are just two of the kinds of activities that will be need if threatened species are to be effectively conserved within their boundaries.

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[288] WWF (2004)
[289] Lobeira (1999)
[290] Holden & al. p. 92 (1993)
[291] WWF (2004)

Box 11: Triple dynamics of *in situ* conservation

- Environmental factors

  Climatic, edaphic, biotic

  Global change (population, climatic)

- Ecosystem dynamics
- Component species' dynamics

Although maintaining species that cannot survive outside natural or near natural conditions and providing an 'ark' for threatened species are now amongst the roles perceived today for protected areas, most of them were not set up with conservation of species in mind and in many if not most cases no proper inventory has been made of the species that they contain so that the occurrence of species of economic importance in them is often not known. As a consequence, a great deal of effort is needed to remedy this situation. Moreover, the representation of target species in protected areas is usually inadequate. For example, in a study of wild peanut (*Arachis* spp.) in South America it was found that the current state of *in situ* conservation areas poorly represents the distribution of the species with only 48 of the 2175 georeferenced observations being from National Parks[292].

It should be noted, however, that as regards Biosphere Reserves, considerable efforts are underway to undertake inventories of the species they contain

On the other hand, some Protected Areas *are* being developed so as to preserve the resources they contain. An example is the series of Natural Protectorates designated in Egypt to be managed to meet the requirements for *in situ* conservation of sets of species[293], such as: the Ras Mohamed Protected Area and National Park, Sinai, which contains the unique northernmost mangroves in the world; the Elomayed Natural protected Area in Matrouh Governorate contains about numerous species of economic importance including medicinal plants, fuel, food, landscaping and soil stabilization; and the Saint Catherine protected Area in South Sinai which houses 22-28 species that exist there alone and contains about 44% of Egypt's endemic flora. It has been the subject of an EU-sponsored development programme that involves not just the protection of target species of plants and animals but maintenance of the Bedouin way of life and livelihoods. It includes a pioneering Bedouin Support Program: the 'inclusion of Bedouin as paid members of the protectorate staff. Seventeen men were selected to be haras al biaa--literally, keepers of the environment, or as they have come to be known, community guards who will work hand in hand with park rangers. The candidates must be local Bedouin, acceptable to the both the community and the protectorate, not in paid employment requiring their presence outside the area, and, if possible, literate to some degree'.

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[292] Jarvis & al. (2003)
[293] http://www.eeaa.gov.eg/English/main/Protectorates.asp

According to the project manager, the project aims at creating a program administrated according to the Bedouin management system[294]. In terms of *in situ* conservation the Protected Area Management Unit [PAMU] has begun a programme for monitoring and conserving the endemic species and thirty-seven plant enclosures are used both for the conservation and monitoring changes of representative and endangered plant species. These enclosures are all in the mountains around St. Catherine and a team of botanists regularly monitors them. The St Catherine's Protectorate is now also included in a UNDP/GEF project on medicinal plants mentioned above (p.__).

The role of protected areas and forest reserves in the conservation *in situ* of forest genetic resources is considered in several publications[295]. A number of protected areas are, however, specifically managed to conserve genetic resources of forest trees such as the Riserva Integrale in the Parco delle Madonie in Sicily the only known locality of the Sicilian fir (*Abies nebrodensis*) which is reduced to a population of fewer than 29 adults and 20 saplings, according to a recent survey[296], restricted within the park to the commune of Polizzi Generosa in the reserve of Quacella. A small number of protected areas have been set up in south east Asia specifically to conserve genetic resources of forest trees such as the Khong Chiam *in situ* Gene Conservation Forest in north-east Thailand which was established to protect an important population of *Pinus merkusii* as well as affording protection to a number of other forest trees.

Sometimes it will be possible to enhance the capacity of protected areas to protect target species although management plans for the areas may not allow this to be done. In the case of forest genetic resources, the sequence of stages that may be followed so as to achieve this improved conservation capacity is given in a review by FAO, DFSC and IPGRI[297].

It should also be noted that the surroundings of an area that is protected or proposed for protection may be just as important as the reserve itself[298].

If it is proposed to locate an *in situ* management project for a target species in a protected area, it is important before going ahead to assess the overall management effectiveness of the area, given that, as we have seen, many protected areas are non-viable. A framework for the assessment of the effectiveness of protected areas has been prepared for the IUCN World Commission on Protected Areas[299] and The Nature Conservancy[300]

- **Types of Protected Area**

Although the IUCN Protected Area Management categories (see below) provide a useful framework, a great diversity of protected area types has been found and some of these are specifically tailored for the genetic conservation of target species.

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[294] John Grainger http://www.cairotimes.com/content/issues/envir/jujob3.html.
[295] Cossalter (1991); FAO,DFSC,IPGRI (2001)
[296] Morandini & al. (1994); see also Farjon & Page (1999)
[297] Thomson & Theilade (1991) Fig 4.1
[298] Perfecto and Vandermeer (2002)
[299] Hockings & al. 2000
[300]

IUCN Protected Areas Management Categories. The various IUCN categories of Protected Area (Box 12) may be of interest for *in situ* conservation of target species. An interesting example of *in situ* conservation in a Category V, Protected Landscapes is the Parque de la Papa[301] in Peru where seven Quechua communities are planning to establish a 'Potato Park', a community-based, agri-biodiversity focused conservation area, that will help conserve native plant genetic resources – including landraces and wild relatives of domesticated plants and animals. It will be managed through an integrated landscape conservation model following the Management Guidelines for Category V Protected Areas[302].

It should be noted that in practice many if not most countries use different or additional categories and definitions. As species do not recognize political boundaries, some of them occur in more than one country. A growing number of Transboundary Conservation Areas (TBCA) has been created during the past 15 years and the World Commission on Protected Areas has issued a series of Guidelines for Transboundary Protected Areas[303].

Box 12: The IUCN Protected Area Management Categories

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

[301] http://www.sur.iucn.org/webtools/noticia.cfm?passcodnot=370
[302]
[303] Sandwith & al. (2001)

sustainable flow of natural products and services to meet community needs.

Source: http://www.iucn.org/themes/wcpa/wpc2003/pdfs/outputs/pascat/pascatrev_info3.pdf

- **Centres of Plant Diversity**

The identification of 'hot spots' or other centres of diversity is one of the approaches to establishing priorities for biodiversity conservation. Other approaches have been proposed based on complementarity or taxonomic or phyletic uniqueness. Hotspots are areas that feature exceptional concentrations of species and are experiencing exceptional loss of habitat. Following an earlier analysis of plant hotspots a later study has shown that as many as 44 percent of all species of vascular plants and 35 percent of all species in four vertebrate groups are confined to 25 hotspots comprising only 1.4 percent of the land surface of the earth. This, it is suggested 'opens the way for a 'silver bullet' strategy on the part of conservation planners, focusing on these hotspots in proportion to their share of the world's species at risk'. Moreover these latest hotspots findings accord well with other priority-setting analyses – showing a 68 percent overlap with Birdlife's International Endemic Bird Areas, 82 percent with the IUCN/WWF Centres of Plant Diversity, and 92 percent with the most critical and endangered ecoregions of WWF/US's Global 200 List.

The 'Centres of Plant Diversity' initiative, developed by IUCN and WWF, identified 234 major sites of plant diversity of global importance, based on their species-richness (and the area had to contain a large number of endemic species); additionally other characteristics such as diversity of habitat types present and presence of genetic resources of plants useful to human activities were applied. A major drawback of such approaches is that they can lead to the neglect of areas that are ecologically or otherwise deserving of conservation but do not contain a sufficiently large number of species to be selected. It is to address such concerns that projects such as the European 'Important Plant Areas' project sponsored by Planta Europa has been developed[304] (see Box 13).

However, the success of any of these methods depends on the practicalities of their implementation. In the case of the 234 sites recognized by the *Centres of Plant Diversity,* worldwide, fewer than one in four (21 percent) are legally protected in full and only about one third (35 percent) have more than 50 percent of their area occurring within existing protected areas. Even more serious is the fact that a large proportion of the sites that are officially protected are not effectively managed and to give one regional example, of the 41 sites in Southeast Asia only 3 are considered to be reasonably safe or secure.

Even where the protected area system is fairly good, as in Borneo, because of the many endemic species and high level of diversity of plants and animals, some species will be missed by the parks, occurring in small areas or fragments, or simply not incorporated in the protected areas system. Most tropical moist forest reserves in the Indo-Pacific region are not large enough to conserve entire ecosystems and maintain minimum viable populations of many larger species. Intensive management is therefore needed to deal with demographic, genetic and environmental threats of extinctions associated with isolated populations in small reserves. The dilemmas associated with managing numerous small

[304] Anderson (2002)

populations will be the legacy conservationists leave for the next generation unless reserves are incorporated into larger conservation units.

- **Special types of protected area for genetic conservation**

Biosphere Reserves. The type of protected area known as a Biosphere Reserve can play a major role in ensuring the *in situ* conservation of target species [305] (see examples mentioned above p.). The now classic structure of a zonation system consisting of a legally strictly constituted **core area**(s) devoted to long-term protection, according to the conservation objectives of the biosphere reserve, and of sufficient size to meet these objectives; a **buffer zone**(s) clearly identified and surrounding or contiguous to the core area or areas, where only activities compatible with the conservation objectives can take place; and an outer **transition area** where sustainable resource management practices are promoted and developed, can be applied to accommodate different types and intensities of human use[307]. There are 440 biosphere reserves in 97 countries (as of July 2003).

Box 13: Important Plant Areas in Europe

Despite all the botanical knowledge in Europe we still cannot say, on a pan-European basis where the most important places for plants are. The recent publication of the second edition of *Important Bird Areas in Europe* highlights the need for a similar project for plants. To meet this challenge, a project called The Important Plant Areas project is being undertaken by Planta Europa, a network of organizations working for plant conservation in Europe, to identify the very best sites for plants across the continent of Europe. The project aims to identify (and ultimately protect) a network of sites, on a biogeographical scale, that are critical for the long-term viability of naturally occurring wild plant populations. Country by country listings of the IPAs will be produced, using selection criteria which allow the inclusion of sites with few very rare plants as well as those with larger numbers of threatened species. Pilot projects to identify IPAs have been carried out in a number of countries: Belarus, Czech Republic, Greece, Slovak Republic, Slovenia, Sweden and the UK.

