Chapter 7

Selection and Prioritization of Species/Populations and Areas

Setting conservation priorities is not an easy or comfortable undertaking (K.A. Saterson, 1995).

The nature of the problem

The amount of resources, both human and financial, available for conservation is insufficient to satisfy all the demands being made. CWR are no exception and actions to conserve them have to compete with other biodiversity conservation activities. As a consequence, some form of triage or priority setting has to be applied. Furthermore, as already noted, in many countries, the number of CWR identified will be so large that it would not be feasible to prepare management plans and monitoring regimes for all of them, nor would it be cost-effective to do so, even assuming finance was made available. As indicated above (in Chapter 6), in preparing a national CWR conservation strategy and action plan, some form of selection should be used so that the candidate species can be placed in different priority categories and appropriate forms of genetic conservation applied to them. These may range from population and habitat recovery programmes, conservation plans with various levels of management intervention, through conservation statements to simply monitoring the status of the CWR populations. In some cases, no formal genetic conservation may be possible and alternative arrangements may be made that limit the threats to them or their habitats (see Chapter 11).

The selection of areas in which conservation of CWR is to be undertaken may be straightforward, for example when a CWR consists of a small population(s) geographically restricted to a small area(s), whether protected or not. Or, it may be complex, as in the case of variable species comprising many populations and with an extensive geographical distribution within the country (and sometimes also in adjacent countries). In recent years, various methods for reserve selection have been proposed, but these are primarily aimed at designing a protected area system that includes the maximum representation of biodiversity. Such considerations are well beyond the scope of this manual.

Selection of priority CWR species

Methodology and criteria

There is no precise or agreed methodology for selecting the species or populations that should be given priority as targets for *in situ* conservation and much will depend on local requirements and circumstances. In practice, the selection made will be influenced by the priorities and mandate of the institution or agency involved commissioning the conservation actions (Ford-Lloyd et al, 2008). Thus the species chosen and the actions proposed by agricultural or forestry staff in a country will most likely differ from those made by conservationists, conservation biologists, ecologists or taxonomists. For example, the CWR of economically important crops might well be given high priority, as was the case in the UNEP/GEF CWR Project where Sri Lanka based their selection of priority CWR for conservation primarily on the importance of the crop; or priority may be given to those CWR that are most threatened or endangered, but such an approach is to oversimplify a complex situation. In the absence of an agreed set of criteria, the UNEP/GEF CWR Project countries adopted different sets of criteria based on the knowledge, experience and interests of those involved in the exercise.

Commonly used criteria are listed in Box 7.1. Because there are so many possible factors that might be taken into account, a multilayer approach may be adopted and a scoring system may be used as in the case of Armenia (see below).

A proposal for applying scientific criteria to establish priorities using indicators was made by Flor et al (2006) (see Box 7.2) at the PGR Forum workshop on Genetic Erosion and Pollution Assessment Methodologies. For each criterion, indicators can be assigned and then values can be attributed to the indicators (see Box 7.3).

In addition, pragmatic considerations that may influence the choice of taxa include:

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

For further information on the various criteria mentioned above, see Maxted et al (1997) and Brehm et al (2010).

Box 7.1 General criteria for selecting target species

A scoring system could be applied to each of the questions below, with some having more weight than others depending on the objective of the strategy.

- What is the actual or potential use of the target species? Is it a CWR, medicinal plant, forest timber tree, fruit tree, ornamental, forage etc.? Can the species be used for habitat restoration or rehabilitation?
- What is the current conservation status of the target species?
- Is the species endemic, with a restricted range or is it widely distributed?
- Is the species experiencing a continuing decline in its occurrence?
- Is there evidence of genetic erosion?
- Does the species have some unique characteristics in terms of:
  - a. ecogeographic distinctiveness;
  - b. taxonomic or phyletic distinctiveness or uniqueness or isolated position;
  - c. focal or keystone species;
  - d. indicator species;
  - e. umbrella species;
  - f. flagship species?
- Does the species have cultural importance or is it in high social demand?
- Does the species occur in a protected area system or does it have some sort of legal or community protected status?

Source: adapted from Heywood and Dulloo, 2005

Box 7.2 Groups of criteria for priority setting

The criteria are grouped in five sets in order to reflect all of the variants that contribute to a taxon's status in terms of genetic importance in relation to its cultivated relatives.

Threat assesses the risk of extinction or any other threat to taxon viability while being an integral part of an ecosystem.

Conservation assesses the existence of programmes or conservation and management plans for the taxon.

Genetic assesses the genetic potential and the status in terms of taxon conservation when its importance as a plant genetic resource is attested.

Economic assesses the economic importance of the taxon.

Utilization assesses the social importance and the extent and frequency of traditional or other uses.

Source: Flor et al, 2006

Box 7.3 Examples of values applied to indicators

Group of criteria	*Criterion*	*Indicator*	*Valuation*
Threat	IUCN threat category	EW (Extinct in the wild)	13
		CR (Critically endangered)	11
		EN (Endangered)	9
		VU (Vulnerable)	7
		NT (Near threatened)	5
		LC (Least concern)	3
		DD (Data deficient)	1
Genetic	Gene pool	Primary gene pool	13
		Secondary gene pool	7
		Tertiary gene pool	3
		Unknown	0

Source: Flor et al, 2006

Conservation status and threat assessment

It is likely that in setting priorities, at some stage preference may be given to CWR that are threatened to some degree; this is usually expressed as their *conservation status or assessment*. What then is involved in evaluating the conservation status of a species? Essentially it is a process of assessing its current state in terms of its distribution and range, population size and numbers, genetic variation, the availability of habitat and the health of the ecosystem, the effects that any threats are having on its current maintenance and prospects for survival in the short, medium and long term.

It should be emphasized that we will rarely, if ever, know the exact population size or range of a species, because of measurement error and natural variation. Moreover, the information available for different species varies enormously and this has to be taken into account when using a set of rules or a framework for deciding on conservation status, which have to be applied irrespective of the amount and quality of the data. A simple approach to the interpretation of such rules, which treats the uncertainty associated with parameters in a precautionary manner, is provided by Burgman et al (1999).

The most commonly used system for assigning conservation status of species is that of the IUCN Red List programme. Red Books and Red Lists are intended both to raise awareness and to help to direct conservation actions. The goals of the IUCN Red List are summarized in Box 7.4 (see also IUCN, 2000). Attention is drawn to the comments on the role of global red lists at a local scale, a subject also addressed by Gardenfors et al (1999) who provide draft guidelines for the application of the IUCN Red List criteria at regional and national levels.

In 1994, a new set of rules was adopted by IUCN for assessing the conservation status of species in Red Lists and Red Data books (IUCN, 1994). Essentially,

Box 7.4 The Goals of the IUCN Red List

The formally stated goals of the Red List are: (1) to provide scientifically based information on the status of species and subspecies at a global level; (2) to draw attention to the magnitude and importance of threatened biodiversity; (3) to influence national and international policy and decision-making; and (4) to provide information to guide actions to conserve biological diversity.

To meet the first two of these goals, the classification system should be both objective and transparent; it therefore needs to be inclusive (i.e. equally applicable to a wide variety of species and habitats), standardized (to give consistent results independent of the assessor or the taxon being assessed), transparent, accessible (a wide variety of different people can apply the classification system), scientifically defensible and reasonably rigorous (it should be hard to classify species without good evidence that they really are or are not threatened). The application of a consistent system also has the benefit that changes in the list over time can be used as a general indicator of the changing status of biodiversity worldwide.

The third and fourth stated goals of the Red List mean that it needs to influence policy- and decision-makers: the challenge here is more complicated. Effective conservation actions generally take place nationally and locally and not at the global level. There are very few mechanisms to conserve species above the national level. Even the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on Biological Diversity (CBD), which are global agreements among countries, rely on implementation within countries for their effectiveness. The Red List is therefore intended to focus national and local conservation actions on the species that most need support. However, it is important to recognize that for various reasons the highest conservation priorities within countries or regions may not simply be the most threatened species found in that region. Certain species may be relatively secure within a politically defined area but nevertheless be at risk globally, whereas other species that are relatively secure globally may be at the edge of their geographic range and hence be highly threatened within a region. For this reason, the role of global red lists within countries must simply be to give shape and force to conservation planning and help set local actions in a global context. There are various ways in which countries might choose to use global information in their own assessments and so far IUCN has provided no more than general guidance.

Source: IUCN, 1996

a new, quantitative system replaced a set of qualitative definitions that had been in place since the early 1960s and were familiar and widely used in scientific, political and popular contexts as a means of highlighting the world's most threatened species. The development of the IUCN criteria took place over a period of five years and led to considerable debate and some controversy from the first proposals to formal adoption by IUCN. According to IUCN (2000), *the most fundamental feature of the new system is its intention to measure extinction risk, and* *not other factors, such as rarity, ecological role or economic importance that are commonly incorporated into conservation priority systems*. Attention is drawn to this as it is widely misunderstood.

Also, it needs to be stressed that global lists of threatened species do not provide a simple assessment of global conservation *priorities* among those species. As the IUCN clearly states (IUCN, 2000):

> *whilst a threat assessment is a necessary part of any conservation priority assessment, it is not on its own sufficient. Priority-setting should involve many other considerations. These might include assessments of the likelihood of successful remedial action for a species, of the wider benefits for biodiversity that will accrue from directed conservation actions (e.g. for other species within the region, the status of the habitat or ecosystem), and of political, economic and logistic realities. Under some circumstances additional factors are also incorporated in priority assessments, such as the evolutionary distinctiveness of the species …, the status of existing protection measures, actual or potential economic value, ecological specialisations of particular note and the level of information on the species …*

The current IUCN categories of threat[1] are given in Box 7.5 and Figure 7.1.

