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The Consumption of Wild Edible Plants

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6.1 Wild Edible Plants

The long history of humans' ability to adapt to natural environments and to interact with nature and social circumstances is profoundly attached to edible wild plants and animals. From the early hunter-gatherers and across different adaptation stages, plants have assumed great importance in human societies and many people all over the world have depended on many wild species particularly for food and medicines. Specific relations between dietary and therapeutic purposes are intrinsic to wild edible plant use and have been well documented by several researchers (Abbasi *et al*. 2013a; Alarcón *et al*. 2015; Etkin 2008; Etkin & Ross 1991; Grivetti 2006; Ogle *et al*. 2003; Sánchez-Mata *et al*. 2012; Touwaide & Appetiti 2015).

Wild edibles, a term used to describe both plants and animals consumed by humans, can be a rather ambiguous concept as in most cases the simple act of foraging and gathering implies some management of resources and habitats, as observed by Turner *et al*. (2011) and Sõukand and Kalle (2015).

It is generally accepted that wild plant species grow spontaneously in self-maintaining populations in natural or seminatural habitats, existing independently of direct human action (Maurer & Schueckler 1999). They are available in various ecosystems and agroecosystems, with unique significance those related to forests and trees which play or have played crucial roles in many food systems, providing direct and indirect resources for human nutrition (Vinceti *et al*. 2013). Ruderal species that colonize disturbed sites and weeds (high competitive species from arable field and crop contexts) are also important sources of food (Bye 1981; Maroyi 2013; Turner *et al*. 2011).

Wild edibles include a rich variety of plant lifeforms and botanical features, including annual and perennial herbs, forbs, vines, sedges and rushes, grasses, broadleaved and needle-like or scale-like leaved shrubs, trees, and ferns. Other living organisms have also been considered as plants, e.g. mushrooms, algae, and lichens. On a seasonal basis, roots, underground storage organs, shoots, stems, sprouts, leaves, flowers, fruits and cones, seeds and nuts, bark, galls, nectar and gum, along with fronds, lichens and algae have been included in sustenance obtained from edible wild plant species, *sensu lato*.

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In many cases, people have quite different food choices although they live in similar environments and explore identical landscapes. Turner *et al.* (2011) argue that such unequal choices and food patterns are not completely explained by levels of biodiversity, territorial differences or resources availability, but can be due to necessity or opportunity, or to remarkable significance within each human group.

Natural dispersal of plants and human transport of propagules and seeds from one place to another led to a huge number of wild and weed plants that have been traditionally collected and consumed throughout the world. These plants may be either native or exotic species, the latter intentionally or accidentally introduced during the dispersal process and becoming adapted to new habitats (i.e. naturalized).

Distinguishings between wild and cultivated plants is not always an easy task because there are many intermediate stages. Some species growing wild may be cultivated in specific sites and cultivated ones may be naturalized or maintained as semidomesticated. For instance, timber trees are also used for their fruits, e.g. hazel (*Corylus avellana* L.) and walnut (*Juglans regia* L.), in some European regions.

Since most wild plants have never been cultivated, their biodiversity, chorology, biology, and agronomy have remained poorly studied. Plant use and management rely on knowledge and skills developed for centuries on a local scale. This local knowledge (LK), sometimes also known as traditional ecological knowledge (TEK), implying the sustainable use of native resources, relates to adaptive complex systems that include perceptions, beliefs, and practices transmitted through generations. Therefore, the true diversity of wild edibles used is still unknown in many regions and linked ethnobotanical and indigenous/local knowledge is not properly documented.

Existing knowledge of plants and their uses, particularly food uses, is an immense valuable legacy of which some part is being lost every day, creating an enormous urgency for further studies in order to make these resources available for future generations and for food sovereignty and security.

6.1.1 Contribution of Wild Edible Plants to People's Diets and Daily Lives

Ethnobotanical surveys show that more than 7000 species of wild plants have been used for human food at some period throughout human history, having a prominent role in both early and contemporary societies. Grivetti and Ogle (2000) observed that edible wild plants were regular components of the diets of millions of people. Despite the fact that in more recent times human diets have used relatively few plant species, which also encompasses the decline of plant use knowledge, subglobal assessments show that several indigenous and traditional communities currently consume 200 or more species (Grivetti & Ogle 2000; MEA 2005).

For many years, scientists have reported the relevance of wild plants used as either vegetables or medicine. Several research approaches have confirmed that many edible wild plants have therapeutic value in addition to their nutritional importance, due to the presence of biologically active compounds, and thus they can be considered as food-medicine or functional foods (Local Food-Nutraceutical Consortium 2005; Vanzani *et al.* 2011). However, as Etkin and Ross (1982) emphasized three decades ago, nowadays our understanding of "the added benefit of regular dietary intakes, in low concentrations, of wild plants with known phytochemical properties is still limited" (Etkin & Ross 1982).

More recent studies carried out in different areas (Bharucha & Pretty 2010; Dansi *et al*. 2008; Delang 2007; Ju *et al*. 2013; Łuczaj *et al*. 2013a; Mattalia *et al*. 2013; Quave & Pieroni 2015; Scarpa 2009) show that many people worldwide still rely on local environmental resources, especially wild plants, for daily subsistence and healthcare.

Dansi *et al*. (2008), studying traditional leafy vegetable usage in the Benin Republic (Africa), reported that most of these plant uses have been neglected by scientific research and development agencies, leading to a decline in consumption and diversity. These findings can certainly be generalized to other developing regions, causing, a significant impact on income and the nutritional status of households throughout the entire world.

Dounias and Froment (2011) established how the history of mankind, shifting from a nomadic hunter-gatherer existence to a farming sedentary lifestyle, is marked by a series of major physiological, demographic, cultural, and dietary transitions that are negatively correlated with food security, nutrition, and health. Moreover, based on case studies conducted in Asia (Borneo) and Africa (Cameroon), they note that diets and illnesses are complex indicators of the ecological and cultural costs that indigenous communities currently pay to benefit from modernity (Dounias & Froment 2011).

According to FAO *et al*. (2015), an unacceptably large number of people in the world still lack the food they need for an active and healthy life. The latest available estimates indicate that one in nine people are/will be undernourished in 2014–16 (about 795 million) which is linked to reduced conditions of health and sanitation, inappropriate care, and poor nutritional status. Although this represents a reduction of 21.4% in the last two decades, advancements towards improved food security and safety (Hanning *et al*. 2012) are still not similar across all regions, and undernourishment is greater in many developing ones (e.g. Central Africa and Western Asia).

