Chapter 2

The state of *in situ* management

2.1 Introduction

The CBD defines *in situ* conservation 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." While the concept has evolved since the CBD was adopted, this definition is used in several major international treaties and initiatives including the ITPGRFA and the Global Strategy for Plant Conservation (GSPC). *In situ* conservation is often envisaged as taking place in protected areas or habitats (as opposed to *ex situ* conservation) and can either be targeted at species or the ecosystem in which they occur. It is a particularly important method of conservation for species that are difficult to conserve *ex situ,* such as many CWR.

The on-farm conservation and management of PGRFA is often regarded as a form of *in situ* conservation. However, in many cases the reasons why farmers continue to grow traditional varieties may have little to do with the desire to conserve and much more to do with reasons of tradition and preferences, risk avoidance, local adaptation, niche market opportunities or simply the lack of a better alternative. Nevertheless, much important diversity continues to be maintained in farmers' fields and efforts to improve management and use have gained much ground during the past decade. There is now a clearer understanding of the factors involved.[1]

This chapter describes progress that has been made since the first SoW report was published in the conservation and management of PGRFA in wild ecosystems, agricultural production systems and the interface between the two. It reviews new knowledge regarding the amount and distribution of diversity of landraces, CWR and other useful plants and assesses current capacity for conserving and managing diversity *in situ*. The chapter describes a few major global challenges that exist today, summarizes the main changes that have occurred since the first SoW report was published and concludes by identifying further gaps and needs.

2.2 Conservation and management of PGRFA in wild ecosystems

Many plant species growing in wild ecosystems are valuable for food and agriculture and may play an important cultural role in local societies. They can provide a safety net when food is scarce and are increasingly marketed locally and internationally, providing an important contribution to household incomes. Approximately a third of the country reports received mentioned the use of wild-harvested plants. Nigeria, for example, cited the use of African mango (*Irvingia gabonensis*) and locust bean (*Parkia biglobosa*) in times of food shortage.

Grassland and forage species are another important component of agrobiodiversity, especially in countries where livestock production is a major contributor to the national economy.[2] However, natural grasslands are becoming seriously degraded in many parts of the world, resulting in a need for greater attention to be devoted to *in situ* conservation in such ecosystems. In many cases the conservation and use of natural grasslands is important in strategies to conserve and use animal genetic resources.

With the development of new biotechnological methods, CWR are becoming increasingly important in crop genetic improvement. Taking a broad definition of CWR as any taxon belonging to the same genus as a crop, it has been estimated that there are 50-60 000 CWR species worldwide.[3] Of these, approximately 700 are considered of highest priority, being the species that comprise the primary and secondary genepools of the world's most important food crops, of which many are included in Annex 1 of the ITPGRFA.

2.2.1 Inventory and state of knowledge

Since the publication of the first SoW report, most countries have carried out specific surveys and inventories, either as part of their National Biodiversity Action Plans[4] or, more commonly, within the framework of individual projects. Switzerland, for example, completed an inventory of its CWR in 2009 in which 142 species were identified as being of priority for conservation and use.[5] Most surveys, however, have been limited to single crops, small groups of species or to limited areas within the national territory.[6] For example, in Senegal inventories were made of selected species of fonio, millet, maize, cowpea and some leafy vegetables. Mali reported carrying out 16 inventories and surveys of 12 crops, and Albania and Malaysia have both conducted inventories of wild fruit species.

Very little survey or inventory work has been carried out on PGRFA in protected areas compared with other components of biodiversity in these areas.[7] The observation made in the first SoW report remains valid, i.e. that *in situ* conservation of wild species of agricultural importance occurs mainly as an unplanned result of efforts to protect particular habitats or charismatic species. While many countries assume that PGRFA, including CWR, are conserved by setting aside protected areas,[8] the reality is that in many countries this tends to fall between the cracks of two different conservation approaches, ecological and agricultural; the former focusing mainly on rare or threatened wild species and ecosystems and the latter mainly on the *ex situ* conservation of domesticated crops. As a result, the conservation of CWR has been relatively neglected.[9] Efforts to redress this situation have included a global project led by Bioversity International, to promote collaboration between the environment and agriculture sectors in order to prioritize and conserve CWR in protected areas (see Box 2.1).

Compared with the first SoW report in which only four countries[10] reported that they had surveyed the status of CWR, the past decade has seen significant progress in this area, with CWR inventories compiled in at least 28 countries. Some also reported that specific sites for *in situ* conservation of CWR had been identified.[11] In Venezuela (Bolivarian Republic of), between 1997 and 2007, 32 inventories and surveys were carried out prioritizing areas of the country where PGRFA were at risk. Jordan, Lebanon, the West Bank and Gaza Strip and the Syrian Arab Republic in collaboration with ICARDA, conducted surveys over the period 1999-2004 to assess the density, frequency and threats to wild relatives of cereals, food legumes, forage legumes and of seven genera of fruit trees and neglected species.

At the regional and global level, efforts have been made by several international organizations to carry out inventories and to determine the conservation status of wild plants. An analysis of the IUCN's Red List of Threatened Species[12] shows that of the14 important crops for food security, identified in the thematic study,

Box 2.1
A Crop Wild Relatives Project: increasing knowledge, promoting awareness and enhancing action

The global project, '*In situ* conservation of CWR through enhanced information management and field application', supported by United Nations Environment Programme (UNEP)/Global Environment Facility (GEF) and coordinated by Bioversity International, has made significant advances in promoting the *in situ* conservation of CWR in protected areas. The project works in Armenia, the Plurinational State of Bolivia, Madagascar, Sri Lanka and Uzbekistan and has sought to establish effective partnerships among stakeholders from both the agriculture and environment sectors. The project has comprehensively assessed threats to CWR and identified activities for their mitigation. Outputs have included the development of CWR national action plans; management plans for specific species and protected areas; guidelines for conserving CWR outside protected areas; and improved legislative frameworks for CWR conservation. Selected species of CWR have been evaluated to identify traits of value in crop improvement. Information from the project has been integrated within national information systems and is available through a Global Portal. This, combined with training and innovative public awareness efforts, means that the project is helping to enhance the conservation of CWR not only in the participating countries but also throughout the world.