An account of the Important Plant Areas of Turkey has recently been published[306]: 122 areas have been selected fom 200 candidate sites, equivalent to 13% of Turkey’s total land area and they house 3045 rare and threatened taxa.

Source Plant Life, and Özhatay & al. (2003)

The biosphere model may enhance sustainable management of native forests by traditional dwellers. Examples include the sustainable extraction of allspice, *chicle* and *xaté* in the Maya Biosphere Reserve in Guatemala, and the production of valuable oil from the *Argania spinosa* woodlands in the Arganeraie Biosphere Reserve in Morocco. The biosphere reserve status ensures the technical structure and scientific backing for sustainable harvesting and efficient marketing, and creates a moral obligation for local authorities to invest the income in the rural communities.

On the other hand, it has to be noted that although there are 440 biosphere reserves, it has often proved difficult in practice to implement the model, especially the use of the buffer zone[308].

[305] Arora & Paroda (1991)
[306] Özhatay & al. (2003)
[307] Batisse (1982); Bridgewater (2002)

Gene Conservation forests. Gene Conservation Forests are forested areas that have been reserved with the objective of protecting the genetic resources of local tree species. An example is the Khong Chiam *in situ* Gene Conservation Forest (GCF), in Ubon Ratchathani Province, north-east Thailand which was set aside specifically to conserve the lowland form of *Pinus merkusii*, one of only six known lowland populations in Thailand, all of which are highly threatened[309].

Genetic Reserves, Gene Conservation Areas, Gene Management Zones (GMZs), Gene Parks/Sanctuaries. Genetic rese**rves** can be defined as dynamic units of conservation of the genetic variability of particular populations of species of actual or potential use, including crop wild relatives, medicinal and aromatic plants, timber and fruit trees and other species of socio-economic importance.

The term **gene conservation area** has been applied areas that have been designated for conservation of the genetic variation found in populations of target species in natural or plantation forests[310].

A **Gene Management Zone** (GMZ) is a type of genetic reserve or long-term monitoring site that contains one or more diverse populations of target species designated for *in sit*u conservation[311]. They were developed for a major GEF-supported project on *in situ* conservation of genetic diversity in wild species in Turkey. GMZs should consists of core and buffer zones and their selection criteria are[312]:

- Target species must be the primary consideration
- They should capture as much genetic variation as possible
- Sites to be considered as GMZs should be accessisble, sustainable and suitable for efficient population management
- Their size and the number of target species should be determined in terms of evolutionary potential, genetic integrity and protection values
- They can be established in either natural or semi-natural environments

Another example of the use of Gene Management Zones is the GEF project on *in situ* conservation of landraces and their wild relatives in Vietnam (see p.). According to the project, 'the aim of a GMZ is to maintain the natural evolution of plants for future generations. It is an *in situ* conservation and long term monitoring site that contains one or more diverse populations of target species to be conserved. Each GMZ has specific management requirements adapted to different species and environmental conditions to ensure natural evolutionary processes, hence serving as an open laboratory, permitting continued evolution and conservation of the component species. A series of GMZs is often required to represent the eco-geographic ranges needed for the selected species and populations in order to support sufficient environmental heterogeneity. GMZs should be

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[308] Wells & Brandon (1993); Tuxhill & Nabhan (2001)
[309] Granhof (1998)
[310] Graudal & al. (1999)
[311] Tan & Tan (2002)
[312] Tan & Tan (2002)

easily accessible, relatively isolated from exotic gene flow and include a wide range of biological diversity and of the genetic diversity of the target species. Important elements for determining the size include:

a. The current threats to the genetic resource. If there are major threats a larger area may be needed.

b. How the species reproduce. The area has to be large enough to support species reproduction.

c. What is known about the ability of the selected species to maintain its biological sustainability'.

Gene Parks/Sanctuaries are parks or reserves established specifically to conserve material of wild relatives of certain crops. The first gene sanctuary established was that set up in the Garo Hills, NE India, to conserve populations of wild orange, *Citrus indica*[313].

Genetic Resources Management Units (GRMUs). Genetic Resource Management Units (GRMUs), a concept introduced some 20 years ago[314] have been defined as 'any designated forest area that meets minimum genetic management objectives'

Sacred groves and forests. An important type of traditional nature conservation, practised as part of the religion-based conservation ethos of ancient people in many parts of the world is the protection of patches of forest as sacred groves or forests and of particular tree species as sacred trees[315]. It is characteristic of such traditional ecosystem approaches that they require a belief system which includes a number of prescriptions, such as taboos, that regulate human behaviour and lead to restrained resource use[316]. An annotated bibliography of ethnoforestry with a detailed table of different kinds of indigenous forest management has been issued for comment[317]

An international workshop[318] on 'The Importance of Sacred Natural Sites for Biodiversity Conservation' was held in Kunming and Xishuangbanna Biosphere Reserve (China) in February 2003. Participants decided to create an International Network on Sacred Natural Sites for Biodiversity Conservation with the scientific objective of better understanding the mechanisms of culture-based environmental conservation using specific case studies and a policy-relevant objective of preparing policy guidelines on the recognition and management of sacred natural sites based on the voluntary cooperation of local communities.

An example of applying community-based sustainable management to sacred forests so as to conserve the biodiversity they contain, including medicinal plants, is an initiative of the Mahafaly and Tandroy communities of southern Madagascar, the local authorities and the Malagasy government[319]. Another example is the Emberà, a group living in the forests on the Colombia-Venezuela border, who reserve large areas of old-growth forest in upper

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[313] Gadgil & Vartak (1974); Singh (1981).
[314] Riggs (1982)
[315] Saraswati (1998)
[316] Colding & Folke (1997); Gadgil (1998)
[317] Narayan Pandey & Kumar (2000)
[318] http://www.unesco.org/mab/docs/WorkshopReport.pdf
[319] WWF (2003a)

watersheds and along the crests of mountain chains regarded as protected by spirits; the areas that benefit from this protection are remarkably similar to those typically set aside as protected areas[320].

In Morocco, the sacred forests (bois sacrés or forêts maraboutiques) that are found around the Qubbas, holy places where the Marabuts are buried, house remnants of natural vegetation, including some important species. Although not legally conserved, they are protected from clearing by the local people on religious grounds.

Extractive reserves

The term extractive reserve is applied to reserves where defined groups of local people are given exclusive rights to exploit and extract non-timber forest products provided they adopt sustainable forestry practices and do not use clear-cutting except on a small scale for growing their own crops. Such reserves have been established in various parts of Meso-America, Kalimantan and in several states in Brazil and the best known ones depend largely on rubber latex (*Hevea brasiliensis*) and Brazil nuts (*Berthelottia excelsa*). The effectiveness of extractive reserves as types of community-based conservation is debatable[321].

Orchid sanctuaries

Areas rich in orchid species have been given protection as orchid sanctuaries in various states of India such as Arunachal Pradesh, West Bengal, Sikkim, and Mizoram and further ones are planned. Some of them are sacred forests and other are associated with orchid research centres and nurseries. Over 20 species of wild orchids are recorded in the Sessa orchid sanctuary which spreads over 100 sq.km in the Dafla Hills of Arunachal Pradesh.

Medicinal Plants Conservation Areas (MCPAs)

The term Medicinal Plant Conservation Area has been applied to the network of 54 *in situ* reserves, each about 200 ha, which capture the inter and intra specific medicinal plant diversity that have been set up across different forest types and altitude zones in five states of peninsular India[322] (see p.). Five such areas have also been established in Sri Lanka.

Crop/weed complexes

The *in situ* conservation of crop/weed complexes that have developed in centres of origin or diversity of crop plants present special problems[323]. The weeds can be wild relatives of the crops with which they are associated and therefore candidates for conservation. Examples of crop/weed complexes are found in the Fertile Crescent and other areas in the Southwest Asia (*Hordeum*, *Triticum*/*Aegilops*) and in the Sierra de Manantlán (*Zea diploperennis*/*Z. mays*) (see Box 14).

Box 14: Sierra de Manantlán and maize and its wild relatives

The discovery in the mid 1970s of the wild maize – the endemic perennial *Zea diploperennis* – in its natural habitat in Jalisco in western Mexico, a discovery that led to the declaration of the Sierra de Manantlán Biosphere Reserve in 1987. Populations of the wild annual relative, *Z. mays* subsp.

[320] Harp (1994)
[321] Salafsky & al. (1993); Moegenberg & Levey (2002)
[322] http://www.frlht-india.org/html/is.htm
[323] Hammer & al. (1991, 1997); Pickersgill (1981).

parviglumis, and the Tabloncilo and Reventador races of maize traditional for this area, are further targets for conservation. Though limits on external inputs (such as exotic improved germplasm and chemicals) may need to be set so as not to endanger the wild relative, plant geneticists are optimistic that *Z. diploperennis* and the three other taxa can be conserved *in situ*, as long as ways can continue to be found to provide opportunities for the cultivators involved in managing the system. Indeed, research has shown that populations of *Z. diploperennis* virtually require cultivation and grazing in adjacent fields to prosper.

Source: http://www.unesco.org/mab/sustainable/chap2/2sites.htm

Microreserves.
Microreserves are small-scale protected areas, usually less than one or two hectares, with a high concentration of endemic, rare or threatened species[324]. They may be considered as an option in areas where the vegetation has been subject to fragmentation and the species populations they contain similarly reduced or fragmented. Because of the small area they occupy and their frequent simplicity in legal and management terms, it may be possible for them to be established in great number and to complement the larger, more conventional protected areas. On the other hand their long-term viability must remain in question. The concept of microreserves was developed in the Autonomous Community of Valencia, Spain where a large network of over 150 such areas has been created since 1991[325] and it is expected that this number will soon increase to about 250, covering the entire threatened Valencian flora.

Combinations of on-farm and *in situ*[326]
Situations where the cultivation of landraces wild relatives co-occur may require a combination of both on-farm conservation and *in situ* protection, as in the case of rye and its wild relative (*Secale strictum*) in south Italy.