As noted above, the IUCN system of threats is primarily intended for making global assessments but has been widely adopted for national use by many

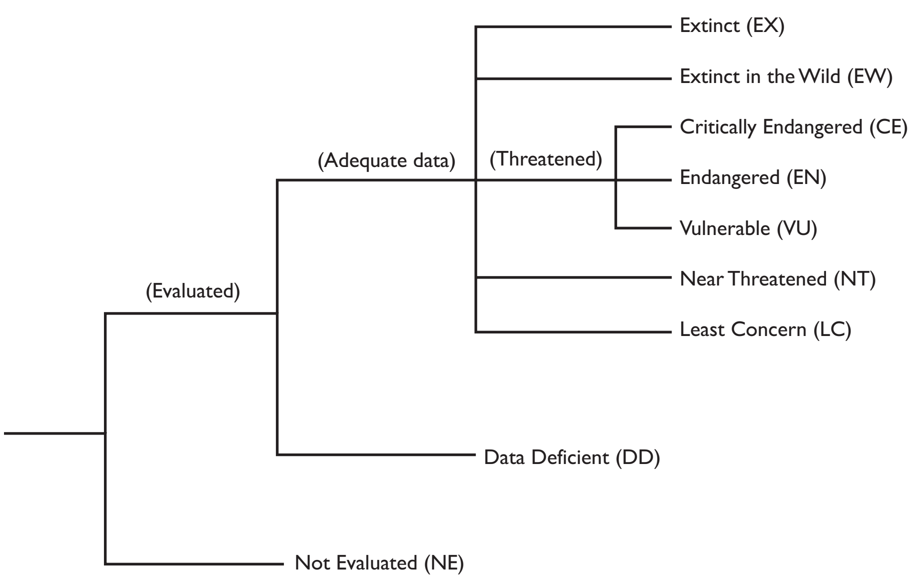

Figure 7.1 *Schema of the current IUCN categories of threat*

Box 7.5 IUCN categories of threat

Extinct (EX) – A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual) throughout its historic range, have failed to record an individual. Surveys should cover a timeframe appropriate to the taxon's life cycle and life form.

Extinct in the wild (EW) – A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual) throughout its historic range have failed to record an individual. Surveys should be over a timeframe appropriate to the taxon's life cycle and life form.

Critically Endangered (CR) – A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinction in the wild.

Endangered (EN) – A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild.

Vulnerable (VU) – A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild.

Near Threatened (NT) – A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

Least Concern (LC) – A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

Data Deficient (DD) – A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

Not Evaluated (NE) – A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

Source: http://intranet.iucn.org/webfiles/doc/SSC/Redlist/RedListGuidelines.pdf (accessed 23 November 2010).

Table 7.1 *Assessing the conservation status of CWR*

	IUCN Red Listing	*Expert-based system evaluation*	*GIS-based assessment*
Advantages	Internationally recognized methodology Includes expert data	Based on field observations	Objective, standardized and repeatable
Disadvantages	Detailed information not always available Comparability (different levels of expertise)	Detailed information not always available Subjective Comparability (different levels of expertise)	Does not include species expertise (Reality check)

Source: Nelly de la Barra, presentation 'Assessing conservation status', delivered at the 5th ISC Meeting of the UNEP/GEF CWR Project, 1–6 December 2008, Cochabamba, Bolivia

countries. Other national or sub-national systems also exist, for example in Australia, the US and New Zealand. Many countries supplement the use of the IUCN system with additional criteria for particular requirements and circumstances.

The advantages and disadvantages of the IUCN system compared with other approaches when applied in Bolivia are summarized in Table 7.1.

Effective conservation of CWR involves the identification of the causes of threats to both the species and its habitat and the implementation of practices to manage them. *Threats or threatening processes* are those that may detrimentally affect the survival, abundance, distribution or potential for evolutionary development of a native species or ecological community.

The IUCN or other red listing systems, by definition, involve some degree of threat assessment, but in deciding on which CWR species should be selected for conservation action, a number of other factors may be taken into account. It should be noted, moreover, that threatened status is not so much a selection criterion as a filter that may be applied after other criteria have been employed. *Endangered status does not automatically qualify a CWR or any other species for selection for conservation action.* As IUCN points out:[2]

> *The category of threat is not necessarily sufficient to determine priorities for conservation action. The category of threat simply provides an assessment of the extinction risk under current circumstances, whereas a system for assessing priorities for action will include numerous other factors concerning conservation action such as costs, logistics, chances of success, and other biological characteristics of the subject.*

It should be noted that a taxon may require conservation action even if it is not listed as threatened. Indeed, a case can be made for conserving *in situ* samples of economically important CWR species that are widespread and not currently threatened. Examples are some major forest trees, many of which have extensive

Box 7.6 Genetic conservation of widespread species

… to effectively conserve the genetic resources of a widespread species several aspects of genetic variation need to be incorporated, i.e. identification of conservation genetic units through integration of patterns of quantitative and neutral genetic structure across multiple spatial scales. Once the organisation and dynamics of genetic diversity are described, an approach that assesses species case-by-case, taking into account unique factors such as recommended forestry practice and geopolitical distribution, should allow formulation of an effective strategy.

Source: Cavers et al, 2004

natural ranges and high levels of diversity within and between populations. An example is the widespread tropical tree *Cedrela odorata* L. for which Cavers et al (2004) bring together the results of previous studies on chloroplast, total genomic and quantitative variation and use the data to describe conservation units and assess their importance for resource management and policy recommendations (Box 7.6). Similar considerations may apply to some other widespread CWR such as *Brassica* crop relatives and leguminous fodder crop relatives.

Threat status and global change

The Intergovernmental Panel on Climate Change (IPCC) and many papers have drawn attention to the likely effects of global and, in particular, rapid climate change on species and their habitats (see Figure 7.2 and Box 14.1), a topic that is discussed in detail in Chapter 14. In the criteria used to assess the threat status of species, these effects have not so far been taken into account. For example, while the current IUCN Red List criteria are designed for classification of the widest set of species facing a diversity of threatening processes, they do not take accelerated climate change as such into consideration. IUCN (2008) does recognize the growing evidence that climate change will become one of the major drivers of species' extinctions in the 21st century and has listed five groups of traits that are believed to be linked to increased susceptibility to climate change:

- specialized habitat and/or microhabitat requirements;
- narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle;
- dependence on specific environmental triggers or cues likely to be disrupted by climate change;
- dependence on inter-specific interactions likely to be disrupted by climate change;
- poor ability to disperse to or colonize a new or more suitable range.

So far, these have only been applied to a small number of taxa. It follows, therefore, that current Red List or other threat assessments of species can only be

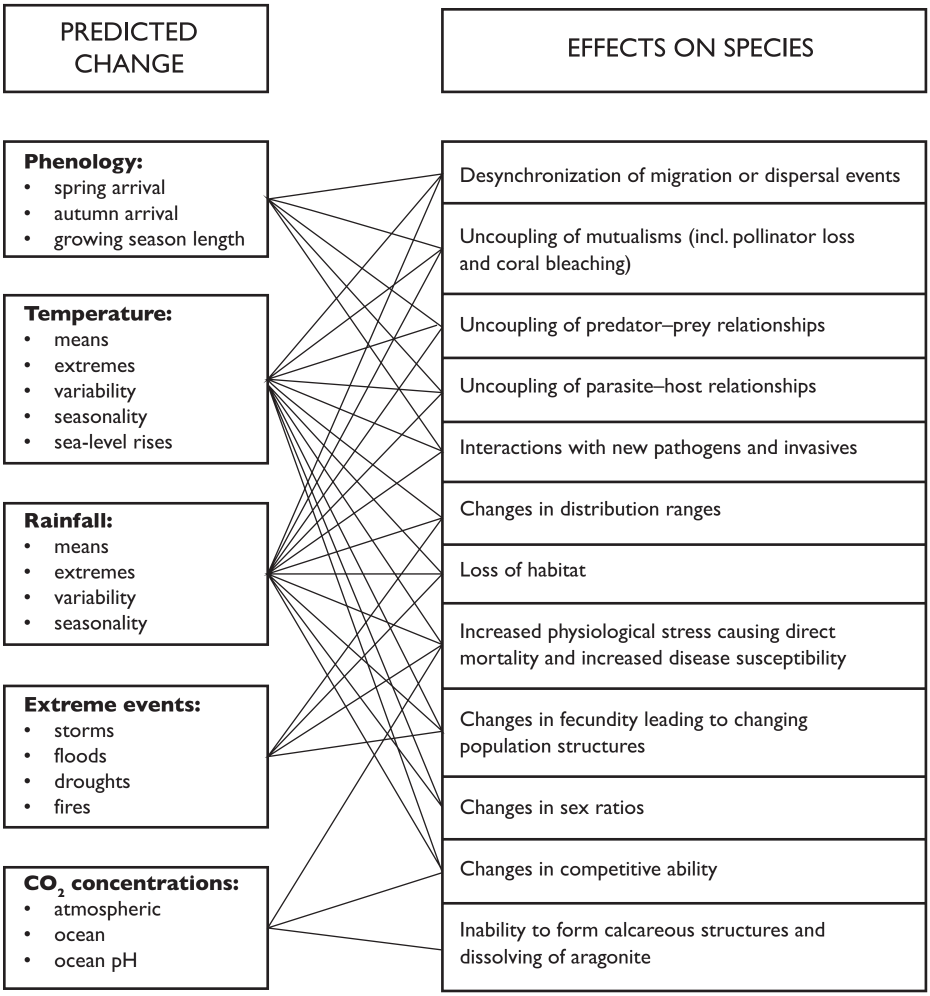

Figure 7.2 *Summary of some of the predicted aspects of climate change and examples of the effects that these are likely to have on species*

Source: Foden et al, 2008

regarded as valid in the short term and will all need to be reviewed and updated to take into account accelerated climate change and other aspects of global change if they are to continue to be used as an effective part of any triage system. There are, however, difficulties in incorporating climate change into the criteria and Akçakaya et al (2006) warn of the dangers of their misuse for this purpose. These issues are discussed by Foden et al (2008) who note that:

> *most assessments of species extinctions under climate change have been based on either isolated case studies or large-scale modelling of species'*

> *distributions. These methods depend on broad and possibly inaccurate assumptions, and generally do not take account of the biological differences between species. As a result, meaningful information that could contribute to conservation planning at both fine and broad spatial scales is limited.*

The possible impacts of climate change on CWR are discussed in Chapter 14.