Shortage of food is particularly high in many rural areas where family farming systems and smallholder agriculture are predominant. Such agricultural schemes are recognized as playing key roles in reducing hunger and poverty (FAO *et al*. 2015). Globally, they are characterized by intense relationships with nature, important crop diversity, and particular resources management to avoid productive risks and encompass wild resources and relevant LK or TEK. In addition, these agricultural heritage systems have relied on generations of family farmers, considered custodians of biodiversity, for their contribution to the preservation of traditional food products, safeguarding the world's agrobiodiversity and sustainable use of natural resources (FAO 2014).

In many communities, lacking basic infrastructure and market access, wild gathering provides considerable subsistence support to local diets (Stryamets *et al*. 2015; Sunderland 2011) and may also generate further benefits (e.g. selling surpluses) (Delang 2006). Nevertheless, Sunderland (2011) notes that gathering from the wild or growing food (family farming and smallholder agriculture) are not enough to meet nutritional needs in developing regions; accordingly, the most vulnerable peoples are particularly at risk of privation and lack of access to food. The report on the state of food insecurity in the world (FAO *et al*. 2015) expresses that "progress towards food security and nutrition targets requires that food is available, accessible and of sufficient quantity and quality to ensure good nutritional outcomes."

6.1.1.1 Famine Foods

The ethnobotanical literature emphasizes the importance of wild edibles under conditions of food shortage, crop failure and seasonal variations, diseases, climatic adversity,

and social or political conflicts (Bvenura & Afolayan 2015; Delang 2006; Grivetti 2006; Kang *et al*. 2012; Nascimento *et al*. 2012; Panda 2014; Scarpa 2009; Stryamets *et al*. 2015). Some species have potential dietary use but are not regularly eaten during normal periods.

Wild and forest foods play a significant role as a source of resilience in the food system. Several surveys have reported how different communities worldwide are able to manage plant resources when food insecurity is highest, specifically during dry or wet seasons according to different climatic regions (Grivetti 2006; Powell *et al*. 2014; Somnasang & Moreno-Black 2000; Svanberg 2012).

For all these reasons, many wild edible plants are seen as something linked to poverty and nutritional deficits, in addition to precarious livelihoods. Frequently, lower incomes are insufficient to buy commercial food crops and staples, which are perceived as signs of progress, modernity, and higher status (Delang 2006).

Lack of knowledge and inability to identify plants existing in the wild and available to sustain survival have led to malnutrition and hunger in certain areas of the world (Grivetti & Ogle 2000).

Some examples of critical foods from the reviewed literature are the corms from *Colchicum montanum* L. used in the Mediterranean region (Leonti *et al*. 2006); the Brassicaceae, wild mustard, *Sinapis arvensis* L., and wild radish, *Raphanus raphanistrum* L. used in Poland (Łuczaj 2010); the starchy rhizomes of waterlilies from the family Nymphaeaceae used by Native Americans and Australian Aborigines, and the inner bark of some gymnosperms in north-western North America (Turner *et al*. 2011); the leaves of *Glechoma hederaceae* L. used for seasoning broths and soup in north-eastern Portugal (Carvalho & Morales 2013).

6.1.1.2 Weeds

Grivetti and Ogle (2000) highlight the importance of edible weeds within regional food security, referring to the concept of *hidden harvest*. Weed species are closely related to crops and agricultural farming systems, and are of nutritional relevance, as reported by several authors (Bye 1981; Maroyi 2013; Molina *et al*. 2014).

Food uses of most of these species comprise the ingestion of raw immature herbaceous leaves and stems although for some the edible portion corresponds to bulbous leaf bases.

Weeds from arable crops and disturbed environments are consumed in several African and Asian countries mainly as vegetables, according to a brief review by Maroyi (2013). Likewise, the author found in other studies that weeds used as traditional greens in Zimbabwe are frequently undervalued by research and governmental institutions, although they are an important part of daily food intake, supplementing conventional vegetables and some being preserved for later use.

Molina *et al*. (2014) evaluated the potential sustainable exploitation of weed vegetables traditionally consumed in the Mediterranean region, which are known to be rich in bioactive compounds that might have important health benefits because of their antioxidant activity. The authors were able to provide quantitative data on yield and availability of 15 Mediterranean wild green vegetables. Edible yields of the studied species were found to be high in most cases, confirming their potential to increase food diversity. Some of the most appreciated of the local wild gathered species, such as *Scolymus hispanicus* L. (Asteraceae) and *Silene vulgaris* (Moench) Garcke. (Caryophyllaceae), showed low

production rates, which suggests that yield and availability are not the main criteria for local selection of wild edible species (Molina *et al* 2014).

It is worth noting that weeds occur in marginal lands, are easily accessible in quantity and, in general, are at low risk of overexploitation. These plants are some of the neglected and underutilized wild species that have associated potential benefits, in terms of nutritional relevance, food security, medicinal value, income generation, economic growth, and cultural advantages.

6.1.2 New Trends in Edible Wild Plant Consumption

Another aspect of wild edibles consumption is the latest trends (Łuczaj *et al*. 2012) based on local traditional behaviors. In many European countries (Dénes *et al*. 2012; Kalle & Sõukand 2012; Łuczaj 2012; Łuczaj *et al*. 2013a,b; Molina *et al*. 2014; Redžić 2006; Tardío 2013; Tardío *et al*. 2006), including rural communities of the Mediterranean (Biscotti & Pieroni 2015; Leonti *et al*. 2006), wild gathered species play a vital role in supplying seasonal food and weed greens and are considered most relevant in terms of nutrition and health (Morales *et al*. 2014; Vanzani *et al*. 2011) and as signs of the cultural identity of such regions. Moreover, they are seen as appealing gastronomic resources for modern culinary experiences. Many restaurants include wild gathered ingredients on their menus and rely far more on home-grown, farmed, and forage foods.

Reyes-García *et al*. (2015) surveyed seven sites in the Iberian peninsula and one in the Balearic Islands in order to identify current trends in the consumption and gathering of wild edible plants. Using information from interviews, they found a generalized decrease in the consumption and gathering of wild edible plants, but while some uses are being abandoned, others remain relatively popular. They conclude that local gastronomic traditions, high cultural appreciation, and recreational functions may explain these tendencies. Currently, the role of wild edible plants as provisioning services is marginal and cultural ecosystem services and nonfood use values may justify the persistence of some uses.