Participatory reserves (with local communities)
Increasingly local communities are becoming involved in the planning and management of various types of protected area. The concept of People's Protected Area (PPA)[327] has developed in India: it aims to address the core concerns of food security, health provision and assured employment through the adoption of an integrated ecosystem approach. In the state of Chattisgarh, 32 PPAs have been established as models of conservation through use. They involve community-based participatory management, resource assessment methodologies, non-destructive harvesting, biodiversity prospecting and partnerships, equitable benefit sharing and enabling policy and legal framework

Private Area & Community Lands Management
In the high valleys of the Himalayas, members of local communities are being encouraged to protect medicinal and aromatic plants in their private/community lands known as 'Dhangs', which basically serve as the areas for grazing and for collecting fodder. Women's groups in different villages are also being motivated to adopt neighbouring

[324] Laguna & al. (1998); Laguna (2001b)
[325] Laguna (2001)
[326] Hammer & Perrino (1995)
[327] Sharma (2003)

natural sites as *in situ* conservation areas for protecting them from excessive grazing and unscientific harvesting[328].

Seed orchards[329]**.** These are plantations or production areas of selected trees of controlled parentage or of clones sufficiently isolated to minimize random pollinization. They are managed in order so as to harvest large quantities of improved seeds under the appropriate conditions.

Conservation outside protected areas

Given that most species, and consequently many potential target species, occur in areas that do not currently receive any form of protection i.e. outside public or private protected areas, consideration needs to be given to the policy options available for such cases, whether for strict *in situ* species conservation or a 'hands off' approach. The maintenance of genetic resources outside protected areas has been carried out traditionally in forestry (*albeit* not consistently, nor in all cases consciously carried out as an act of conservation)[330].

According to the USDA[331], approximately 90 percent of global forest area lies outside of public protected areas and a World Bank study[332] notes that while existing parks and protected areas are the cornerstones of biodiversity conservation, they are insufficient on their own to assure the continued existence of a vast proportion of tropical forest biodiversity. Promoting more biodiversity-sensitive management of ecosystems outside protected areas, especially of those known to contain target species, need to be given high priority. This is especially applicable to forests that are already subject to some form of management such as for timber production. Indeed a recent paper suggests that there should be no forests without management[333] and the World Bank study cited above suggests that priority must be given to ensuring that the greatest possible amount of biodiversity is conserved outside protected areas by changing logging or timber harvest patterns. Some of the key issues involved are discussed in an FAO review of conservation of forest genetic resources and tropical forest management[334], including strategies for *in situ* conservation in production forests.

The conservation and management of plant resources outside protected areas is thus a major challenge and involves close collaboration with the relevant stakeholders. The USDA report also notes that 'Private landowners, including local communities, have often had little if any incentive to collaborate in conservation strategies because governmental "command and control" conservation policies have not provided incentives for conservation' and suggests that private landowners will be more likely to employ conservation management practices if they are likely to benefit from implementing them.

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[328] http://www.whitley-award.org/Articles/projects/gold/Gargi_june_2001.doc
[329] Flora Bank Guideline 7: seed production areas for woody native plants. http://www.florabank.org.au/Default.htm
[330] Palemberg-Lerche (2003 personal communication)
[331] http://www.forest-trends.org/keytrends/pdf/USDA%20Briefs/6bioconservation.pdf.
[332] Putz & al. (2000)
[333] Poore & al. (1999)
[334] FAO (1993); see also Kemp (1992)

The relevance of areas not under protection to the *in situ* conservation of target species resides in two aspects: one the one hand there is the need to address what actions may be taken to ensure that such areas whether on public or private lands do in fact afford a sufficient degree of protection to the selected species so as to ensure maintenance of viable populations. In a sense, in that such actions will amount to some form or degree of protection, the concept of conservation outside protected areas in such cases ceases to be valid.

On the other hand, actions may be proposed so that many areas which are not protected as such and that are found to house target species will be maintained in such a way as to ensure their protection at the ecosystem or landscape level by the prevention of certain forms of activity. Examples are the application of easements – legal agreements that allows landowners to voluntarily restrict or limit the kinds of development that may occur on their land. Such agreements are legally binding and can afford permanent protection. They can be used to conserve land that houses biologically significant values and at the same time the landowner can continue to own and use the property. An example is the Grassland Reserve Program[335] administered by the USDA Natural Resources Conservation Service (NRCS) and USDA Farm Service Agency (FSA) in cooperation with the USDA Forest Service. It is a voluntary program that helps landowners and operators restore and protect grassland, including rangeland and pastureland, and certain other lands, while maintaining the areas as grazing lands. The program emphasizes support for grazing operations, plant and animal biodiversity, and grassland and land containing shrubs and forbs under the greatest threat of conversion. The Nature Conservancy (TNC) and the National Cattlemen's Beef Association (NCBA) have created a programme with the same name to conserve native grasslands in the USA.

Another approach, albeit one that has sparked a great deal of controversy, that has been developed in the USA is the so-called system of Habitat Conservation Planning (HCP). This was introduced under the Endangered Species Act to address the issue of landowners using their land for legitimate purposes in such a way that might unintentionally endanger a listed species[336]. It allows private landowners who undertake development, logging, or other actions that negatively affecting land known to house listed species to destroy some endangered species habitat through a permit system. They are required to design and implement a plan that will minimize and mitigate harm to the impacted species during the proposed project. They have been criticized for not providing adequate protection measures for many of the listed species they cover[337]. As of July 15, 2003, 425 Habitat Conservation Plans have been approved, covering approximately 38 million acres and protecting more than 532 species.

In San Diego County, California, the Habitat Conservation Plan was taken a stage further because of the large number of sensitive and endangered species that occurred there. This led to the development of the concept of a Multiple Species Conservation Program Plan to address a large number of species at the same time. It assessed 85 species of plants and

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[335] Grassland Reserve Program Fact Sheet Electronic Edition (June 2003) *http*://www.fsa.usda.gov/pas/publications/facts/html/GRP03.htm
[336] Nelson (1999)
[337] see the review by Kareiva & al. (1999)

animals that were already listed as rare and endangered, and involved the creation of a 69 500 ha preserve as the centrepiece to secure key areas of natural habitat[338]. Note should be taken, however, of the findings of the review of US Endangered Species Act recovery plans that putting species together in recovery plans may be better justified on the basis of the similarity of the threats to which they are exposed rather than on their taxonomic relatedness or geographic proximity[339].

The majority of wild species have of course managed to survive, at least up to now, outside protected areas, but the chances of their survival in the longer term in the face of worldwide habitat loss and fragmentation will be enhanced if the areas in which they occur are managed or set aside for some other reason that does not cause harm to the ecosystem[340]. Examples include land that is set aside for military use, airport protection zones, grounds of public and private institutions such as hospitals, universities and commercial companies. Some of the side-effects of war may also be beneficial for biodiversity such as demilitarized zones or 'no-man's lands', some of which can be very substantial such as the demilitarized zone of the Korean peninsula which provides a biodiversity sanctuary for many native species, including some that are elsewhere rare[341] . Such survival is of course subject to the prevailing dynamics of the system and may not result in a sufficiently broad or representative sample of the species being maintained. In a broad biodiversity conservation context, it is however, valuable but cannot be regarded as full *in situ* species conservation.

Involving local and other relevant stakeholders

It is now a widely accepted that local people need to share in the benefits that can be derived from protected areas and this is best achieved through their playing a role in the management and protection of such areas. This is reflected in WWF's global work on protected areas which has as its theme 'Partnerships for People and Nature'[342] and in its participation in the 'People and Plants Initiative' along with UNESCO-MAB and the Royal Botanic Gardens Kew (see above p.)

As noted in one of the regional preparatory reports for the Leipzig Conference, one of the shortcomings of the development of policies on plant resources … has been that formulation and implementation has largely excluded the local people … leading to lack of conservation responsibilities at community level[343] and to negative attitudes emanating from feelings of alienation of people from their resources. The involvement NGO's and local communities in *in situ* conservationis growing and it is becomhg clear that full participation of the local people is just as important as the development of practical strategies for integrated resource conservation and its sustainable utilisation by the primary custodians.

[338] http://www.dfg.ca.gov/nccp/mscp/mscp_faqs.htm
[339] Clark & al. (2002).
[340] Primack (1993)
[341] McNeely (2003)
[342] WWF (2003)
[343] FAO (1995)

Although the role of local people has not figured highly in most examples of *in situ* conservation of rare and endangered species or in recovery plans, except perhaps as a nuisance factor, when we deal with species that have an economic or social value or otherwise impinge on the interests of local communities, such an approach is no longer tenable. This is especially true in the case of medicinal and aromatic plants where community involvement in the conservation and management of such species is becoming increasingly common. Examples are community participation in the management of *Prunus africana* in the Mount Cameroon region[344], *in situ* conservation and use of medicinal plants by Afro-Colombian communities in Colombia[345], and community-based conservation of medicinal plants in Kenya. Other examples are given above for India and Sri Lanka (Medicinal and aromatic plants p.).

In the case of forestry species, various initiatives have recognized the usufruct rights of local communities and their role in community or participatory management, for example in China[346], Nepal, Thailand, Sri Lanka, Bangladesh, Mexico[347] and India. In India, some 35 000 villages participate in the Joint Forestry Management Programme[348].

The participation of people (and the role of government) in the conservation of forest genetic resources is the subject of a DFSC Guideline and Technical Note[349]. This draws attention to the fact that in many countries, plans to protect forest resources in reserves and protected areas have often failed to take into account the needs and knowledge of local people who lie in or on the edges of forests, especially in the tropics[350]. It considers that engaging in participatory processes and creating an appropriate legal and administrative environment for them to proceed are complementary aspects of forest genetic resource conservation. In Figure 1 it offers a model that lists the steps that can be involved in the participatory process.

The precise role of local people in the development and implementation of *in situ* conservation programmes for target species will, of course, vary according to the particular circumstances and the nature of the operations involved. They are more likely to be involved in management and protection than in more technical issues but what is certain is that in many cases, without their active participation conservation will be difficult to implement. Some of the problems of community participation in forestry conservation are discussed in a recent review[351].