The nature of threats

> *… any system that tries to summarize the complexity of threats to wild nature in a simple, categorical classification is bound to be imperfect* (Balmford et al, 2009).

Threats to CWR species and the communities in which they occur arise in various ways, many of them directly or indirectly as a result of human action. Various attempts have been made to develop classifications of direct threats to the various components of biodiversity, notably the schemes developed by the Conservation Measures Partnership (CMP, 2005) and the IUCN Species Survival Commission (IUCN 2005a, 2005b). In the belief that a single global comprehensive classification of threats and of the conservation actions needed to address them, Salafsky et al (2008) merged these two schemes into a unified classification of direct threats to biodiversity and a unified classification of conservation actions. The schemes are too complex to be reproduced here and the reader should refer to the original paper for details. They have been criticized as 'combining two key but sequential aspects of threat – the threat mechanism and its source – into a single and incomplete linear system' (Balmford et al, 2009), a criticism that has been countered by Salafsky et al (2009). These schemes should, in principle, be applicable to CWR, but so far have not been tested in such a context.

The main kinds of threats are:

- at population level: small subpopulations caused through fragmentation of habitat; low numbers in a population; narrow or small distributional range;
- changes in disturbance regime: for example, as a result of fragmentation and the consequent effects on dispersal and gene flow between isolated populations;
- fire: changes in components of fire regimes, including season, extent, intensity or frequency, inhibiting regeneration from seed or by vegetative reproduction; generally, inappropriate fire regimes lead to the competitive disadvantage of the threatened species against local and introduced species, or represent a future threat if fire recurs before plants are mature and seed is produced;
- threats of biotic origin: disease or predation, e.g. fungal disease; interactions with native species, e.g. allelopathy, competition, parasitism, feral grazing by

rabbits, goats, pigs, cattle, camels etc., including trampling by wild and feral animals and damage caused by rabbit warrens, pika tunnels;

- invasive alien species;
- threats due to development;
- threats due to contamination or pollution;
- indirect threats;
- potential accidents;
- global change (demographic, disturbance regimes, climatic).

Threats primarily due to human action include:

- habitat loss or destruction, degradation, modification or simplification as a result of land-use change such as clearing for agriculture (for crops and pastures, draining swamps and wetlands), forestry, plantations; housing and urban and coastal development; energy production and mining; agriculture edge effects (including herbicides, pesticides, drainage etc.);
- pollution;

Table 7.2 *Main threats to biodiversity in Armenia and their causes*

Threats	*Causes*
Loss of habitat	– agriculture – land appropriation – cattle breeding – drainage of marshes – forest logging – open mining – construction – recreation and tourism – hydroelectric engineering – decrease in level of lakes
Overexploitation of bio-resources (timber, medicines, fodder, fruits, nuts, fibres, oils)	– defective/incomplete legislation – incomplete control over use of resources – lack of inventory data and of bio-resources and quotas for their use – absence of a biodiversity monitoring system
Environmental pollution	– impact of industry – impact of agriculture – transport
Impact of alien invasive species	– deliberate introduction of species and natural introductions
Climate change	

Based on the Fourth Armenia National Report to the CBD in 2009

Table 7.3 *A summary of the major threats to biodiversity in Bolivia and their causes*

Threats	*Causes*
Loss of habitat	– Mainly caused by the expansion of agriculture (Baudoin and España, 1997). In 2008, the agricultural boundary was expanding at a rate of 300,000ha/year in Bolivia. – Opening of roads, establishment of pipelines and others related to the development process of urban expansion and centres of population (MDSP, 2001). – The replacement of forest by crops or livestock pasture and agricultural methods, such as the use of fire for regeneration of grasslands, are having major impacts on wildlife. The effects of these activities on the degradation of specific ecosystems such as savannas and cloud forests are evident (MDSP, 2001).
Degradation of habitat	– Fires and the expansion of other economic activities, such as forest overexploitation, mining and hydrocarbon exploitation (MDSP, 2001).
Impact of alien invasive species	– Competition for habitat, introduction of invasive alien species, introduction of new diseases, which affect both the flora and fauna, even in some cases to become pests for crops (Baudoin and España, 1997). – Introduction of goats in areas of the dry valleys of the Departments of La Paz, Cochabamba, Potosi, Chuquisaca, Santa Cruz and Tarija, which have generated an extensive loss of vegetation and the consequent destruction of habitat for wildlife (Baudoin and España, 1997).
Overexploitation of wildlife	– Overexploitation of species for consumption. – Overexploitation of species or products derived from them for trade, mainly for export.

Source: Wendy Tejeda Pérez, Technical Assistant and Beatriz Zapata Ferrufino, CWR Project Coordinator Proyecto UNEP/GEF 'Conservación *in situ* de parientes silvestres de cultivos a través del manejo de información y su aplicación en campo', 4 January 2009

- overexploitation for commercial, recreational, scientific or educational purposes;
- tourism and ecotourism;
- recreation (e.g. off-road vehicles).

A synopsis of the main threats to biodiversity in Armenia and their impacts is given in Armenia's Fourth National Report to the CBD (Table 7.2).

A synopsis of the main threats to biodiversity in Bolivia, most of which will affect CWR and their habitats, is given in Table 7.3; Table 7.4 for Madagascar.

Table 7.4 *The main threats to biodiversity in Madagascar*

Ecosystems	*Threats*	*Direct causes*	*Indirect causes*	*Consequences*
Agricultural ecosystems	Genetic erosion of agrobiodiversity	– Erosion and silting – Diseases – Lack of measures to conserve cultivars and seeds – Invasive species	– Poverty – Lack of scientific knowledge – Under-utilization of traditional and local knowledge – Unsustainable production methods – Lack of resources for management purposes	– Diminution of production rate – Food insecurity
Forest ecosystems	– Deforestation and forest degradation – Ecosystem fragmentation	– Agriculture expansion – Slash and burn and uncontrolled forest fires – Invasive species – Climatic change – Forest exploitation – Mining – Firewood collecting – Overexploitation of resources – Hunting, gathering and extraction	– Poverty – Usages and customs – Lack of good governance – Insufficient safeguard measures – Unsustainable means of consumption and production – Underestimation of value of biodiversity goods and services – Increase and density of population – Insufficiency of regulation mechanisms	– Impoverishment of ecosystems species richness – Disappearance of threatened species – Reduction of ecosystem services

Source: Fourth National Report to the CBD – Madagascar, 2009

Invasive alien species (IAS)

Globally, invasive alien species are acknowledged as one of the major threats to biodiversity, second only to habitat loss and degradation. In South Africa, for example, alien plant species are considered the single biggest threat to the country's biological biodiversity and now cover more than 10.1 million hectares, threatening indigenous plants.[3]

The term '*invasive*' is applied to alien plants that have become naturalized and are or have the potential to become a threat to biodiversity through their ability to reproduce successfully at a considerable distance from the parent plants and have an ability to spread over large areas and displace elements of the native biota. When they cause significant habitat transformation, leading to biodiversity loss and reduction in ecosystem services, they are often known as *transformers or transformer species*.

Information on invasive species may be obtained from:

- *Global Invasive Species Programme* (GISP)[4] which aims to facilitate and assist with the prevention, control and management of invasive species throughout the world.
- *GISP Global Strategy on Invasive Alien Species*[5] which highlights the dimensions of the problem and outlines a framework for mounting a global-scale response.
- *Global Invasive Species Information Network* (GISIN)[6] which was formed to provide a platform for sharing invasive species information at a global level, via the internet and other digital means.
- *Invasive Alien Species: A Toolkit of Best Prevention and Management Practices*[7] which provides advice, references and contacts to aid in preventing invasions by harmful species and eradicating or managing those invaders that establish populations.

Threats from IAS are likely to increase substantially in some regions as a consequence of global change (see Chapter 14). Examples of the effects of invasive species in the project countries are given in continuation. Although there are few examples so far of their effects on CWR and their habitats, it is highly likely that some of the areas in which CWR conservation will be proposed will be impacted.

Armenia

According to the Botanical Institute, there are over 100 invasive species that can cause damage to Armenia's natural ecosystems. A range of invasive species has been introduced to Armenia and some of them have expanded their ranges to the detriment of native species, and have resulted in population declines and disruptions of ecological relationships, affecting both biodiversity and agricultural systems. Among the most aggressive invasive plant species are *Xanthium*, *Cirsium*, and *Galinsoga parviflora*, while *Ambrosia artemisiifolia* has expanded its distribution by over 200km^2 within the last decade (ECODIT, 2009).

