

Kell, S.P., Knüpfer, H., Jury, S.L., Ford-Lloyd, B.V. and Maxted, N. (2008) Crops and wild relatives of the Euro-Mediterranean region: making and using a conservation catalogue. In: Maxted, N., Ford-Lloyd, B.V., Kell, S.P., Iriondo, J., Dulloo, E. and Turok, J. (eds.), Crop Wild Relative Conservation and Use. CAB International, Wallingford, UK. Pp. 69–109.

II **Establishing Inventories and Conservation Priorities**

Copyright protected material
Not for circulation

Copyright protected material
Not for circulation

5

Crops and Wild Relatives of the Euro-Mediterranean Region: Making and Using a Conservation Catalogue

S.P. KELL, H. KNÜPFER, S.L. JURY, B.V. FORD-LLOYD
AND N. MAXTED

5.1 Why Catalogue the Crop Resources of Europe and the Mediterranean?

The combined European and Mediterranean region (the Euro-Mediterranean region) is an important centre for the diversity of crops and their wild relatives – a major socio-economic resource and the cornerstone of agrobiodiversity for the region. Major food crops, such as wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), cabbage (*Brassica oleracea* L.) and olive (*Olea europaea* L.), originated in the Euro-Mediterranean and the wild relatives of these crops, along with several other major crops that have wild relatives in the region, are an important genetic resource for crop improvement and food security. Many minor crops have also been domesticated and developed in the region, such as chickpea (*Cicer arietinum* L.), lentil (*Lens culinaris* Medik.), sugarbeet (*Beta vulgaris* L.), almond (*Prunus dulcis* (Mill.) D.A. Webb) and apple (*Malus domestica* Borkh.). Other crops of socio-economic importance with wild relatives in the region are forestry species such as *Abies alba* Mill., *Populus nigra* L. and *Quercus ilex* L., ornamentals such as species of *Dianthus* L., *Euphorbia* L., *Geranium* L. and *Primula* L. and medicinal and aromatic plants such as species of *Anemone* L., *Campanula* L., *Helianthemum* Mill., *Orchis* L. and *Verbascum* L. Although it is acknowledged that populations of crop wild relatives (CWR) are under threat in the Euro-Mediterranean region, their conservation has historically received relatively little systematic attention. Creating a CWR inventory is the first step in the conservation and effective use of these vital resources – to tackle CWR conservation, we need to know how many taxa there are, what they are and where they are.

Taxon inventories provide the baseline data critical for biodiversity assessment and monitoring, as required by the Convention on Biological Diversity (CBD) (CBD, 1992), the Global Strategy for Plant Conservation (GSPC) (CBD, 2002), the European Plant Conservation Strategy (EPCS) (Council of Europe

and *Planta Europa*, 2002) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (FAO, 2001). They provide the essential foundations for the formulation of strategies for *in situ* and *ex situ* conservation and on the species' current and potential uses as novel crops or gene donors. Some species may already be included in areas managed for conservation purposes, but their status as CWR may be unknown and they may not be actively monitored and managed. We already know that relative to the number of crops conserved *ex situ* in European gene banks, the number of CWR conserved are few (see Maxted *et al.*, Chapter 1, this volume). Inventories are needed to establish which species are already conserved, where the gaps are in their conservation and to provide the data needed for integrating CWR into existing conservation initiatives.

At regional level, a CWR inventory provides policy makers, conservation practitioners, plant breeders and other user groups with an international view of CWR species' distributions and a means of prioritizing conservation activities (see Ford-Lloyd *et al.*, Chapter 6, this volume). A regional inventory provides the basis for monitoring biodiversity change internationally, by linking CWR information with information on habitats, policy and legislation and climate change. It also serves to highlight the breadth of CWR diversity available in the region, which may include important resources for CWR conservation and use in other parts of the world. Furthermore, a regional inventory provides the backbone for the creation of national CWR inventories (e.g. see Scholten *et al.*, Chapter 7, this volume; Maxted *et al.*, in press).

The creation of CWR inventories within Europe has been tackled in some cases at country level – for example, Schlosser *et al.* (1991) for the former German Democratic Republic, and Mitteau and Soupizet (2000) for France – and at regional level, for Europe – especially those proposed by Zeven and Zhukovsky (1975), Heywood and Zohary (1995) and Hammer and Spahillari (1999). However, a comprehensive and systematic approach has not yet been proposed and applied, and previously there has not been a coordinated effort focusing on the production of a comprehensive online Euro-Mediterranean Catalogue.

This chapter summarizes a methodology for establishing a regional catalogue of crops and their wild relatives for the Euro-Mediterranean region (see Kell *et al.*, 2007, unpublished data, for a full explanation of the methodology). The Catalogue (Kell *et al.*, 2005a) is made available through the web-enabled Crop Wild Relative Information System (CWRIS) (PGR Forum, 2005), which provides access to CWR information to a broad user community, including plant breeders, protected area managers, policy makers, conservationists, taxonomists and the wider public (see Kell *et al.*, Chapter 33, this volume) – information that is vital for the sustainable utilization and conservation of CWR. The Catalogue has been created using a systematic approach that can accommodate changes in nomenclature and status, and can be applied at both regional and national levels in any part of the world.

In addition to providing an online information resource, the actual Catalogue data can be analysed to provide statistics on the crop and CWR taxa of the region. This chapter provides information on the number of crop and CWR

taxa in the region and how many are native and endemic; the number of crop and CWR species present in individual nations and intranational regions; the number of species within and shared by the different crop groups; the number of worldwide crop genera that are found in the region; the major and minor food crops of the world that are native to the Euro-Mediterranean region and those that have wild relatives in the region. The Catalogue data can also be compared with taxon lists from existing conservation initiatives to establish which species are currently conserved and/or have undergone conservation assessment as a step towards the recognition and inclusion of CWR in current conservation programmes – some examples of this are given here.

5.2 Creating the Catalogue

5.2.1 Scope and basic methodology

The scope of the Catalogue is all species of direct socio-economic importance and their wild relatives – including food, fodder and forage crops, medicinal plants, condiments, ornamental and forestry species, as well as plants used for industrial purposes, such as oils and fibres. Applying the broad definition proposed by Maxted *et al.* (2006), a CWR includes any taxon belonging to the same genus as a crop species – it is upon this premise that the methodology for the creation of the CWR Catalogue is based.

In its simplest terms, the process of creating the Catalogue involves creating a list of genera containing crops, matching these with the genera contained in the flora of the country or region and selecting the taxa within the matching genera from the flora to create the Catalogue (see Kell *et al.*, 2007, unpublished data, for a detailed explanation of the methodology). For example, taking the crop species, *B. oleracea* L. (cabbage) as an example, because taxa within the genus *Brassica* L. occur in the Euro-Mediterranean region, we include all the accepted *Brassica* taxa that occur in the region in the CWR Catalogue – in this case, 34 species and 54 subspecies. All taxa, whether cultivated, wild, native or introduced, are included. For example, the introduced, cultivated taxon, *B. napus* L. subsp. *napus*, is included in the Catalogue, along with native or introduced wild-occurring taxa – for example, *B. tournefortii* Gouan (native) and *B. elongata* Ehrh. subsp. *elongata* (mainly introduced but possibly native in some countries) – and native, cultivated taxa – for example, *B. macrocarpa* Guss.

The reason for including both cultivated and wild taxa in the Catalogue is that we are providing an information resource as a tool for the conservation of plant genetic resources (PGR) of socio-economic importance (i.e. both the crops and their wild relatives). It is not only the wild relatives that may harbour useful genes for crop improvement, but also the crops themselves, particularly in the case of locally adapted forms or landraces. There is also a strong argument for including native and introduced taxa in the Catalogue – populations of crops or wild relatives that are not native may still be an important genetic resource and worthy of conservation efforts, particularly in cases where native populations of taxa have suffered from genetic erosion. While countries may

choose to conserve their native flora above the introduced flora, at regional level, in terms of conservation of crop genetic resources, the need to actively conserve introduced populations in some areas may be justified. Ultimately, the CWR Catalogue is a comprehensive information resource, which policy makers, conservation practitioners and crop germplasm user groups can use as an aid to conservation planning and sustainable use. Therefore, the more comprehensive the Catalogue is, the greater its uses will be.

5.2.2 Data sources

The Catalogue is primarily derived from two major databases: Euro+Med PlantBase (Euro+Med PlantBase, 2005), which provides the taxonomic core, and Mansfeld's World Database of Agricultural and Horticultural Crops (Hanelt and IPK Gatersleben, 2001; IPK Gatersleben, 2003), which provides lists of genera containing agricultural and horticultural crops and the crop species themselves.

Euro+Med PlantBase is an online database and information system for the vascular plants of the Euro-Mediterranean region. The database comprises names and associated data from *Flora Europaea*, the MedChecklist database, the Flora of Macaronesia data set and published Floras from the Euro-Mediterranean region. Euro+Med PlantBase includes native species, naturalized aliens, frequently occurring casuals, frequent and well-characterized hybrids, crop weeds and plants that are conspicuously cultivated outdoors. The geographical area covered includes all of Europe,¹ the Caucasus, Asiatic Turkey and the East Aegean Islands, Syria, Lebanon, Israel, Jordan, Cyprus, Egypt, Libya, Tunisia, Algeria, Morocco and Macaronesia.

Mansfeld's World Database of Agricultural and Horticultural Crops (Hanelt and IPK Gatersleben, 2001; IPK Gatersleben, 2003) contains more than 6100 cultivated species of agricultural and horticultural plants worldwide, including medicinal and aromatic plants, but with the exception of ornamental and forestry plants. The database also includes cultivated algae and fungi, pteridophyta and gymnosperms.

Genus lists for forestry and ornamental species and additional medicinal and aromatic plant taxa were drawn from other sources. For forestry taxa, a list of genera was extracted from the 'enumeration of cultivated forest plant species' (Schultze-Motel, 1966). For ornamentals, a list of taxa was provided by the Community Plant Variety Office (CPVO, 2001), which is the organization responsible for implementing the 'system for the protection of plant variety rights' established by European Community legislation, allowing intellectual property rights to be granted for plant varieties within the European Union

¹ The eastern boundary of Europe in Russia and Kazakhstan follows the definition of *Flora Europaea* (Tutin *et al.*, 1968–1980, 1993): from the Arctic Ocean along the Kara River to 68°N, along the crest of the Ural Mountains (following administrative boundaries) to 58°30'N, then by an arbitrary straight line to a point 50 km east of Sverdlovsk, and by another arbitrary straight line to the headwaters of the Ural River (south of Zlatoust); and finally along the Ural River to the Caspian Sea.

(EU). This list contains taxa for which the title had been granted and all active applications as of July 2003 (T. Kwakkenbos, France, 2003, personal communication). For medicinal and aromatic plants, a genus list was extracted from the database, Medicinal and Aromatic Plant Resources of the World (MAPROW) (U. Schippmann, Bonn, 2004, personal communication), which includes wild-harvested as well as cultivated medicinal and aromatic plant species (the cultivated ones are also included in Mansfeld's Database), thus broadening the scope of the CWR Catalogue.

Accepted and synonymous genus names were selected from Mansfeld's Database in order to capture as wide a range of agricultural and horticultural crop and CWR taxa in the Catalogue as possible; thus, when a genus name is considered a synonym in Mansfeld's Database but is accepted by Euro+Med PlantBase, it is included in the CWR Catalogue in addition to accepted genus names that match. Only accepted genus names were selected from Schultze-Motel (1966); since the data was not previously digitized, extraction of synonyms in addition to accepted names was not possible with the available resources. However, it is unlikely that this would have a significant effect on the number of species included in the Catalogue overall, since analysis shows that 95% of forestry species are common to the species in the list of agricultural and horticultural crops. The CPVO and MAPROW do not adopt specific accepted taxonomies; therefore, no distinction was made in these data sets between accepted and synonymous genus names – the genus names were thus used as provided by these data sources. However, again, the list of agricultural and horticultural crop and CWR species shares 90% of its taxa with the ornamental list and 92% with the medicinal and aromatic plants list, thus, taking into account the synonymy in Mansfeld's Database captures the majority of species in all groups. For a detailed discussion on dealing with synonymy in the creation of the CWR Catalogue, readers are referred to Kell *et al.* (2007, unpublished data).

The crop genus list contains 7363 genera in total. Table 5.1 summarizes the number of genera attributable to each data source. Note that some genera are common to two or more sources; for example, Mansfeld's Database contains 68% of the CWR genera sourced from the other crop data sources (forestry, ornamental, medicinal and aromatic genera combined). When the crop genera are matched with Euro+Med PlantBase to select those taxa that occur in Europe and the Mediterranean, Mansfeld's Database is found to contain 82% of the CWR genera sourced from the other crop data sources.

5.2.3 Euro+Med PlantBase data filtering

Euro+Med PlantBase (version September 2005) provides the taxonomic backbone to the CWR Catalogue. The database contains more than 45,000 accepted species and infraspecific taxa (of which more than 33,000 are species and nearly 12,000 are infraspecific taxa) and more than 39,000 specific and infraspecific synonyms (Table 5.1). Only accepted names in Euro+Med PlantBase were used to create the CWR Catalogue. However, the online Catalogue can be searched on any taxon name to find its associated data.

Table 5.1. Summary statistics: CWR Catalogue data sources.