It is essential that all relevant stakeholders should be identified and their needs and concerns taken into account when developing an *in situ* conservation strategy. General principles to be taken into consideration are[352]:

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[344] Gabriel (2003)
[345] IDRC (2003)
[346] Lai (2003)
[347] Gómez-Pompa, A. & Bainbridge, D.A. (1993)
[348] Pandey (2003)
[349] Isager & al. (2002)
[350] Tuxhill & Nabhan (!998)
[351] Donovan (2001)
[352] Palmberg-Lerche (2002)

- build from the bottom up: review and consider the priorities and needs of the full range of local users and interested parties and, to the degree possible, incorporate them into national strategies for conservation and resource management;
- ensure feedback and links among all levels of users and interested parties;
- ensure links between conservation management and related activities in other sectors at both the local and national levels;
- give due consideration to regional and global needs and priorities.

Informing the public

Although considerable publicity has been given to the plight of nationally rare or endangered wild species facing extinction through conservation agencies and NGOs, little public awareness exists about the need for conservation of wild species of economic importance. Much greater attention needs to be paid to informing the general public when conservation plans are being formulated for the *in situ* conservation of target species and when local populations are directly affected their role as stakeholders should be clearly recognized and they should be involved in both planning and management whenever possible and appropriate.

Incorporating the conservation strategy into the national biodiversity strategy and action plans

Once conservation strategies have been prepared for the *in situ* conservation of target species, the appropriate national agencies should be informed (if they are not already involved) and the strategies should be included in national biodiversity strategies and action plans. This does not yet appear to be common practice in many countries although an exception is the case of forestry species where a number of countries have national programmes for forest genetic resources.

IV. Recovery programmes

One of the aims of many *in situ* species-orientated conservation programmes is the recovery of species, i.e. to achieve such a level of recovery of the species concerned that their populations become secure and self-maintaining within their natural habitats and no longer in need of intervention or protection. For example, recovery of species (and the ecosystems in which they grow) is the ultimate goal of the US Endangered Species Act[353]. Recovery plans are often complex documents: some idea of their diversity may be obtained from perusal of the list of species or populations with recovery plans of the US Fish & Wildlife Service[354] which is the largest system of its kind globally.

Recovery plans may cover single or multiple species: an outstanding example of the latter is the South Florida Multi-species Recovery Plan which covers 24 animal and 35 plant

[353] http://endangered.fws.gov/
[354] https://ecos.fws.gov/tess_public/TESSWebpageRecovery?sort=1#Q

species[355]. The recovery criteria for each of the listed species in this plan 'consist of several or all of the following short, narrative statements: (1) a statement that requires amelioration of threats to the species or its habitat, (2) a statement of the probability of persistence for the species (that is, 95 percent probability of persisting for 100 years), (3) the rate of increase (r) to measure over a specific period of time, (4) the minimum number of populations (or subpopulations) to establish, (5) a minimum population size, and (6) a habitat condition over a particular geographic area (or areas)'. The Recovery actions at the species level fall into the following broad categories: (1) determining the distribution of the species in South Florida; (2) protecting and enhancing populations; (3) conducting research on biology/ecology; (4) monitoring populations; and (5) informing and involve stakeholders and the general public in the recovery process[356].

Another significant multi-species recovery programme is the Recovery Plan for Oahu Plants which covers 66 plant taxa listed as endangered, all of which are endemic to the eight main Hawaiian islands[357].

A variety of procedures is used to recover listed species such as[358]:

– protective measures to prevent extinction or further decline
– reintroduction or reinforcement of populations
– consultation to avoid adverse impacts of other activities
– habitat acquisition and restoration
– other on-the-ground activities for managing and monitoring endangered and threatened species such as restoration of the ecological community in which target species occurs; fencing to prevent damage by stock, vehicles, etc; rabbit control; weed control; assessing role of fire in e.g. regeneration, disease prevention; labelling, marking populations to advise the public

Under the Australian revised recovery guidelines for nationally listed threatened species and ecological communities, the requirements of a recovery plan are that it[359]:

- must provide for the research and management actions necessary to stop the decline, and support the recovery, of the listed threatened species or listed threatened ecological community concerned so that its chances of long-term survival in nature are maximised;

- will state what must be done to stop the decline, and support the recovery and survival, of the species or ecological community;

- must specify the actions needed to achieve the objectives;

- will state what must be done to stop the decline, and support the recovery and survival, of the species or ecological community, including action to manage and reduce threatening processes;

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[355] U. S. Fish & Wildlife Service (1999)
[356] U. S. Fish & Wildlife Service (1999)
[357] U. S. Fish & Wildlife Service (1998)
[358] https://ecos.fws.gov/docs/recovery_plans/1999/990518.pdf ; Environment Australia (2002)
[359] Environment Australia (2002)

- must identify the habitats that are critical to the survival of the species or community concerned and the actions needed to protect those habitats;
- will state what must be done to stop the decline, and support the recovery and survival, of the species or ecological community, including action to protect and restore habitat;
- must identify any populations of the species or community concerned that are under particular pressure of survival and the actions needed to protect those populations; and
- will state what must be done to stop the decline of, and support the recovery and survival of, the species or ecological community, including action to protect important populations.

Under the US Endangered Species Act, if recovery measures are deemed successful, species may be taken off the list but the Service is required to monitor the populations for a minimum of five years to confirm that they are effectively self-maintaining. Two plants have been delisted as a result of successful recovery while six have been removed as a result of taxonomic revison or other new information.

Recovery plans have mainly been prepared for endangered wild plant species and seldom applied so far to species of economic value such as forest trees. However, some of the endangered species which are the subject of recovery plans are of economic importance although this fact is not necessarily highlighted in the documentation. Certainly the many published recovery plans are a major source of information and contain pointers for the preparation of management plants for target species of economic imprtance. On the other hand, recovery plans by definition deal with species which possess few remaining populations and usually little natural habitat so that opportunities for genetic conservation are limited[360].

V. Available Guidelines

A wide range of guidelines or planning documents relating to various aspects of *in situ* conservation of wild species, such as enhancing the effectiveness of protected areas to achieve this, for sampling, monitoring, species recovery and related topics[361], can be found in the literature. These vary from the cursory to the highly detailed. Some of them are general conservation planning approaches that include targeted species as part of a whole planning process. Several countries have produced their own guidelines and although targeted at the national situation, they may be much more generally applicable and are therefore included here. Some of the guidelines are generally applicable to plant genetic conservation while others are aimed at particular groups of plants. Selected examples of guidelines are given below:

General

[360] Rogers (2002)
[361] such as seed orchards for production of native seed for revegetation and conservation (Flora Bank Guideline 10: Seed Collection Ranges For Revegetation 1999) http://www.florabank.org.au/Default.htm

An integrated conservation approach, called 'Conservation by Design', has been proposed by The Nature Conservancy[362], comprising four basic components:

- Setting **priorities** through ecoregional planning;
- Developing **strategies** to conserve both single and multiple conservation areas;
- Taking direct conservation **action**; and
- **Measuring** conservation success.

The concepts, standards, and procedures for these steps (except taking action) are encapsulated in two practitioner's handbooks *Setting Priorities: Designing a Geography of Hope: Guidelines for Ecoregion-Based Conservation* which presents the methodology and guidelines for conservation planning at the ecoregional scale and *Developing Strategies: The Five-S Framework for Site Conservation: A Practitioner's Handbook for Site Conservation Planning and Measuring Conservation Success* which sets out a framework for site-based conservation, including strategic conservation of medicinal plants.

Although aimed specifically at TNC's own policy approach, these documents are a [363]valuable guide and source of information for anyone developing and implementing a conservation strategy.

One of the earliest reviews of *in situ* conservation of wild plant genetic resources was undertaken by IUCN in 1984[364].

The *ad hoc* Working Group on *in situ* Conservation of Plant Genetic Resources established by the Ecosystem Conservation Group (FAO, UNESCO, UNEP, IUCN and IBPGR (later IPGRI) included the preparation of an information document on *in situ* conservation in its work programme. This led to the preparation of a booklet *Plant Genetic Resources: Their conservation* in situ *for human use* by FAO[365] which contains valuable guidelines for *in situ* conservation.

The edited volume *Plant Genetic Conservation: the* in situ *approach*[366] is a valuable resource with chapters by experts covering most aspects of *in situ* conservation. The proceedings of a symposium on *in situ* conservation of agrobiodiversity worldwide is in press[367].

The IUCN Species Survival Commission has commissioned a series of Action Plans which contain conservation strategies/guidelines for a number of plant groups such as palms[368], cycads[369], cacti and succulents[370], orchids[371] and conifers[372].

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[362] Conservation by Design: A Framework for Mission Success (1996)
[363] Prain (2003) pers.comm. (4 August 2003)
[364] IUCN (1984).
[365] FAO (1989).
[366] Maxted & al. (1997).
[367] T. Hodgkin (pers. comm..)
[368] Johnson (1996)
[369] Donaldson (2003)
[370] Oldfield (1997)

Endangered wild species

Genetic sampling guidelines for conservation collections of endangered plants have been proposed by the US Center for Plant Conservation[373]. Although these are aimed at *ex situ* collections, they are partly relevant to *in situ* conservation.

Medicinal plants

The *Guidelines for the Conservation of Medicinal Plants* [374]arising from the WHO/IUCN/WWF International Consultation on Conservation of Medicinal Plants, Chiang Mai, 21-26 March 1988 were the first to be specifically aimed at medicinal and aromatic plants. Although in need of revision[375], they are still a useful source of information.

The US *Plant Conservation Alliance Medicinal Plant Working Group*[376] is engaged in what it terms an 'Evolving Strategy' for medicinal plant conservation.