Box 7.7 Summary of the situation of invasive alien species (IAS) in Bolivia

Until 2007, the impact of invasive alien species on the biodiversity and the national economy had not been considered as a problem in Bolivia. The issue is not referred to in the National Strategy of Biodiversity Conservation of Bolivia, approved in 2001, which covers current national policy about the environment and agriculture.

A workshop on biological invasions, held in May 2007 in La Paz, highlighted the need to generate documented sources of information about the effects of invasive species on Bolivia's biodiversity. Subsequently, the Institute of Ecology, Universidad Mayor de San Andrés of La Paz, was given the responsibility of developing a system for collecting and organizing national information on invasive alien species, under the project 'Establishment in Bolivia of Data Bases on Invasive Alien Species, as part of the Inter-American Biodiversity Information Network – IABIN' (Rico, 2009).

According to Rico (2009), as of August 2009, the National Information System of Invasive Alien Species, contained information about invasive species of grass, acacia, pine, and eucalyptus. On the other hand, according to Fernández (2009), 17 species of alien invasive plants have been recorded and verified in three ecological zones of Bolivia: Altoandino: *Poa annua*, *Pennisetum clandestinum* and *Hordeum muticum*; Puna*: Pennisetum clandestinum*, *Taraxacum oficcinale*, *Medicago polymorpha*, *Trifolium pratense* and *Erodium circutarium*, and Dry Valley: *Pennisetum clandestinum*, *Rumex acetocella*, *Matricaria recutita*, *Taraxacum officinale*, *Atriplex suberecta*, *Medicago polymorpha*, *Spartium junceum*, *Dodonaea viscosa* and *Opuntia ficus-indica*.

Source: Wendy Tejeda Perez and Beatriz Zapata Ferrufino, December 2009

Bolivia

The issue of IAS in South America is enormous both in terms of the number and diverse range of species invading the continent, and of their impact on the health and livelihoods of all peoples of the region.[8] In Bolivia, however, little information is currently available but ten alien invasive species are reported by the Global Invasive Species Database: *Acacia melanoxylon*, *Ambrosia artemisiifolia*, *Leucaena leucocephala*, *Melia azedarach*, *Pittosporum undulatum*, *Rubus niveus*, *Cedrela odorata*, *Pisidium guajava*, *Arundo donax*, *Rottboellia cochinchinensis* (see Box 7.7).

Madagascar

About 49 invasive species have been recorded from Madagasacar: *Acacia dealbata*, *Acacia farnesiana*, *Acacia tortilis*, *Acanthospermum hispidum*, *Agave ixtli*, *Agave sisalana*, *Albizia lebbeck*, *Carica papaya*, *Cissus quadrangularis*, *Citrus aurantifolia*, *Citrus aurantium*, *Citrus medica*, *Clidemia hirta*, *Eichhornia crassipes*, *Erigeron albidus*, *Eucalyptus* spp., *Grevillea banksii*, *Lantana camara* var. *aculeate*, *Mimosa pigra*, *Mimosa pudica*, *Opuntia ficus-indica*, *Opuntia monacantha*, *Passiflora foetida*, *Passiflora incarnata*, *P. suberosa*, *Phoenix reclinata*, *Pinus patula*, *Pithecellobium dulce*, *Psidium guajava*, *Psidium cattleianum*, *Rubus moluccanus*, *Rubus rosifolius*, *Salvinia* *molesta*, *Solanum mauritianum*, *Syzygium jambos*, *Vangueria madagascariensis*, *Ziziphus jujube* and *Zizyphus spina-christi*.

The impact of invasive species on forest composition in Ranomafana National Park in south-eastern Madagascar, a global 'hotspot' of biodiversity, is serious. Common invasive trees and large shrubs established in south-eastern Madagascar include *Clidemia hirta* (Melastomacaceae), *Psidium cattleianum* Sabine (Myrtaceae), *Eucalyptus robusta* (Myrtaceae), *Lantana camara* (Verbenaceae) and *Syzygium jambos* (Myrtaceae,) and can dramatically alter the trajectory of forest succession. The impacts of the invasive species in the Park were compared inside and outside the Park. Studies based on paired transects inside and outside the boundaries of the Park and measuring and counting all the individuals over 1.5cm diameter showed that the percentage of non-native or invasive plants was significantly lower inside the Park as well as the diversity of utilitarian species. Therefore, it was assumed that protected areas play an important role in reducing the spread of invasive plants (Brown et al, 2009).

Detailed information on the extent of plant invasions in Madagascar and their effects are given by Bingelli (2003).

Sri Lanka

Twenty plant species (some of which are now domesticated) have already reached, or have high probability of reaching, invasive proportions in the country. In parts of the country, *Prosopis juliflora* is now a serious problem, where it has invaded agricultural and grazing land, protected areas and national parks. The national list of invasive species for Sri Lanka is presented in Table 7.5.

Uzbekistan

The decreased availability of downstream water and increased salinity levels have led to the shrinkage of wetlands and lakes by up to 85 per cent. Their loss is resulting in the widespread disappearance of native flora and fauna. As water availability declines, native plants are being replaced by invasive species more suited to the dry, saline environment. The following native species are reported as being invasive in Uzbekistan by the Global Invasive Species Database (http://www.gisp.org/): *Brassica elongata*, *B. tournefortii*, *Bromus rubens*, *Butomus umbellatus*, *Elaeagnus angustifolia*, *Erodium cicutarium*, *Hydrocharis morsus-ranae*, *Hypericum perforatum*, *Lepidium latifolium*, *Melilotus alba*, *Phalaris arundinacea*, *Populus alba*, *Tamarix ramosissima*, *Typha latifolia*.

Threat management

After the assessment of threat status, actions need to be taken for the control, mitigation or elimination of threats to target populations. A *threat management strategy* (sometimes known as a *threat abatement strategy*) needs to be developed as part of the conservation or recovery plan/actions (see Chapter 10). The strategy may contain protocols and guidelines directed at how best to abate, ameliorate or

Table 7.5 *National List of Alien Invasive Plants for Sri Lanka*

No.	Botanical Name	Status (Distribution)	
1	*Alstonia macrophylla* Wall. ex D.Don (Apocynaceae)	Degraded forests and forest edges in moist lowland	Provincial
2	*Annona glabra* (L.) (Annonaceae)	Coastal and inland	Provincial
3	*Clidemia hirta* (L.) D.Don (Melastomataceae)	Degraded forests in moist lowlands	Provincial
4	*Clusia rosea* Jacq.(Clusiaceae)	Mid-country moist, open and rocky areas, forest edges	Provincial
5	*Chromolaena odorata* (L.) King & Robinson (Asteraceae)	Road sides, waste ground in lowlands	National
6	*Dicranopteris linearis* (L.) (Gleicheniaceae)	Wastelands and fallow fields	Provincial
7	*Eichhornia crassipes* (Mart.) Solms. Laub (Pontederiaceae)	Inland stagnant water bodies	National
8	*Lantana camara* (L.) (Verbenaceae)	Open scrublands, waste ground	National
9	*Mikania cordata* (Burm.) Robinson (Asteraceae)	Secondary forests in moist regions up to 1000m	Provincial
10	*Miconia calvescens* DC. (Melastomataceae)	Degraded forests in sub-montane regions	Provincial
11	*Mimosa pigra* (L.) (Mimosaceae)	River banks and reservoir edges up to 1000m in moist regions	Provincial
12	*Panicum maximum* Jacq. (Poaceae)	Grasslands, open areas up to 1000m	Provincial
13	*Panicum repens* L.(Poaceae)	Grasslands, open areas up to 2000m	Provincial
14	*Pennisetum polystachyon* (L.) (Poaceae)	Grassland, fallow fields, roadsides up to 1100m	Provincial
15	*Pistia stratiotes* (L.) (Araceae)	Water bodies in wet zone and dry zone	National
16	*Pteridium aquilinum* (Dennstaedtiaceae)	Grassland and/or bare ground	National
17	*Salvinia molesta* D.Mitch. (Salviniaceae)	Inland stagnant water bodies	National
18	*Swietiena macrophylla* (Meliaceae)	In forests	
19	*Ulex europaeus* (Fabaceae)	Nuwara Eliya (Horton Plains)	Provincial
20	*Wormia suffruticosa* (Dilleniaceae)	Degraded forests and scrublands in wet lowlands	Provincial

Source: prepared by the First National Experts Committee on Biological Diversity of the Ministry of Environment, Sri Lanka, 1999*

* Since 1999, two other invasive plant species, *Alternanthera philoxeroides* (alligator weed) and *Parthenium hysterophorus* (congress weed), were recorded in Sri Lanka.

eliminate the impacts that threatening processes have on the target species or on the areas they occupy. Because threats may occur at any level from the landscape to individual populations, actions will need to be directed at the appropriate levels. The management of threats may involve a range of stakeholders and land managers (see Chapter 10). The agency or team responsible for designing and implementing the threat management strategy will need to coordinate actions and liaise with these stakeholders, such as protected area managers, other government agencies, local authorities, community members, conservation bodies and individuals.

Threat management has political, local and training dimensions and the success of threat management strategies may depend, to a large extent, on being able to establish effective community awareness and education programmes. The local community and landholders need to be made aware of the nature of the threats to the CWR and their habitats and how they might become involved in remedial measures.

Country experience and challenges

One of the problems found by some of the countries was disagreement between specialists from different fields as to which species should be given priority. As noted earlier, such differences of opinion between experts is to be expected, given their different interests and experience.