(banana/plantain, barley, cassava, cowpea, faba bean, finger millet, garden pea, maize, pearl millet, potato, rice, sorghum, sweet potatoes and wheat), only 45 related wild species have been assessed globally, the majority of which are relatives of the potato.[13] The SSC-IUCN has established a new CWR Specialist Group to support and promote the conservation and use of CWR. Botanic Gardens Conservation International (BGCI) has made an inventory of all CWR occurring in botanical gardens and has added a CWR flag in its plant database.[14] The most comprehensive inventory of CWR is the catalogue for Europe and the Mediterranean,[15] which lists over 25 000 species of CWR that occur in the Euro-Mediterranean region. As a first step towards the creation of a European inventory of *in situ* CWR populations, the ECPGR has called for focal points to be appointed with the responsibility of developing national *in situ* inventories.[16]

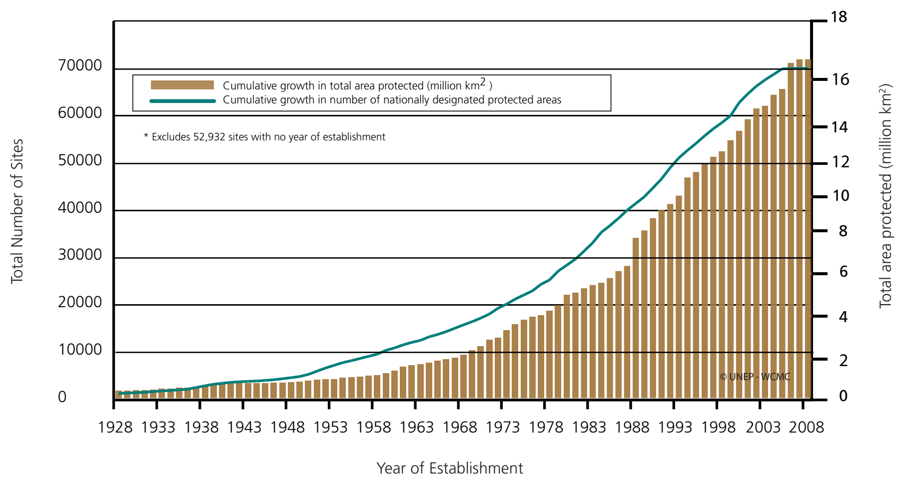
Many of the country reports listed major obstacles to systematic national inventorying and surveying of PGRFA. These include: lack of funding, lack of human resources, skills and knowledge,[17] lack of coordination and unclear responsibilities,[18] low national priority,[19] inaccessibility of *in situ* areas,[20] and difficulties in obtaining necessary permissions.

2.2.2 *In situ* conservation of crop wild relatives in protected areas

The number of protected areas in the world has grown from approximately 56 000 in 1996 to about 70 000 in 2007 and the total area covered has expanded in the same period from 13 to 17.5 million km² (see Figure 2.1).[21] This expansion is reflected at the national level with most countries reporting an increase in the total area protected. Paraguay, for example, has increased its protected area from 3.9 to 14.9 percent of the country's territory and Madagascar pledged that one-third of its territory would be protected by 2008.[22]

Figure 2.1 shows the cumulative growth in nationally designated protected areas (marine and terrestrial) in both total number of sites and total area protected (km²) from 1928 to 2008. Only sites that are designated and have a known year of establishment have been included.

FIGURE 2.1
Growth in nationally designated protected areas (1928-2008)



Source: World Database on Protected Areas (WDPA).[24]

In an assessment of the extent to which wild PGRFA is actually conserved in protected areas[23] it was observed that, in general, areas with the greatest diversity (e.g. within centres of origin and/or diversity) received significantly less protection than the global average. Most countries have less than five percent of their areas under some form of protection.

Since the last report, there has been a substantial increase in the number of articles published describing the status of CWR[25] and drawing attention to specific action needed.[26] However, few of the recommendations have been implemented, largely due to a lack of funds and appropriately skilled personnel (see Section 2.5).

A recent study of the current status and trends in the conservation of CWR in 40 countries[27] has shown that conservation activities can take many forms including field or database inventories and mapping;[28] ecogeographic surveys;[29] investigation of policy structures and decision-making;[30] studies of traditional and indigenous ethnobiology;[31] and monitoring of CWR once management plans have been adopted.[32]

While a global survey of *in situ* conservation of wild PGRFA,[33] as well as an analysis of the country reports, reveal that relatively few countries have been active in conserving PGRFA in protected areas, some progress has been made as the following examples show:

- CWR are actively conserved in at least one protected area in each of the five countries of the CWR project coordinated by Bioversity International (see Box 2.1);
- in Ethiopia, wild populations of *Coffea arabica* are being conserved in the montane rainforest and studies are being carried out to assess the extent of Ethiopian coffee genetic diversity and its economic value. The aim is to develop models for conserving *C. arabica* genetic resources both within and outside protected areas;[34]
- Mali reported that wild fruit trees, that are important for food security, are managed in protected forests and in southern United Republic of Tanzania, special conservation methods are used to manage the indigenous fruit tree *Uapaca kirkiana*;
- in Guatemala, priority conservation areas have been recommended for 14 'at risk' species including *Capsicum lanceolatum, Carica cauliflora, Phaseolus macrolepis, Solanum demissum* and *Zea mays* subsp. *huehuetenangensis*;[35]
- the Sierra de Manantlán Reserve in Southwest Mexico has been established specifically for the conservation of the endemic perennial wild relative of maize, *Zea mays*;
- in the Asia and Pacific region, a comprehensive conservation project on native tropical fruit species, including mango, citrus, rambutan, mangosteen, jackfruit and litchi, was implemented by ten Asian countries with technical support from Bioversity International.[36] In China, 86 *in situ* conservation sites for wild relatives of crops had been established by the end of 2007 and a further 30 sites planned. In Viet Nam, *Citrus* spp. are included in six Gene Management Zones (GMZs) and, in India, sanctuaries have been established in the Garo Hills of Meghalaya to conserve the rich native diversity of wild *Citrus* and *Musa* species;[37]
- in Europe, surveys have been carried out on wild *Prunus* species[38] and on wild apples and pears.[39] The European Crop Wild Relative Diversity Assessment and Conservation Forum[40] has established *in situ* conservation methodologies for CWR[41] with the aim of promoting genetic reserves for crop complexes such as those of the *Avena*, *Beta*, *Brassica* and *Prunus* species;
- the Erebuni Reserve has been established in Armenia to conserve populations of cereal wild relatives (for example *Triticum araraticum*, *T. boeoticum*, *T. urartu*, *Secale vavilovii S. montanum*, *Hordeum spontaneum, H. bulbosum and H. glaucum*)[42] and in Germany, the Flusslandschaft Elbe Biosphere Reserve is important for the *in situ* conservation of wild fruit crop genetic resources and perennial ryegrass (*Lolium perenne*);
- in the Near East, in addition to the protected area established in Turkey for conserving wild relatives of cereals and legumes, in 2007 the Syrian Arab Republic established a protected area at Alujat and has banned the grazing of small ruminants in the Sweida region to contribute to conserving wild relatives of cereals, legumes and fruit trees.

In spite of the aforementioned examples and the overall increase in the number of protected areas, the range of genetic diversity of target species within them remains inadequately represented and many of the ecological niches that are important for wild PGRFA remain unprotected. In a study of wild peanut (*Arachis* spp.) in South America, it was found that the current conservation areas poorly cover the distribution of the species, with only 48 of the 2 175 georeferenced observations included in the study originating from national parks.[43]

2.2.3 *In situ* conservation of PGRFA outside protected areas

A World Bank study[44] reported that while existing parks and protected areas are the cornerstones of biodiversity conservation, they are insufficient to ensure the continued existence of a vast proportion of tropical biodiversity. A significant number of important PGRFA species, including CWR and useful plants collected from the wild, occur outside conventional protected areas and consequently do not receive any form of legal protection.[45] Cultivated fields, field margins, grasslands, orchards, recreation areas and roadsides may all harbour important CWR and other useful wild plants. Plant diversity in such areas faces a variety of threats including the widening of roads, removal of hedgerows or orchards, overgrazing, expansion in the use of herbicides or even just different regimes for the physical control of weeds.[46]

The effective conservation of PGRFA outside protected areas requires that social and economic issues be addressed. This may require, for example, specific management agreements to be concluded between conservation agencies and those who own or have rights over prospective sites. Such agreements are becoming more common, especially in North America and Europe. Microreserves, for example, have been established in the Valencia region of Spain.[47] In Peru, farming communities have signed an agreement with the CIP to establish a 15 000 ha 'Potato Park' near Cusco where the genetic diversity of the region's numerous potato varieties is protected by local indigenous people who own the land and who are also allowed to control access to these local genetic resources.

Many CWR and other useful species grow as weeds in agricultural, horticultural and silvicultural systems, particularly those associated with traditional cultural practices or marginal environments. In many areas such species may be particularly threatened as a result of the move away from traditional cultivation systems. Several national governments, especially in developed countries[48] now provide incentives, including financial subsidies, to maintain these systems and the wild species they harbour. While such options are largely unaffordable and unenforceable throughout most of the developing world, opportunities do exist for integrating the on-farm management of landraces and farmer varieties with the conservation of CWR diversity.[49] Several countries in West Africa, for example, have commented on the important role of local communities and traditional methods in the sustainable management of grassland ecosystems.

While several country reports mention that measures have been taken to support *in situ* conservation outside protected areas, few details have been provided. In Viet Nam, a research project on the *in situ* conservation of landraces and CWR outside protected areas was developed to conserve globally significant agrobiodiversity of rice, taro, litchi, longan, citrus and tea, at 11 sites in 7 provinces. The strategy was to promote community-based Plant Genetic Resources Important Zones (PGR-IZs). In Germany, the '100 fields for biodiversity'[50] project focuses on the conservation of wild plant species (including CWR) outside protected areas through the establishment of a nationwide conservation network for wild arable plant species. Research in West Asia has found significant CWR diversity in cultivated areas, especially at the margins of fields and along roadsides.[51] It has also been reported that in Jabal Sweida in the Syrian Arab Republic, rare wheat, barley, lentil, pea and faba bean CWR are common in modern apple orchards.[52]

2.2.4 Global system for *in situ* conservation areas

The first SoW report recommended the establishment of a system of *in situ* conservation areas and the development of guidelines for site selection and management. In response, the CGRFA commissioned a study[53] on the establishment of a global network for the *in situ* conservation of CWR. The study report proposed conservation priorities and specific locations in which to conserve the most important wild relatives of 14 of the world's major food crops (see Table 2.1). The report points out that about 9 percent of the CWR of the 14 crops require urgent conservation attention. A brief summary of the regional priorities presented in the report is given below:

Africa

High priority locations have been identified in Africa for the conservation of wild relatives of finger millet (*Eleusine* spp.), pearl millet (*Pennisetum* spp.), garden pea (*Pisum* spp.) and cowpea (*Vigna* spp.).