Forest genetic resources

A considerable number of guidelines and methodologies for genetic conservation of forest trees has been issued. The first appears to have been that published by FAO in 1975[377], including a substantial section on *in situ* conservation. An important contribution is Volume 2 in the series *Forest Genetic Resources Conservation and Management* [378] which contains guidance and a checklist for developing a programme of *in situ* conservation of target species or a group of species, based on local conditions and specific objectives, and includes a step-by-step approach to enhancing the conservation of role of Protected Areas for forest genetic resources. Criteria and indicators for sustainable forest management which 'includes a balance of productive, protective, environmental and social components', as it relates to forest genetic diversity are summarized in a paper on status and trends of forest genetic diversity[379]. More specifically genetic aspects are reviewed in an FAO working paper[380]on criteria and indicators for sustainable forest management in terms of assessment and monitoring of genetic variation.

The Committee on Managing Global Genetic Resources: Agricultural Imperatives of the National Research Council, US National Academy of Sciences published an assessment of the need to manage the world's forests, and conserve tree genetic resources and the

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371 Hágsater & Dumont (1996)
372 Farjon & Page (1999)
373 Falk & Holsinger (1991) Appendix
374 WHO/IUCN/WWF. *Guidelines on the Conservation of Medicinal Plants*. IUCN, Gland (1993).
375 A revision of the guidelines is in fact being carried out by WHO, IUCN, WWF and TRAFFIC together with many medicinal plant experts world-wide (Wolfgang Kathe pers.comm. 1 August 2002)
376 http://www.nps.gov/plants/medicinal/index.htm
377 FAO (1975)
378 *Forest Genetic Resources Conservation and Management*: *In Managed Natural forests and Protected areas* (*in situ*). FAO, DFSC, IPGRI. IPGRI, Rome (2001). See also Patiño-Valera (2002)
379 McKinnell (2002).
380 Namkoong & al. (2002)

methods and technologies available[381]. It is a valuable reference source and includes a section on *in situ* methods.

Members of EUFORGEN Networks are producing a set *of Technical Guidelines for genetic conservation and use*[382]**.** These are already available for nine species[383] and it is planned that altogether about 30 will be published.

A Technical Bulletin on the European black poplar (*Populus nigra*), gives information and provides guidance for the *in situ* conservation and management of this a pioneer tree species of the riparian forest ecosystem[384]. It is the result of the collaborative activities of European countries within the *Populus nigra* Network of the European Forest Genetic Resources Programme (EUFORGEN).

Management guidelines for *in situ* conservation of wind-pollinated temperate conifers such as Norway spruce (*Picea abies*) have been produced[385]

National guidelines or strategies have been produced by several European countries for the genetic conservation of forest tree species or those of economic importance, for example Denmark, Finland, France.

Conservation guidelines for a number of native South Pacific trees have been prepared[386] (see also p.)

A very detailed account of the *in situ* genetic conservation of the Monterey pine (*Pinus radiata* D. Don) has been published by the University of California Genetic Resources Conservation Program[387]. In addition to a detailed account of the biology and genetics of this species, it contains a series of principles and recommendations for its *in situ* conservation.

Crop Wild Relatives

The Plant Germplasm Operations Committee of the USDA-ARS National Germplasm System (NPGS) has produced a set of *in situ* conservation guidelines for the American wild relatives of crops[388] based on work on a number of groups. They focus on natural populations in undisturbed or relatively undisturbed ecosystems and cover principally:

- Selection of target taxa
- Compiling species information
- Field and lab procedures

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[381] *Managing Global Genetic Resources. Forest Trees.* Board on Agriculture, National Research Council. National Academy Press, Washington DC (1991).
[382] http://www.ipgri.cgiar.org/networks/euforgen/Technical_Guidelines.asp
[383] *Picea abies, Pinus brutia, Pinus halepensis, Pinus pinaster, Acer pseudoplatanus, Alnus glutinosa, Fraxinus excelsior, Prunus avium , Sorbus domestica*
[384] Lefèvre (2001).
[385] Koski (1996); Koski & al. (1997)
[386] Thomson (1998)
[387] Rogers (2002).
[388] USDA (1999)

- Proposing preserves

A set of recommendations on *in situ* conservation of wild relatives was made to the *European Symposium on the Implementation of the Global Plan of Action in Europe*, Braunschweig, Germany 1988[389].

Although not in the form of Guidelines, the Proceedings of the three workshops on 'Conservation of the Wild Relatives of European Cultivated Plants: developing integrated strategies'[390], held under a Council of Europe initiative, contain articles on most aspects of *in situ* conservation.

Fruit germplasm

A review of *in situ* conservation of tropical fruit germplasm, including a series of guidelines is included in the Workshop Tropical Fruits in Asia: Conservation and Use[391].

Conservation strategies and management guidelines for wild *Prunus* genetic resources have been prepared for Spain[392].

Ornamentals

A recent review[393] notes that 'the conservation and sustainable use of those wild species that may have potential for introduction as new ornamentals crops or as sources of genetic material that can be used in the development of existing crops, needs a much more coherent strategy than at present exists'. This should be implemented at a national level and cover areas such as:

- Surveying at national level of the various holdings, both in cultivation and in seed banks, of the different categories of species of ornamental or amenity value
- An assessment of the conservation status and needs of these resources
- Information and documentation resources and needs
- Identification of priority species or other taxa in need of urgent conservation action
- Assessment of the role of protected areas for the *in situ* conservation of target ornamental species
- Sampling methodologies
- The capacity of germplasm banks, botanic gardens and other institutions for the exploration and maintenance of genetic resources of ornamentals
- The role of the nursery trade in the conservation of ornamentals
- Research on germination, propagation and regeneration of seeds of ornamental species
- Setting achievable targets.

Genetic Resources in Protected Areas

[389] Heywood & Firat (1999)
[390] Valdés & al. (1997)
[391] van den Hurk (1998)
[392] Vivero & al. (2001)
[393] Heywood (2003)

A set of recommendations for the conservation of genetic resources in Protected Areas was made at a Workshop held at the IV World Congress on National Parks and Protected Areas, Caracas[394].

The sequence of steps involved in enhancing the management of protected areas that contain genetic resources of forest tree species so as maintain the target species as well as the ecosystem is given in a recent review of the conservation and management of forest genetic resources[395]

Monitoring

The most comprehensive set of guidelines on measuring and monitoring plant populations is that produced by the US Bureau of Land Management – *Measuring and Monitoring Plant Populations*[396]. This is a major technical reference work that should be widely available for consultation on many aspects of species conservation, not just monitoring. The various chapters cover, in 477 pages, topics such as setting priorities and selecting scale, management objectives, principles of sampling, sampling objectives and design, field techniques for measuring vegetation, data management, communication and monitoring plans, statistical analysis, demography and reporting results.

Biosphere reserves and Buffer zones

A guide for the management of biosphere reserves has been published as a UNESCO MAB Digest[397]. A set of guidelines for the buffer zones in tropical forests has been prepared by IUCN[398]

Participatory process

A review and set of guidelines for the participatory approach in the conservation of forest genetic resources is published in the DFSC Guidelines and Technical Notes series[399]. The proceedings of an international seminar on participatory approaches to the conservation and use of plant genetic resources has been published by IPGRI[400]

Reintroductions

The Re-introduction Specialist Group of the IUCN's Species Survival Commission has prepared the *IUCN/SSC Guidelines for Re-Introductions*[401] (1995). These policy guidelines were prepared as a response to growing occurrence of reintroduction programmes worldwide. Although now somewhat dated they still provide a useful summary.

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394 Heywood & al. (1993)
395 Thomson & Theilade (2001)
396 Elzinga & al. (1998a); see also Elzinga (1998b)
397 Bioet & al. (1998)
398 Sayer (1991)
399 Isager & al. (2002)
400 Friis-Hansen & Staphit (2000)
401 IUCN/SSC (1995)

A handbook for reintroduction of plants to the wild has been published by Botanic Gardens Conservation International[402].

A Reference List for Plant Re-introductions, Recovery Plans and Restoration Programmes was prepared by Royal Botanic Gardens Kew in 1995 but has not been subsequently updated[403].

In 1998, the Plant Conservation Alliance initiated a project to create a comprehensive Restoration Directory which includes both restoration experts and native plant sources. It is currently available on the Society for Ecological Restoration International's website[404]:

The Australian Network for Plant Conservation (ANPC)[405] has published Guidelines for Germplasm Conservation for the conservation, recovery and management of threatened flora[406] and for the translocation of threatened plants in Australia[407] that have been supported by the Standing Committee on Conservation of the Australia and New Zealand Environment and Conservation Council (the Council of Australian and New Zealand Environment and Conservation Ministers). Recovery Plan Guidelines for Nationally Listed Threatened Species and Ecological Communities have been published for Australia by the Federal Government[408].

A valuable introduction to restoration genetics has been prepared for the Society for Ecological Restoration[409] and a useful volume on strategies for the reintroduction of endangered plants has been published[410].

A 400-page manual *Plant Conservation Approaches and Techniques*, a practical guide of issues and methods prepared by a series of experts for the ANPC is in press[411]

VI. Effects of global change

One of the major factors affecting biodiversity conservation is global change (Table 1) although the biodiversity movement and conservation planners have so far conspicuously failed to factor global change into their planning models and strategies[412].

It will have effects on both ecosystems and species and their populations and genes.
The ways in which ecosystems respond to global warming will be complex and varied and will depend on the location and the levels of changes in temperature and other climatic parameters. Current patterns of habitat loss, fragmentation and loss of species diversity will be exacerbated by climate change and as far as species are concerned, the rates of global warming will exceed the migration capacity of many of those affected.

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402 Akeroyd & Wyse Jackson (1995)
403 Atkinson & al. (1995)
404 Society for Ecological Restoration: http://www.ser.org/work.php?pg=restorationexpertise
405 Mill (2002)
406 ANPC (1997a). See also Stephens & Maxwell (1998)
407 ANPC (1997b).
408 Environment Australia (2002).
409 Falk & al. (2001).
410 Falk & al. (1996).
411 Jeanette Mill, National Coordinator, Australian Network for Plant Conservation, Personal communication to vhh (12 June 2003). Now published: Brown & al. (2003)
412 Heywood (2002)

Global warming is expected to raise extinction rates significantly. The interplay between ecosystems and the species they comprise under these changing circumstances will lead to novel situations and assemblages that will challenge ecologists and conservationists. Responses at the genetic and physiological levels within species, populations and individuals require detailed case studies and long-term monitoring. Increased fragmentation of populations within ecosystem fragments will lead to significant loss of genetic diversity within species. With the disruption of habitats, an increase in invasive species and others with high dispersal abilities is likely and this will impact on native species and natural ecosystems.