Nowadays, wild edible plant foods serve commercial and recreational purposes too and have a renewed meaning for many rural areas. In some European countries and in Morocco, commonly consumed species of wild edibles, particularly herbs, greens, and berries, are available in local markets (Carvalho 2010; Łuczaj *et al*. 2013a; Powell *et al*. 2014; Svanberg 2012) where they may be bought by inhabitants and by foreigners visiting the area. Small businesses and industries for processing wild edibles, for example marmalades and preserves, are common in some rural areas, such as north-eastern Portugal. Agritourism in Europe is a developing activity gaining popularity; it is highly related to contact with countryside and sustainable wild gathering. Several outdoor initiatives also promote wild edible foods as a recreational activity (Stryamets *et al*. 2015; Svanberg 2012); collecting and consuming such species are much appreciated and provide important cultural ecosystem services, comprising cultural landscape, recreation, and identity (Schulp *et al*. 2014). Surviving in the wild is a new approach in more economically developed societies. Users searching the web can easily find different field guides for subsisting on wild edibles from Europe, North America, Canada, and Australia. An example of wilderness survival using wild plants as food is mentioned by Svanberg (2012) in Sweden.

A case study focusing on incentives for wild plant gathering shows that, at least in Europe, there is a growing interest in such activity, after being abandoned over the last decades (Schunko *et al.* 2015). Although their outcomes cannot be generalized, the authors have identified five types of motivation for gatherers (quality type, fun type, traditional type, income-oriented type, and nongatherer type). Gathering from the wild has gained popularity and fashionable attention because people prefer quality products with known provenance, and enjoy direct contact with nature and the activity itself. So for many, the motivation for wild food collection has changed from the necessity of satisfying diverse essential needs to the preference for quality products and pleasure of collecting. These motivations denote a positive self-perception and personal commitment to plant gathering from the wild, enabling persistence of plant knowledge and wild gathering specifically (Schunko *et al.* 2015).

Global movements, such as the Slow Food and Terra Madre networks, were founded to prevent the disappearance of local food cultures and traditions, contributing to raising awareness about food security, perceived as quality, variety and access to food, with a commitment to consumers, producers, cultural diversity, and the environment (www.slowfood.com).

These new attitudes also represent changed perceptions about wild plant gathering and consumption. As mentioned before, until very recently, many cultures harbored a prejudice against wild edibles, leading to a decline of interest; such foods were negatively associated with starvation (Carvalho & Morales 2013) and considered "famine foods" (Kang *et al.* 2012; Nascimento *et al.* 2012). However, negative insights and attitudes towards wild foods are still reported in many studies conducted in Africa (Bvenura & Afolayan 2015) and Asia (Panda 2014), where wild edibles are literally considered as "nourishment for women, children and the weak," natural disasters foods (e.g. flood or drought), and tasteless and unappetizing but necessary resources during acute food shortage (Addis *et al.* 2013).

6.1.3 Wild Edible Plants, Food Security, and Research Approaches

Multidisciplinary studies of wild edible resources need to be conducted because it is already evident that local ecological knowledge about traditional and particular diets will benefit humankind in many ways; however, this heritage is largely decreasing due to economic, ecological, and societal changes. Food security, safety and sovereignty, subsistence, undernourishment, and new ideas about food and health are two sides of the same coin.

Sustainable diets are deeply interconnected with several key factors such as food and nutrients needs, wellbeing and health, food security and accessibility, seasonal foods, equity and fair trade, biodiversity and environment, local development, traditional knowledge and skills, and cultural heritage (Lairon 2012).

Combining traditional knowledge and expertise with more recent concepts and applied research is a useful approach but public policies, increasing human rights to food, health, and welfare, in addition to enhancing biodiversity and ecosystems services, are also required. Appropriate transdisciplinary abilities and attitudes are needed to improve staple foods yields in a sustainable way, while protecting natural and crop biodiversity, as well as avoiding harmful anthropogenic effects on the biophysical environment (de Schutter 2011).

6.2 Foraging and Wild Edible Plant Resources

Foraging, the act of searching for food or provisions, was a form of social organization with profound implications in many cultures. Foraging and wild gathering embody a deep knowledge of plants and sites, sustainable practices of handling the available resources, daily interaction with nature and environment, and the answer to limited food supplies.

Bharucha and Pretty (2010) undertook a detailed analysis of the best existing evidence for the roles and values of wild foods and their relation to agricultural systems. They found that, for many reasons, foraging and gathering should not be considered outdated and an earlier stage of human evolution, but just a way to adapt to different ecological and socioeconomic circumstances. They also suggest that foraging and farming practices overlap, and people manage and improve wild and agricultural resources in the same manner using similar approaches and techniques; both activities are thus complementary.

In many cultures, a multitude of wild edible plants were, and sometimes still are, included in the food basket, contributing to macro- and micronutrient intake. Many of these species are versatile and quite often, women's knowledge and skills are fundamental for using and managing wild edibles. Besides providing food and medicine, these plants may be traded and generate cash income. Opposing forces and attitudes influence decisions on plant use and wild gathering practices, endangering the reservoir of diversity available for conservation of traditional foods and for a broad understanding of the role of wild plants in health and nutrition.

Increased demands from a growing population, the rapid expansion of intensive agriculture, the loss of forest cover and changes in essential habitats, greater pressure on ecosystems and biodiversity, and the lack of sustainable use linked to LK or TEK are the principal factors threatening wild plant resources and are absolutely critical to its accessibility (MEA 2005).

6.2.1 Wild Plant Resources Worldwide

Although there is rising interest in developed societies, there are also clear signs of an accelerated decline in wild species use and associated local knowledge and management practices. However, wild edibles are still consumed across both industrialized and developing countries.

Turner *et al.* (2011) produced the most comprehensive review to date of various categories of edible wild and tended plants used in different regions of the world, and they discuss the concept of tending and managing not only wild plants but fungi and algae as well. They also emphasize the richness and diversity of wild food and its contribution to nutrition and cultural identity, reflecting important TEK.