Data source	No. of records	Data source/notes
Euro+Med PlantBase		
Euro+Med PlantBase: accepted species	33,471	a
Euro+Med PlantBase: accepted infraspecific taxa	11,989	
Euro+Med PlantBase: synonyms (species and infraspecific taxa)	39,924	
Crop genera		
Agricultural and horticultural crop genera	1,983	b
Forestry genera	338	c
Ornamental genera	366	d
Medicinal and aromatic genera	1,057	e
<i>Total crop genera</i>	2,539	f
Crop species		
Euro+Med PlantBase species coded 'cultivated'	1,299	
Agricultural and horticultural crop species	6,076	g
Forestry crop species	1,038	h
Ornamental crop species	300	

^aEuro+Med PlantBase (www.euromed.org.uk) version September 2005.

^bMansfeld's World Database of Agricultural and Horticultural Crops (Hanelt and IPK, 2001; <http://mansfeld.ipk-gatersleben.de>) – accepted genus names. This list includes, amongst others, genera containing cultivated medicinal and aromatic plants. Note that accepted and synonymous genus names from Mansfeld's Database (6914 taxa) were matched with accepted names in Euro+Med PlantBase to create the Catalogue (see Kell *et al.*, 2007, unpublished data).

^c'Enumeration of cultivated forest plant species' (Schultze-Motel, 1966) – accepted names only.

^dCommunity Plant Variety Office (www.cpvo.eu.int) (T. Kwakkenbos, France, 2003, personal communication) – no accepted taxonomy.

^eMedicinal and Aromatic Plant Resources of the World (MAPROW) (Schippmann, Bonn, 2004, personal communication) – no distinction between accepted names and synonyms. These genera cover all species known to be utilized for medicinal purposes, whether wild-harvested or cultivated.

^fThe four groups listed form the crop genus list, containing 2539 genera (7363, including the synonymous genus names from Mansfeld's Database (see note 2). Note that some genera are common to two or more sources.

^gMansfeld's World Database of Agricultural and Horticultural Crops (Hanelt and IPK, 2001; <http://mansfeld.ipk-gatersleben.de>) – accepted species only. Note that accepted and synonymous species names from Mansfeld's Database (24,578 taxa) were matched with the Catalogue to tag the cultivated species (see Kell *et al.*, 2007, unpublished data).

^hFigure from the preface of Schultze-Motel's (1966) preliminary worldwide account of cultivated forestry species.

Therefore, if a user searches for a synonym of an accepted taxon name in the Catalogue, CWRIS takes the user to the accepted name and the data associated with it.

Euro+Med PlantBase uses the 'Plant Occurrence and Status Scheme' (WCMC, 1995) – a Standard of the International Working Group on Taxonomic Databases (TDWG) – to record the status of taxa within each geographical unit (Table 5.2). Some taxa are recorded as 'extinct', 'recorded as present in error' or 'absent' – taxon records with these codes were therefore excluded from the Catalogue. Where there is any doubt about the presence

Table 5.2. Codes used in the fields 'native', 'introduced', 'cultivated' and 'status unknown' in Euro+Med PlantBase. (Adapted from Euro+Med PlantBase Secretariat, 2002.) Original data standard: WCMC (1995).

Code	Value	Explanation
<i>Native status</i>		
N	Native	The taxon is native (autochthonous) within the area concerned (as contrasted with 'introduced' and 'cultivated' defined below).
S	Assumed to be native	Assumed to be native to the area concerned.
D	Doubtfully native	There is doubt as to whether the status of the plant in the area concerned is native or not.
E	Formerly native (extinct)	The plant is native, doubtfully native or assumed to be native in the area concerned and has become extinct as such.
A	Not native	The plant is definitely not native.
F	Recorded as native in error	The plant has been recorded as native in the area concerned, but all such records have been disproved or discounted.
<i>Introduced status</i>		
I	Introduced	The plant has been recorded growing in an area that is outside of its assumed true and normal distribution. This implies evidence that the plant did not formerly occur in the area and also that the plant is either established and successfully reproducing (either sexually or asexually) or a frequently occurring casual. The plant must not be in cultivation: it does not mean (or include) 'introduced to cultivation'. The means of introduction, whether by man or any natural means, is irrelevant and may be unknown.
S	Assumed to be introduced	Assumed to be introduced to the area concerned.
D	Doubtfully introduced	There is doubt as to whether the status of the plant in the area concerned is introduced, as defined above, or not. All records about the introduced status of the plant in the area are in doubt.
E	Formerly introduced (extinct)	The plant is introduced, doubtfully introduced or assumed to be introduced in the area concerned and has become extinct as such. The criterion of extinction is that the plant was not found (as an introduction) after repeated searches of known and likely areas (i.e. sites within the area covered by the record), even though the plant may be extant elsewhere.
A	Not introduced	The plant is definitely not introduced (as defined above) in the area concerned.
F	Recorded as introduced in error	The plant has been recorded as introduced in the area concerned, but all of those records have been disproved or discounted. A known fallacious introduced record must have been made, and it must be known that the plant does not occur as an introduction in the area.

Continued

Table 5.2. *Continued*

Code	Value	Explanation
<i>Cultivated status</i>		
C	Cultivated	The plant is established in outdoor cultivation in the area concerned. Only plants that are conspicuously cultivated outdoors should be included (includes crops planted on a field-scale and street and roadside trees).
S	Assumed to be cultivated	Assumed to be cultivated in the area concerned.
D	Doubtfully cultivated	There is doubt as to whether the status of the plant is cultivated or not in the area concerned. All records about the cultivated status of the plant in the area are in doubt.
E	Formerly cultivated (extinct)	The plant was at one time cultivated, doubtfully cultivated or assumed to be cultivated in the area concerned and has become extinct in cultivation in this area, even though it may be extant elsewhere.
A	Not cultivated	The plant is definitely not cultivated (as defined above) in the area concerned.
F	Recorded as cultivated in error	The plant has been recorded as cultivated in the area concerned, but all of those records have been disproved or discounted. A known fallacious record of cultivation must have been made, and it must be known that the plant is not cultivated in the area.
<i>Status unknown</i>		
P	Present	The plant is present in the area and meets the criteria for inclusion in Euro+Med PlantBase; i.e. it is a native species, naturalized alien, frequently occurring casual, frequent and well-characterized hybrid, crop weed or a plant that is conspicuously cultivated outdoors (either a crop planted on a field-scale or street tree, but not a commonly grown park or garden plant). Adventives, casuals, etc. are not included although noxious weeds (other than those that have become naturalized which will be included for that reason) may be recorded.
S	Assumed present	It is highly probable that the plant does occur in the area.
D	Doubt about presence	There is doubt about whether the plant presently occurs in the area. This might be because all records are very old, locality details are uncertain, etc.
E	Extinct	The plant was once in the area (P or S) or may once have been in the area (D), but is now extinct in the area.
F	Recorded as present in error	The plant has been recorded as present in the area concerned, but the record has been discounted or disproved.
A	Absent	There are no records to suggest that a plant has ever occurred in the area concerned.

of a taxon, the record is maintained in the Catalogue until such time as the Euro+Med PlantBase records for that taxon are updated and the status is confirmed (note that the Catalogue is updated automatically by linking directly to the Euro+Med PlantBase data set). Inclusion of these records in the Catalogue makes very little difference to the overall number of species. After filtering, the number of accepted species names in Euro+Med PlantBase is reduced from 33,471 to 30,983; these species are contained within 218 families and 2437 genera (Table 5.3). These taxa form the base taxonomy for the CWR Catalogue.

Table 5.3. Creation of the CWR Catalogue: summary statistics. The total number of families, genera and species are shown for the filtered version of Euro+Med PlantBase (E+Mf), Mansfeld's World Database of Agricultural and Horticultural Crops and for each crop group after matching the crop genus list with Euro+Med PlantBase. The total number of crop taxa in the Euro-Mediterranean region and the number of crop and CWR native and endemic to Europe and the Euro-Mediterranean region are given.

Plant taxa present in the Euro-Mediterranean region	No. of taxa		
	Families	Genera	Species
Total no. of plant taxa (E+Mf)	218	2,437	30,983
Agricultural and horticultural taxa	166	1,109	23,513
Forestry taxa	57	143	2,843
Ornamental taxa	90	230	7,499
Medicinal + aromatic taxa	146	618	19,784
<i>CWR Catalogue for Europe and the Mediterranean</i> (total no. of crop and CWR taxa)	183	1,239	25,687
<i>Crop taxa^a</i>			
Agricultural and horticultural crops	147	754	1,994
Forestry crops	41	102	282
Ornamental crops	62	104	131
Other crops ^b	66	166	486
<i>Total crop taxa</i>	155	817	2,204
<i>Native and endemic species</i>			
Crop and CWR species native to Europe and the Mediterranean	–	–	23,216
Crop and CWR species endemic to Europe and the Mediterranean	–	–	14,994
Crop and CWR species native to Europe	–	–	15,656
Crop and CWR species endemic to Europe	–	–	8,624

^aTaxa known to be cultivated worldwide and not necessarily cultivated in the Euro-Mediterranean region. It is not possible to create a list of medicinal and aromatic crops using this data because MAPROW includes wild-harvested taxa and Mansfeld's Database does not contain a single data field that categorizes crop species according to their use.

^bOther crops are species recorded by Euro+Med PlantBase as cultivated in the region that are not already included in the lists of agricultural and horticultural, forestry and ornamental crops.
– Not applicable.

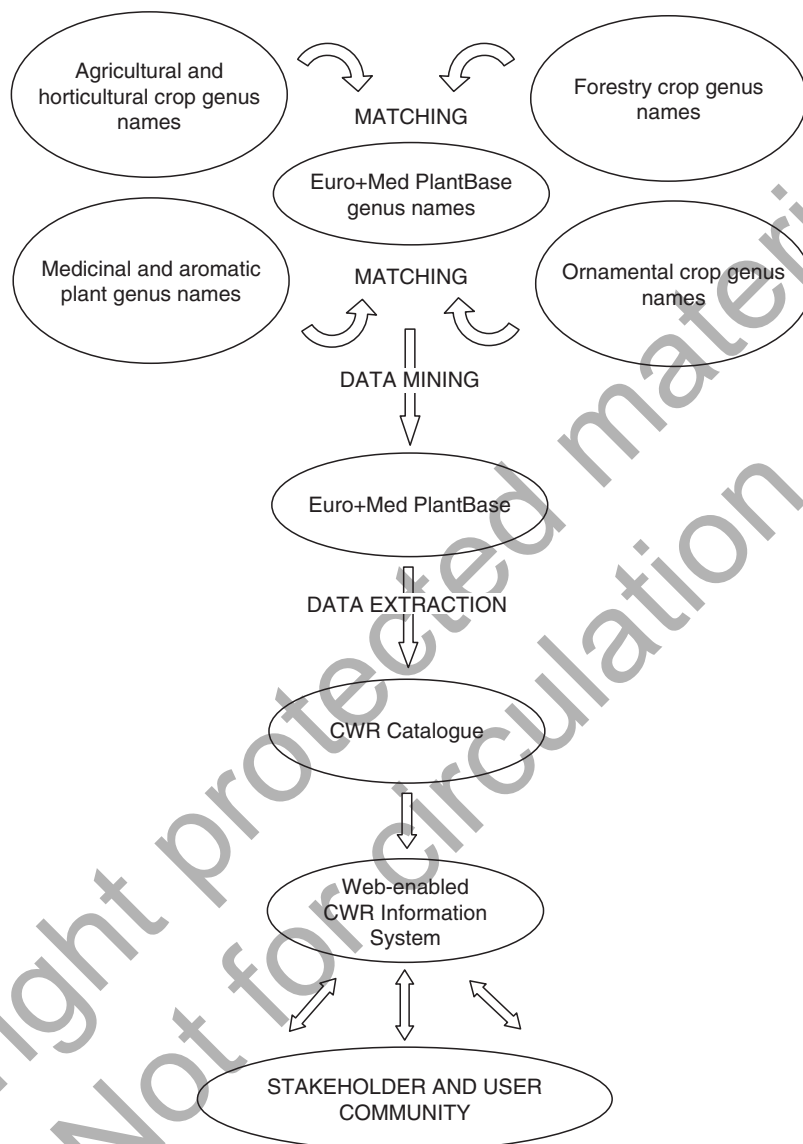


Fig. 5.1. Flow chart showing the basic methodology for the creation and utilization of the CWR Catalogue for Europe and the Mediterranean.

5.2.4 Mining and extraction of crop and CWR taxa from Euro+Med PlantBase

The genera in the filtered version of Euro+Med PlantBase corresponding with the crop genus list described earlier were selected. Following the genus name matching, the accepted taxa within the harmonized genera were selected, forming the CWR Catalogue. Figure 5.1 is a simplified flow chart illustrating the basic methodology, which could be utilized in any region or country. The chart shows the four

crop name sources forming the crop genus list, which is matched with the genera contained in the flora of the country or region – in this case, the flora of Europe and the Mediterranean. The flora is then mined for the accepted taxa contained in the matching genera and these are extracted to form the CWR Catalogue.

5.2.5 Coding crop species in the Catalogue

We generally refer to the Catalogue as the 'CWR Catalogue'; however, the Catalogue also contains the crop taxa themselves. To distinguish the crop taxa in the Catalogue, all taxa coded 'C' (cultivated) in Euro+Med PlantBase were selected and tagged. These include plants that are conspicuously cultivated outdoors, such as crops planted on a field-scale and street and roadside trees (Euro+Med PlantBase Secretariat, 2002). In addition, species names from Mansfeld's World Database of Agricultural and Horticultural Crops (Hanelt and IPK Gatersleben, 2001; IPK Gatersleben, 2003), the 'enumeration of cultivated forest plant species' (Schultze-Motel, 1966) and the CPVO ornamental list (T. Kwakkenbos, France, 2003, personal communication) matching species listed in the Catalogue were tagged as crops. To capture as wide a range of crop species as possible, matching between synonymous species in Mansfeld's Database and species in the Catalogue was carried out.