Global change will have major impacts on conservation strategies and facilities such as Protected Areas, botanic gardens, field gene banks, clonal collections, and seed forests, and in some regions the survival of some of these will be placed in jeopardy. The design of Protected Area systems will require serious rethinking and more flexibility in size and scale so as to provide a connected network of patches of different habitat types at various scales to allow species to migrate and adjust their ranges in response to the various kinds of change. The effects of global change on agrobiodiversity and on agricultural patterns will be significant but in some regions adaptation will mitigate adverse effects much more effectively than in the case of natural ecosystems.

Reviews of global warming and terrestrial biodiversity decline[413] and of global warming and species loss in globally significant terrestrial ecosystems[414] have been published by WWF. The effects of environmental change on forests are considered in a recent IUFRO report[415]and a report on Forests and Climate Change has been prepared for WWF International[416]. The World Bank has issued a working paper on global change and biodiversity[417].

Table 1: Main Components of Global Change (from Heywood 2002)

- Demographic change
  - Human population movement/migrations
  - Demographic growth
  - Changes in population pattern
- Changes in land use and disturbance regime
- Climate change (IPPC definition)
  - Atmospheric change (greenhouse gases)

[413] Malcolm & Markham (2000)
[414] Malcolm & al. (2002)
[415] Sidle (2002)
[416] Dudley ((1998)
[417] Furtado & al. (1999).

– Temperature change

VII. The way forward

As has been noted in this review, the number of candidate species for *in situ* conservation is far in excess of those for which human and financial resources are likely to be made available for the preparation and implementation of management, action or recovery plans for them. Although the Convention of Biological Diversity, in recognizing that 'the fundamental requirement for the conservation of biological diversity is the *in-situ* conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings', does not restrict action to those species that are threatened, the latter alone are estimated at some 80–100 000 which again is such a high figure that even restricting effective conservation action to these is most unlikely to be possible. It is clear therefore that if a major impact is to be made on this problem, a range of different conservation scenarios needs to be considered and a multi-level strategy will be need to be adopted.

A first requirement is that lists of priority species at global, regional and national levels need to be agreed for each of the major target groups of species – e.g. forestry, medicinal, aromatic, crop relatives, ornamentals, industrial – and then filtered according their degree of endangerment so that efforts can initially be directed preferentially at these. Secondly, the presence of these priority species within protected areas should be recorded. Then, a strategy needs to be devised that will provide at least some degree of *in situ* protection for as many species as possible, whether or not threatened, even though this falls short of full effective conservation.

Although presence in a protected area(s) is a preferred option for *in situ* conservation, this is not a prerequisite nor in itself a necessary guarantee that any particular species will be adequately protected. Even in terms of coverage, protected areas are insufficient for *in situ* conservation – they are seldom selected with the conservation of individual plant species in mind; they are often sited in marginal areas; the populations that occur within them are often not representative of the genetic diversity of a species; their management plans do not normally address individual species or groups of particular species; and their management effectiveness is often poor.

On the other hand, the very presence in a protected area affords some degree of protection at least in the short term for the species that they house and so another high priority is to ensure that the area is *effectively* managed and conserved. But as a recent report on the effectiveness of protected areas observes[418], '…in the medium to long term, protected areas only work if they really are protected'.

A number of different situations will be found to occur, depending on whether the species is known to be threatened or not, whether or not it occurs in a protected area, whether it is of economic importance or not. Thus:

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[418] WWF (2004)

- for **widespread** species which are **not currently known to be threatened** and **of no known particular economic importance**, a minimum goal is identification and monitoring of the populations of the species concerned and effective management of any protected area(s) in which they occur; or monitoring their presence and the habitat conditions if they occur outside any protected areas .

- For species of **known economic importance** that are **not threatened**, ecogeographical surveying should be undertaken to establish the amount and distribution of genetic variation and how much of it is represented in protected areas, and an assessment of conservation and monitoring needs undertaken.

- For **threatened species**, whether **of known economic importance or not**, which occur **in protected areas**, ecogeographical surveying should be undertaken, the extent of the genetic representation in the protected area assessed and further areas for eventual protection identified to ensure that an adequate representation of the diversity is covered; then action taken to control or remove the factors that cause the threats and **if the species is considered of sufficient priority**, any necessary further conservation action that is needed, such as detailed management or recovery, should be planned and implemented. Priority determining mechanisms for determining which species to select for priority conservation management and the various steps that such management may involve are described in the appropriate section of this report. Clearly, the more threatened the species is, the more intensive the conservation interventions needed are likely to be. Multi-species as opposed to single-species plans are an option provided the different species face the same or similar threats although experience suggests that for many such plans this is not the case and their effectiveness is in proportion to the amount of time and money that is devoted to the individual species.

- In the case of **threatened species** that are found **outside protected areas**, if considered of sufficiently high priority, efforts should be made to protect sufficient of the area in which they occur to allow viable populations covering a sufficient sample of the genetic variation to be represented. If this is not possible, alternative means of protection, including community participation, easements or habitat conservation planning (see p.).

The *in situ* conservation of target species of economic importance, often termed genetic conservation, normally requires a much more structured and focused approach, as described in the main part of this review, than that for species of no known economic value. The exception is those species for which recovery actions need to be implemented if they are to continue to survive as viable populations.

VIII. Conclusions and recommendations

1. Conservation *in situ* is a poorly understood process and covers a range of different situations that cover wild population and species, domesticates, ecosystems, agroecosystems, landscapes and bioregions. Conservation *in situ* of target species in natural or semi-natural habitats should be seen as but one component of an overall

species conservation strategy and for many species, especially where no *in situ* conservation is possible, alternative approaches should be considered.

2. The maintenance of viable populations of species in their natural surroundings is identified as a fundamental requirement for the conservation of biological diversity by the Convention on Biological Diversity. However, effective *in situ* conservation of target species is a complex, multidisciplinary, time-consuming and expensive process, involving different agencies, and because of the restricted resources and finance available, can only be applied to a small minority of species, even those that are endangered. Consequently, it cannot be considered for the majority of species for which various less formal (and effective) approaches may be adopted.

3. The number of potential candidate species that might be selected for *in situ* conservation in the various target groups such as forestry, medicinal, aromatic, ornamentals and industrial species, crop relatives, and species of scientific importance, is so high (many thousand) that effective conservation management of only a small selection of those that are identified as targets is possible. Priority mechanisms for selecting target species is therefore a critical process and the criteria adopted will depend on the group of species, national priorities and economic and environmental considerations. It is likely that greatest priority will be given to species that are known to be threatened.

4. Even if the wild populations of target species selected for *in situ* conservation need little direct management or intervention, the processes involved in the assessment of their distribution, ecology, demography, reproductive biology, and genetic variation and in the selection of number and size of populations and sites to be conserved as well as containing or eliminating any threats to their survival are onerous.

5. For the majority of potential target species, therefore, no formal conservation management strategy is possible and for these, the burden of effort must fall on Protected Area Systems and Managers on local communities. At a minimum, awareness of the presence of target species in Protected Areas should lead to some form of monitoring if no further action can be taken to help meet the conservation needs of the species.

6. The target of '60 per cent of the world's threatened species conserved *in situ*' by 2010 proposed in the Global Plant Conservation Strategy will not be practicable in a formal sense (management, action or recovery programmes) except for a minority of these. For the majority of threatened species (which have been recently estimated as numbering some 80–100 000), other kinds of action, such as strengthening the role of protected areas in which they occur, surveying and monitoring of populations, moderating or removing the source of the threats, may afford some degree of protection. Local communities can play a significant role in these actions in some cases. It is recommended that the SBSTTA and the CBD review the whole issue of *in situ* species conservation as a matter of urgency.

7. A key requirement for assessing the requirements for *in situ* conservation of species is an adequate information base. This is not available for most countries and no global assessment exists.

8. National lists of target species in the various priority groups should be prepared and then information gathered on the distribution, ecology, demography, variation patterns and conservation status of the species listed.

9. A review of the literature and discussions with experts reveals that the number of cases of effective practical *in situ* conservation of target species is still small and mainly confined to developed countries in temperate and Mediterranean regions of the world such as the United States, most European states, Australia and New Zealand. Probably the number of species which are currently the subject of active *in situ* conservation action represents less than 0.5% of the total plant species (c.400 000), most of them being rare or endangered wild species identified by national Red List programmes.

10. The two main groups of species that have been the subject of most *in situ* conservation action to date – nationally or locally rare and endangered Red List species and forestry species – have both attracted a large body of literature referring to theoretical and practical aspects of priority determination, selection, sampling, management and conservation strategies but those involved have tended to pay little attention to each other's work. It is strongly recommended that each sector should take active steps to learn from the experience of the other. This review should provide an introduction to what is available.

11. Species recovery programmes have been instituted for several hundred species worldwide, mainly in temperate-climate countries. They are complex, time-consuming and expensive and it is too early to judge how successful they will be in the longer term.

12. The review also reveals that for economically important species three main groups have been the focus of *in situ* conservation: forestry tree species, wild crop relatives and medicinal and aromatic plants. Conservation of forest genetic resources *in situ* in natural or seminatural forests is a long standing tradition and considerable practical experience has been gained during the past 50 years. This experience is largely unknown outside forestry and has been largely overlooked by other sectors involved in *in situ* species conservation. Similarly the very extensive theoretical and practical background gained in species recovery programmes is often overlooked by the agricultural and forestry sectors.

13. Most of the efforts that have been invested in crop genetic resources have been directed at conservation in *ex situ* facilities such as seed banks. Until recently, the only form of *in situ* conservation at the species and infraspecies level practised or even recognized has been on-farm for landraces of crops.