Armenia

In Armenia, during long discussions on choosing priority taxa, there were some disagreements between botanists from different fields. Wild relatives of cereals, pulses, vegetables and fruits were evaluated using unique criteria, specifically developed for each group. The main problem was the existence of biological and ecological differences among CWR families. It must be noted that each of these families' socio-economic characteristics were also evaluated and considered as very important for agronomy and economy.

Priority taxon selection

An evaluation method for three to five classes of crops to be selected for protection was devised as a result of meetings, debates and discussions held to consider particular crops and methods for their evaluation and selection. Botanists representing various fields were involved to ensure objectivity and transparency of the project and, on the basis of the chosen criteria, the crops were evaluated. As a result of the discussions, all CWR were divided into four key groups: cereals; pulses; vegetables; and fruits, berries and nuts. For each group a separate set of criteria was developed, paying special attention to the group's ecological, biological, economic and agricultural indicators/values. Despite the fact that this separation is a mechanical process, it allows one to bring together the groups that have similar qualities and at the same time allows a new strategy for priority taxa selection to be developed.

Box 7.8 List of priority CWR selected for Armenia

Cereals

Triticum boeoticum
Triticum araraticum
Triticum urartu
Aegilops tauschii
(Selection made by Estela Nazarova, Institute of Botany, National Academy of Sciences)

Pulses

Vavilovia formosa
Cicer anatolicum
Onobrychis transcaucasica
Trifolium pratense
(Selection made by Zirair Vardanyan, Institute of Botany, National Academy of Sciences)

Vegetables

Beta lomatogona
B. macrorrhiza
B. corolliflora
Asparagus officinalis
(Selection made by Andreas Melikyan, Armenian Agricultural Academy)

Fruits, berries and nuts

Pyrus caucasica (pear)
Armeniaca vulgaris
Amygdalus fenzliana
Malus orientalis
(Selection made by Eleanora Gabrielyan, Institute of Botany, National Academy of Sciences)

Leading professionals in various fields were involved in the selection process for each of the CWR. The main deciding factors were the same for all four groups – conservation status and gene sources – and were included in the list of criteria. A list of characteristics for each of the four type groups was developed by the editing and grouping method, using additional characteristics such as plant products, use as fodder, honey-yielding plants, environmental uses and food supplements.

In the list of the criteria for each of the species group, every indicator was evaluated on a 10-point system. Therefore, each list of evaluated criteria was applied to the corresponding group in order to select the priority species for protection (see Box 7.8). The cumulative number of points assigned to the particular species group is the summation of the points given to the indicators of the individual species. Subsequently, the species having the highest total points from

Table 7.6 *The conservation status and distribution of CWR selected as target species for Armenia*

Name	*Conservation status*	*In-country distribution*
Triticum araraticum	EN under B1ab (ii, iii, iv, v) +2ab (ii, iii, iv, v)	Yerevan and Darelegis floristic regions corresponding to Ararat, Kotayk, Vayots Dzor marz (administrative regions) and Yerevan city
Triticum boeoticum	EN under B1ab(ii, iii, iv, v) +2ab (ii, iii, iv, v)	Yerevan and Darelegis floristic regions corresponding to Ararat, Kotayk, Vayots Dzor marz (administrative regions) and Yerevan city
Triticum urartu	CR under B1ab(iii) +2ab(iii)	Yerevan floristic region, corresponding to administrative boundaries of Yerevan city
Aegilops tauschii	LC	Yerevan city, Tavush, Shirak, Lori, Kotayk, Ararat, Aragatsotn, Vayots Dzor, Armavir and Syunik marzes, corresponding to floristic regions of Shirak, Ijevan, Yerevan, Darelegis, Zangezur and Meghri
Beta lomatogona	EN under B1ab (i, ii, iii, iv) +2ab(i, ii, iii, iv)	Aragatsotn and Kotayk marzes (administrative regions)
Pyrus caucasica	LC	Lori, Tavush, Kotayk, Aragatsotn, Gegharkunik, Vayots Dzor, Syunik and Ararat marzes
Vavilovia formosa	EN under B1ab(iii) +2ab(iii)	Kotayk, Gegharkunik and Syunik marzes (administrative regions)

each group were selected as the priority species for conservation. The list includes 104 from approximately 250 CWR. Using the above method, seven species were selected for priority conservation (by the highest point score): *Triticum araraticum*, *Triticum boeoticum*, *Triticum urartu*, *Aegilops tauschii*, *Beta lomatogona*, *Vavilovia formosa* and *Pyrus caucasica*. The conservation status of the target CWR in Armenia is presented in Table 7.6.

It should be noted that none of the seven priority species listed above is endemic to Armenia.

Bolivia

During the period from 2000 to 2002, as part of the preparatory PDF-B phase of the UNEP-GEF CWR Project, Bolivia identified 53 genera of wild species important for food and agriculture, medicine and other uses as a part of their National Report (see Table 7.7). Twenty-two of the genera (in bold in Table 7.7) selected had already been the subject of a project to prepare an inventory of CWR in Bolivia, the outcome of which was an 'Atlas of Crop Wild Relatives'. The systemization of the information included in the atlas, was conducted with the support of

Table 7.7 *Genera of crop wild relatives in Bolivia*

Amaranthus	*Cuphea*	***Manihot***	*Psidium*
Anacardium	***Cyphomandra***	*Nicotiana*	*Pseudoananas*
Ananas	*Dioscorea*	***Oryza***	*Rheedia*
Annona	*Euterpe*	***Oxalis***	*Rollinia*
Arachis	***Gossypium***	***Pachyrhizus***	***Rubus***
Arracacia	*Hevea*	*Passiflora*	*Saccharum*
Bactris	***Hordeum***	*Persea*	***Solanum* sect. *Petota***
Bixa	***Ipomoea***	***Phaseolus***	*Spondias*
Canna	*Ilex*	*Physalis*	*Swietenia*
Capsicum	*Inga*	*Piper*	*Theobroma*
Carica	***Juglans***	*Polymnia*	*Tripsacum*
Chenopodium	***Lupinus***	*Pouteria*	*Ullucus*
Cinchona	***Lycopersicon***	*Prunus*	*Vaccinium*
Cucurbita			

the National Herbarium of Bolivia, the Museum of Natural History Noel Kempff Mercado, the Herbario Nacional Forestal Martín Cárdenas, Centro de Investigaciones de Pairumani Fitoecogéneticos, PROINPA and FAN. In addition, other national institutions from Argentina: Instituto Darwinion, Buenos Aires (SI); Universidad Nacional del Noreste, Corrientes (CTES); Herbarium of the Fundación Miguel Lillo, Tucuman (LIL); and Instituto Nacional de Tecnología Agropecuaria (INTA); from the United States: Missouri Botanical Garden, St Louis, Missouri (MO); New York Botanical Garden, New York (NY); National Herbarium, Washington, DC; Field Museum of Natural History, Chicago; and National Plant Germplasm System (NPGS); and from Brazil: National Center Genetic Resources (CENARGEN) were involved, as were three CGIAR centres, Centro Internacional de Agricultura Tropical (CIAT), Colombia; International Potato Centre (CIP), Peru; and the International Rice Research Institute (IRRI), the Philippines.

In June and August 2005, national workshops were held involving the eight national partner institutions of the CWR Project, DGBAP and Ecology Institute of UMSA, based in La Paz, Cochabamba and Santa Cruz to further prioritize this extensive list of 53 genera. As a result, the national research institutions of public universities from La Paz, Cochabamba and Santa Cruz, three genebanks, a national organization of indigenous peoples and a non-governmental organization dedicated to biodiversity conservation systemized information from different sources and identified 195 species of CWR from 17 genera (*Anacardium*, *Ananas*, *Annona*, *Arachis*, *Bactris*, *Capsicum*, *Chenopodium*, *Cyphomandra*, *Euterpe*, *Ipomoea*, *Manihot*, *Phaseolus*, *Pseudananas*, *Rubus*, *Solanum*, *Theobroma* and *Vasconcellea*) to be the primary focus for conservation activities during the full implementation of the project (see Table 7.8).

The taxon selection procedure used a number of sub-criteria under the following broad headings:

Table 7.8 *Priority CWR identified for Bolivia*

National Partner Institution	Genus	Spanish Common Name	English Common Name
Herbario Nacional de Bolivia (LPB)	*Euterpe*	Asaí	
	Bactris	Chima, palmito	Palm heart
	Theobroma	Cacao	Cocoa
	Anacardium	Cayú	Cayu
Centro de Biodiversidad y Genética (CBG-BOLV)	*Annona*	Chirimoya	Custard apple
	Rubus	Mora	Blackberry
	Cyphomandra	Tomate de árbol	Tree tomato
	Vasconcellea	Papaya	Papaya
Centro de Investigaciones Fitoecogenéticas de Pairumani (CIFP)	*Phaseolus**	Frijol	Beans
	Arachis	Maní	Peanut
	Capsicum	Ajíes	Chilli pepper
Museo de Historia Natural Noel Kempff Mercado (MHNNKM)	*Manihot**	Yuca	Cassava
	Ananas	Piña	Pineapple
	Pseudananas		
	*Ipomoea**	Camote	Sweet potato
Fundación para la Promoción e Investigación de Productos Andinos (PROINPA)	*Chenopodium*	Quinua, Cañahua	Quinoa
	*Solanum**	Papa	Potato

* crops listed in Annex 1 of the ITPGRFA

- potential use and economic, social and cultural importance;
- state of knowledge;
- inclusion in the International Treaty (ITGRFA).