Mansfeld's Database is inclusive of a very wide range of cultivated species, so the agricultural and horticultural species tagged as crops in the Catalogue are wide-ranging. For example, in addition to food, fodder, forage, medicinal, aromatic and industrial crops, plants cultivated for soil improvement, sand dune fixation, hedging, grafting stock, shade and support are included; thus, a broad definition of a 'crop' is adopted. On the other hand, the list of species used to tag the cultivated ornamental species in the Catalogue cannot be considered representative of the extensive number of species utilized in the ornamental plant industry. The reasons for this are that the ornamental genera from the CPVO varieties list were deliberately chosen to keep the ornamental component of the Catalogue to a reasonable minimum, since the use of plant species in the ornamental industry is extremely wide-ranging, and the CPVO does not use a standard nomenclatural system, therefore, many cultivars are listed without inclusion of the specific epithet. A better coverage of cultivated ornamental species could be provided by matching the species in the Catalogue with a more comprehensive database such as the RHS Horticultural Database (Royal Horticultural Society, 2006), which was not completed and thus not available during the time that the CWR Catalogue was created.

It is important to point out that not all the species tagged as crops are necessarily cultivated in the Euro-Mediterranean region – some crop species may occur in the region, but only in their wild form. For example, 1313 species of agricultural and horticultural crops that occur in the region are not actually recorded by Euro+Med as being cultivated. However, knowledge that a cultivated taxon occurs as a wild relative in a country where it is not cultivated may be important for crop security, because the wild material may be utilized in breeding for crop improvement. Table 5.1 summarizes the number of crop species from each data source used to code species in the Catalogue as cultivated.

5.3 What Does the Catalogue Tell Us about Crops and CWR in the Region?

5.3.1 Analysing the Catalogue data

The Catalogue data can be analysed in numerous ways to provide both broad brush-stroke statistics about the crop and CWR species present in the region and more detailed analysis about the species present at national level and about individual crops or crop groups. Results of the following data analyses are presented here:

- The number of crop and CWR species within the Euro-Mediterranean region and within Europe alone, including the number of species native and endemic to the regions;
- The number of crops and their wild relatives within the different crop groups;
- The number of species shared by the different crop groups;
- The number of worldwide crop genera that are found in the region;
- National species richness;
- Which major and minor food crops of the world are native and endemic to the Euro-Mediterranean region and which have wild relatives in the region.

However, the role of the Catalogue goes far beyond provision of interesting statistics on the crop and CWR species of the region – one of its most important functions is to provide a basis for creating comprehensive national inventories (e.g. see Scholten *et al.*, Chapter 7, this volume; Maxted *et al.*, in press) and to aid CWR conservation gap analysis. For example, a regional or national inventory can be compared with protected area inventories (where the data is available), to establish which CWR species are already included within existing protected areas. Detailed gap analysis is beyond the scope of this chapter; however, we have undertaken some preliminary analysis to investigate which CWR taxa are included in: (i) the IUCN Red List of Threatened Species; (ii) the EC Habitats Directive; (iii) Important Plant Areas (IPAs); and (iv) the Plant Search Database of world botanic garden collections, to begin to build up a picture of to what extent CWR have been assessed and included in existing conservation initiatives.

5.3.2 Numbers of crop species and their wild relatives in Europe and the Mediterranean

The CWR Catalogue contains 25,687 of the 30,983 plant species recorded by Euro+Med PlantBase as present in the region. This indicates that approximately 83% of the Euro-Mediterranean flora consists of crops and their wild relatives; in other words, more than three-quarters of plant species in the region have a current or potential direct use to humankind. Ninety percent (23,216 species) are native to the Euro-Mediterranean region and 58% (14,994) are endemic (Table 5.3). However, taking into account synonymy and issues of taxonomic uncertainty, this is probably a slightly artificially large number of species (Kell *et al.*, 2007, unpublished data). Therefore, for the purposes of argument, we may conclude that around 80% of the flora of the region is of current or potential direct use.

Forty-nine percent of genera containing agricultural, horticultural, forestry and ornamental crops and medicinal and aromatic plants worldwide are found in the Euro-Mediterranean region and at least 2204 species in the CWR Catalogue (9%) are known to be cultivated worldwide (Table 5.3). As noted earlier, not all these species are necessarily cultivated within the Euro-Mediterranean region. At least 8% of the species listed in the CWR Catalogue are agricultural and horticultural crops in the Mansfeld sense (see Hanelt and IPK Gatersleben, 2001; IPK Gatersleben, 2003), while at least 1% are forestry crops as recorded by Schultze-Motel (1966). At least 8% of agricultural and horticultural and 10% of forestry crop and CWR species are cultivated worldwide. Although a taxon can be both cultivated and a wild relative (i.e. in some places it might be cultivated, while in others it may occur in its wild form), we can say that approximately 90% of the species in the agricultural, horticultural and forestry groups are wild relatives. In the CPVO (ornamental) list, 131 species match the names in the CWR Catalogue; however, this is not representative of the number of cultivated ornamental species. As explained earlier, if another source of data were consulted, such as the RHS Horticultural Database (Royal Horticultural Society, 2006), the figures for ornamental crop species would undoubtedly increase significantly.

Table 5.4 shows the total number of crop and CWR species in each of the four socio-economic groups: agricultural and horticultural crops, forestry species, ornamentals and medicinal and aromatic plants (note that the medicinal and aromatic species list includes wild-harvested plants and their wild relatives, as well as cultivated species). The percentage of the total number of Euro-Mediterranean crop and CWR species (25,687) attributable to each group is given. Table 5.5 is a matrix showing the percentage of species common to all four groups. Note that very high percentages of crop and CWR species extracted from the genus list derived from Mansfeld's World Database of Agricultural and

Table 5.4. Total number of crop and CWR species in the Euro-Mediterranean region and the numbers and percentages of species in each group.

	Crops	CWR	Total crop and CWR species	Total species per group as percentage of Catalogue
Agricultural and horticultural species ^a	1,994	21,519	23,513	92%
Forestry species	282	2,561	2,843	11%
Ornamental species	131	7,368	7,499	29%
Medicinal and aromatic species ^b	–	–	19,784	77%
<i>Total Euro-Mediterranean species</i>	2,204 ^c	23,483	25,687	–

^aThe agricultural and horticultural species list includes cultivated medicinal and aromatic plants.

^bThe medicinal and aromatic species list includes wild-harvested plants and their relatives, as well as cultivated species.

^cIncludes 486 'other' crop species recorded as cultivated in Euro+Med PlantBase (see Table 5.3).

– Not applicable or data not available.

Table 5.5. Matrix showing the percentage of crop and CWR species shared by each of the four groups. The bottom left side of the matrix shows the percentage of species shared by each group in the left-hand column as a percentage of the species in each group given across the top row. The top right side of the matrix expresses the percentages in reverse. For example, 11% of species in the agricultural and horticultural list are also found in the forestry list; and conversely, 95% of forestry species are found in the agricultural and horticultural list. Note that the medicinal and aromatic species list includes wild-harvested plants and their wild relatives, as well as cultivated species.

	Agricultural and horticultural (%)	Forestry (%)	Ornamental (%)	Medicinal and aromatic (%)
Agricultural and horticultural (%)	–	95	90	92
Forestry (%)	11	–	17	14
Ornamental (%)	29	45	–	33
Medicinal and aromatic (%)	77	95	88	–

– Not applicable.

Horticultural Crops are common to the other three socio-economic groups – i.e. 95% of the species in the forestry list, 90% in the ornamental list and 92% in the medicinal and aromatic plant list. This can be explained by the fact that many crop species have several uses, as do ornamental plants (e.g., medicinal and vegetable), and that cultivated medicinal and aromatic plants are also included in the Mansfeld's Database. Moreover, there are many species within the same genera as the agricultural and horticultural crop genera that have been classified within one of the other three socio-economic groups; thus, these groups will share many of the same CWR. The high percentages of medicinal and aromatic plant species common to the other three groups are also notable (i.e. 77% of agricultural and horticultural crops – though as observed earlier, Mansfeld's Database also includes cultivated medicinal and aromatic plants – 95% of forestry species and 88% of ornamental species). This illustrates the extremely broad use of plants for medicinal and aromatic purposes, many of which are species harvested from the wild. Perhaps not surprisingly, the forestry group has the lowest percentages of species common to the other three groups, with 11% of species common to the agricultural and horticultural crops, 17% to the ornamental species and 14% to the medicinal and aromatic plants.

Looking at Europe alone (as defined by Hollis and Brummitt, 2001), there are 17,495 crop and CWR species; therefore, 68% of crop and CWR species found across the Euro-Mediterranean region are found in Europe alone. Of these, 15,656 species (89%) are native to Europe and 8624 (49%) are endemic. As many as 1078 (42%) worldwide crop genera are found in Europe.

5.3.3 National species richness

Data in Euro+Med PlantBase are recorded within 130 geographical units, representing 58 nations. The number of crop and CWR species of each nation is shown in Table 5.6. Four nations contain more than 20% of the species in the region: Turkey, Spain, Italy and France. The nation with the highest CWR species richness is Turkey,

Table 5.6. List of Euro-Mediterranean nations, showing the total number of crop and CWR species per nation in descending order. The right column shows the number of species as a percentage of the total number of crop and CWR species in the region.

Nation	No. of crop and CWR species	Percentage of Euro-Mediterranean crop and CWR species
Turkey	7235	28
Spain	6669	26
Italy	5712	22
France	5528	22
Greece	4818	19
Ukraine	4265	17
Russia	4259	17
Germany	4211	16
Slovakia	3873	15
Bulgaria	3619	14
Austria	3563	14
Czech Republic	3526	14
Romania	3484	14
Croatia	3436	13
Switzerland	3413	13
Morocco	3409	13
Portugal	3296	13
Albania	3030	12
Algeria	2911	11
Poland	2751	11
Hungary	2639	10
Lebanon	2577	10
Slovenia	2533	10
Syria	2421	9
Sweden	2362	9
Serbia	2359	9
Norway	2276	9
Armenia	2235	9
United Kingdom	2169	8
Israel	2084	8
Denmark	2056	8
Tunisia	1882	7
Georgia	1882	7
Moldova	1795	7
Finland	1771	7
Egypt	1745	7
Belgium	1730	7
The Netherlands	1723	7
Libya	1547	6
Estonia	1501	6
Lithuania	1477	6
Cyprus	1448	6
Latvia	1323	5
Ireland	1299	5
Azerbaijan	882	3

Continued

Table 5.6. *Continued*

Nation	No. of crop and CWR species	Percentage of Euro-Mediterranean crop and CWR species
Belarus	754	3
Malta	738	3
Kazakhstan	592	2
Iceland	540	2
Andorra	504	2
Jordan	474	2
Bosnia-Herzegovina	241	1
Montenegro	185	1
Serbia and Montenegro	148	1
Luxembourg	118	<1
Liechtenstein	43	<1
San Marino	8	<1

with 7235 species – 28% of the crop and CWR species of the Euro-Mediterranean region. As might be expected, the proportion of the flora of these four countries that comprises crops and their wild relatives is fairly consistent with the overall proportion of the flora of the region: Turkey – 83%, Spain – 81%, Italy – 84% and France – 86%. Nineteen nations contain between 10% and 20% of the crop and CWR flora of the region, 31 between 1% and 10% and three less than 1%.

We can also look at which crop groups are most prevalent in individual countries and the number of crop species present. For example, of the 2276 crop and CWR species recorded in Norway, 2084 species (92%) are included in the agricultural and horticultural crop group, 345 (15%) in the forestry group, 782 (34%) in the ornamental group and 1855 (82%) in the medicinal and aromatic plant group. Also, 633 of these species (28%) are known to be cultivated worldwide and these comprise: agricultural and horticultural crops – 550 species (87%); forestry crops – 113 species (18%); ornamental crops – 46 species (7%). Euro+Med PlantBase indicates that at least 95 of these species (15%) are cultivated in Norway – of these species, 56 (59%) are agricultural and horticultural crops, 45 (47%) are forestry crops and 10 (11%) are ornamental crops. By comparison, taking a southern European example, of the 6669 crop and CWR species found in the Spanish territories, 5947 species (89%) are included in the agricultural and horticultural crop group, 659 (10%) in the forestry group, 2073 (31%) in the ornamental group and 4829 (72%) in the medicinal and aromatic plant group. Of these, 1279 (19%) are known to be cultivated worldwide (agricultural and horticultural crops – 1172 species (92%); forestry crops – 173 species (14%); ornamental crops – 92 species (7%)) and of the 215 species recorded by Euro+Med PlantBase as cultivated in Spain, 194 (90%) are agricultural and horticultural crops, 54 (25%) are forestry crops and 20 (9%) are ornamental crops. Notable are the significantly different percentages of agricultural and horticultural crops and forestry species cultivated in Norway and Spain.