14. On the other hand there is greatly increased awareness of the need for *in situ* conservation of species following the publication of the CBD and the GPA, and in a growing number of countries considerable effort is going into establishing baseline information on which species are candidates for selection and undertaking ecogeographical surveying that will allow such programmes to be planned. Many countries, however, have no plans to take action in this area. Likewise, most

conservation organizations have not given *in situ* conservation of species, other than those that are on Red Lists, much prominence.

15. In priority-determining strategies, many factors can be taken into account, some of them obvious while others may have to be taken into account in particular cases or types of plant; others may be applicable only at a later stage of the process, such as degree of management needed.

16. Degree of threat or endangerment is widely adopted as a filter for all groups of target species, including those of economic importance. Although this is understandable, it does run the risk of excluding taking conservation measures for widespread species of major economic importance, such as forestry species where the need to preserve particular values such as alleles, genotypes or ecotypes for present and future use, while they still exist, is justified. It should also be recognized that information on which species are threatened and the nature of the threats is not available for most species that occur in tropical biomes.

17. Protected areas play a major role in the *in situ* conservation of species of economic importance, as habitats where many of them will be found to occur. A first requirement is that the long-term protection of the area should be effective. It should be emphasized that simple presence in a protected area is not sufficient to constitute an adequate conservation plan for the target species as this would require a selection to be made of which and how many populations and individuals in each population are needed to ensure the maintenance, survival and continued evolution of a significant part of the genetic variability of the species concerned.

18. Most protected areas were not set up with conservation of particular species in mind and even the presence of what will be identified as target species will not be known in many cases. Floristic inventories of protected areas should be given priority as part of national strategies for *in situ* species-orientated conservation.

19. Protected area managers should consider the possibility of enhancing the level of protection to be afforded to the populations of species of economic importance that are found to occur within their reserves, through modifying the management of the area. Although this would fall far short of effective *in situ* conservation of such species, it would contribute to the overall goal.

20. Apart from the different categories of protected areas recognized by IUCN, a wide range of specialized types of protected areas designed for genetic conservation exist but much more work needs to be undertaken to establish their effectiveness.

21. In the case of species of economic importance that are directly harvested or consumed (such as medicinal plants or fruits), *in situ* conservation needs to be closely integrated into the overall framework of sustainable resource management.

22. The *in situ* conservation of species outside protected areas, where the majority of them occur, is a subject that deserves much further consideration by conservation agencies. While the very act of taking steps to protect, manage or conserve species populations in

such area effectively brings them under the umbrella of protected areas, there are other indirect means, such as easements, whereby some degree of protection to the species can be afforded by agreements to reduce the level of exploitation or to contain threats. Much greater attention should be paid to the actual and potential role of local communities in protecting species in their natural habitats.

23. Promoting more biodiversity-sensitive management of ecosystems outside protected areas, especially of those known to contain target species, needs to be given high priority.

24. Numerous guidelines exist for the various components of *in situ* conservation strategies; some are general while others are highly detailed; some apply to particular classes of target species while others are focused on particular species. It is not possible to make a useful synthesis of these guidelines apart from some basic elements they have in common and it is clear that great care needs to be taken when adopting any particular set to ensure that they are appropriate to the species involved. It is clear from the review that the circumstances and requirements in each case of target species *in situ* conservation is unique and that there is no single set of procedures which can be applied although some general principles apply, .

25. The future effects of the various components of global change on *in situ* conservation programmes are difficult to predict but it seems likely that in some areas not only the individual species but the ecosystems in which they are conserved *in situ* will be put at risk.

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Annex 1: Terms of reference

It will include a detailed assessment of: (1) the various guidelines and methodologies published by FAO, IUCN, DIVERSITAS/Council of Europe, BGCI and other bodies on *in situ* conservation; (2) the data collected in the process of country reporting during preparations for the International Technical Conference on Plant Genetic Resources, and reviewed in the State of the World's Plant Genetic Resources for Food and Agriculture; (3) National Biodiversity Actions Plans and Strategies and National Reports prepared by Parties to the Convention on Biological Diversity (under Article 6); (4) results obtained from GEF-financed projects involving *in situ* conservation of target species. It will review different kinds of *in situ* activities involving wild species undertaken by local and national conservation bodies, including species recovery programmes, genetic resource conservation of agricultural and forestry species, habitat restoration and rehabilitation. This will be the first global survey of this field and will be of importance to all countries attempting *in situ* conservation of target species.

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Annex 3: IPGRI Networks

AMS Networks

REDARFIT, REMERFI, TROPIGEN, PROCISUR, CAPGERNet, NORGEN

- Networks in the Americas

APO Networks

EA-PGR, RECSEA-PGR, SANPGR

- Regional Networks in Asia, the Pacific and Oceania (APO)
- Regional Network for Conservation and Utilization of Plant Genetic Resources in East Asia (EA-PGR)
- Asian Network for Sweet Potato Genetic Resources (ANSWER)
- Crop and Forestry networks in Asia, the Pacific and Oceania (APO)
- International Network on Bamboo and Rattan (INBAR)
- Networking and forest genetic resources in the Asia, the Pacific and Oceania region (APO)
- Regional Co-operation in Southeast Asia for Plant Genetic Resources (RECSEA-PGR)
- South Asia Network on Plant Genetic Resources (SANPGR)

COGENT
International Coconut Genetic Resources Network

- **COGENT Home Page**
- A fact sheet on COGENT

CWANA Networks
CA-TC/PGR, WANANET

- Regional Networks in Central & West Asia and North Africa (CWANA)

DIT
Documentation, Information and Training group

- SINGER - System-wide Information Network for Genetic Resources

ECP / GR
European Cooperative Programme for Crop Genetic Resources Networks

- **About ECP/GR**
- A fact sheet on ECP/GR

EUFORGEN
European Forest Genetic Resources Network

- **EUFORGEN Home Page**
- A fact sheet on EUFORGEN
- EUFORGEN *Populus nigra* Network
- EUFORGEN Bibliographic Database on Gray Literature
- EUFORGEN Conifers Network
- EUFORGEN Mediterranean Oaks Network
- EUFORGEN Noble Hardwoods Network
- EUFORGEN Publications
- EUFORGEN Temperate Oaks and Beech Network

INIBAP
International Network for the Improvement of Banana and Plantain

- About INIBAP
- INIBAP Publications
- INIBAP Publications search within IPGRI Publications Catalogue
- INIBAP and COGENT activities in Latin America
- INIBAP Databases
- INIBAP Networking Mode
- INIBAP Office Locations
- INIBAP Research

- Second

SGRP
System-Wide Genetic Resources Programme

- About SGRP - *System-wide Genetic Resources Programme*
- SGRP Publications

SINGER
System Wide Information Network for Genetic Resources

- Taxonomic Nomenclature Checker

SSA Networks
GRENEWECA, SPGRC, EAPGREN, MUSACO , BARNESA, SAFORGEN

- Networks in sub-Saharan Africa (SSA)

Annex 4: IUCN/SSC Plant Conservation Strategy 2000-2005

Goal:
The extinction crisis is acknowledged as a global problem, and the current rate of loss of plant diversity is decreased.

Objective 1:
Sound interdisciplinary scientific information underpins decisions and policies affecting plant diversity.

OUTPUT 1.1: The SSC Plants Programme promotes conservation of important plant areas by refining the criteria for identification of Centres of Plant Diversity and other priority plant areas, and assisting in implementing programmes to conserve such sites at appropriate regional, national and local scales.

Activitiy 1: Undertake a review of criteria for selecting priority plant conservation areas involving appropriate stakeholder groups, with a view to refining criteria at a range of geographic scales.

Activity 2: Develop a Centres of Plant Diversity and Important Plant Areas booklet, that provides guidelines and criteria for selection (along the lines of the Red List Criteria), together with models for associated conservation action.

Activity 3: Through workshops encourage the process of selecting important plant areas at regional, national and local levels, in association with IUCN members, IUCN regional offices and other appropriate organisations and agencies.

Activity 4: Through partnerships with national, regional and local networks, facilitate one or more workshops for the development of site-based Action Plans for priority plant areas and plant area clusters, and ensure that these plans are available to local groups.

Activity 5: Promote and develop appropriate monitoring programmes for tracking action and implementation of site-based Action Plans.

OUTPUT 1.2: The SSC Plants Programme participates in projects on specific conservation issues, such as the conservation of wild plants of importance for food and agriculture and other selected economic plants, and the study and mitigation of major threats by providing inputs to the development and implementation of these projects.

Activity 6: The SSC Plants Programme collaborates in reviews and analyses of existing guidelines for *in situ* conservation of plants and their further development, utilising the experience gained from *in situ* research and management.

Activity 7: The SSC Plants Programme collaborates in projects on the conservation of wild relatives of crop plants, for example, in the development of a catalogue of wild relatives and the distribution and use of protected areas for their *in situ* conservation.

Activity 8: Particular attention is paid to building capacity to combat major threats to plants, with particular emphasis on the growing global problem of invasive alien species.

OUTPUT 1.3: The SSC Plants Programme should assist the functioning, implementation, and growth of programmes and information networks which facilitate effective and rigorous listing of conservation status of plants.

Activity 9: The SSC Plants Programme will promote, in collaboration with other interest groups, the concept of indicators which provide periodic and regular 'global state of biodiversity' assessments by tracking extinction, changes in overall threats and numbers of taxa under threat, action effectiveness, and data on critically threatened sites.

Activity 10: The SSC Plants Programme vigorously seeks, in co-operation with the SSC Red List Programme and other like-minded organisations, to establish funding to ensure ongoing security for plant listing programmes including the listing process itself.

Activity 11: Conservation status information provided (especially) by the work of the SSC Specialist Groups is integrated into and provides guidance for the SSC Red Listing Programme, and is used to help determine conservation priorities.

Objective 2
Collaboration and strategic alliances, including local and national organisations outside the SSC, are increasingly used within the plant conservation community to achieve plant conservation success.

OUTPUT 2.1: In developing and implementing the SSC Plants Programme, strategic alliances with appropriate international, national, and local organisations outside the SSC are formed and nurtured as part of an expanding global network.

Activity 12: The SSC Plants Programme identifies existing partnerships and gaps, and actively seeks and establishes international, national and local partnerships to develop and implement its Plants programme.