The different kinds of edible parts obtained from wild species are commonly consumed in different ways according to particular cultures and specific needs. Moreover, recent scientific approaches (see Chapters 7 and 8) have confirmed the nutritional value of many of these foods. For instance, numerous fruits and seeds have useful vitamin content and appreciable amounts of soluble fiber and antioxidant compounds such as ascorbic acid (Barros *et al.* 2010, 2011a; Morales *et al.* 2013); many sprouts, stems, leaves, and aerial parts are rich in micronutrients (Martins *et al.* 2011; Morales *et al.*

2014; Pereira *et al*. 2011; Sánchez-Mata *et al*. 2012); some underground organs (roots, tubers, corms, bulbs, and rhizomes) and tropical fleshy fruits have rich starchy cells and pulp and a high fat content, contributing to human caloric needs (Crowe 2005; Hladik *et al*. 1984; Kuhnlein & Turner 2009).

Furthermore, in the Mediterranean region seasoning is a very important practice, primarily for the taste and aroma it imparts to food but also for the nutritional value of the main species consumed (Barros *et al*. 2011b; Pardo de Santayana *et al*. 2007), as well as for its role in preservating sauces, sausages, meat, and fish (Póvoa *et al*. 2006). Asian gastronomy also uses a strong aromatic component; herbs, leaves, and seeds of wild species are key ingredients used to make vegetal oils or flavor food (Bortolotto *et al*. 2015; Ju *et al*. 2013; Li *et al*. 2015; Rajasab & Isaq 2004). All over the world, leaves, flowers, and fruits of wild native plants have been used for flavor (steeping in water) and to prepare beverages (fermenting and distilling) that were used in rituals or events with cultural and religious significance (Bortolloto *et al*. 2015; Estrada-Castillón *et al*. 2014; Hong *et al*. 2015; Kuhnlein *et al*. 2009; Pardo de Santayana *et al*. 2007; Sõukand *et al*. 2013).

Some wild edibles may be eaten fresh and raw, such as greens and fruits; others require previous preparation (e.g. peeling or deseeding). Plus, for many, further procedures are needed to render them digestible or to remove toxins and poisonous constituents (e.g. destemming, blanching, leaching or boiling; see Chapter 7). For storage and preserving purposes, several practices are used: dehydrating by sun, wind or heat; hanging and shade drying at room temperature; steaming or hanging in smoke; burying or storing in specific containers (e.g. baskets and wooden boxes); soaking in water; steeping in olive oil, honey, wine or brandy; preserving in pig fat or other fats and oils; simply mashing with spices, garlic and vegetal oils or animal greases; combining previous roasting with mashing and seasoning; making pastes; preserving in vinegar or salt water; baking or processing in jams, jellies, and conserves; fermenting (Carvalho 2010; Kuhnlein & Turner 2009; Póvoa *et al*. 2006; Quave & Pieroni 2014).

A review of the literature provides relevant information about wild edible plant resources explored within different ecosystems (e.g. tropical and temperate forest, grasslands, wetlands) in many parts of the globe. These works document local knowledge and consumer procedures with reference to indigenous, rural, migrant or urban peoples, and reflect both historical and recent data.

The different contexts, methodological approaches, and tools applied in most of the studies meana that it is impossible to rigorously compare data, but the number of species per area or per inhabitant is less significant than which and how species are used. Likewise, in most cases, it is also practically impossible to estimate intakes or to generalize the described patterns of consumption across different user groups. Therefore, selected examples, compiled from the latest publications found using the keyword *wild edible plants*, give an interesting overview of the range of species and the pattern of plant uses recently documented worldwide (Table 6.1).

6.2.1.1 Africa

According to data cited by Bharucha and Pretty (2010), 1500 wild edible plant species were reported for Central and West Africa. Additionally, Maroyi (2014) documented 24 taxa of ferns belonging to 14 genera and 11 families of pteridophytes that are still used in sub-Saharan Africa. During the last decade, many authors have studied wild edibles consumption and related local knowledge in African regions and countries. Some examples are summarized within the following paragraphs.

Table 6.1 Selected examples of recent literature reporting plant use of wild food species from all over the world. The key words *wild edibles plants* and Google search engine were used to find the last studies. Only Equisitopsida (APG III, 2009), formerly Embriophyta, are considered. Data are organized by descending alphabetical order of region's name and main continents (Africa, Asia, Europe, Americas).

Region	No. of wild edible species	Habitat	Lifeform	Food category	Botanical diversity/most reported families	References
Amuria, north-eastern Uganda, East Africa	51	Savannah	47% herbs 39% trees	51% fruits 43% greens	**32 botanical families** Malvaceae (17%) Fabaceae, Moraceae, Solanaceae (13%)	(Ojelel & Kakudidi 2015)
Konso Wereda, South Ethiopia, north-eastern Africa	127	Great Rift Valley, plateaus, wide topographic-induced climatic variation	62% shrubs, trees 28% herbs 10% vines	26% greens 12% ground organs 4% fruits	**45 botanical families** Malvaceae (11%) Fabaceae (9%) Apocynaceae (8%)	(Addis *et al.* 2013)
Morocco, northern Africa	246	Mountainous and Sahara areas	66%herbs 34%trees	31% greens 14% seasoning 13% fruits 9% baking	**60 botanical families** Asteraceae (13%) Lamiaceae (8%) Fabaceae (7%) Brassicaceae (5%)	(Nassif & Tanji 2013)
Nhema, Midlands Province, Zimbabwe, southern Africa	67	Tropical savannahs and scrublands biome, semiintensive farming	39% trees 31% shrubs 27% herbs	67% fruits 15% greens	**30 botanical families** Anacardiaceae (9%) Moraceae (9%)	(Maroyi 2011)
Shurugwi District, Midlands Province, Zimbabwe, southern Africa	21	Tropical savannahs and scrublands biome, semiintensive farming	Weeds 55% herbs	81% greens	**11 botanical families** Amaranthaceae (19%) Asteraceae (14%) Malvaceae (14%)	(Maroyi 2013)
Five provinces of South Africa	103	Different physiographic and climate conditions	68% herbs 7% trees 6% vines	95% greens 19 fruits%	**33 botanical families** Amaranthaceae (13,5%) Malvaceae (12%) Asteraceae (9%)	(Bvenura & Afolayan 2015)

(*Continued*)

Table 6.1 (Continued)