Americas

In the Americas, priority locations for genetic reserves have been identified for barley (*Hordeum* spp.), sweet potato (*Ipomoea* spp.), cassava (*Manihot* spp.), potato (*Solanum* spp.) and maize (*Zea* spp.).

Asia and the Pacific

Potential genetic reserve locations have been identified for the four highest priority taxa of wild rice (*Oryza* spp.) and ten priority taxa related to cultivated banana/plantain (*Musa* spp.).

Near East

The highest priority locations for conserving the wild relatives of garden pea (*Pisum* spp.), wheat (*Triticum* spp. and *Aegilops* spp.), barley (*Hordeum spontaneum* and *H. bulbosum*), faba bean (*Vicia* spp.), chickpea (*Cicer* spp.), alfalfa (*Medicago* spp.), clover (*Trifolium* spp.) and wild relatives of fruit trees, particularly, Pistachio (*Pistacia* spp.) and stone fruits (*Prunus* spp.) occur in this region.

These highest priority sites provide a good basis for establishing a global network of CWR genetic reserves, in line with the draft Global Strategy for Crop Wild Relative Conservation and Use[54] developed in 2006.

2.3 On-farm management of PGRFA in agricultural production systems

The on-farm management and conservation of PGRFA, in particular the maintenance of traditional crop varieties in production systems, has gained much ground since the publication of the first SoW report. Many new national and international programmes have been set up around the world to promote on-farm management and the published literature over the last ten years has resulted in a clearer understanding of the factors that influence it.[55] New tools have been developed that enable this diversity and the processes by which it is maintained, to be more accurately assessed and understood[56] and there is a better understanding of the complementarities between *in situ*/on-farm and *ex situ* conservation. However, relatively little is still known about how to achieve the best balance in the use of these two approaches, or about the dynamic nature of that relationship. The country reports provided information, summarized in Table 2.1, on the extent and distribution of crop genetic diversity within agricultural production systems, the management processes that have maintained this diversity, the national capacity to support the maintenance of diversity and progress in on-the-ground conservation interventions.

2.3.1 Amount and distribution of crop genetic diversity in production systems

Efforts to measure genetic diversity within production systems have ranged from the evaluation of plant phenotypes using morphological characters, to the use of new tools of molecular biology. Considerable variation exists among production systems and many country reports pointed out that the highest levels of crop genetic diversity occurred most commonly in areas where production is particularly difficult, such as in desert margins or at high altitudes, where the environment is extremely variable and access to resources and markets is restricted.

Little information was available from country reports regarding actual numbers of traditional varieties

TABLE 2.1
Summary of 14 priority CWR species as reported by Maxted & Kell, 2009

Crop	High priority CWR	Centers of diversity	Likely occurrence inside protected area	Known occurrence inside protected area	Known occurrence outside protected area	Countries in which suggested priority site/ areas should be located	Suggested sites are specific protected areas or in their vicinity? (Y/N)
Finger millet *(Eleusine coracana)*	*E. intermedia*	East Africa	X			Burundi, Democratic Republic of the Congo, Ethiopia, Kenya, Rwanda, Uganda	Y
	E. kigeziensis		X		X		Y
Barley *(Hordeium vulgare)*	*H. chilense*	Main: Southwestern Asia; Others: Central Asia, Southern South America, Western North America	X		X	Chile	Y
Sweet potato *(Ipomoea batatas)*	*I. batatas* var. *apiculata*	Main: Northwestern South America Others: Indonesia, Papua New Guinea, Sub-Saharan Africa	X			Mexico	Y
	I. tabascana				X		N
Cassava *(Manihot esculenta)*	*M. alutacea* *M. foetida* *M. leptopoda* *M. neusana* *M. oligantha* *M. peltata* *M. pilosa* *M. pringlei* *M. tristis*	Brazil, Bolivia (Plurinational State of), Latin America				Brazil	N

TABLE 2.1 (continued)
Summary of 14 priority CWR species as reported by Maxted & Kell, 2009

Crop	High priority CWR	Centres of diversity	Likely occurrence inside protected area	Known occurrence inside protected area	Known occurrence outside protected area	Countries in which suggested priority site/areas should be located	Suggested sites are specific protected areas or in their vicinity? (Y/N)
Banana/plantain *(Musa acuminate)*	*M. basjoo* *M. cheesmani* *M. flaviflora* *M. halabanensis* *M. itinerans* *M. nagensium* *M. ochracea* *M. schizocarpa* *M. sikkimensis* *M. textilis*	India, Malaysia				Bhutan, India, Papua New Guinea, Sumatra, Philippines	N
Rice *(Oryza sativa)*	*O. longiglumis* *O. minuta*			X			Y
	O. rhizomatis	Asia, Pacific, Africa		X	X	India, Papua New Guinea, Sri Lanka	Y
	O. schlechteri		X		X		Y
Pearl millet *(Pennisetum glaucum)*	*P. schweinfurthii*	Western Africa	X		X	Sudan	Y
Garden pea *(Pisum sativum)*	*P. abyssinicum* *P. sativum* subsp. *elatius* var. *brevipedunculatum*	Ethiopia, Mediterranean, Central Asia			X	Cyprus, Ethiopia, Syrian Arab Republic, Turkey, Yemen	N
Potato *(Solanum tuberosum)*	110 species with 5 or fewer observation records	Southcentral Mexico, South America				Argentina, Bolivia (Plurinational State of), Ecuador, Mexico, Peru	N
Sorghum *(Sorghum bicolor)*	none	Southeast Asia, India, South America, Africa					