Because Euro+Med PlantBase is organized into geographical units, it is also possible to look at the proportion of crop and CWR species within different intrans-

tional regions, where they exist. This is particularly interesting for those nations that include islands – especially, the oceanic islands such as the Canary Islands (Spain) and the Azores (Portugal) – and also other islands such as Sicily and Malta (Italy) and Corsica (France). Islands exhibit high levels of endemism due to their isolation from continental areas, so they are natural reservoirs of unique genetic diversity. However, it is widely recognized that island populations are also extremely vulnerable to genetic erosion because of the disruption caused by human colonization and associated biological invasions; for example, see Loope and Mueller-Dombois (1989), Schofield (1989), Bramwell (1990), Vitousek (1992) and Simberloff (1995). Taking Spain as an example, around 10% of the crop and CWR taxa of the Spanish territories occur in the Canary Islands – taxa that are not found in mainland Spain – and, of these, an estimated 249 species and 162 subspecies are endemic.² The islands of Sicily and Malta also contain a large proportion of the crop and CWR species of Italy – 2404 out of a total of 5712 species. Of the species found in Sicily and Malta, 277 are not found in mainland Italy and of these, 24 are recorded as endemic.³ Of these endemic species, 23 fall into the agricultural and horticultural group, 3 in the forestry group, 13 in the ornamental group and 21 in the medicinal and aromatic group. As these taxa are endemic to small islands, their conservation may be considered of high priority due to their potential use for crop improvement in the future, combined with their innate vulnerability as island populations.

It is therefore possible to extract a list of crop and CWR taxa for each nation in the Euro-Mediterranean region and to provide a breakdown of the taxa for each geographical unit per nation, for those nations where this occurs. National crop and CWR lists have already been sent to each National PGR Coordinator in the region. Individual nations can then use these lists as a basis for conservation planning, once the list has been checked and verified to account for any potential errors. In turn, nations can feed back any errors they have found and their proposed corrections to the Euro+Med PlantBase Secretariat. Any changes that are made to Euro+Med PlantBase will automatically be made in the CWR Catalogue, which will remain available through the Internet. The Catalogue can be utilized not only to aid national conservation planning, but also to estimate the distribution of crops and their wild relatives within the region – for example, to aid regional conservation planning within the EU. Furthermore, the data can be used to target those taxa that have limited distributions (i.e. they occur in one to a few nations or intranational regions) (see Ford-Lloyd *et al.*, Chapter 6, this volume). For example, of the 25,687 crop and CWR species in the Euro-Mediterranean region, at least 2873 (11%) are endemic to one nation.⁴ One of

² Estimates are based on taxa only recorded as occurring in the Canary Islands and endemic to the geographical unit 'Macaronesia'.

³ Analysis of the Catalogue data indicates that there are probably significantly more endemic CWR species in Sicily (possibly as many as 86). However, the data are not complete; therefore, using the current data set, we cannot be certain of the exact number.

⁴ This is a conservative estimate because there are more species recorded in Euro+Med PlantBase in only one country (6867) than are recorded as endemic to the Euro-Mediterranean region, but the data have not yet been verified and we cannot be certain that these taxa do not occur in other countries.

the major reasons for providing an information resource on where crop and CWR taxa can be found and for conserving these taxa is for their utilization as gene donors for crop improvement. The CWR Catalogue provides the information needed for plant breeders to source new material and for conservationists to collect material from as wide a range of a taxon's distribution as possible.

5.3.4 Major and minor food crops

So far, we have looked at the number of species within four socio-economically important plant groups: agricultural and horticultural crops, forestry crops, ornamentals and medicinal and aromatic plants. This is useful information, but many people might ask, how many species are found in the region in the major crop groups or within the world's food crops? This is a very good question and one which we have at least partially addressed by looking at the major and minor food crops of the world. Using the food crops of major significance (major food crops) and secondary or local importance (minor food crops) listed by Groombridge and Jenkins (2002), an analysis was undertaken to ascertain how many taxa (cultivated and wild, native and introduced) are found in the Euro-Mediterranean region within the major and minor food crop groups.

Of the 28 major food crop genera of the world, 22 occur in the Euro-Mediterranean region – 15 (54%) of these encompassing wild relatives (Table 5.7). There are 219 species and 100 subspecific taxa (subspecies and varieties) within these major food crop genera which can be found growing in the region. Of these, 106 species are known to be cultivated worldwide and at least 44 species and 24 subspecies are recorded by Euro+Med PlantBase as being cultivated in the region. National-level analysis is required to ascertain the exact number of cultivated and wild-occurring taxa within this list; however, even those taxa that are cultivated, whether also found in their wild form or not, may be a useful, if not vital source of germplasm for crop improvement, especially locally adapted forms or landraces. Four (11%) of the 38 major food crops of the world are native to the Euro-Mediterranean region: cereals – *H. vulgare* L. (barley) and *T. aestivum* L. (wheat); leaf vegetables – *B. oleracea* L. (cabbage); and oil crops – *O. europaea* L. (olive).⁵ Three of these crops are native to Europe (as defined by Hollis and Brummitt, 2001): wheat, cabbage and olive.

Within the 28 major food crop genera of the world, 57 species are endemic to the Euro-Mediterranean region. Of these, at least 11 species are endemic to only one nation⁶ and many of these are limited to islands

⁵ *Vigna unguiculata* (L.) Walp. is also recorded by Euro+Med PlantBase as native to Egypt, but its native distribution is probably limited to sub-Saharan Africa; therefore, it is probably naturalized in Egypt.

⁶ Estimate based on Euro+Med PlantBase (version September 2005) data only. There are likely to be further species within the major and minor food crop genera recorded in Euro+Med PlantBase in only one country, but the data have not yet been verified and we cannot be certain that these taxa do not occur in other countries.

Table 5.7. Major food crops of the world with wild relatives in the Euro-Mediterranean region (including both native and introduced taxa), the number of species and subspecific taxa within each genus (including crops) and the major food crop species native to the region.

Crop ^a	Genus	No. of species	No. of sub-specific taxa ^b	Native crop species
Barley	<i>Hordeum</i> L.	13	8	<i>H. vulgare</i> L.
Beans	<i>Vigna</i> Savi	4	1	— ^c
Cabbage	<i>Brassica</i> L.	34	54	<i>B. oleracea</i> L.
Millet	<i>Echinochloa</i> P. Beauv.	11	2	—
Millet	<i>Eleusine</i> Gaertn.	5	2	—
Millet	<i>Panicum</i> L.	21	3	—
Millet	<i>Pennisetum</i> Rich.	11	5	—
Millet	<i>Setaria</i> P. Beauv.	16	7	—
Olive	<i>Olea</i> L.	4	5	<i>O. europaea</i> L.
Potato	<i>Solanum</i> L.	60	6	—
Rye	<i>Secale</i> L.	6	3	—
Sorghum	<i>Sorghum</i> Moench	8	0	—
Sunflower seed	<i>Helianthus</i> L.	12	0	—
Wheat	<i>Triticum</i> L.	13	4	<i>T. aestivum</i> L.
Yam	<i>Dioscorea</i> L.	1	0	—
Total	11	219	100	4

^aMajor food crops based on food crops of major significance listed by Groombridge and Jenkins (2002).

^bSubspecies and varieties.

^c*Vigna unguiculata* (L.) Walp. is recorded by Euro+Med PlantBase as native to Egypt but its native distribution is probably limited to sub-Saharan Africa; therefore, it is probably naturalized in Egypt.

— Not applicable.

(Table 5.8). For example, *Brassica balearica* Pers. is endemic to the Balearic Islands (Spain), *B. rupestris* Raf., *B. macrocarpa* Guss. and *B. villosa* Biv. are endemic to the islands of Sicily and Malta (Italy), *B. hilarionis* Post is endemic to Cyprus and *Solanum patens* Lowe and *S. trisetum* Dunal are endemic to Macaronesia (possibly endemic to the island of Madeira). In addition, 46 subspecies within the 28 major food crop genera of the world are endemic to the Euro-Mediterranean region and at least 22 of these are endemic to only one nation (Table 5.8). Again, some of these taxa are limited to islands; for example, *B. oleracea* subsp. *bourgeauii* (Webb) Gladst. & K. Hammer and *O. europaea* subsp. *guanchica* P. Vargas, J. Hess, Muñoz Garm. & Kadereit are only found in the Canary Islands (Spain).

Of the 51 minor food crop genera of the world (listed by Groombridge and Jenkins, 2002), 39 (76%) occur in the Euro-Mediterranean region – 35 (69%) of these encompassing wild relatives (Table 5.9). Within these minor food crop genera, 938 species and 372 subspecific taxa (subspecies and varieties) can be found growing in the region. Of these, 382 species and 46 subspecies are endemic and at least 99 species and 41 subspecies are endemic to only one nation (Table 5.8). Of the 69 minor food crops of the world, 23 (33%) are native to the Euro-Mediterranean region and 22 are native to Europe.

Table 5.8. Taxa within the 28 major and 51 minor food crop genera of the world endemic to one nation in the Euro-Mediterranean region.^a

Crop	Taxon	Endemic to
<i>Wild relatives of major food crops</i>		
Cabbage	<i>Brassica balearica</i> Pers.	Baleares (Spain)
	<i>B. cadmea</i> O.E. Schulz	Greece
	<i>B. cretica</i> subsp. <i>laconica</i> M.A. Gust. & Snogerup	Greece
	<i>B. desertii</i> Danin & Hedge	Sinai (Egypt)
	<i>B. desnottesii</i> Emb. & Maire	Morocco
	<i>B. elongata</i> subsp. <i>imdrhaiana</i> Quézel	Morocco
	<i>B. elongata</i> subsp. <i>subscapoza</i> (Maire & Weiller) Maire	Morocco
	<i>B. fruticulosa</i> subsp. <i>numidica</i> (Coss.) Maire	Algeria
	<i>B. fruticulosa</i> subsp. <i>poméliana</i> Maire	Algeria
	<i>B. fruticulosa</i> subsp. <i>radicata</i> (Desf.) Batt.	Algeria
	<i>B. hilarionis</i> Post	Cyprus
	<i>B. macrocarpa</i> Guss.	Sicily with Malta (Italy)
	<i>B. nivalis</i> subsp. <i>jordanoffii</i> (O.E. Schulz) Akeroyd & Leadlay	Bulgaria
	<i>B. nivalis</i> Boiss. & Heldr. subsp. <i>nivalis</i>	Greece
	<i>B. oleracea</i> subsp. <i>bourgeauri</i> (Webb) Gladis & K. Hammer	Canary Islands
	<i>B. repanda</i> subsp. <i>almeriensis</i> Gómez-Campo	Spain
	<i>B. repanda</i> subsp. <i>blancoana</i> (Boiss.) Heywood	Spain
	<i>B. repanda</i> subsp. <i>cadevallii</i> (Font Quer) Heywood	Spain
	<i>B. repanda</i> subsp. <i>cantabrica</i> (Font Quer) Heywood	Spain
	<i>B. repanda</i> subsp. <i>dertosisensis</i> Molero & Rovira	Spain
<i>B. repanda</i> subsp. <i>diplofaxiformis</i> (Maire) Gómez-Campo	Morocco	
<i>B. repanda</i> subsp. <i>galissieri</i> (Giraudias) Heywood	France	
<i>B. repanda</i> subsp. <i>glabrescens</i> (Poldini) Gómez-Campo	Italy	
<i>B. repanda</i> subsp. <i>gypsicola</i> Gómez-Campo	Spain	
<i>B. repanda</i> subsp. <i>humilis</i> (DC.) O. Bolòs & Vigo	France	
<i>B. repanda</i> subsp. <i>silenifolia</i> (Emb.) Greuter & Burdet	Morocco	
<i>B. rupestris</i> Raf.	Sicily with Malta (Italy)	
<i>B. spinescens</i> Pomet	Algeria	
<i>B. villosa</i> Biv.	Sicily with Malta (Italy)	

- Olive
Olea europaea subsp. *cerasiformis* G. Kunkel & Sunding
O. europaea subsp. *guanchica* P. Vargas, J. Hess, Muñoz Garm. & Kadereit
- Potato
Solanum patens Lowe
S. trisectum Dunal
- Wild relatives of minor food crops
Onion, garlic
Allium autumnale P. H. Davis
A. bourgeau subsp. *creticum* Bothmer
A. callimischon Link subsp. *callimischon*
A. chrysantherum Boiss. & Reut.
A. chrysonemum Stearn
A. circinnatum Sieber
A. corsicum Jauzein, J.-M. Tison, Deschâtres & H. Couderc
A. cupani subsp. *cypricum* Meikle
A. czelghauricum Bordz.
A. deciduum Özhatay & Kollmann subsp. *deciduum*
A. deciduum subsp. *retrosum* Özhatay & Kollmann
A. djimilense Regel
A. eldivanense Özhatay
A. favosum Zahar.
A. fuscum Waldst. & Kit. subsp. *fussii*
A. guttatum subsp. *dilatatum* (Zahar.) B. Mathew
A. gorumsense Boiss.
A. grosii Font Quer
A. heldreichii Boiss.
A. hierochuntinum Boiss.
A. hierosolymorum Regel
A. humbertii Maire
A. hymettium Boiss. & Heldr.
A. ilgazense Özhatay
A. incensiodorum Radić
- Madeira, Porto Santo, Desertas (Portugal)
Canary Islands (Fuerteventura with Lobos, Tenerife, Lanzarote with Graciosa, La Palma, Hierro, Gomera, Gran Canaria) (Spain)
Macaronesia (possibly endemic to Madeira (Portugal))
Macaronesia (possibly endemic to Madeira (Portugal))
- Cyprus
Crete (with Karpathos, Kasos and Gavdhos) (Greece)
Greece
Turkey
Spain
Crete (with Karpathos, Kasos and Gavdhos) (Greece)
Corsica (Italy)
Cyprus
Turkey
Turkey
Turkey
Turkey
Turkey
Turkey
Greece
Romania
Crete (with Karpathos, Kasos and Gavdhos) (Greece)
Turkey
Ibiza with Formentera (Spain)
Greece
Israel
Israel
Algeria
Greece
Turkey
Croatia