Region	No. of wild edible species	Habitat	Lifeform	Food category	Botanical diversity/most reported families	References
Sudanian & Sudano-Guinean regions, Benin, west Africa	70	Woodland and savannah	36% trees 33% herbs	57% greens 47% fruits	**38 botanical families** Asteraceae (10%) Anacardiaceae (8%) Bombacaceae (5%)	(Segnon & Achigan-Dako 2014)
Gongba Valley, Gansu, China, eastern Asia	76	Vegetation from desert, through dry grasslands, to deciduous forests in the mountainous	34% herbs 30% trees 25% shrubs	46% fruits 40% greens	**21 botanical families** Rosaceae (21%) Asteraceae (9%) Caprifoliaceae (8%)	(Kang *et al.* 2014)
Hassan District, Karnataka, India, south Asia	29	Deccan plateau, extreme diversity of climatic conditions, and wide vegetation range	Mainly trees and herbs	66% greens	**19 botanical families** Fabaceae (21%) Poaceae (17%) Arecaceae (10%)	(Prashanth Kumar & Shiddamallaya 2015)
Kendrapara District, India, south Asia	86	Central coastal plain zone, warm and humid climate	38% trees 29% herbs	37% greens 33% fruits	**51 botanical families** Amaranthaceae (7%) Fabaceae (6%)	(Panda 2014)
Kupwara, India, south Asia	28	Himalayan mountains and several valleys, climate monsoonal, diverse biogeography	89% herbs 7% shrubs	79% greens 18% fruits	**17 botanical families** Asteraceae (14%) Amaranthaceae (11%) Polygonaceae (11%)	(Mir 2014)
Nanyi, Milin County, south Tibet, China, Asia	27	Extreme altitudinal differences, subtropical humid and semihumid climate, temperate semihumid monsoon forest	41% herbs 34% shrubs 24% trees	65% fruits	**12 botanical families** Berberidaceae (17%) Lamiaceae (17%) Rosaceae (17%)	(Li *et al.* 2015)

Nepal, south Asia	74	Mainly broadleaf forest and subtropical pine forest	51% trees 19% herbs	54% fruits 44% greens 15% pickles	**39 botanical families** Moraceae (11%) Anacardiaceae (9%) Fabaceae (6%) Euphorbiaceae (5%)	(Uprety *et al.* 2012)
Qinling Mountains, Shaanxi, central China, eastern Asia	185	Mountainous, humid temperate climate, deciduous forest, highly diverse flora	69% herbs 15% shrubs 13% trees	62% greens 21% fruits 12% ground organs	**67 botanical families** Rosaceae (16%) Asteraceae (11%) Brassicaceae (5%)	(Kang *et al.* 2013)
Shangri-La, Yunnan, China, eastern Asia	157	Mountainous, unique geographical location and climate diversity. 17 000 species of higher plants, 15% endemic	43 % herbs 30% shrubs	51% greens 49% fruits 11% seasoning 7% wine	**51 botanical families** Rosaceae (22%) Brassicaceae (6%) Asparagaceae (6%) Araliaceae (4%)	(Ju *et al.* 2013)
Alava, Basque Country, Spain, southern Europe	73	Mountainous Mediterranean and Eurosiberian transition	56% herbs 28% trees 16% shrubs	56% greens 45% fruits 22% seasoning and liqueur	**32 botanical families** Asteraceae (15%) Rosaceae (15%) Lamiaceae (12%)	(Alarcón *et al.* 2015)
Czech Republic, central Europe	150 (175)	Landlocked, oceanic and continental climate, mixed, conifer and broadleaf, forests	74% herbs 12% trees 11% shrubs	49% greens 21% seasoning 17% fruits	**57 botanical families** Asteraceae (13%) Rosaceae (9%) Brassicaceae (7%)	(Simkova & Polesny 2015)
Emilia-Romagna Region, Bologna, northern Italy, Europe	66	Mediterranean edaphic conditions and flora	48% herbs 33% trees 8% shrubs	38% greens 26% liqueurs 21% fruits 20% snacks	**33 botanical families** Rosaceae (21%) Asteraceae (14%) Lamiaceae (11%)	(Sansanelli &Tassoni 2014)

(*Continued*)

Table 6.1 (Continued)

Region	No. of wild edible species	Habitat	Lifeform	Food category	Botanical diversity/most reported families	References
Gargano, Foggia Province, northern Apulia, Italy, Europe	79	Hilly, Mediterranean climate and extremely rich flora, ca. 2100 species, many endemic	92% herbs and forbs 4% vines	100% greens	**19 botanical families** Asteraceae (38%) Brassicaceae (13%) Apiaceae (8%)	(Biscotti & Pieroni 2015)
Turkey & Balkans, south-eastern Europe	60	Mostly mountainous, climate diversity, European ecoregion, high proportion of endemic species	75% herbs 11% trees	100% leaves used for preparing *sarma*	**23 botanical families** Polygonaceae (18%) Malvaceae (17%) Asteraceae (13%)	(Dogan *et al.* 2015)
Rio Negro, central Guatemala, Central America	44	Plateaus, subtropical moist and dry forest	43% trees 27% herbs	55% fruits 30% greens	**26 botanical families** Solanaceae (19%) Fabaceae (16%) Amaranthaceae (12%) Arecaceae (12%) Cactaceae(12%)	(Turreira-García *et al.* 2015)
Paraguay River, Pantanal, Brazil, South America	54	Floodplain and areas of residual relief, riparian, deciduous and semideciduous forests, and Cerrado flora	Mainly trees and shrubs	81% fruits 19% seasoning 7% wine	**31 botanical families** Arecaceae (26%) Fabaceae (16%) Myrtaceae (13%)	(Bortolotto *et al*. 2015)

A total of 140 species of wild leafy vegetables was inventoried within 29 ethnic areas in Benin, West Africa (Dansi *et al*. 2008); three ethnic groups of the Democratic Republic of Congo consumed 166 wild species (Termote *et al*. 2010); in Ethiopia, north-eastern Africa, 413 wild edible plants were compiled from different ethnic groups in three different territories of the Tshopo district (Lulekal *et al*. 2011), and 127 plants were listed in the Konso district (Addis *et al*. 2013); 27 species were used as sources of food and beverage in Botswana (Neudeck *et al*. 2012); in Marmoucha, Middle Atlas, 246 species were reported (Nassif & Tanji 2013); in Benue State, Nigeria, 42 plants (Shomkegh *et al*. 2013); within three provinces of Morocco (Powell *et al*. 2014), 30 species of wild leafy greens; in Obalanga, Amuria District, Uganda (Ojelel & Kakudidi 2015), 51 species were registered; and 103 species were mentioned in five provinces from South Africa (Bvenura & Afolayan 2015).