TABLE 2.1 (continued)
Summary of 14 priority CWR species as reported by Maxted & Kell, 2009

Crop	High priority CWR	Centres of diversity	Likely occurrence inside protected area	Known occurrence inside protected area	Known occurrence outside protected area	Countries in which suggested priority site/areas should be located	Suggested sites are specific protected areas or in their vicinity? (Y/N)
Wheat (*Triticum aestivum*)	*T. monococcum* subsp. *aegilopoides* *T. timopheevii* subsp. *armeniacum* *T. turgidum* subsp. *aleocolchicum* *T. turgidum* subsp. *dicoccoides* *T. turgidum* subsp. *polonicum* *T. turgidum* subsp. *turanicum* *T. urartu* *T. zhukovskyi*	Transcaucasia, Fertile Crescent, Eastern Mediterranean		X	X	Georgia, Iran (Islamic Republic of), Iraq, Lebanon, Turkey	N (except one)
Faba bean (Vicia faba)	*V. eristalioides* *V. faba* subsp. *paucijuga V. galilaea* *V. hyaeniscyamus* *V. kalakhensis*				X	Syrian Arab Republic, Turkey	N
Cowpea (*Vigna unguiculata*)	*V. unguiculata* - subsp. *aduensis* - subsp. *alba* - subsp. *baoulensis* - subsp. *burundiensis* - subsp. *letouzeyi* - subsp. *unguiculata* var. *spontanea*	India/Southeast Asia; Tropical Africa			X	Numerous African countries	Y
	V. unguiculata - subsp. *pawekiae* - subsp. *pubescens*			X			
Maize (*Zea mays*)	*Z. luxurians* *Z. mays* subsp. *huehuetenangensis* *Z. diploperennis*	Mexico	X	X	X X	Guatemala, Nicaragua Guatemala Mexico	Y/N

Source: Maxted, N. & Kell, S.P. 2009. Establishment of a Global Network for the *In Situ* Conservation of CWR: Status and Needs. FAO CGRFA. Rome, Italy. 266 pp.

maintained in farmers' fields. The Georgia country report mentioned that 525 indigenous grape varieties are still being grown in the mountainous countryside and isolated villages, while in the Western Carpathians of Romania, more than 200 local landraces of crops have been identified.

In contrast to the country reports, published scientific literature since the first SoW report contains a considerable amount of information on numbers of traditional varieties grown on farm. A major conclusion from these publications is that a significant amount of crop genetic diversity in the form of traditional varieties continues to be maintained on farm even through years of extreme stress.[57] In a study in Nepal and Viet Nam of whether traditional rice varieties are grown by many households or only a few, and over large or small areas,[58] it was found that more than 50 percent of traditional varieties are grown by only a few households in relatively small areas.

Farmers' variety names can provide a basis for estimating the actual numbers of traditional varieties occurring in a given area and, more generally, as a guide to the total amount of genetic diversity. However, different communities and cultures approach the naming, management and distinguishing of local cultivars in different ways and no simple, direct relationship exists between cultivar identity and genetic diversity.[59]

2.3.2 Management practices for diversity maintenance

Practices that support the maintenance of diversity within agricultural production systems include agronomic practices, seed production and distribution systems and the management of the interface between wild and cultivated species.

A widespread system that conserves a wealth of traditional varieties is production in home gardens. Cuba, Ghana, Guatemala, Indonesia, Venezuela (Bolivarian Republic of) and Viet Nam all reported that significant crop genetic diversity exists in home gardens, which can act as refuges for crops and crop varieties that were once more widespread. Farmers often use home gardens as a site for experimentation, for introducing new cultivars, or for the domestication of wild species. Useful wild species may be moved into home gardens when their natural habitat is threatened, e.g. through deforestation, as in the case of loroco (*Fernaldia pandurata*) in Guatemala.[60]

A recent review[61] revealed that traditional varieties and landraces of horticultural crops, legumes and grains are still extensively planted by farmers and gardeners throughout Europe and they are often found in the home gardens of rural households. Invaluable diversity of traditional varieties of many crops, especially of fruits and vegetables but also of maize and wheat, is still available, even in countries where modern commercial varieties dominate the seed systems, crop fields and commercial orchards.

Many country reports indicated that 'informal' seed systems remain a key element in the maintenance of crop diversity on farm (see Section 4.8) and can account for up to 90 percent of seed movement.[62] While seed exchange can take place over large distances, in many cases it appears to be more important locally, especially within traditional farming systems. In Peru, for example, between 75 and 100 percent of the seeds used by farmers in the Aguaytia Valley was exchanged within the community with little going outside.[63]

Access to seeds of traditional varieties of field crops can be an issue in some developed countries. In the European Union, for example, only certified seeds of officially registered varieties can be marketed commercially, although local, small-scale, non-commercial exchange of planting material remains quite common. However, the European Union Directive 2008/62/EC provides for a certain flexibility in the registration and marketing of traditional, locally adapted but threatened agricultural landraces and varieties; so-called 'conservation varieties'. For more information on seed legislation and its impacts see Section 5.4.2.

Several countries report on how the genetic make-up of local varieties depends on the effects of both natural selection and selection by farmers. In Mali, studies have shown that local varieties of sorghum collected in 1998 and 1999 matured seven to ten days earlier than those collected 20 years earlier, as the result of natural selection, farmer selection, or both. This underlines the dynamic nature of *in situ* management, it can result in the conservation of many components of the genetic makeup of the varieties concerned, but also allows genetic change to occur.