Continued

Table 5.8. Continued

Crop	Taxon	Endemic to
	<i>A. insubricum</i> Boiss. & Reut.	Italy
	<i>A. integerrimum</i> Zahar.	Greece
	<i>A. junceum</i> subsp. <i>tridentatum</i> Kollmann, Özhatay & M. Koyuncu	Turkey
	<i>A. karamanoglui</i> Koyuncu & Kollmann	Turkey
	<i>A. kastambulense</i> Kollmann	Turkey
	<i>A. kurtzianum</i> Kollmann	Turkey
	<i>A. lenkoranicum</i> Misoz.	Azerbaijan
	<i>A. leonidi</i> Grossh.	Azerbaijan
	<i>A. luteolum</i> Halácsy	Greece
	<i>A. macedonicum</i> Zahar.	Greece
	<i>A. mareoticum</i> Borm. & Gauba	Egypt
	<i>A. mariae</i> Bordz.	Azerbaijan
	<i>A. materulae</i> Bordz.	Azerbaijan
	<i>A. negrianum</i> Maire & Weiller	Libya
	<i>A. nemrutdagense</i> Kit Tan & Sorger	Turkey
	<i>A. olympicum</i> Boiss.	Turkey
	<i>A. palentinum</i> Losa & P.Monts.	Spain
	<i>A. paniculatum</i> subsp. <i>antiatlanticum</i> (Emb. & Maire) Maire & Weiller	Morocco
	<i>A. paniculatum</i> subsp. <i>breviscapum</i> Litard. & Maire	Morocco
	<i>A. paniculatum</i> subsp. <i>exaltatum</i> Meikle	Cyprus
	<i>A. parnassicum</i> (Boiss.) Halácsy	Greece
	<i>A. phthioticum</i> Boiss.	Greece
	<i>A. pruinatum</i> Spreng.	Portugal
	<i>A. pruinatum</i> var. <i>bulbiferum</i> Cout.	Portugal
	<i>A. regnieri</i> Maire	Morocco
	<i>A. robertianum</i> Kollmann	Turkey
	<i>A. rouyi</i> Gaut.	Spain
	<i>A. ruhmerianum</i> Asch.	Libya
	<i>A. seirotrichum</i> Duce'llier	Algeria
	<i>A. sintenisii</i> Freyn	Turkey

	<i>A. talyshense</i> Miscz.		
	<i>A. tardans</i> Greuter & Zahar.		
	<i>A. trichocnemis</i> J. Gay		
	<i>A. valdecallosum</i> Maire & Weiller		
	<i>A. vuralii</i> Kit Tan		
	<i>A. willeaenum</i> Holimboe		
Sugarbeet	<i>Beta nana</i> Boiss. & Heldr.		
	<i>B. patula</i> Aiton		
Mustard seed, rape seed	See major crops, cabbage (<i>Brassica</i> spp.)		
Chickpea	<i>Cicer graecum</i> Boiss.		
Hazel, filbert	<i>Corylus cervorum</i> Petrov		
Artichoke	<i>Cynara alba</i> DC.		
	<i>C. baetica</i> (Spreng.) Pau		
	<i>C. cyrenaica</i> Maire & Weiller		
	<i>C. hystrix</i> Ball		
	<i>Daucus carota</i> subsp. <i>gadecaei</i> (Rouy & E.G. Camus) Heywood		
Carrot	<i>D. tenuisectus</i> Coss.		
Fig	<i>Ficus hyrcana</i> Grossh.		
Mate	<i>Ilex perado</i> Aiton subsp. <i>perado</i>		
Lettuce	<i>Lactuca</i> x <i>impure</i> Maire		
	<i>L. livida</i> Boiss. & Reut.		
	<i>L. longidentata</i> DC.		
	<i>L. reviersii</i> Litard. & Maire		
	<i>L. seticuspis</i> Boiss.		
	<i>L. triquetra</i> (Labill.) Benth. & Hook. f.		
	<i>L. viminea</i> subsp. <i>alpestris</i> (Gand.) Feráková		
	<i>L. virosa</i> subsp. <i>cornigera</i> (Pau & Font Quer) Emb. & Maire		
	<i>L. watsoniana</i> Trel.		
Almond, apricot,	<i>Prunus lusitanica</i> subsp. <i>azorica</i> (Mouill.) Franco		
plum, cherry	<i>P. ramburii</i> Boiss.		
	<i>P. spinosa</i> subsp. <i>insitioides</i> (Ficalho & Cout.) Franco		
	<i>A. talyshense</i> Miscz.	Azerbaijan	
	<i>A. tardans</i> Greuter & Zahar.	Crete (with Karpathos, Kasos and Gavdhos) (Greece)	
	<i>A. trichocnemis</i> J. Gay	Algeria	
	<i>A. valdecallosum</i> Maire & Weiller	Morocco	
	<i>A. vuralii</i> Kit Tan	Turkey	
	<i>A. willeaenum</i> Holimboe	Cyprus	
	<i>Beta nana</i> Boiss. & Heldr.	Greece	
	<i>B. patula</i> Aiton	Madeira, Desertas (Portugal)	
	See major crops, cabbage (<i>Brassica</i> spp.)		
	<i>Cicer graecum</i> Boiss.	Greece	
	<i>Corylus cervorum</i> Petrov	Azerbaijan	
	<i>Cynara alba</i> DC.	Spain	
	<i>C. baetica</i> (Spreng.) Pau	Spain	
	<i>C. cyrenaica</i> Maire & Weiller	Libya	
	<i>C. hystrix</i> Ball	Morocco	
	<i>Daucus carota</i> subsp. <i>gadecaei</i> (Rouy & E.G. Camus) Heywood	France	
	<i>D. tenuisectus</i> Coss.	Morocco	
	<i>Ficus hyrcana</i> Grossh.	Azerbaijan	
	<i>Ilex perado</i> Aiton subsp. <i>perado</i>	Madeira (Portugal)	
	<i>Lactuca</i> x <i>impure</i> Maire	Morocco	
	<i>L. livida</i> Boiss. & Reut.	Spain	
	<i>L. longidentata</i> DC.	Sardinia (Italy)	
	<i>L. reviersii</i> Litard. & Maire	Morocco	
	<i>L. seticuspis</i> Boiss.	Syria	
	<i>L. triquetra</i> (Labill.) Benth. & Hook. f.	Lebanon	
	<i>L. viminea</i> subsp. <i>alpestris</i> (Gand.) Feráková	Crete (with Karpathos, Kasos and Gavdhos) (Greece)	
	<i>L. virosa</i> subsp. <i>cornigera</i> (Pau & Font Quer) Emb. & Maire	Morocco	
	<i>L. watsoniana</i> Trel.	Azores (Faial, Pico, São Jorge, São Miguel, Terceira) (Portugal)	
	<i>Prunus lusitanica</i> subsp. <i>azorica</i> (Mouill.) Franco	Azores (Terceira, São Miguel, São Jorge, Pico) (Portugal)	
	<i>P. ramburii</i> Boiss.	Spain	
	<i>P. spinosa</i> subsp. <i>insitioides</i> (Ficalho & Cout.) Franco	Portugal	

Continued

Table 5.8. Continued

Crop	Taxon	Endemic to
Pear	<i>Pyrus communis</i> subsp. <i>mamorensis</i> (Trab.) Maire	Morocco
	<i>P. complexa</i> Rubtzov	Armenia
	<i>P. elata</i> Rubtzov	Slovenia
	<i>P. hakkjarica</i> Browicz	Turkey
	<i>P. magyarica</i> Terpo	Hungary
	<i>P. mamorensis</i> Trab.	Morocco
	<i>P. medvedevii</i> Rubtzov	Armenia
	<i>P. nutans</i> Rubtzov	Armenia
	<i>P. raddeana</i> Woronow	Armenia
	<i>P. rossica</i> A.D. Danilov	Russia
	<i>P. sosnovskyi</i> Fed.	Armenia
	<i>P. tamamschianae</i> Fed.	Armenia
	<i>P. voronovii</i> Rubtzov	Armenia
	<i>P. zangezura</i> Maleev	Armenia
	<i>Ribes multiflorum</i> subsp. <i>sandaliticum</i> Arrigoni	Sardinia (Italy)
<i>Ribes sardoum</i> Martelli	Sardinia (Italy)	
Blackcurrant, redcurrant	Baleares (Spain)	
Aubergine	Madeira, Desertas (Portugal)	
Broad bean	See major crops, potato (<i>Solanum</i> spp.)	Madeira, Porto Santo (Portugal)
	<i>Vicia bifoliolata</i> Rodr.	Madeira, Porto Santo (Portugal)
	<i>V. capreolata</i> Lowe	Spain
	<i>V. costae</i> A. Hansen	Madeira (Portugal)
	<i>V. ferreirensis</i> Goyder	Madeira, Porto Santo (Portugal)
	<i>V. glauca</i> subsp. <i>giennensis</i> (Cuatrec.) Blanca & F. Valle	Madeira (Portugal)
	<i>V. pectinata</i> Lowe	Madeira, Porto Santo (Portugal)
	<i>V. sativa</i> subsp. <i>devia</i> J.G. Costa	Sinai (Egypt)
	<i>V. sinaica</i> Boulos	

*Estimate based on Euro+Med PlantBase (version September 2005) data only. There are likely to be more single country endemic taxa within the major and minor food crop genera, but these are not verified as single country endemic taxa in this data set.

Table 5.9. Minor food crops of the world with wild relatives in the Euro-Mediterranean region (including both native and introduced taxa), the number of species and subspecific taxa within each genus (including crops), and the minor food crop species native to the region.

Crop ^a	Genus	No. of species	No. of sub-specific taxa ^b	Native crop species
Almond	<i>Prunus</i>	41	24	<i>P. dulcis</i> (Mill.) D.A. Webb
Apple	<i>Malus</i>	12	4	<i>M. domestica</i> Borkh.
Apricot	<i>Prunus</i>	41	24	<i>P. armeniaca</i> L.
Artichoke	<i>Cynara</i>	10	3	<i>C. scolymus</i> L.
Aubergine	<i>Solanum</i>	60	6	–
Avocado	<i>Persea</i> ^c	1	0	–
Blackcurrant	<i>Ribes</i>	18	5	<i>R. nigrum</i> L.
Broad bean	<i>Vicia</i>	141	73	–
Carrot	<i>Daucus</i>	26	18	<i>D. carota</i> L.
Cherry	<i>Prunus</i>	41	24	<i>P. avium</i> L.
Chickpea	<i>Cicer</i>	17	0	<i>C. arietinum</i> L.
Cucumber	<i>Cucumis</i>	7	2	–
Date	<i>Phoenix</i>	3	0	<i>P. dactylifera</i> L. ^d
Fig	<i>Ficus</i>	10	4	<i>F. carica</i> L.
Filbert	<i>Corylus</i>	11	0	<i>C. maxima</i> Mill.
Fonio	<i>Digitaria</i>	11	2	–
Garlic	<i>Allium</i>	276	76	–
Grape	<i>Vitis</i>	10	2	<i>V. vinifera</i> L.
Hazel	<i>Corylus</i>	11	0	<i>C. avellana</i> L.
Lentil	<i>Lens</i>	8	0	<i>L. culinaris</i> Medik.
Lettuce	<i>Lactuca</i>	31	11	–
Lupin	<i>Lupinus</i>	15	8	–
Mate	<i>Ilex</i>	4	8	–
Melon	<i>Cucumis</i>	7	2	<i>C. melo</i> L.
Melon seed/ watermelon	<i>Citrullus</i>	2	0	<i>C. lanatus</i> (L.) Schrad.
Mustard seed	<i>Brassica</i>	34	54	–
Oats	<i>Avena</i>	29	17	–
Onion	<i>Allium</i>	276	76	–
Pea	<i>Pisum</i>	2	5	<i>P. sativum</i> L.
Pear	<i>Pyrus</i>	49	16	<i>P. communis</i> L.
Pistachio	<i>Pistacia</i>	7	5	–
Plum	<i>Prunus</i>	41	24	<i>P. domestica</i> L.
Quinoa	<i>Chenopodium</i>	51	16	–
Rapeseed	<i>Brassica</i>	34	54	<i>B. napus</i> L.
Redcurrant	<i>Ribes</i>	18	5	<i>R. rubrum</i> L.
Sesame seed	<i>Sesamum</i>	2	0	–
Spinach	<i>Spinacia</i>	2	0	–
Strawberry	<i>Fragaria</i>	12	3	–
Sugar beet	<i>Beta</i>	14	6	<i>B. vulgaris</i> L.
Sweet potato	<i>Ipomoea</i>	13	1	–

Continued

Table 5.9. *Continued*

Crop ^a	Genus	No. of species	No. of sub-specific taxa ^b	Native crop species
Taro	<i>Colocasia</i>	1	0	–
Tomato	<i>Lycopersicon</i>	2	2	–
Walnut	<i>Juglans</i>	6	0	<i>J. regia</i> L.
Total	43	938^c	372^c	23

^aMinor food crops based on food crops of secondary or local importance listed by Groombridge and Jenkins (2002).

^bSubspecies and varieties.

^c*Persea indica* (L.) Spreng. – occurs in the Azores only.

^dAll crop species native to the Euro-Mediterranean region are native to Europe, except *Phoenix dactylifera*.

^eThe total number of species and subspecific taxa within genera containing minor food crops of the world (i.e. not the column totals).

– Not applicable.

The major and minor food crop groups that can be found in the Euro-Mediterranean region, along with other crops of high socio-economic value that are not included in this analysis, for example, forage and fodder crops, are an important genetic resource which may contribute to crop improvement in the future. Taxa that have limited distributions, particularly those that are endemic to one country should be a high priority for conservation and steps need to be taken to assess their conservation status, both *in situ* and *ex situ* (see Ford-Lloyd *et al.*, Chapter 6, this volume, for further discussion about prioritization).