These findings suggest that there is still a remarkable array of wild plants with potential use, at least for their nutritional and health value as already confirmed by applied research (Chetty 2013; Omoyeni *et al*. 2015; Schönfeldt & Pretorius 2011). Such species also have an economical role within rural households and small farmers' incomes and in attempting food insecurity alleviation.

Wild leafy vegetables and underground organs (e.g. roots, tubers, and rhizomes) are well known useful foods, being central components of diets in across Africa (Bvenura & Afolayan 2015; Chweya & Eyzaguirre 1999; Dansi *et al*. 2008; Lulekal *et al*. 2011; Nassif & Tanji 2013; Neudeck *et al*. 2012; Powell *et al*. 2014). The wild leafy food category includes plant materials ranging from leaves of annuals and shrubs to leaves of trees of major plant groupings such as angiosperms, but Maroyi (2014) also provided evidence of the importance of pteridophytes as food sources.

Some priority traditional leafy vegetable species used in Botswana, Cameroon, Kenya, Senegal, and Zimbabwe have been identified (Chweya & Eyzaguirre 1999) such as *Amaranthus dubius* Mart. ex Thell., *Brassica juncia* (L.) Czern., *Cleome gynandra* L., *Corchorus olitorius* L., *Hibiscus esculentus* L. and *Hibiscus sabdariffa* L., *Solanum nigrum* L., *Sonchus cornutus* Hochst. ex Oliv. & Hiern.

In many African countries, some wild species are very popular and are grown in home gardens and sold at local markets (e.g. *Cleome gynandra*, *Corchorus olitorius*, and *Amaranthus* spp.). Other noteworthy species are those from the genera *Adansonia*, *Cassia*, and *Dioscorea*.

6.2.1.2 Americas

There are many significant works focusing on the importance of wild edibles throughout the New World, comprising North America and South America and associated islands. This territory encompasses a wide variation in geological, climatic, and ecological conditions, which have influenced landscape, biodiversity, human history and consequently the development of traditional knowledge about useful plants.

Native American people used a very wide range of plant species for food. Some examples are found in works by Lévi-Strauss (1952) about wild plants in tropical South America and by Krochmal *et al*. (1954) focusing on native plants in the American south-western deserts.

Based on preview surveys, Morton (1963) provided a comprehensive list of the main wild food plants of the United States, excluding Alaska and Hawaii. This included about 1500 species and summarized information about plant parts consumed, processing methods, and potential hazards.

An analysis of food and drug plants of Native North America was performed by Moerman (1996). A database was created comprising a total of 44 775 items, describing the use of various plant taxa by Native American groups, representing 291 different tribes and 3895 uses of different species, 3380 of them vascular plants, of which 1625 species and 10 328 items concern food use. Most native groups used 50–150 food species. Liliaceae s.l., Rosaceae, Ericaceae, and Apiaceae are families widely used for foods (Moerman 1996).

A study from southern Ecuador documents 354 species of wild edible plants, belonging to 66 families, mostly consumed raw. Fabaceae (37 spp.), Arecaceae (29 spp.), Solanaceae (28 spp.), Ericaceae and Myrtaceae (each 23 spp.) are relevant families. Most plants inventoried (85%) have edible fruits. Twenty-two species have edible seeds; some are eaten like nuts, raw or roasted (van den Eynden *et al*. 2003).

Ethnic groups of Gran Chaco, Argentina, used a total of 179 native plant taxa belonging to 46 botanical families; 46.5% of the reported species are Cactaceae (27 species) and 11% are from Apocynaceae, Fabaceae, and Solanaceae (19 species each) (Arenas & Scarpa 2007; Scarpa 2009).

The history of California Indian dependency on and knowledge of the natural world and landscape was highlighted by Anderson (2005). All types of lifeforms from the rich local flora and fauna were gathered from below sea level to above the timberline. A great variety of native vascular and nonvascular plants (e.g. mosses, liverworts, and hornworts) was utilized by different tribes for many purposes, such as foods and medicines. Plant materials provided 60–70% of the primary nourishment in aboriginal California; one tribe relied on nearly 160 plant species for food and more than 110 plant species for medicines. A rich and balanced diet was based on four established food categories; seeds and grains; bulbs, corms, rhizomes, taproots, and tubers; leaves and stems; and fleshy fruits. Seeds of wildflowers and pines, the grains of native grasses, and acorns of oaks were among the staples of most Indian diets (Anderson 2005).

Kuhnlein and Turner (2009) produced the most complete review of plant foods easily accessible online. They documented traditional plant foods of the indigenous peoples of Canada and neighboring areas and found 550 different species of plants *sensu lato* (including algae, fungi, ferns, and lichens) that provide different food categories (e.g. greens, fruits, grains or mushrooms) and, sometimes, more than one type of edible product per species.

Data from interviews conducted in different environments in different parts of Brazil (Amazon Forest, Brazilian savannah, and the south-eastern coast of the Atlantic Forest) are discussed by Hanazaki *et al*. (2006). Most of the species used have edible fruits but usually shoots, roots or leaves are used in folk remedies.

Surveys from Brazilian dry forest (Cruz *et al*. 2014; Nascimento *et al*. 2012) present extensive information on wild food plants known and used by local people. Comparing different areas, these authors analyze the actual patterns of plant use and people's perceptions of food plant resources.

Examples of some edible wild plants from the Americas, chosen randomly, are the tuberous roots of hog peanut, *Amphicarpa bracteata* (L.) Fernald (Fabaceae); the fruits and roots of Brazil plum, *Spondias tuberosa* Arruda (Anacardiaceae); fruits of prickly pear cactus, *Opuntia* sp. pl. (Cactaceae); berries from *Rubus* sp. pl. (Rosaceae) and *Vaccinium* sp. pl. (Ericaceae); leaves of *Stanleya pinnata* (Pursh.) Britton (Brassicaceae);

Passiflora sp. pl (Passifloraceae); *Agave* sp. pl. and *Yucca* sp. pl (Asparagaceae); and sugar maple, *Acer saccharum* Marshall (Sapindaceae), among many others.

6.2.1.3 Asia

The last five years have been quite prolific in terms of wild food species research within the different Asian regions, providing interesting and significant information about species, distribution, and availability, as well as plant uses and knowledge (Boesi 2014; Chen & Qiu 2012; Ghorbani *et al*. 2012; Hong *et al*. 2015; Ju *et al*. 2013; Kang *et al*. 2012, 2013, 2014; Li *et al*. 2015; Panda 2014; Uprety *et al*. 2012).