Farmer seed selection practices vary widely. They may select seeds from plants growing in a certain part of a field, from particularly 'healthy' plants, from a special part of the plant, from plants at different stages of maturity, or they may simply take a sample of seeds from the overall harvest. In some local communities in Ouahigouya, Burkina Faso, for example, pearl millet farmers harvest seeds from the centre of the field to maintain 'purity', selecting a range of types and taking into account uniformity of grain colour and spikelet dehiscence. This practice appears to favour seed quality and seed vigour.[64]

The Cyprus and Greece country reports indicated that many farmers in these countries prefer to save their own seeds and when replaced, the same variety is generally obtained from a relative, neighbour, or the local market (usually in that order of preference). In this way, over a period of years much mixing occurs. Community genebanks have also been established in a number of countries[65] and can be important sources of seeds for local farmers.

A sharp decrease in the number of farmers growing a particular variety and a switch to a single, or restricted number of new varieties, can create a genetic bottleneck and may result in the loss of genetic diversity. This can occur, for example, as a result of natural disasters, war or civil strife when local seed availability may be severely reduced; seeds and other propagating materials may be lost or eaten, supply systems disrupted and seed production systems destroyed (see Chapter 1). At the same time, relief organizations may distribute seeds of new cultivars that can result in further changes in the number and type of varieties grown.

The interface between wild and agricultural plants and ecosystems is highly complex and can result in both positive and negative effects regarding the maintenance of genetic diversity. The natural introgression of new genes into crops can expand the diversity available to farmers. Geneflows between crop cultivars and their wild relatives have been a significant feature of the evolution of most crop species[66] and continue to be important today.[67] In Benin and other West African countries, for example, it has been reported that introgression between wild and domesticated yams is important in the continuing improvement of yam cultivars by farmers.[68] At the same time, many wild relatives and crop cultivars avoid losing their identities even when they grow in close proximity, often using reproductive mechanisms such as pollen competition. This can happen for example when a wild relative is surrounded by cultivated fields, as in the teosinte-maize relationship in Mexico,[69] and in the opposite case when wild relatives surround crop fields, such as pearl millet in the Sahel.[70]

Several country reports provide examples of the management of the crop-wild interface. In southern Cameroon, for example, wild yams (*Dioscorea* spp.) are important as a food and in the culture of the Baka Pygmies. Through a variety of technical, social and cultural practices, referred to as 'paracultivation', they are able to make use of the wild resources while keeping them in their natural environment. In Tajikistan, superior genotypes of walnut (*Juglans regia*) and pistachio (*Pistacia vera*) have been selected from the wild and are now in cultivation, and wild apples have been planted in orchards in some parts of the Pamir mountain range.

In Jordan and in the Syrian Arab Republic, natural gene flows between cultivated and wild *Triticum* species were confirmed using morphological and molecular techniques.[71]

2.3.3 Farmers as custodians of diversity

During the last decade extensive work has been carried out to improve understanding on why and how farmers continue to maintain diversity in their fields. This has resulted in a greater appreciation of the range of custodians, the role of traditional knowledge and the needs and choices farmers have within their livelihood systems. The diversity of stakeholders who maintain and use PGRFA has been looked at in many countries. Work in China and Nepal, for example, has found that only one or two expert farmers in a given community account for the maintenance of most of the diversity.[72] Age, gender, ethnic group and wealth status all have a bearing on who maintains diversity, what diversity is maintained and where (see Chapter 8). Especially in developed countries, individuals may be involved for hobby or other non-commercial reasons. Japan has implemented a system to recognize and register people as leaders in the cultivation of local crops, based on their experience and technical capabilities.

Many country reports recognize the importance of traditional knowledge in the conservation and use of PGRFA on farm. Bangladesh, Ethiopia, India, Kazakhstan, the Lao People's Democratic Republic and the United Republic of Tanzania, for example, all describe efforts to document and protect indigenous knowledge, while many others state the need to do so or point to a need for appropriate policies to this end.

Many factors influence the choice of how many and which varieties to grow and in which areas, including the need to minimize risk, maximize yields, ensure nutritional balance, spread workloads and capture market opportunities. A series of empirical studies in Burkina Faso, Hungary, Mexico, Nepal, Uganda and Viet Nam have suggested that major factors affecting varietal choice also include market access, seed supply, farmer age and gender and whether the variety is common or rare.[73]

2.3.4 Options to support the conservation of diversity in agricultural production systems

While there are many ways in which farmers can benefit from a greater use of local crops and varieties, in many cases action is needed to make them more competitive with modern varieties and major crops. Potential interventions to increase competitiveness include: better characterization of local materials, improvement through breeding and processing, greater access to materials and information, promoting increased consumer demand and more supportive policies and incentives. Often, efforts to implement such interventions are led by Non-governmental Organizations (NGOs) that may or may not be linked to national research and education institutes.

2.3.4.1 Adding value through characterizing local materials

While work has been carried out in a number of countries on characterization of local materials, landraces are often inadequately characterized, especially under on-farm conditions. There is some indication from the country reports that greater efforts have been made to characterize traditional and local varieties over the past decade and the Czech Republic reported that state financial support is available for the evaluation of neglected crops.