Each sub-criterion was scored as either 1= low, 3= medium or 5= high. Each sub-criterion was also given a weighting (1 to 5) based on its overall importance as assessed by the national partners. The final tally for each sub-criterion was determined by multiplying the given score by the weighted value. Of the 53 genera, a final list of 17 were selected.

To further prioritize the many species that exist within the selected 17 genera, the national partner institutions selected the most threatened species for conservation. National partner institutions initially selected the species, from the 17 genera, which existed in protected areas before deciding on the target species.

The information generated by national research institutions on prioritized CWR species in Bolivia is available to the general public on the National Portal (www.cwrbolivia.gov.bo) and through the Global CWR Portal (www.cropwildrelatives.org).

In addition, during the period from 2006 to 2008, 195 CWR species were identified in Bolivia by the six national partner institutions (see Annex I).

Madagascar

The selection of the five priority taxa for conservation action was discussed with representatives of partner institutions involved in the implementation of the CWR Project and members of the Ministry in charge of the environment and forest resources as well as the Ministry of National Education and Research. They covered various fields of expertise in plant biology, such as taxonomy and systematics, botany and ecology, genetics and plant breeding, forestry and agronomy, and management of natural resources.

Based on the knowledge of the participants and development that had taken place in the CWR Project, a first list of eight CWR taxa were proposed as important: *Cinnamosma*, *Coffea*, *Dioscorea*, *Musa/Ensete*, *Oryza*, *Piper*, *Tacca* and *Vanilla*. *Musa* and *Ensete* were considered as congeneric. To reduce this list to five, the following selection criteria and value were used (also see Table 7.9):

- number of species occurring in Madagascar for each genus;
- the presence status of the species in each taxon (0 – introduced; 1 – naturalized; 3 – endemic);
- use of the taxon as food (0 – no; 3 – yes);
- contributions of species within the genus to food security (0 – no; 3 – yes);
- economic value of the crop relative (0 – low; 1 – mid; 3 – high);
- potential of the species as specific gene donor for crop improvement (0 – low; 1 – mid; 3 – high);
- level of threats to the taxon (unrated due to lack of data);
- availability of information (0 – high; 1 – mid; 3 – low), a lack of information is highly rated because the committee considered the CWR Project as an opportunity to gather information on the taxa.

Table 7.9 *Priority taxa selection in Madagascar*

TAXA	*Number of species*	*Presence status (0-1-3)*	*Used as food (0-3)*	*Contribution to food security (0-3)*	*Economic value of the crop relative (0-1-3)*	*Gene donor potentiality (0-1-3)*	*Availability of information (0-1-3)*	*Total score*
Cinnamosma	1	0	3	0	1	0	0	4
Coffea	60	3	0	0	3	3	1	10
Dioscorea	32	1	3	3	0	1	1	9
Musa and *Ensete*	3	3	0	0	3	3	1	10
Oryza	2	1	0	0	3	3	1	8
Piper	4	1	0	0	3	1	3	8
Tacca	11	3		3	0	0	1	7
Vanilla	6	3	0	0	3	3	1	10

In case of equal scoring, and so as to vary the plant types being represented, an additional criterion was applied – the category of use of the crop relative (aromatic, cereal, fruit, spice and tonic, tuber). Thus, the following taxa were selected: *Vanilla* as an aromatic plant; *Coffea* as a stimulant and tonic; *Dioscorea* as a tuber; *Musa/Ensete* as a fruit; and *Oryza* as a cereal.

The selection of the actual species on which conservation action would be carried out was only done after the ecogeographical surveys on the different species had been undertaken.

Sri Lanka

As noted above, in the absence of agreed criteria at the outset of the project, Sri Lanka based its selection of priority CWR for conservation primarily on the importance of the crop and, by default, gave priority to the wild relatives of the crops finally selected. This approach differed from that employed by the other UNEP-GEF CWR Project countries. As a result, five field crops were selected that represented a potential total of 33 CWR species.

Eighteen participants at a national workshop involving Agriculture, National Botanic Garden and Biodiversity Secretariat staff met to discuss and classify the important field crops in Sri Lanka. A list of 187 food crops was compiled of which only 103 were considered to be native to the South Asian region. As a next step, the most commonly grown crop species that were native to the region and which had known wild relatives in Sri Lanka, were selected from the list of 103 crops. This resulted in a core group of 31 crops with a corresponding total of 98 CWR. To further reduce the list of 31 crops the following list of criteria and values were used:

1 availability of wild relatives (1=many; 5=few);
2 degree of genetic erosion (1=high; 5=low);
3 potential crop improvement (1=high; 5=low);
4 presence status/endemism (1=high; 5=low);
5 geographical distribution (1=scanty; 5=well distributed);
6 current and potential economic value (1=high; 5=low);
7 multiple/combined value (1=high; 5=low);
8 traditional value (1=high; 5=low);
9 present state of conservation of wild relatives (1=neglected; 5=conserved);
10 availability of information (1=low; 5=high).

Other than criteria 1 and 4, the assessment for each crop was subjective and the final scores for each crop were decided through participant consensus. Following assessment using all criteria, a total of 14 crops with the lowest aggregate scores were selected, representing a potential total of 57 CWR (see Table 7.10).

Due to limited project resources, and the obvious fact that 57 CWR is too many to deal with in a five-year project, a decision was made to prioritize this list even further. An internal consultation within the project recommended that only

Table 7.10 *Priority CWR for conservation action – Sri Lanka*

Crop	*Total score*
Mangosteen (*Garcinia*)	12
Pepper	14
Cinnamon	16
Mango	16
Brinjal	18
Snake gourd	18
Rice	20
Banana	20
Okra	20
Green gram	22
Bitter gourd	24
Vanilla	24
Cardamom	32
Onion	34

five field crops be selected and that at least three of the five selected crops be from those included in Annex 1 of the ITPGRFA. The final decision to select the priority crops fell to the Director General of Agriculture, Director of the National Botanic Garden and the Director of the Biodiversity Secretariat. The final list included rice (*Ozyza*), banana (*Musa*) and cowpea (*Vigna)* as representatives from Annex 1 of the ITPGRFA, as well as pepper (*Piper*) and cinnamon (*Cinnamomum*), which were considered among the most economically important crops for the country. The importance of the final selected crops to the work of the different institutions in Sri Lanka was also a deciding factor. This final list represented a potential total of 33 wild relatives as priority CWR for Sri Lanka.

Uzbekistan

The approach for prioritizing CWR in Uzbekistan initially involved specialists from the Scientific Plant Production Centre 'Botanica' defining a list of genera including CWR that grow in Uzbekistan. They selected 48 genera and 70 species of CWR.

A further working group was organized with experts from five scientific research institutions (Institute of Genetics and Plant Experimental Biology; Scientific Research Institute of Fruit Growing, Viticulture and Winemaking; Scientific Plant Production Centre 'Botanica'; Scientific Research Centre for Ornamental Gardening and Forestry; and the Scientific Research Institute of Plant Industry), two universities (National University of Uzbekistan and Tashkent Agrarian University) and the Department of Forestry Management. The working group consisted of 30 specialists from the above-mentioned organizations; this group defined the criteria to further prioritize wild relative species for conservation action. The criteria were:

Table 7.11 *Selected genera and species for targeted CWR conservation – Uzbekistan*

Genus	Species	Genus	Species
1 *Aegilops*	*Aegilops crassa*	6. *Amygdalus*	*Amygdalus bucharica*
	Aegilops cylindrica		*Amygdalus communis*
	Aegilops juvenalis		*Amygdalus petunnikovii*
2 *Hordeum*	*Hordeum bulbosum*		*Amygdalus spinosissima*
	Hordeum spontaneum		*Amygdalus vavilovii*
	Hordeum turkestanicum	7. *Pyrus L.*	*Pyrus korshinskyi*
	Hordeum leporinum		*Pyrus bucharica*
	Hordeum brevisubulatum		*Pyrus regelii*
3 *Allium*	*Allium pskemense*		*Pyrus vavilovii*
	Allium suvorovii	8. *Pistacia*	*Pistacia vera*
	Allium vavilovii	9. *Juglans*	*Juglans regia*
	Allium aflatunense	10. *Crataegus*	*Crataegus pontica*
	Allium oschaninii		*Crataegus turkestanica*
4 *Cucumis*	*Cucumis melo*	11. *Elaeagnus*	*Elaeagnus angustifolia*
5 *Malus*	*Malus sieversii*		*Elaeagnus orientalis*
	Malus niedzwetzkyana		

- cultural importance for mankind (socio-cultural importance of species in genera);
- use by the local people as a food source;
- local and national commercial importance;
- nearness to the centre of origin;
- diversity in habitat of the species;
- threat of species' extinction;
- importance for breeding;
- availability of information on the species.

Each genus on the list was scored by a '+' (if the criterion was important) or a '–' (if the criterion was not important). The maximum any genus could score was eight and the minimum was zero. From the initial list, 11 genera (representing 31 species of CWR) were selected (see Table 7.11).

At the final stage, the same scoring system was reapplied to the 31 remaining species, and the following CWR species were prioritized as a result: *Malus sieversii* (apple); *Allium pskemense* (onion); *Amygdalus bucharica* (almond); *Pistacia vera* (pistachio); *Juglans regia* (walnut); *Hordeum spontaneum*, *H. bulbosum* (barley – also listed in Annex 1 of ITPGRFA).

Malus sieversii, *M. niedzweckiana*, *Allium pscemense*, *Amygdalus bucharica*, *A. petunnikova*, *A. spinosissima* and *Pistacea vera* are endemic to Central Asia. *Hordeum spontaneum* and *H. bulbosum* are endemic to Uzbekistan.