5.3.5 How many CWR are included in the IUCN Red List of Threatened Species?

The answer to this question is simple – currently, very few. The CWR Catalogue data were cross-checked with the 2004 IUCN Red List of Threatened Species to reveal only 161 species and 23 subspecific CWR taxa that occur in the Euro-Mediterranean region are included in the global Red List⁷ (Table 5.10). The majority of these taxa are trees and the explanation for this is that much work has been undertaken in the past decade to assess the conservation status of the world's trees; for example, see Oldfield *et al.* (1998) and Farjon (2001). Of the CWR taxa included, 130 are native to the region and 76 are endemic. At least 13 of these are endemic to only one country and of these, one is extinct in the wild (*Betula szaferi* Jentys-Szaferowa & Stasz.) and two are critically endangered (*Abies nebrodensis* (Lojac.) Mattei, endemic to Sicily (Italy), and *Salix tarraconensis* Pau, endemic to Spain). Of the CWR species included in the Red List, 120 fall into the agricultural and horticultural crop group,⁸ 152 in the forestry group, 124 in the ornamental group and 148 in the medicinal

⁷ Matching carried out with accepted names in the Catalogue only.

⁸ Although most of the CWR species in the Red List are trees, they are included in the agricultural and horticultural crop group because Mansfeld's Database includes a very wide range of cultivated plants.

Table 5.10. The number of CWR taxa (species, subspecies and varieties) that occur in the Euro-Mediterranean region that are included in the 2004 IUCN Red List of Threatened Species.^a

Red List category ^b	No. of taxa	No. of native taxa ^c	No. of endemic taxa ^c	Taxa endemic to one nation ^d
Extinct in the wild	1	1	1	1
Critically endangered	14	10	6	2
Endangered	9	9	3	0
Vulnerable	33	28	14	6
Least concern	2	2	2	0
Lower risk/near threatened	31	27	17	0
Lower risk/conservation dependent	11	8	5	2
Lower risk/least concern	77	40	25	0
Data deficient	6	5	3	2
<i>Total</i>	184	130	76	13

^aAnalysis based on taxa matching accepted names in the CWR Catalogue only.

^bThe taxa listed have been assessed using the 1994 Categories and Criteria (IUCN, 1994).

^cTaxa native and endemic to the Euro-Mediterranean region.

^dTaxa verified as endemic according to Euro+Med PlantBase (version September 2005).

and aromatic group, so at least we know that the small number of CWR included have a wide range of uses. Only one taxon, *O. europaea* subsp. *cerasiformis* is a wild relative of a major food crop (olive) – 16 taxa are wild relatives of the minor food crops: almond, apricot, avocado, cherry, date, mate, pear and plum.

While it is interesting to look at which CWR taxa are included in the global Red List, we cannot draw any firm conclusions from this analysis, except to state obviously that there are currently very few taxa included. We must not assume that only few CWR are under threat, because although it is the Red List of Threatened Species, not all species listed are under threat – they have simply been assessed using the IUCN criteria. A Red List assessment may show that a taxon is not threatened, but the taxon will still appear in the Red List. It is only those taxa assigned the categories ‘critically endangered’, ‘endangered’ and ‘vulnerable’ that are considered threatened – the other categories present the conservation status of the taxon and provide a reference point for future monitoring. In fact, of this small number of assessed CWR taxa, 30% have been categorized as threatened and 42% as lower risk or least concern (Table 5.10). We cannot take this small sample of global Red List assessments as representative of CWR in general, but it would be interesting to review the percentage of threatened CWR over time, as more taxa are assessed and added to the List.

One reason for the lack of CWR taxa included is likely to be that the vast majority of plant taxa listed in the 1997 IUCN Red List of Threatened Plants (Walter and Gillett, 1998) have not yet been evaluated against the revised Red List Criteria and are therefore not included in the 2004 Red List. Analysis of the 1997 Red List would probably provide a more realistic picture of progress with Red Listing of CWR, but to ascertain how many CWR are included in the 1997 Red List, we would need access to the electronic data set, which was not available for this analysis

(except through an online search facility – see WCMC and RBG Edinburgh, no date). However, analysis of IPA data indicates that at least 488 European CWR species were categorized as globally threatened in the 1997 Red List.

Another reason for the lack of CWR species in the Red List may be that, historically, there has not been a group of specialists taking CWR Red Listing in hand. The establishment of the CWR Specialist Group (CWRSRG) of the IUCN Species Survival Commission should rectify this (see Dulloo and Maxted, Chapter 48, this volume). Ultimately, while it is useful to have global Red List assessments available for CWR taxa (or any plant taxa), it may be more useful to investigate which taxa have been assessed at national level. Again, national Red Listing, or investigating which CWR taxa are already included on national Red Lists, could be an important role for the CWRSRG.

5.3.6 Does the EU Habitats Directive aid CWR conservation?

In 1992, the European Community adopted Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the EU Habitats Directive). The provisions of the Directive require EU member states to introduce a range of measures, including the protection of species listed in the Annexes, to undertake surveillance of habitats and species and produce a report every 6 years on the implementation of the Directive. Annexes I and II list natural habitat types and plant (and animal) species of community interest, 'whose conservation requires the designation of special areas of conservation', Annex IV lists plant (and animal) species of community interest 'in need of strict protection' (most species listed in Annex II are also listed in Annex IV) and Annex V lists plant (and animal) species of community interest 'whose taking in the wild and exploitation may be subject to management measures' (European Communities, 1995–2007). Species of community interest are those that are: (i) endangered, except those species whose natural range is marginal in that territory and which are not endangered or vulnerable in the western Palearctic region; or (ii) vulnerable (i.e. believed likely to move into the endangered category in the near future if the causal factors continue operating); or (iii) rare (i.e. with small populations that are not at present endangered or vulnerable, but are at risk); the species are located within restricted geographical areas or are thinly scattered over a more extensive range; or (iv) endemic and requiring particular attention by reason of the specific nature of their habitat and/or the potential impact of their exploitation on their habitat and/or the potential impact of their exploitation on their conservation status (European Communities, 1995–2007).

Each member state is required to prepare and propose a national list of sites for evaluation in order to form a European network of sites of community importance (SCIs). Once adopted, these are designated by member states as special areas of conservation (SACs) and, along with special protection areas (SPAs) classified under the EC Birds Directive, form a network of protected areas known as Natura 2000.

Species listed in Annexes II, IV and V (as of March 2007, including data from all 27 member states) were cross-checked against the Catalogue to see how many CWR are included (Table 5.11).⁹ There are 641 plant species listed

⁹ Matching carried out with accepted names in the Catalogue only.

Table 5.11. CWR of the European Union member states included in Annexes II, IV and V of the EU Habitats Directive.

Species list	No. of species in the four crop groups						Total no. of species	Percentage of EU CWR species	Percentage of vascular plant species in Annexes II, IV and V of the Habitats Directive
	Agricultural and horticultural	Forestry	Ornamental	Medicinal and aromatic	—	—			
EU CWR species ^a	14,515	2,126	4,785	12,448	16,052	—	—	—	
Vascular plant species listed in Annexes II, IV and V of the EU Habitats Directive	—	—	—	—	641	—	—	—	
EU CWR in HD Annex II ^b	331	18	120	275	380	2	59	—	
EU CWR in HD Annex IV ^c	370	21	137	312	422	3	66	—	
EU CWR in HD Annex V ^d	15	2	4	18	18	<1	3	—	
EU CWR HD priority species ^e	117	9	42	105	141	1	22	—	
Total no. of EU CWR included in Annexes II, IV and V of the EU Habitats Directive	385	23	141	330	440	3	69	—	

^aIncludes all crop and CWR species that occur within the territories of the 27 EU member states.
^bAnnex II includes plant (and animal) species of community interest whose conservation requires the designation of special areas of conservation. Most species listed in this Annex are also listed in Annex IV.
^cAnnex IV lists plant (and animal) species of community interest in need of strict protection.
^dAnnex V lists plant (and animal) species of community interest whose taking in the wild and exploitation may be subject to management measures.
^ePriority species are endangered species for which the Community has particular responsibility in view of the proportion of their natural range which falls within the territory.
 — Not applicable.

in Annexes II, IV and V – 440 (69%) of these are included in the CWR Catalogue. Of these, 385 species (60%) fall into the agricultural and horticultural crop group, 23 species (4%) in the forestry group, 141 species (22%) in the ornamental group and 330 species (51%) in the medicinal and aromatic plant group. A high percentage of priority species (endangered species for which the Community has particular responsibility in view of the proportion of their natural range which falls within the territory) are in the agricultural and horticultural, and medicinal and aromatic plant groups (83% and 74%, respectively). It is notable that only four species included in the Habitats Directive Annexes II, IV and V are wild relatives of major food crops: three *Brassica* species and one *Solanum* sp. This is out of a total of 153 wild relative species of major food crops that occur in the EU territories. A further 13 species are included in the minor food crop group, out of a total of 542.

It is not surprising that quite a high percentage of species listed in Annexes II, IV and V of the Habitats Directive are CWR because more than three-quarters of the flora of the region is of current or potential socio-economic use. What is striking is the relatively small percentage of CWR species listed overall as a proportion of the CWR flora of the region (3%); however, this equates almost exactly to the proportion of vascular plant species that occur in the EU territories included in the Habitats Directive Annexes (641 species out of an estimated total of 19,020). Perhaps this raises a question about the overall effectiveness of the Habitats Directive for plant conservation, let alone the conservation of CWR. Certainly, a small number of CWR in the major and minor food crop groups that are listed in the Habitats Directive Annexes is a strong indication that *in situ* CWR conservation of the most important groups is not being adequately addressed within the EU territories.

It is important to stress that the above analysis only takes into account the species listed in the Habitats Directive Annexes II, IV and V – there are, of course, many more species included within the habitats that are designated for conservation within the Natura 2000 network. As for any *in situ* conservation area, site inventories are required to find out which species are included. At EU level, these data are not available; however, it is possible to look at which CWR species are mentioned as characteristic of the habitats listed in the European Nature Information System (EUNIS) Database (EEA, 2007), some of which are included in the Habitats Directive Annex I (natural habitat types of community interest whose conservation requires the designation of SACs). Here, 1665 CWR species that occur in the EU territories are included (10% of the CWR flora of the EU) – 54 of these species are included in Annex II, 55 in Annex IV and five in Annex V. Of these, 91% are in the agricultural and horticultural crop group, 17% in the forestry group, 36% in the ornamental group and 78% in the medicinal and aromatic plant group. Nine wild relatives in the major food crop genera and 57 in the minor food crop genera, are included. Although not all these habitats are necessarily included in the Natura 2000 network, it is useful to discover that around 10% of the CWR flora of the EU is mentioned as characteristic of the habitats, because many of these habitats are included in the network – however, we cannot assume that these species are actively conserved.

5.3.7 Are CWR important in Important Plant Areas?

IPAs are natural or semi-natural sites exhibiting exceptional botanical richness and/or supporting an outstanding assemblage of rare, threatened and/or endemic plant species and/or vegetation of high botanical value (PlantLife International, no date). IPAs are not legal site designations, but a framework for identifying and highlighting the best sites for plants, and by implication, their conservation. Site selection is based on three criteria: threatened species, botanical richness and threatened habitats – a site qualifies as an IPA if it fulfils one or more criteria.

The CWR Catalogue data for Europe (as defined by Hollis and Brummitt, 2001) were compared with the list of species included in IPAs (designated under Criterion A) as of May 2005 (Table 5.12).¹⁰ Criterion A sites hold significant populations of one or more species that are of global or European conservation concern. Criterion A is further divided into four categories: A(i) – the site contains globally threatened species; A(ii) – the site contains regionally threatened species; A(iii) – the site contains national endemic species with demonstrable threat not covered by A(i) or A(ii); A(iv) – the site contains near endemic or limited range species with demonstrable threat not covered by A(i) or A(ii) (Anderson, 2002). Species included under Criteria A(iii) and A(iv) are nationally threatened species from Belarus, Czech Republic, Slovakia, Estonia, Slovenia, Poland and Romania only, which were the first seven countries in Europe to identify IPAs (see Anderson *et al.*, 2005).

Nine hundred and twelve CWR species of Europe are included in the IPAs – 51% of the vascular plant species included in the IPAs and 5% of the CWR flora of Europe. Of these, 488 (54%) are globally threatened species¹¹ and 426 (47%) are regionally threatened. The endemic species included under Criteria A(iii) and A(iv) (Belarus, Czech Republic, Slovakia, Estonia, Slovenia, Poland and Romania only) represent around 10% of the CWR species included in the IPAs. Three per cent of the agricultural and horticultural crops and CWR of Europe are included under the globally threatened Criterion A (i). Likewise, 2% of species in the forestry group, 4% in the ornamental group and 2% in the medicinal and aromatic group are included under this criterion. Looking at the overall number of European CWR species included in the IPAs, 5% of species in the agricultural and horticultural crop group are included, 3% in the forestry group, 7% in the ornamental group and 5% in the medicinal and aromatic plant group.

As for the CWR species included in the EU Habitats Directive, a relatively small percentage of the CWR species of Europe are included in IPAs (5%); however, this is in the context of the proportion of vascular plant species of Europe included in IPAs – 912 species out of an estimated total of 20,590 – around 4%. Again, the number of CWR in the major and minor food crop groups included in the IPAs may be an indication of how much attention is being paid to CWR in the context of this conservation initiative. With only three out of the 152 species in the major food crop genera that occur in Europe included and none of the 559 species in the minor food crop genera, we might conclude that more needs to be done to ensure that CWR are represented in IPAs.