There are estimated to be 1000–2000 edible wild plant species existing in Japan, as documented in Japanese literature cited by Chen *et al*. (2012). A high level of plant diversity has been utilized for more than 100 years, particularly in mountainous villages in Japan. In recent times, land use changes and modernization have led to an important reduction in wild edibles knowledge and availability; consumers' current attitudes towards plant species are still little known (Chen & Qiu 2012).

China is noted for its wide contemporary use of wild components in human diets, probably due to cultural behavior and severe food crises until recently, as mentioned by Kang *et al*. (2012). Research on potentially edible wild plants is well developed and an interesting number of studies are accessible, despite the focus being mainly centered on ethnic minorities (e.g. Mongolians, Shaxi in Sichuan, and Miao in Hunan) rather than in north-central, central, and eastern China, where the dominant Chinese population lives and wild food plant approaches are less well documented (Kang *et al*. 2012).

Using similar methodologies and research efforts, Kang *et al*. (2012, 2013, 2014) found that patterns in wild food plant use in China can be rather different. For instance, they observed that wild vegetables dominate in central China (Kang *et al*. 2012), while fruits formed the largest category in north-west China (Kang *et al*. 2014). Moreover, these authors have registered an impressive number of utilized species of the local edible flora, considering that ethnobotanical studies have been developed at such a small scale. They also reported that people in the Qinling Mountains value forest wild greens over the ruderal taxa, which are still widely used throughout the year and preserved for winter (Kang *et al*. 2012, 2013, 2014).

Zhang *et al*. (2014) undertook an extensive review of regional literature and found 350 wetland plant species, belonging to 66 botanical families, traditionally used in China, of which 101 species were explicitly used as food and 22 for making liqueurs, altogether corresponding to 35% of the total listed. Ten botanical families contributed nearly 50% (47 species) of all species assigned to food categories; for instance, Polygonaceae, Brassicaceae, and Lamiaceae accounted for 11%, 8%, and 5% of edible species respectively. For liqueur making, Polygonaceae, Poaceae, and Trapaceae represented 54% of the species used (Zhang *et al*. 2014).

Ethnobotanical studies from India (Mir 2014, Panda 2014; Prashanth Kumar & Shiddamallayya 2015) and Pakistan (Abbasi *et al*. 2013a,b,c) also highlight the use of wild plant foods, at times because of their assumed health benefits. Wild fruits and leaves are the best known and consumed plant materials in these regions; some of them are sun dried and stored for several months. Quite a lot of species are described as having more than one edible product, i.e. edible leaves, flowers, fruits, and seeds.

Thirty-nine of the most popular edible plants used in Uzbekistan for improving local diets and helping digestive processes were described by Khojimatova *et al*. (2015).

These edible species correspond to 18 families, the most significant being Rosaceae, Amaryllidaceae, and Xanthorrhoeaceae (Chase & Reveal 2009). Analysis of this data shows that some of the reported plants are also used as traditional food in China, Russia, Korea, India, and other countries.

Sometimes, mainly among pastoralist communities, wild foods are consumed as snacks during travels and summer transhumance, as noticed by Boesi (2014). In many cases, nonfood uses of wild edible plants are also relevant; in particular, additional medicinal properties are strongly linked with wild edibles intake (Abbasi *et al*. 2013a,b,c; Uprety *et al*. 2012). This is also the case in Vietnam, studied by Ogle *et al*. (2003), where they have acknowledged the multifunctionality of wild edible plants.

Considering regional biodiversity and availability, in most Asian regions, the number of inventoried wild greens species is higher than wild fruits, as reported by many researchers (Boesi 2014; Ghorbani *et al*. 2012; Kang *et al*. 2013; Mir 2014, Panda 2014; Prashanth Kumar & Shiddamallayya 2015). However, within other surveys (Kang *et al*. 2014; Li *et al*. 2015 Uprety *et al*. 2012), wild edible fruits are the most cited category (see Table 6.1).

6.2.1.4 Europe

Schulp *et al*. (2014) estimate that 65 million people in Europe (14% of all EU citizens), mainly living in rural areas, collect wild food occasionally (including game, mushrooms, vascular plants), and at least 100 million Europeans consume wild food. Despite these facts, research on wild edible vascular plants does not have the same coverage in all Europe. Countries such as Italy, Spain, and Scandinavia are those where many different studies have been conducted and published (Schulp *et al*. 2014), along with several works developed in Eastern European regions (Łuczaj *et al*. 2013a).

The information summarized by Schulp *et al*. (2014) underlines the use of 592 edible species from 305 genera, identified in 33 studies on wild vascular plant gathering and covering 17 European countries. Most species were reported in one or two countries only, but 81 species are used in four or more countries. Hilly or mountainous areas in central and southern Europe present the highest species richness; lower values are found in agricultural areas, for example in parts of eastern and north-western Europe (Schulp *et al*. 2014).

An interesting overview of changes in the present-day use of wild food plants in Europe, based on examples from different regions, is provided by Łuczaj *et al*. (2012). They confirm a decrease of plant knowledge and contact with nature, but they also discuss that fluctuations in plant use are not linear, because consumption of some species may be linked to temporary needs, habits, and fashions. Besides, they suggest that nowadays in some European countries, wild plants are part of new trends about food, i.e. healthy, good quality, and safe.

Historical ethnobotanical reviews of wild edible plants in Eastern European countries are very good sources of information for comparing earlier and more recent plant use. Records available from Belarus (Łuczaj *et al*. 2013b), Estonia (Kalle & Sõukand 2012), Hungary (Dénes *et al*. 2012), Poland (Łuczaj 2010), Sweden (Svanberg 2012), and Slovakia (Łuczaj 2012) present some ideas about plant resources and patterns of usage in such areas. Moreover, the food use of 175 vascular plant species of the Czech Republic native flora was recently documented by Simkova and Polesny (2015), and Stryamets *et al*. (2015) discussed ethnobotanical and socioeconomic tendencies in wild food collection in rural areas of Russia, Sweden, and Ukraine. Significantly, in most of these

studies the use of wild food plants is very similar and characterized by a high interest in wild fruits and seeds and low appreciation of wild greens, which has an important effect on local knowledge and practices, as many available species are not used any more.