Box 7.9 Conservation of walnut (*Juglans regia*) in Uzbekistan

Although the fruits of some other species of *Juglans* are edible, English or Persian walnut (*Juglans regia*) is the most horticulturally developed and widely cultivated species. Wild walnut populations in Uzbekistan grow in three isolated areas – in Western Tien Shan, Nurata and South Gissar – remote from each other by more than 200km. They occur in Ugam Chatkal State Natural National Park and in Nurata State Reserve, but are only partially protected. Uncontrolled cattle pasturing and harvesting is widespread in the reserves so that regeneration is not observed and the trees are of very old age. Ecosystems that include this species are partially or completely disturbed. The second tree layer is absent and the underneath layer is only partially conserved. The diversity of grass species is very poor because many have been eliminated, especially those that are grazed by cattle. Because of disturbances to the ecosystem, the walnut trees are almost completely affected by fungal diseases of the leaves and fruits. Recommendations for action to conserve the species in the wild include: strengthening the protection of areas containing walnut populations by restricting cattle grazing and fruit harvesting; improving and implementing existing legislation targeting the protection of CWR; creating walnut regeneration sites; involving local communities in conservation work; increasing public awareness on the importance of CWR conservation; and carrying out research to select genetic material for breeding purposes.

Box 7.10 *Malus sieversii* and the origin of the domestic apple

For many years, there has been a debate about whether *Malus domestica* evolved from chance hybridization among various wild species. Recent DNA analysis has indicated, however, that the hybridization theory is probably incorrect. Now, it appears that a single species, *Malus sieversii*, a wild apple native to the mountains of Central Asia in southern Kazakhstan, Kyrgyzstan, Tajikistan and Xinjiang, China, is the sole progenitor of most of today's domestic and commercial apples (Juniper and Mabberley, 2006). Leaves taken from trees in this area were analysed for DNA composition, which showed them all to belong to the species *M. sieversii*, with some genetic sequences common to *M. domestica*. Another recent DNA analysis (Coart et al, 2006), however, indicated that *Malus sylvestris* has also contributed to the genome of *M. domestica*. A third species that has been thought to have made contributions to the genome of the domestic apples is *Malus baccata*, but there is no hard evidence for this in older apple cultivars. The government of Kazakhstan and the United Nations Development Programme have established a conservation project and a protected reserve for *Malus sieversii* in the Zailijskei Alatau mountains. Fauna & Flora International (FFI) is working in Kyrgyzstan to save and restore one of the most highly threatened apple species, the Niedzwetzky apple (*Malus niedzwetzkyana*), as part of the Global Trees Campaign.

Box 7.11 Summary of CWR taxa selected by the project partners

Armenia – cereals: *Triticum boeoticum*, *Triticum araraticum*, *Triticum urartu*, *Aegilops tauschii*; pulse: *Vavilovia formosa*; vegetable: *Beta lomatogona*; fruits, berries and nuts: *Pyrus caucasica*.

Bolivia – *Annona*, *Rubus*, *Cyphomandra*, *Carica*, *Phaseolus*, *Arachis*, *Capsicum*, *Chenopodium*, *Solanum*, *Euterpe*, *Bactris*, *Theobroma*, *Anacardium*, *Manihot*, *Ananas*, *Ipomoea.*

Madagascar – rice (*Oryza*), *Ensete* (a wild relative of banana), vanilla (*Vanilla*), yam (*Dioscorea*), coffee (*Coffea*)

Sri Lanka – 5 wild species of rice (*Oryza*); 2 wild species of banana (*Musa*); 6 wild species of *Vigna*; 8 wild species of cinnamon (*Cinnamomum*); 8 wild species of pepper (*Piper*).

Uzbekistan – onion (*Allium*), apple (*Malus*), walnut (*Juglans*), pistachio (*Pistacia*), almond (*Amygdalus*), barley (*Hordeum* – 2 species).

It is estimated that around 90 per cent of the fruit and nut forests in Kyrgyzstan, Kazakhstan, Uzbekistan, Turkmenistan and Tajikistan have been destroyed over the past 50 years so that conservation of genetic resources of the species involved is a matter of high priority (see also Boxes 7.9 and 7.10).

A summary of the CWR selected by the UNEP/GEF CWR Project countries is given in Box 7.11.

Selection of priority areas

Protected areas can play a significant role in the conservation of agrobiodiversity, including CWR. The WWF report *Food Stores: Using Protected Areas to Secure Crop Genetic Diversity* (Stolton et al, 2006) (see Box 7.12) looks at how protected area managers can find which CWR species are present in the protected areas they manage and how they might adapt management practices to facilitate conservation of CWR and landraces.

The presence of populations of target species in an already existing protected area obviously confers an advantage in that, provided the conditions are suitable, the need for often lengthy and expensive negotiations in setting up a new protected area or reserve is obviated.

For further details on the selection of priority areas, the volume *Conserving Plant Diversity in Protected Areas* (Iriondo et al, 2008) is a useful resource, as is *Establishment of a Global Network for the In Situ Conservation of Crop Wild Relatives: Status and Needs* (Maxted and Kell, 2009).

Many CWR, probably the majority, occur outside protected areas and are found in a variety of natural and semi-natural habitats or even occur as weeds. The options for *in situ* conservation of CWR in such areas are reviewed in Chapter 11.

Box 7.12 Main conclusions of the *Food Stores* report

- Many of the centres of diversity of our principal cultivated plants are poorly protected.
- The role of protected areas in conserving crop genetic diversity could be greatly increased by better understanding of this issue within protected area organizations.
- The promotion of the conservation of crop genetic diversity within existing protected areas may further enhance the public perception of protected areas and help to ensure longer-term site security.
- There are already a few protected areas that are being managed specifically to retain landraces and CWR, and there are many more protected areas that are known to contain populations essential to the conservation of plant genetic resources.
- By conserving locally important landraces, protected areas can contribute to food security, especially for the poorest people.

Source: Stolton et al, 2006

Criteria for selection of areas

Selection of areas for *in situ* conservation of target species is quite different from designing a national system of protected areas that aim to include the maximum biodiversity possible or maintenance of ecosystem services. Extensive literature on reserve selection exists (e.g. Pressey et al, 1993, 1997; Balmford, 2002; Kjaer et al, 2004) and a review of genetic reserve location and design is given by Dulloo et al (2008). To a large extent, the areas for CWR conservation are self-defining by the presence in them of the target species as revealed by ecogeographical surveying (see Chapter 8). The issues here are more concerned with deciding how many populations and how much genetic variation is to be included and then whether the resultant area(s) required is ecologically viable and physically maintainable. The following criteria for locating genetic reserves have been suggested (cf. Dulloo et al, 2008):

- distribution pattern and abundance of the target species;
- level and pattern of genetic diversity of the target species' populations and presence of desirable alleles, if known;
- number of populations;
- number of individuals within the population;
- current conservation status;
- presence in protected areas or centres of plant diversity;
- accessibility;
- size of reserves;
- health and quality of the reserve;
- state of management of the reserve;
- political and socio-economic factors.

These and other factors that will influence the choice of reserve are discussed in continuation:

Size – Different species require reserves of different sizes. Generally, populations in larger areas are exposed to less risk of extinction: a larger population implies less vulnerability to inbreeding and stochastic factors and less negative influence of edge effects. On the other hand, the larger an area, the more likely it is to be at risk from invasive species and the larger an area and the lower its protection status (in terms of the IUCN classification of Protected Areas), the less likely the management of the area is to address the conservation needs of target species.

Boundaries, shape, integrity and context – The nature, location, state and effectiveness of the boundaries of a reserve are factors that need to be considered in choosing a protected area or reserve. If the range of biophysical conditions and habitats, and native organisms and ecosystems needed to maintain the ecological processes are not included within the boundaries set, then there is a risk of changes taking place in the disturbance regimes, ecological productivity and species dynamics, which could lead to a loss of species.[9] Natural boundaries are normally to be preferred to arbitrarily drawn ones.

Shape is a feature commonly associated with the selection of nature reserves: an irregular or elongated reserve has relatively more exposed areas so organisms may be more vulnerable to external threats, including invasion by alien species.

Integrity and context are two other issues of relevance. Internal roads, railways, power lines and fences are sources of fragmentation that create new borders with the undesired effects that these promote, including their role as pathways for invasive species. Biodiversity within the reserve is also influenced by the context of the countryside in which it occurs: it is not worth designing a reserve that is not incorporated into the surrounding environment or without considering land-use patterns at different scales.

Presence of invasive species – The presence of invasive species in the reserve can cause serious problems, especially when active measures (and a budget) are needed to control them. Their elimination or control may be an important component of management plans both for protected areas and for targeted species.

Sustainability – The sustainability of a protected area is a key concern and this will depend on a series of factors such as good governance, adequate finance and staffing. Many areas are what are termed 'paper parks', which have been designated but not properly implemented. Fewer than one-third of protected areas report having a full management plan (Ervin et al, 2008); in most cases, their biodiversity has not been adequately inventoried and many protected areas are inadequately protected, staffed or managed (WWF, 2004). While these are matters that are outside the responsibility of those undertaking *in situ* conservation of target species, they will clearly influence the choice of areas.