¹⁰ Matching carried out with accepted names in the Catalogue only.

¹¹ Based on the 1997 IUCN Red List of Threatened Plants (Walter and Gillett, 1998).

Table 5.12. CWR of Europe included in Important Plant Areas (IPAs).

Species list	No. of species in the four crop groups				Total no. of species	Percentage of total European CWR	Percentage of total vascular plant species in IPAs	Percentage of total CWR species in IPAs
	Agricultural and horticultural	Forestry	Ornamental	Medicinal and aromatic				
European CWR species ^a	15,828	2,267	5,123	13,727	17,495	–	–	–
Vascular plant species included in IPAs	–	–	–	–	1,803	–	–	–
Criterion A(i) European CWR species (globally threatened)	400	52	214	338	488	3	27	54
Criterion A(ii) European CWR species (regionally threatened)	379	16	138	328	426	2	24	47
Criterion A(iii) European CWR species (national endemic species not covered by A(i) or A(ii)) ^b	86	16	41	69	95	<1	5	10
Criterion A(iv) European CWR species (near endemic or restricted range species not covered by A(i) or A(ii)) ^b	83	2	22	73	86	<1	5	9
Total European CWR species in IPAs ^c	791	75	349	668	912	5	51	–

^aIncludes all crop and CWR species that occur in Europe (Europe as defined by Hollis and Brummitt (2001)).

^bSpecies included under Criteria A(iii) and A(iv) are nationally threatened species from Belarus, Czech Republic, Slovakia, Estonia, Slovenia, Poland and Romania only.

^cIncluded under Criterion A only (A(iii) and A(iv) species from Belarus, Czech Republic, Slovakia, Estonia, Slovenia, Poland and Romania only).

– Not applicable.

5.3.8 Are botanic gardens' living collections helping to conserve crop resources?

Using data extracted from the Plant Search database managed by Botanic Gardens Conservation International (BGCI, 2007), which is a database compiled from lists of living collections submitted to BGCI by the world's botanic gardens, an analysis of the number of crop and CWR taxa in cultivation in botanic gardens around the world was undertaken (Table 5.13).

Table 5.13. Crop and CWR species in botanic gardens' living collections.^a

Species in Plant Search (BGCI, 2007)	No. of species in the four crop groups				Total no. of species
	Agricultural and horticultural	Forestry	Ornamental	Medicinal and aromatic	
Total no. of species	–	–	–	–	89,803
Crop and CWR species	54,828	12,199	22,522	38,375	62,746
Species cultivated worldwide ^b	6,388	–	–	–	–
Total species in the major food crop genera ^c	–	–	–	–	791
Crop species in the major food crop genera	–	–	–	–	323
Total species in the minor food crop genera ^d	–	–	–	–	2,668
Crop species in the minor food crop genera	–	–	–	–	633
Crop and CWR species in Europe and the Mediterranean ^e	9,107	1,312	3,631	7,553	9,948
Euro-Mediterranean species in the major food crop genera	–	–	–	–	152
Euro-Mediterranean species in the minor food crop genera	–	–	–	–	521

^aBased on analysis of data contained in Plant Search (BGCI, 2007).

^bSpecies in Plant Search matching species in Mansfeld's Database (accepted names and synonyms). Mansfeld's Database includes cultivated medicinal and aromatic plants.

^cBased on food crops of major significance, listed by Groombridge and Jenkins (2002).

^dBased on food crops of secondary or local importance, listed by Groombridge and Jenkins (2002).

^eMatching accepted species in the CWR Catalogue for Europe and the Mediterranean. Total no. of species in the Catalogue – 25,687.

– Not applicable, or data not available.

Initial results indicate that botanic gardens may be the storehouses of important crop resources and other species of socio-economic importance. Of the 25,687 accepted species in the Euro-Mediterranean Catalogue, 9948 (39%) are recorded in Plant Search as being cultivated in botanic gardens around the world. Of these, 92% are included in the agricultural and horticultural crop group, 13% in the forestry group, 36% in the ornamental group and 76% in the medicinal and aromatic group.

The above analysis only takes into account the socio-economically important species in the Euro-Mediterranean region. Taking a global view, of the 89,803 species included in Plant Search, 62,746 (70%) are species within the combined list of genera containing crops and wild-harvested medicinal and aromatic plants of the world (including synonymous genera in Mansfeld's Database) – at least 10% of these species are known to be agricultural and horticultural species cultivated worldwide. Breaking this list of 62,746 species down into the four crop groups, 87% are in the agricultural and horticultural group, 19% in the forestry group, 36% in the ornamental group and 61% in the medicinal and aromatic group – fairly consistent with the ratios of Euro-Mediterranean crop and CWR species in the database.

Although the total number of species housed in the botanic gardens' living collections that are included in the Plant Search database is not wholly representative of the world flora, if we assume that they are a representative sample, the figure of 70% is not far off what might be expected, since the results of the Euro-Mediterranean analysis indicate that at least three-quarters of the flora of the region are of current or potential socio-economic use. Of course, we cannot confirm this conclusion without further detailed analysis. Other possible explanations for the large proportion of species of socio-economic importance in cultivation in botanic gardens' living collections are that: (i) historically, some botanic gardens were physic gardens and therefore almost exclusively housed medicinal plants; (ii) some gardens were used as repositories and/or quarantine centres for the early movement of crops around the world; and (iii) many gardens have educational displays of crop plants to show visitors what they look like and how they grow; for example, coffee, tea, banana and coconut.

If we look at the major and minor food crop groups (as defined earlier in the chapter) we find that 791 species in the 28 major food crop genera of the world and 2668 in the 51 minor food crop genera can be found in cultivation in the botanic gardens whose collections are recorded in Plant Search – not a vast number, but significant none the less. It is notable that 41% of the species in the major food crop genera and 24% in the minor food crop genera are cultivated species listed in Mansfeld's Database. Perhaps the high proportion of cultivated species in the major food crop groups may be attributable to the fact that botanic gardens often maintain educational displays of important food crops and other cultivated plants.

So, what does this tell us about the potential role of botanic gardens' living collections in crop genetic resources conservation? Taxonomically (i.e. looking at the number of species included), this preliminary analysis indicates that botanic gardens may harbour important resources that could have a role to play in providing germplasm for crop improvement.

However, the analysis does not inform us of the quantity or quality of the plant material in cultivation.¹² Botanic gardens' living collections are sometimes accused of effectively being plant 'museums' because they frequently maintain only one or a few accessions of a taxon in cultivation. None the less, although they may not always conserve genetically representative samples of a taxon or population, the germplasm that is maintained may still be of some value, especially in cases where a taxon is severely threatened in the wild. Another common criticism of botanic gardens' living collections is that once plants have been kept in cultivation for several years, they may no longer resemble the genetic make-up of the wild form that was originally collected. This may be so, but only genetic analysis could reveal the true picture (i.e. if there is still wild material available to compare the cultivated material with). Furthermore, many botanic gardens are focusing their efforts on the conservation of threatened populations and these days are more aware of the need to collect and maintain representative samples.

Even if the germplasm itself is of limited use to plant breeders, perhaps the associated information contained in botanic gardens' collections databases, such as details on locations and habitats, may be a useful resource to the conservation and user community in itself. This, of course, is dependent on the quality and efficiency of botanic gardens' information management systems. Finally, we should acknowledge the important role that botanic gardens' living collections play in educating the public. Many botanic gardens already provide educational information about the importance of directly utilized plants to society – perhaps this role could be extended to include educational information about the wild relatives of crop plants, their role in future food security and what needs to be done to conserve them.

5.4 Conclusions

The Catalogue of CWR for Europe and the Mediterranean (Kell *et al.*, 2005a) is the first comprehensive CWR Catalogue at a continental scale and, through extraction, for the countries included. It provides an informative regional overview of crop and CWR diversity and acts to raise awareness about the importance of crop genetic resources in the region, both within the professional PGR community and other interest groups. Furthermore, it provides the baseline data needed to monitor biodiversity change and to improve access to germplasm for the CWR user community. The Catalogue can be used as the basis for creating national crop and CWR inventories, as a vehicle for conservation gap analysis and for integrating CWR conservation into existing conservation initiatives. It is a core data set providing an opportunity for linking to and building on existing taxon data, such as information on uses, population biology, threats and *in situ* and *ex situ* conservation activities. The Catalogue is available online through CWRIS (PGR Forum, 2005), where users can search by

¹² This information could be obtained by contacting individual botanic gardens.

taxon names and geographical units to obtain this information. To read more about CWRIS and for examples of use cases, see Kell *et al.* (Chapter 33, this volume).

The methodology used for creating the Euro-Mediterranean Catalogue can be applied in any part of the world, either at regional or national level. Although digitized floras are not immediately available in all parts of the world, increasingly, countries are working to create biodiversity databases, particularly in response to the requirements of the provisions of the CBD. Even without a digitized flora, it is possible to undertake the analysis, although this would obviously take more time.

An important and fundamental application of the CWR Catalogue is to aid gap analysis for CWR conservation – for example, by analysing which taxa are already included within existing protected areas and *ex situ* collections and to ascertain how many taxa are included in other conservation databases, such as the IUCN Red List of Threatened Species (IUCN, 2006). Some examples of how the data can be used in this way have been provided in this chapter. Although these are preliminary and largely broad brush-stroke investigations, results do indicate that we may not be paying sufficient attention to CWR in current conservation endeavours. We strongly urge policy makers and conservationists to give greater credence to the inclusion of crops and wild relatives within existing or new conservation initiatives (including legislation), both at regional and national level. For example, by creating a priority list of CWR for the Euro-Mediterranean region (see Ford-Lloyd *et al.*, Chapter 6, this volume), combined with the formulation of national priority lists, the conservation status of these taxa could initially be assessed and a more detailed gap analysis undertaken. Building on the data that are now available, networks of national genetic reserves can be established, following the guidelines provided by the draft Global Strategy for CWR Conservation and Use (see Heywood *et al.*, Chapter 49, this volume).

A more systematic approach to complementary CWR conservation is certainly needed. Looking, for example, at the number of species included in botanic gardens' living collections, we find that there are a significant number of CWR in cultivation around the world. However, it is likely that these were collected for diverse reasons, rather than specifically because of their value as gene donors for crop improvement. National PGR Coordinators and regional and international conservation organizations could do more to put in place a coordinated approach to CWR conservation. A combined approach targeting existing protected areas and establishing new *in situ* conservation sites where necessary, and encouraging managers of *ex situ* collections (gene banks and botanic gardens' living collections) to take a more systematic approach to CWR conservation is needed.

There is undoubtedly an urgent need to undertake Red List assessments for Euro-Mediterranean CWR and most likely for CWR worldwide. Red Listing could initially be undertaken in three phases: (i) the CWR taxa listed in the 1997 IUCN Red List of Threatened Plants could be reassessed using the 2001 Criteria (IUCN, 2001) and assessments submitted for inclusion in the IUCN Red List of Threatened Species; (ii) single country endemic taxa could be

assessed and submitted for inclusion in the IUCN Red List; and (iii) national PGR Coordinators could establish which CWR are included in national Red Lists and make these data available for regional and global assessments.

Further investigation can be carried out to provide an indication of to what extent CWR are already conserved, both within the Euro-Mediterranean region and elsewhere in the world. Many taxon data sets are available electronically – it is simply a matter of working together and making the data accessible. For example, global protected area data are available and, using the CWR Catalogue for Europe and the Mediterranean (or other regional CWR inventories as they become available), analysis can be undertaken to assess how many species are afforded some level of protection *in situ*. At national level, the data can also be compared with protected area inventories and *ex situ* collections, which would provide a more detailed picture of CWR conservation within any given region. It would also be interesting to compare CWR inventories with the data contained in EURISCO (European Internet Search Catalogue of *Ex Situ* PGR Accessions) (ECPGR, no date), though this is not straightforward because the data within EURISCO do not currently follow a standard taxonomy.

Sharing and cross-checking conservation data sets is one way of assisting CWR conservation gap analysis. Another way is to bring CWR information together through the Internet, which provides a unique opportunity to link any number of information sources together. CWRIS (PGR Forum, 2005) (see Kell *et al.*, Chapter 33, this volume), which was created under the auspices of the EC-funded project, PGR Forum (see Maxted *et al.*, Chapter 1, this volume; PGR Forum, 2003–2005), goes some way towards achieving this goal. The Catalogue data housed in CWRIS is linked to a number of selected online information resources, such as the Germplasm Resources Information Network (GRIN) (USDA, ARS, National Genetic Resources Programme, 2006), IUCN Red List of Threatened Species (IUCN, 2006), Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) (Royal Botanic Gardens, Kew, 1999), International Legume Database and Information Service (ILDIS, 2007) and FAO Worldwide Information System on Forest Genetic Resources (REFORGEN) (FAO, no date). With the appropriate financial resources, the opportunity exists to develop CWRIS further as a sophisticated online tool to provide access to CWR information at both taxon and geographic level to cater for a wide range of user groups (Kell *et al.*, Chapter 33, this volume).

The results presented in this chapter are based on data extracted from Euro+Med PlantBase (version September 2005). Euro+Med PlantBase is undergoing a process of critical review and updating by taxon experts on a family by family basis. Although it is not anticipated that the overall number of species included in the Catalogue will change significantly once the updates to Euro+Med PlantBase have been incorporated, there are likely to be some changes, particularly with regard to the number of single country endemic species. Currently, the coding system used in the database to record endemic species makes it difficult to gain a reliable estimate. However, crop and CWR lists extracted from the Catalogue have already been sent to National PGR Coordinators throughout the region. These lists can be used as a basis for the development of national CWR Catalogues and this may provide an opportunity

to ascertain more accurately how many single country endemic species exist. Data from National PGR Coordinators could be fed back to the Euro+Med PlantBase Secretariat to be considered for inclusion in the database, and in turn, the data in the CWR Catalogue for Europe and the Mediterranean will be automatically updated.