2.3.4.2 Improving local materials through breeding and seed processing

Improvement of local materials can be achieved through plant breeding and/or through the production of better quality seed or planting material. Since the first SoW report was published, particular attention has been given to participatory approaches to crop evaluation, improvement and breeding, especially involving local farmer varieties (see Chapter 4). Several case studies have been conducted by the ECPGR Working Group on on-farm conservation and management. These relate to cowpea and beans in Italy, Shetland cabbage in Scotland, fodder beets in Germany, Timothy grass in Norway and tomatoes in Spain.[74]

2.3.4.3 Increasing consumer demand through market incentives and public awareness

Raising public awareness of local crops and varieties can help build a broader base of support. This can be achieved in many ways, for example, through personal contacts, group exchanges, diversity fairs, poetry, music and drama festivals and the use of local and international media.[75] Albania, Azerbaijan, Jordan, Malaysia, Namibia, Nepal, Pakistan, Portugal, the Philippines and Thailand, for example, all reported on the establishment of markets and fairs for the promotion of local products. Other ways of income generation include promoting ecotourism and branding products with internationally accepted certificates of origin or the like for niche markets.[76] In Jamaica, on-farm management is supported by the development of local and export markets for a wide range of traditional and new products originating from local underutilized crops. Malaysia, likewise, reported on efforts to develop commercial value-added, 'diversity-rich' products.

2.3.4.4 *Improved access to information and materials*

The importance of maintaining and managing information and knowledge about diversity at the community or farmer level is recognized in many country reports. A number of initiatives have been developed through the NGO community, aiming to strengthen indigenous knowledge systems, for example 'Community Biodiversity Registers' in Nepal, that record information on cultivars grown by local farmers.[77] Cuba, Ethiopia, Nepal, Peru and Viet Nam all report that 'diversity fairs' allow their farmers to see the extent of diversity available in a region and to exchange materials. In Azerbaijan, for example, action was taken by the Government to improve farmer's PGRFA knowledge. These fairs have proven to be a popular and successful way of strengthening local knowledge and seed supply systems.[78] In Finland, the project 'ONFARMSUOMI: Social and cultural value, diversity and use of Finnish landraces' aims to find new ways to encourage the on-farm management of traditional crop diversity. It has developed a web based 'landrace information bank' to encourage and support the cultivation of landraces among farmers as well as to enhance awareness among the general public.

2.3.4.5 *Supportive policies, legislation and incentives*

Traditional varieties are generally dynamic and evolving entities, characteristics that need to be recognized in policies designed to support their maintenance. Recent years have seen several countries enact new legislation to support the use of traditional varieties. In Cyprus, for example, the Rural Development Plan 2007-2013 is the main policy instrument covering the on-farm management of PGRFA. It contains a range of different measures to promote the conservation and use of diversity in agricultural and forest land within protected areas. In Hungary, the National Agri-Environment Programme (NAEP) has adopted a system of Environmentally Sensitive Areas (ESA) through which areas of low agricultural productivity that have, however, high environmental value are designated for special conservation attention. (For a more extensive discussion of policy issues in relation to the conservation and use of PGRFA see Chapters 5 and 7).

2.4 Global challenges to *in situ* conservation and management of PGRFA

The Millennium Ecosystem Assessment (MEA)[79] identified five major drivers of biodiversity loss: climate change, habitat change, invasive alien species, overexploitation and pollution. Of these, the first three arguably pose the greatest threat to PGRFA and are discussed in the following sections. In addition, in many countries, the introduction of new varieties is also seen as a significant factor in the loss of traditional crop diversity and is also discussed briefly below.

2.4.1 Climate change

Many country reports[80] refer to the threat of climate change to genetic resources. All the predicted scenarios of the Intergovernmental Panel on Climate Change (IPCC)[81] will have major consequences for the geographic distribution of crops, individual varieties and CWR. Even the existing protected area system will require a serious rethink in terms of size, scale and management.[82] Wildlife corridors, for example, will become increasingly important to enable species to migrate and adjust their ranges. Small island states, which often have numerous endemic species, are also highly vulnerable to climate change, particularly to rises in sea level.

A recent study[83] used current and projected climate data for 2055 to predict the impact of climate change on areas suitable for a number of staple and cash crops. A picture emerged of a loss of suitable areas in some regions, including many parts of Sub-Saharan Africa and gains in other regions. Of the crops studied, 23 were predicted to gain in terms of overall area suitable for production at the global level while 20 were predicted to lose. Another study predicted similar trends[84] including the overall loss of suitable land and potential production of staple cereal crops in Sub-Sahara Africa. Many developed nations, on the other hand, are likely to see an expansion of suitable arable land into latitudes further away from the equator.

Ex situ conservation will become increasingly important as a safety net for conserving PGRFA that is threatened with extinction due to climate change. At the same time, the genetic diversity conserved in genebanks will become increasingly important in underpinning the efforts of plant breeders as they develop varieties adapted to the new conditions. Likewise *in situ* conservation, because of its dynamic nature, will also become more important in the future as a result of climate change. In cases where *in situ* populations of CWR and landraces are able to survive climate change, their evolution under climatic selection pressure will result in populations that may not only be important in their own right but also have the potential to contribute valuable new traits for crop genetic improvement.

2.4.2 Habitat change

The expansion of agriculture itself, in large part due to the direct and indirect effects of a growing and increasingly urbanized human population, is one of the biggest threats to the conservation of wild genetic diversity of agricultural importance. MEA has reported that cultivated land covers one-quarter of the Earth's terrestrial surface and that while the cropped areas in North America, Europe and China have all stabilized since 1950, this is not true in many other parts of the world. A further 10–20 percent of land currently under grass or forest will be converted to agriculture by 2050. Some countries, e.g. Argentina and the Plurinational State of Bolivia, specifically refer to the expansion of land devoted to agriculture as a major threat to CWR.