Activity 13: The SSC Plants Programme develops and nurtures partnerships which lead to funding for plant conservation activities.

Activity 14: The SSC Plants Programme encourages the involvement of Programme members at relevant conferences and meetings to promote SSC activities and programmes, the development of a calendar of such meetings, and the identification of participation opportunities.

OUTPUT 2.2: Partnerships and working collaborations are formed among the SSC Plants Programme and other sectors of the SSC and the IUCN, while the SSC Plants Programme maintains and strengthens its own network.

Activity 15: SSC members and other parts of IUCN develop integrated and effective ways to ensure that the needs of plants are fully recognised within all appropriate SSC/IUCN programmes, including such initiatives as "Plant-Link" (working with animal-based SSC Specialist Groups), and participation in the Species Information Service (SIS) and the Biodiversity Conservation Information System (BCIS).

Activity 16: The SSC continues to create and implement its Plants Programme as a core activity and to plan plant conservation actions primarily through Plant Specialist Groups, which are encouraged to seek their own strategic alliances with appropriate local groups (both within and outside IUCN).

Objective 3

Modes of production and consumption that result in the conservation and restoration of plant diversity are adopted by users of plant resources.

OUTPUT 3.1: Activities promoting the sustainable use of plant resources are identified and supported through the SSC by Specialist Group programmes and strategic links to other SSC and IUCN activities and appropriate non-IUCN partnerships.

Activity 17: Maintain and develop collaboration with appropriate organisations and programmes (such as the Sustainable Use Specialist Group) to achieve standards for assessing and managing the impact of use on wild plant resources.

Activity 18: To promote the dissemination of the sustainable use concept for plants and ensure inclusion in national, regional and local planning documents, and ensure that Action Plans and activities involving plants take into account the sustainable use of plants.

Activity 19: The SSC Plants Programme participates through the Medicinal Plants Specialist Group in inter-agency collaboration on the conservation and use of medicinal plants with particular reference to sustainable production, benefit sharing and community participation.

Objective 4

SSC's plant policy recommendations, guidelines, and advice are valued, adopted, and implemented by relevant audiences.

OUTPUT 4.1: The SSC Plants Programme targets conservation professionals and institutions as part of its outreach activity.

Activity 20: SSC Plants Programme outputs are made widely available through an established and comprehensive network of professionals, practitioners and institutions, with the Programme becoming a clearing house for information on plant conservation, especially through its website.

OUTPUT 4.2: The SSC Plants Programme builds resources and helps others to build resources to support awareness campaigns on priority plant conservation sites, threatened species, and related issues.

Activity 21: Existing links with widespread and effective disseminating media are used and strengthened; new media relationships are vigorously developed, including regular and effective press releases and articles on plant conservation needs, challenges, and achievements.

Activity 22: Capacity is built to create, review, and promote documented Top 50 plant lists with a view to promoting conservation action from global to local levels, linking this with the IUCN Commission on Education and Communication.

OUTPUT 4.3: The SSC Plants Programme promotes an integrated plant conservation philosophy and methodology that includes the concept of sustainable use as well as protection, and this integration is increasingly strengthened by appropriate collaboration with *in situ* and *ex situ* organisations, both nationally and internationally.

Activity 23: Integrated conservation messages, stressing the combined values of *in situ* and *ex situ* conservation, and promoting the roles of research, education, habitat restoration and species recovery are incorporated into all SSC Plants Programme documents, relevant IUCN publications, and consultations.

Activity 24: As a general principle, the SSC Plants Programme promotes rapid response to changes in conservation priorities and needs, and the adoption of appropriate new concepts and methodologies by plant research, management and conservation communities.

Objective 5
Capacity to provide long-lasting, practical solutions to plant conservation problems is markedly increased.

OUTPUT 5.1: Well-funded training, technology transfer, personnel exchanges, and information availability are encouraged by the SSC Plants Programme as principal plant conservation capacity-building measures for lesser-resourced nations.

Activity 25: The SSC Plants Programme identifies and works in partnership with existing international, national, and local plant conservation training programmes, promoting within-country capacity building and the identification of training gaps.

Activity 26: The SSC Plants Programme promotes the concept of 'best practice', the identification of 'best practice' case-studies, and the dissemination of this information to conservation practitioners through publications and web sites (including the SSC plant web site).

OUTPUT 5.2: Research in conservation biology, sustainable plant use, off-site techniques, and the management of plants and their habitats (especially when linked to management and restoration of landscapes, ecosystems and natural resources), is vigorously promoted and facilitated by the SSC Plants Programme.

Activity 27: The SSC Plants Programme collaborates with other plant conservation interest groups to formulate and promote a collaborative agenda of global research priorities leading to practical application at the local level.

OUTPUT 5.3: Programmes for conservation of plants are vigorously pursued at appropriate and linked scales from global to local, with overall capacity and levels of both discretionary and targeted funding raised.

Activity 28: A project for linking funding sources and new initiatives is developed to facilitate both the operation of the SSC Plants Programme and effective linkages to related programmes and initiatives.

Annex 5: Summary of discussions and recommendations on *in situ* conservation of wild

relatives made to the European Symposium *Implementation of the Global Plan of Action in Europe – Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture,* Braunschweig, Germany, 30 June–3 July 1998[419]*.*

In situ conservation of wild relatives

Chairs: V. Heywood and E. Firat

Summary of the discussions and recommendations

Papers presented in this session covered the following topics: national networks for *in situ* conservation in France; genetic diversity in German PGR; the Ammiad (Israel) experimental *in situ* project; *in situ* conservation of PGRFA in Armenia, and the existing opportunities for collaboration between *in situ* conservation and the UNESCO Man and Biosphere (MAB) project. These set the scene for the following report and recommendations.

Conservation of wild relatives of crop plants *in situ* is a major weakness in the implementation of the GPA in Europe (as in other parts of the world). The need for action is critical in each of the Member States.

The workshop emphasized the highly interdisciplinary nature of *in situ* conservation actions and drew attention to the fact that, unlike *ex situ* conservation, the *in situ* approach, by its nature, is a dynamic, not a static process, and as a consequence target species' populations and the ecosystems in which they occur will change in time.

Recommendations to the ECP/GR Steering Committee

The workshop endorses the need for an active *in situ* conservation thematic network under the aegis of the ECP/GR to address many fundamental issues. It recommends the following priority actions at the national and European levels to facilitate further the implementation of *in situ* conservation of wild relatives of crops.

The following comments were made:

1. *In situ* action should, where appropriate, be complemented by *ex situ* actions.
2. It was stressed that *in situ* populations of target species should be monitored at an appropriate frequency to measure the change in genetic diversity of target populations and, when appropriate, the consequent need for *ex situ* sampling.
3. The workshop welcomes the initiative of IPGRI in commissioning a revised edition of the booklet "Conserving the wild relative of crops" (Hoyt 1992).
4. It is recognized that all types of *in situ* conservation involve some degree of human intervention, even if that intervention is limited to the monitoring of genetic

419

diversity in target populations. It also recognized that the design and implementation of any management plan for a target species will often require research and experimentation, and these may well necessitate revision of the protected area management plan.

5. The importance of marginal populations, which are characterized by limited diversity but may contain unique alleles and therefore represent special situations with respect to their genetic make-up, make them a priority for *ex situ* conservation.

The following recommendations were made:

1. It is recommended that a list be made of existing examples of *in situ* conservation projects for conservation of PGRFA in Europe and neighbouring regions, and that a database of project details be established.

2. Action should be taken to build upon the Council of Europe catalogue of wild relatives of European cultivated plants (Heywood and Zohary 1995) by checking and supplementing the information therein on a national basis. New fields to be added should include: detailed in-country distribution, ecology, breeding system, crossing information, population dynamics and IUCN category of threat.

3. The ECP/GR *In situ* and on-farm conservation Network should compile and issue from various existing sources (e.g. Valdés *et al.* 1997; the Bern Convention Criteria 1979; Maxted *et al.* 1997; Given 1994; Heywood *et al.* 1993; the UNESCO MAB Seville Strategy) a consolidated list of guidelines for the practical implementation of PGRFA conservation and these should be issued as a booklet.

4. Liaison should be established with other organizations (e.g. MAB, FAO, DIVERSITAS, IUCN, etc.) that have competence in this area to promote and facilitate mutual benefits.

5. The amount of genetic diversity that may be duplicated between the wild relatives and their related crops should be investigated.

6. There is a need to research the relative costs of *in situ* and *ex situ* conservation of species' populations.

7. The workshop recognized that *in situ* conservation of wild relatives and on-farm conservation are two distinct but related subjects. Therefore it recommended that two separate but allied working groups be formed, although certain species or situations may be of interest to both working groups, e.g. forage and weedy species.

8. To assist countries in determining priorities for *in situ* conservation, the workshop recommended that the following criteria be considered:

- is the target species/ecotype/population threatened nationally, regionally or globally?

- does the species occur in a recognized protected area?

- is the species subject to environmental legislation at a national, regional or global level that requires conservation action?
- if the species does not occur in a recognized protected area, does it occur in an area where ownership/control/access can be gained and monitoring undertaken?
- is it a 'keystone', 'umbrella', 'flagship' or culturally important species?
- is it a component of an ECP/GR or other crop network?
- ecogeographical range or specificity of the species
- population size, structure and whether isolated, marginal, introgressed
- breeding system and phenological characteristics of the species
- once priority species have been determined, an effective strategy is to conserve those that occur in the same ecosystem or habitat, i.e. give priority to the conservation of sites that are rich in species of wild relatives.

9. The workshop recommends that an *ad hoc* meeting be held to assess work at national levels to review project experiences, identify further conservation, research and training initiatives, coordinate research and training priorities at a European level, and that the meeting should involve the participation of representatives from EUFORGEN, MAB and DIVERSITAS. The workshop further recommends that invitations to the *ad hoc* meeting be extended through Europe and neighbouring regions in view of the close biogeographical links between Europe and the Mediterranean region.
10. The workshop recognizes that owing to severe threats to many wild relatives in certain European countries, emergency survey and inventory works are required and it therefore requests IPGRI to assist strengthen national programmes in these areas.

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