The Catalogue shows that a large proportion of the Euro-Mediterranean flora is of current or potential socio-economic use, both within the region and elsewhere in the world. These resources need to be conserved to benefit the environment and humankind in the future. Knowing what occurs in nature in the region is a first step in CWR conservation. The next steps are to use the Catalogue data to establish conservation priorities, both regionally and nationally, then to ascertain which species are conserved and to what extent they are protected. This should be part of a coordinated systematic approach to the complementary conservation of CWR. This is likely to involve the establishment of new *in situ* sites or at least the adaptation of existing site management plans to accommodate monitoring and management of CWR populations, and systematic collection and *ex situ* conservation of genetically representative CWR population samples.

Results of this analysis confirm the direct and indirect use values of a high proportion of the vascular flora of the Euro-Mediterranean region. We may confidently assume that a similar proportion of the world's flora has the same current or potential use. The method used to create the Euro-Mediterranean Catalogue can be repeated in other regions of the world and/or nationally as a first step in putting in place a systematic complementary global approach to CWR conservation to ensure that these vital resources are maintained for the benefit of society worldwide. The Global Strategy for CWR Conservation and Use, which was a significant outcome of the First International Conference on CWR Conservation and Use (see Kell *et al.*, 2005b; Heywood *et al.*, Chapter 49, this volume) is already being taken forward as an adjunct to the ITPGRFA. This will provide the much-needed guidance and framework for a coordinated approach to the conservation and sustainable utilization of CWR.

Acknowledgements

We are indebted to the following people who provided access to data, without which the creation of the Catalogue of CWR for Europe and the Mediterranean and associated data analysis would not have been possible: Tarik El Atechi, Euro+Med PlantBase Secretariat, University of Reading, United Kingdom; Werner Greuter, Anton Güntsch and Eckhard von Raab-Straube, Euro+Med PlantBase Secretariat, Botanic Garden and Botanical Museum, Berlin-Dahlem, Germany; Norbert Biermann, Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany; Ton Kwakkenbos, Community Plant Variety Office, Angers, France; Uwe Schippmann, Fachgebiet Botanik und Naturschutz, Bundesamt für Naturschutz, Bonn, Germany; Dominique Richard, Grégoire Lois and Doug Evans, European Topic Centre on Biological Diversity, Paris, France; Craig Hilton-Taylor and Caroline Pollock, IUCN Red List Programme,

Cambridge, United Kingdom; Liz Radford and Seona Anderson, PlantLife International, Salisbury, United Kingdom; Diane Wyse Jackson and Suzanne Sharrock, Botanic Gardens Conservation International, Kew, United Kingdom.

The concepts discussed in this chapter were stimulated by PGR Forum (the European crop wild relative diversity assessment and conservation forum – EVK2-2001-00192) (see PGR Forum, 2003–2005), funded by the EC Fifth Framework Programme for Energy, Environment and Sustainable Development.

References

- Anderson, S. (2002) *Identifying Important Plant Areas*. PlantLife International, London.
- Anderson, S., Kušik, T. and Radford, E. (eds) (2005) *Important Plant Areas in Central and Eastern Europe*. PlantLife International, London.
- BGCI (2007) *Plant Search*. Botanic Gardens Conservation International, London. Available at: http://www.bgci.org/plant_search.php/
- Bramwell, D. (1990) Conserving biodiversity in the Canary Islands. *Annals of Missouri Botanical Garden* 77, 28–37.
- CBD (1992) *Convention on Biological Diversity: Text and Annexes*. Secretariat of the Convention on Biological Diversity, Montreal, Canada. Available at: <http://www.biodiv.org/convention/convention.shtml> (accessed 12 April 2007)
- CBD (2002) *Global Strategy for Plant Conservation*. Secretariat of the Convention on Biological Diversity, Montreal, Canada. Available at: <http://www.biodiv.org/decisions/?lg=0&dec=VI/9> (accessed 3 April 2007)
- Council of Europe and Planta Europa (2002) *European Plant Conservation Strategy*. The Hague, The Netherlands. Available at: http://www.plantaeuropa.org/pe-EPCS-what_it_is.htm (accessed 5 April 2007)
- CPVO (2001) *Community Plant Variety Office website*. Available at: <http://www.cpvo.eu.int/index.php> (accessed 13 April 2007)
- ECPGR (no date) *European Internet Search Catalogue of Ex Situ PGR Accessions*. Bioersivity International. Available at: <http://eurisco.ecpgr.org/> (accessed 5 April 2007)
- EEA (2007) *European Nature Information System (EUNIS)*. European Environment Agency, Copenhagen K, Denmark. Available at: <http://eunis.eea.europa.eu/index.jsp> (accessed 13 April 2007)
- European Communities (1995–2007) *Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora*. Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0043:EN:HTML> (accessed 2 April 2007)
- Euro+Med PlantBase (2005) *Euro+Med PlantBase: The Information Resource for Euro-Mediterranean Plant Diversity*. Dipartimento di Scienze botaniche ed Orto botanico, Università degli Studi di Palermo. Available at: <http://www.emplantbase.org/home.html> (accessed 13 April 2007)
- Euro+Med PlantBase Secretariat (2002) *Preparation of the initial checklist: data standards version 2.8, 5 July 2002*.
- FAO (no date) *REFORGEN – the FAO Forestry Database on Forest Genetic Resources*. Food and Agriculture Organization of the United Nations, Rome, Italy. Available at: <http://www.fao.org/forestry/site/39116/en/> (accessed 3 April 2007)
- FAO (2001) *International Treaty on Plant Genetic Resources for Food and Agriculture*. Food and Agriculture Organization of the United Nations, Rome, Italy. Available at: <http://www.fao.org/ag/cgrfa/itpgr.htm> (accessed 4 April 2007)

- Farjon, A. (2001) *World Checklist and Bibliography of Conifers*, 2nd edn. World Checklists and Bibliographies, 3. Royal Botanic Gardens, Kew, London.
- Groombridge, B. and Jenkins, M.D. (2002) *World Atlas of Biodiversity*. Prepared by the UNEP World Conservation Monitoring Centre. University of California Press, Berkeley, California.
- Hammer, K. and Spahillari, M. (1999) *Alternative Crops for Sustainable Agriculture*. Research progress COST 814. Workshop held at BioCity, Turku, Finland. Office of Official Publications of the European Communities, EUR-OP, Luxembourg.
- Hanelt, P. and IPK Gatersleben (eds) (2001) *Mansfeld's Encyclopedia of Agricultural and Horticultural Crops*. 6 vols. 1st English edition. Springer, Berlin/Heidelberg/New York, 3645 pp.
- Heywood, V.H. and Zohary, D. (1995) A catalogue of the wild relatives of cultivated plants native to Europe. *Flora Mediterranea* 5, 375–415.
- Hollis, S. and Brummitt, R.K. (2001) *World Geographical Scheme for Recording Plant Distributions*. Plant Taxonomic Database Standards No. 2. 2nd edn. Published for the International Working Group on Taxonomic Databases for Plant Sciences (TDWG) by the Hunt Institute for Botanical Documentation, Carnegie Mellon University, Pittsburgh. Available at: <http://www.tdwg.org/standards/109/> (accessed 20 March 2007)
- ILDIS (2007) *International Legume Database and Information Service*, University of Southampton, UK. Available at: <http://www.ildis.org/> (accessed 4 April 2007)
- IPK Gatersleben (2003) *Mansfeld's World Database of Agricultural and Horticultural Crops*. Leibniz Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany. Available at: http://mansfeld.ipk-gatersleben.de/mansfeld/mf-inf_e.htm (accessed 13 April 2007)
- IUCN (2001) *The IUCN Red List of Threatened Species: 2001 Categories and Criteria (v. 3.1)*, Gland, Switzerland. Available at: http://www.iucnredlist.org/info/categories_criteria2001 (accessed 4 April 2007)
- IUCN (2006) *The IUCN Species Survival Commission 2006 Red List of Threatened Species*, Gland, Switzerland. Available at: <http://www.redlist.org> (accessed 27 March 2007)
- Kell, S.P., Knüpfner, H., Jury, S.L., Maxted, N. and Ford-Lloyd, B.V. (2005a) *Catalogue of Crop Wild Relatives for Europe and the Mediterranean*. University of Birmingham, Birmingham, UK. Available online via the Crop Wild Relative Information System (CWRIS – <http://cwris.ecpgr.org/>) and on CD-ROM.
- Kell, S.P., Heywood, V. and Maxted, N. (2005b) Towards a global strategy for crop wild relative conservation and use. *Crop Wild Relative* 5, 11.
- Loope, L.L. and Mueller-Dombois, D. (1989) Characteristics of invaded islands, with special reference to Hawaii. In: Drake, J.A., Mooney, H.A., di Castri, F., Groves, R.H., Kruger, F.J., Rejmánek, M. and Williamson, M. (eds) *Biological Invasions: a Global Perspective*. Wiley, Chichester, UK, pp. 257–280.
- Maxted, N., Ford-Lloyd, B.V., Jury, S.L., Kell, S.P. and Scholten, M.A. (2006) Towards a definition of a crop wild relative. *Biodiversity and Conservation* 15(8), 2673–2685.
- Maxted, N., Scholten, M.A., Codd, R. and Ford-Lloyd, B.V. (in press) Creation and use of a national inventory of crop wild relatives. *Biological Conservation*.
- Mitteau, M. and Soupizet, F. (2000) Preparation of a preliminary list of priority target species for *in situ* conservation in Europe. In: Laliberté, B., Maggioni, L., Maxted, N. and Negri, V. (compilers). *ECP/GR In situ and On-farm Conservation Network Report of a Task Force on Wild Species Conservation in Genetic Reserves and a Task Force on On-farm Conservation and Management: Joint meeting, 18–20 May 2000, Isola Polvese, Italy*, pp. 32–42.
- Oldfield, S., Lusty, C. and MacKinven, A. (1998) *The World List of Threatened Trees*. World Conservation Press, Cambridge.
- PGR Forum (2003–2005) *European Crop Wild Relative Diversity Assessment and Conservation Forum*. University of Birmingham, Birmingham, UK. Available at: <http://www.pgrforum.org/> (accessed 3 April 2007)
- PGR Forum (2005) *Crop Wild Relative Information System (CWRIS)*. University of Birmingham, Birmingham, UK. Available at: <http://cwris.ecpgr.org/> (accessed 3 April 2007)

- PlantLife International (no date) *Introduction to Important Plant Areas (IPAs)*, Salisbury, UK. Available at: <http://www.plantlife.org.uk/international/plantlife-ipas-about.htm> (accessed 23 March 2007)
- Royal Botanic Gardens (1999) *Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database*, Kew, London. Available at: <http://www.rbgekew.org.uk/ceb/sepasal/internet/> (accessed 3 April 2007)
- Royal Horticultural Society (2006) *The RHS Horticultural Database*, London. Available at: <http://www.rhs.org.uk/databases/summary.asp> (accessed 5 April 2007)
- Schlosser, S., Reichhoff, L. and Hanelt, P. (1991) *Wildpflanzen Mitteleuropas. Nutzung und Schutz*. Deutscher Landwirtschaftsverlag Berlin GmbH, Berlin.
- Schofield, E.K. (1989) Effects of introduced plants and animals on island vegetation: examples from the Galápagos Archipelago. *Conservation Biology* 3(3), 227–238.
- Schultze-Motel, J. (1966) *Verzeichnis forstlich kultivierter Pflanzenarten [Enumeration of cultivated forest plant species]*. Kulturpflanze Beiheft 4.
- Simberloff, D. (1995) Why do introduced species appear to devastate islands more than mainland areas? *Pacific Science* 49(1), 87–97.
- USDA, ARS, National Genetic Resources Programme (2006) *Germplasm Resources Information Network – (GRIN)* [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. Available at: <http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl> (accessed 3 April 2007)
- Vitousek, P.M. (1992) Effects of alien plants on native ecosystems. In: Stone, C.P., Smith, C.W. and Tunison, J.T. (eds) *Alien Plant Invasions in Native Ecosystems of Hawaii: Management and Research*. Cooperative National Park Resources Studies Unit, University of Hawaii, Honolulu, Hawaii, pp. 29–41.
- Walter, K.S. and Gillett, H.J. (eds) (1998) *1997 IUCN Red List of Threatened Plants*. Compiled by the World Conservation Monitoring Centre. IUCN – The World Conservation Union, Gland, Switzerland and Cambridge, UK, pp. 862
- WCMC (1995) *Plant Occurrence and Status Scheme: a Standard for Recording the Relationship between a Plant and a Place*. A Taxonomic Databases Working Group (TDWG) Standard. World Conservation Monitoring Centre, Cambridge. Available at: http://www.tdwg.org/poss_standard.html (accessed 5 April 2007)
- WCMC and RBG Edinburgh (no date) *Plants of Global Conservation Concern: 1997 IUCN Red List of Threatened Plants*. World Conservation Monitoring Centre and Royal Botanic Gardens, Edinburgh. Available at: <http://www.unep-wcmc.org/species/plants/plants-by-taxon.htm> (accessed 13 April 2007)
- Zeven, A. and Zhukovsky, P. (1975) *Dictionary of Cultivated Plants and Their Centres of Diversity. Excluding Ornamentals, Forest Trees and Lower Plants*. PUDOC, Wageningen, The Netherlands.