2.4.3 Invasive alien species

The MEA cited invasive alien species, including pest and disease organisms, as one of the biggest threats to biodiversity. While the problem may be particularly severe on small islands, several continental countries, including Bosnia and Herzegovina, Nepal, Slovakia and Uganda, also specifically reported this as a threat to wild PGRFA. The problem has been exacerbated in recent years due to increased international trade and travel. Many small island developing states now have to confront huge problems of biological invasion. French Polynesia, Jamaica, Mauritius, Pitcairn, Reunion, Saint Helena and the Seychelles, are all among the top ten most affected countries based on the percentage of their total flora, under threat.[85] Cyprus reported that a variety of crop species are known as invasive alien species and are having negative effects on local biodiversity.

2.4.4 Replacement of traditional with modern varieties

The replacement by farmers of traditional varieties with new, improved modern varieties, has been recognized as an issue in more than 40 of the country reports (see Chapter 1). Ecuador reported this effect in the Sierra region. Georgia, for example, cited the fact that local varieties of apples and other fruits were being replaced by introduced modern varieties from abroad and Pakistan reported that the release of high yielding varieties of chickpea, lentil, mung bean and blackgram have resulted in the loss of local varieties from farmers' fields. Jordan reported that crops such as wild almond and historical olive trees are under threat due to the replacement by the new varieties.

2.5 Changes since the first State of the World report was published

The first SoW report emphasized the need to develop specific conservation measures for CWR and wild food plants, particularly in protected areas; sustainable management systems for rangelands, forests and other humanized ecosystems; and systems for the conservation and sustainable use of landraces or traditional crop varieties in farmers' fields and in home gardens. While there is good evidence of progress over the past decade in developing tools to support the assessment, conservation and management of PGRFA on farm, it is less evident that the *in situ* conservation of wild relatives has advanced significantly, especially outside protected areas. Major trends and developments since the first SoW report was published are summarized below:

- a large number of surveys and inventories of PGRFA have been conducted;
- the *in situ* conservation of PGRFA (in particular CWR) in wild ecosystems still occurs mainly in protected areas. Less attention has been given to conservation elsewhere. There has been a significant increase in the number and coverage of protected areas;
- CWR have received much more attention. A global strategy for CWR conservation and use has been drafted, protocols for the *in situ* conservation of CWR are now available and a new Specialist Group on CWR has been established within SSC-IUCN;
- while many countries have reported an increase in the number of *in situ* and on-farm conservation activities, they have not always been well coordinated;
- there has been little progress on the development of sustainable management techniques for plants harvested from the wild, which are still largely managed following traditional practices;
- the last decade has seen an increase in the use of participatory approaches and multistakeholder teams implementing on-farm conservation projects;
- a number of new tools, especially in the area of molecular genetics, have become available and training materials have been developed for assessing genetic diversity on farm;
- new legal mechanisms enabling farmers to market genetically diverse varieties, coupled with legislation supporting the marketing of geographically identified products have provided additional incentives for farmers to conserve and use local crop genetic diversity in a number of countries;
- significant progress has been made in understanding the value of local seed systems and in strengthening their role in maintaining genetic diversity on farm;
- there is evidence that more attention is now being paid to increasing the levels of genetic diversity within production systems as a means of reducing risk, particularly in the light of the predicted effects of climate change.

2.6 Gaps and needs

An analysis of the country reports, regional consultations and thematic studies identified a number of gaps and needs for the improvement of *in situ* conservation and on-farm management of PGRFA. While the major issues identified in the first SoW report remain (lack of skilled personnel, financial resources and appropriate policies) a few new needs have also been identified:

- the draft global strategy on the conservation of CWR needs to be finalized and adopted by governments as a basis for action;[86]
- there is a need to strengthen the ability of farmers, indigenous and local communities and their organizations, as well as extension workers and other stakeholders, to sustainably manage agricultural biodiversity;
- there is a need for more effective policies, legislation and regulations governing the *in situ* and on-farm management of PGRFA, both inside and outside of protected areas;
- there is a need for closer collaboration and coordination, nationally and internationally, especially between the agriculture and environment sectors;
- there is a need for specific strategies to be developed for conserving PGRFA *in situ* and for managing crop diversity on farm. Special attention needs to be given to the conservation of CWR in their centres of origin, major centres of diversity and biodiversity hotspot areas;
- the involvement of local communities is essential in any *in situ* conservation or on-farm management effort and traditional knowledge systems and practices need to be fully taken into account. Collaboration between all stakeholders needs to be strengthened in many countries;
- there is a need in all countries to develop and put in place early warning systems for genetic erosion;
- greater measures are needed in many countries to counter the threat of alien invasive species;
- strengthened research capacity is required in many areas and, in particular, in taxonomy of CWR and conducting inventories and surveys using new molecular tools;

- specific research needs relating to on-farm management or *in situ* conservation of PGRFA include:
  - studies on the extent and nature of possible threats to existing diversity on farm and *in situ;*
  - the need for better inventories and characterization data on land races, CWR and other useful wild species, including forages, in order to better target *in situ* conservation action;
  - studies on the reproductive biology and ecological requirements of CWR and other useful wild species;
  - ethnobotanical and socio-economic studies, including the study of indigenous and local knowledge, to better understand the role and limits of farming communities in the management of PGRFA;
  - studies of the effectiveness of different mechanisms for managing genetic diversity and how to improve them;
  - studies of the dynamic balance between *in situ* and *ex situ* conservation. What combination works best, where, under what circumstances and how should the balance be determined and monitored;
  - studies on the mechanisms, extent, nature and consequences of geneflow between wild and cultivated populations;
  - further research to provide information to underpin the development of appropriate policies for the conservation and use of genetic diversity, including the economic valuation of PGRFA.

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