Box 7.13 Selection of genetic management zone sites for lychee (*Litchi chinensis*) in Vietnam

The selection of study sites proceeded in two steps. The first step was to identify genetically important areas (henceforth, referred to as 'genetic management zones' – GMZs) or 'hot spots' based on the following criteria:

- *presence and genetic diversity of target species;*
- *presence of endemic species;*
- *presence of high numbers of other economic species;*
- *overall floristic species richness;*
- *presence of high numbers of other economic species;*
- *containing natural and/or semi-natural ecosystems;*
- *presence of traditional agricultural systems; and*
- *protection status and/or existence of conservation-oriented farmers or communities that manage a number of species and cultivars …*

The second step was to select specific sites and communities within the larger GMZs where socio-economic conditions indicate good feasibility for on-farm agrobiodiversity conservation activities. Several workshops, stakeholder consultations and numerous meetings between IAG, NGOs working in the GMZs, local institutes, and farmer groups aided this process. Visits were made to each site to assess community receptivity to sharing traditional knowledge and practices that promote in situ *conservation.*

Source: Thi Hoa et al, 2005

The criteria adopted for the selection of gene management zones or genetic reserves in Vietnam for lychee (*Litchi chinensis*) are described in Box 7.13.

It is likely that many protected areas will become vulnerable to the effects of global and, in particular, climate change and human population growth. This is discussed in Chapter 14.

Special requirements for species with extensive distributions

While many of the species targeted for *in situ* conservation are restricted in distribution, if not rare, in the case of species which are widespread and of economic importance, such as major forest trees, special considerations apply when choosing which populations and areas to conserve. Sampling and conservation strategies for such species may involve including genetic core areas, important ranges of diversity, particular ecotypes or ranges of clinical variation, and outlier or marginal populations. In situations where populations of the target CWR occur in more than one area, a decision has to be made about which and how many areas should be selected for their *in situ* conservation. In the case of lychee (*Litchi* *chinensis*) conservation in Vietnam, it was found that a series of gene management zones was often required to ensure an adequate representation of the ecogeographic ranges needed for the selected species and populations in order to support sufficient environmental heterogeneity.

In the case of species whose populations consist of a series of isolated, widely scattered individuals – for example, in arid zones – this may require very large reserves to include a viable population. In such cases, the individual specimens may require additional protection. Rupicolous plants in inaccessible habitats and with highly niche-specific ecology, e.g. some *Brassica* wild relatives, which occur on rock faces in various parts of Europe and the Mediterranean, pose special challenges (Heywood, 2006).

Priority areas selected by the countries

Faced with financial and technical resource limitations, as well as political and socio-economic factors in certain instances, the selection of priority areas in countries was pragmatically determined, usually based on the actual presence of a priority species in an already established protected area, as well as accessibility to the area. In Bolivia, due to a moratorium imposed by the government on any activities planned within the country's protected areas, the selection of protected areas for CWR conservation was severely impacted and obviously delayed. Below is a detailed description of the protected areas and the species that were targeted for management plans by the project: wild cereals in Armenia, wild cacao in Bolivia, wild yams in Madagascar, wild cinnamon in Sri Lanka and wild almond in Uzbekistan (see Table 7.12).

Armenia

The area selected for *in situ* management is the Erebuni State Reserve. Occupying an area of approximately 89ha, the Erebuni State Reserve is Armenia's smallest protected area managed by the Reserve Park Complex of the Ministry of Nature Protection of the Republic of Armenia. It was established in 1981, in the vicinity of Yerevan, specifically to protect wild cereal species such as wheat (*Triticum araraticum*, *T. urartu*, *T. boeticum*), goatgrasses (*Aegilops* spp.), barley (*Hordeum glaucum*) and rye (*Secale vavilovii*). The reserve is also home to 292 species of vascular plants, representing 196 genera from 46 families. Participatory work carried out with local communities living in close proximity to the park has raised the profile of CWR and helped raise awareness on the need to conserve them. The reserve is located within the administrative boundaries of Yerevan city (see Chapter 9 and http://www.reservepark.mnp.am/htmls_eng/regions_1.htm).

Bolivia

Due to political delays, consultation with SERNAP (Servicio Nacional de Áreas Protegidas – the protected area authorities) commenced only in September and October 2009. SERNAP proposed working on the management plan of the Parque Nacional y Territorio Indigena Isiboro-Secure (TIPNIS) and with

Theobroma species as the target for a species management plan. Ranging in altitude from 180m to 3000m and extending for 1,372,180ha between the northern part of the Cochabamba Department and the southern part of the Beni Department, the TIPNIS (IUCN Category II – NP) is home to a high level of species and ecosystem diversity. Its range of habitats includes montane cloud forests, sub-Andean Amazonian forests, mid- to lowland evergreen rainforests and flooded savannas, each harbouring a unique flora and fauna. The protected area, established in 1965, is also an indigenous territory, property of the Chimán, Yuracaré and Moxeño tribes. SERNAP, which manages the Park, and the local organization of the indigenous people living in the Park (*Sub Central Indígena del TIPNIS*), have agreed to develop and establish a specific 'Programme for the *in situ* conservation of crop wild relatives existing within the park' and formulate a 'Management Plan for the protection of wild relatives of cocoa' to be included in the Park's management plan. The wild cacao (*Theobroma* spp.) existing inside the Park is currently threatened by habitat destruction and deforestation.

Madagascar

The area selected for *in situ* conservation of *Dioscorea maciba* and other *Dioscorea* species is Ankarafantsika National Park. *Dioscorea*, which includes over 40 species, is of high economic value as a staple food crop and several species of wild yams are now threatened due to overexploitation and are listed as critically endangered. A conservation programme has been initiated with local communities in the framework of the management plan for Ankarafantsika National Park, trying to reduce the pressure on wild species by convincing communities to grow cultivated yams. Located in the north-western part of Madagascar, the national park (IUCN Category II) was established in 1997, covers an area of 130,026km^2 and is managed by the Madagascar National Parks Association (PNM-ANGAP). See: http://www.parcs-madagascar.com/fiche-aire-protegee_en.php?Ap=15.

Sri Lanka

The area selected for *in situ* management of *Cinnamomum capparu-coronde* Blume is the Kanneliya Forest Reserve (see Chapter 9). Located in the Southern Province, near Galle, Kanneliya-Dediyagala-Nakiyadeniya (KDN) is the last large remaining rainforest in Sri Lanka, covering an area of 10,139ha. Its importance in terms of biodiversity and ecosystem services is such that it was designated as a biosphere reserve in 2004 by UNESCO. This protected area harbours many plant and animal species endemic to Sri Lanka. The Sri Lanka component of the UNEP/GEF CWR Project has worked hand in hand with the park's governing body – the Department of Forest Conservation – to modify the existing management plan for the area, which now includes a species management plan for the important endemic *Cinnamomum capparu-coronde* Blume, which is normally harvested for medicinal and commercial purposes. Awareness-raising activities have also been carried out to educate local communities on the importance of preserving such species.

Table 7.12 *Examples of CWR conserved in protected areas in Armenia, Bolivia, Madagascar, Sri Lanka and Uzbekistan*

Crop gene pool	*CWR*	*Protected area*	*Country*
Yam	*Dioscorea maciba*, *D. bemandry*, *D. antaly*, *D. ovinala* and *D. bemarivensis*	Ankarafantsika National Park	Madagascar
Cinnamon-tree	*Cinnamomum capparu-coronde*	Kanneliya Forest Reserve	Sri Lanka
Almond	*Amygdalus bucharica*	Chatkal Biosphere Reserve	Uzbekistan
Wheat	*Triticum araraticum*, *T. boeoticum*, *T. urartu* and *Aegilops tauschii*	Erebuni State Reserve	Armenia
Cacao	*Theobroma* spp.	Parque Nacional y Territorio Indígena Isiboro-Secure	Bolivia

Uzbekistan

Ugam-Chatkal State Natural National Park has been selected for *in situ* conservation of walnut, where this species is widely distributed (about 1500ha). The Park is located in Bostanlik region of the Tashkent district. Better forest stands with walnut (*Juglans*) are located on the Ugam range (Boguchalsay, Sidjaksay and Nauvalisay) and on the Pscem range (Aksarsay). Walnut is under better protection in the territory of Aksarsay where monitoring of the state of the walnut populations in the State Forestry Fund managed by Brichmulla Forestry has been agreed.

Ugam-Chakal State Natural National Park and Chatkal Biosphere Reserve have been chosen as areas selected for *in situ* management for barley (*Hordeum*).

Conclusions and lessons learned

In selecting species for priority conservation action, the countries used a range of criteria and a weighting mechanism. In the case of priority species, the absence of prior agreed guidelines for their selection led to considerable delays and confusion. On the other hand, it is quite clear in discussions with the five countries that the choice of areas and species was mainly influenced by the information already available on CWR conservation, as well as local knowledge of the situation in the countries concerned, and that a largely pragmatic approach was adopted. Considering that, for the purposes of the project, only a small number of priority species were selected, the choice of CWR related to important crops, especially those listed in Annex I of the ITPGRFA, and the selection of well-known protected areas in which they occurred is understandable. However, such an approach cannot be applied by the countries when the national CWR conservation strategy is implemented for all the CWR recorded.

It was also clear that there is a certain amount of confusion about the application of the global IUCN Red Listing process, its application at national level, the use of threat assessments other than those of the IUCN, the relative importance of the IUCN criteria and other threat assessment criteria.

A general conclusion that can be drawn is that it is very difficult and probably unrealistic to expect that uniform sets of criteria can be used for selecting species and selecting areas for CWR conservation. Nonetheless, it is important, especially when selecting the taxa, that as much information as possible be taken into account so that CWR representing a wide range of situations and values are chosen for conservation, subject of course to the availability of financial and technical resources.

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