In contrast to north-eastern Europe, in the south, coinciding with the Mediterranean area, the consumption of wild vegetables, included leafy greens, is widespread and well represented in traditional and local cuisines (Biscotti & Pieroni 2015; Leonti *et al*. 2006; Tardio *et al*. 2006). Gathering vegetables and fruits in the wild and weeds in disturbed habitats were current practices in southern Europe (Albania, Greece, Cyprus, Malta, Italy, France, Spain, and Portugal), although nowadays they are consumed on a less regular basis (Leonti *et al*. 2006). Despite several ethnobotanical surveys and reviews of food plants covering areas of Italy, Sicily, Spain, Greece, Turkey, and Croatia, the inventory of traditionally gathered wild edibles is still relatively scarce for the Mediterranean basin (Biscotti & Pieroni 2015; Local Food-Nutraceutical Consortium 2005).

The Local Food-Nutraceutical Consortium (2005) project documented 318 wild or semicultivated food plant species (173 species in Spain, 147 in Greece, and 84 in Italy), of which only 18 were used in all the surveyed countries (Leonti *et al*. 2006).

Hadjichambis *et al*. (2008) performed a comparative analysis of the wild food plants recorded by seven selected study sites around the Mediterranean (Albania, Cyprus, Greece, Egypt, Italy, Morocco, and Spain). They documented 406 wild food plants, corresponding to 294 taxa, of which 77% were used exclusively at a local level, and concluded that even though some species have a general distribution and are commonly used around the Mediterranean, others have a strong connection with local biocultural heritage. Although biological availability is widespread, plant use and traditional knowledge are exclusive to some countries, and the cultural importance of common taxa is very different in each regional gastronomy.

Numerous studies carried out by different researchers contribute to important ethnobotanical, anthropological, socioeconomic, and nutritional information about wild edible plant consumption and associated local knowledge in southern Europe (Dogan *et al*. 2015; Ertug 2000; Ghirardini *et al*. 2007; Guarrera & Savo 2013; Łuczaj & Dolina 2015; Pieroni & Giusti 2009; Pieroni *et al*. 2002; Sansanelli & Tassoni 2014; Turner *et al*. 2011).

Research projects and studies in the Iberian peninsula, particularly in Spain (Alarcón *et al*. 2015; Bonet *et al*. 2002; Carvalho 2010; Carvalho & Morales 2013; González *et al*. 2011; Menendez-Baceta *et al*. 2012; Molina *et al*. 2014; Parada *et al*. 2011; Pardo de Santayana *et al*. 2007; Tardío *et al*. 2006), have reemphasized the cultural and dietary importance of wild edible plants, also strengthening their nutraceutical value, interest as functional foods, and contribution to a healthy diet (Leonti *et al*. 2006; Morales *et al*. 2013, 2014; Sánchez-Mata *et al*. 2012).

Overall, in Europe, Rosaceae, Asteraceae, Brassicaceae, and Ericaceae are the botanical families of wild edible plants most often consumed, among many other locally relevant families such as Apiaceae, Lamiaceae, Amaryllidaceae, and Polygonaceae (Chase & Reveal 2009). Frequently reported categories of plant uses include wild fruits, green vegetables, seasonings, and beverages.

6.2.1.5 Oceania

Literature about the use of wild edible species in Australasia (Australia, New Zealand, and New Guinea) and in the other archipelagos, islands, and atolls of the Pacific Ocean (Micronesia, Melanesia, and Polynesia) is not easily accessible. Several books focus on

the uses of native and introduced plant species that have sustained human life (Balick 2009; Clarke 2011; Cox 1994; Whistler 2001). Searching the main full-text scientific databases may provide some papers on ethnobotanical approaches (Brooker *et al.* 1989; Haberle 2005; Merlin 2000; Sillitoe 1995; Smith 1991), but they are not centered on wild edibles and there are few more recent articles.

Brooker *et al.* (1989) provided an overview on the history of the utilization of New Zealand native flora and mentioned some of the root crops, leafy vegetables, fruits, beverages, seaweeds, and fungi used by the Maori and early settlers. Some examples cited are ferns used as vegetables, like the rootstock of bracken (*Pteridium esculentum* (G. Forst.) Cockayne) and *Blechnum capense* (L.) Schltdl.); the berries from snowberry (*Gaultheria antipoda* G. Forst.), wineberry (*Aristotelia serrata* (J. R. Forst. & G. Forst.) Oliv.), and tree fuchsia (*Fuchsia excorticata* (Forst. & Forst. L. f.); the sea-lettuce (*Ulva lactuca* L.), which is green like ordinary lettuce and was used extensively by the Maori as a vegetable (Brooker *et al.* 1989).

In 1991, Smith combined information from the literature on Aboriginal plant usage in the tropical northern territory of Australia, where people are generally described as having lived on yams, roots, seeds, and fruits, with data from interviews. Fieldwork confirmed that gathering of plant foods was a very important activity in most Aboriginal communities and delivered a list of 148 species used for food. Vegetables, fruits, and seeds were the main food categories mentioned (Smith 1991).

Stewart and Percival (1997) described 30 of the most common bush food plants of New South Wales, Australia. Bush food, also known as bush tucker, is any food native to Australia. Specifically, the bush tucker of plants included fruits, berries, nuts, roots, and greens that sustained Aboriginal existence and promoted a healthy condition, providing a diet rich in vitamins and fibers. Some interesting edible species are the Fabaceae *Acacia aneura* Benth. and *Acacia sophorae* (Labill.) R. Br.; the screwpine, *Pandanus tectorius* Parkinson ex. Du Roi; the Orchidaceae, *Dendrobium speciosum* Sm.; and the fern *Balantium antarcticum* (Labill.) C. Presl (Stewart & Percival 1997).

The Huli people living in the Tari Basin (above 1500 m altitude) in the Southern Highland Province of Papua New Guinea managed about 67 plant species for food purposes (Haberle 2005).

Foods traditionally eaten within the geographic area known as Remote Oceania were categorized and described by McClatchey (2012), based on the emic classification system of Austronesian languages. The author found three categories of ingredients used in meals: starches (mostly roots and rhizomes), other components (vegetables, meats), and nonmeal foods (raw fruits and raw fish). The majority of species registered are wild foods, and most of these are used as leafy vegetables and fruits. McClatchey suggested in addition that cultural factors such as expectations and preferences may influence the selection and use of plant species, because this author observed that the diversity of wild plants used in Near Oceania (west of Solomon Islands) is greater than in Remote Oceania (Micronesia and Polynesia), even when existing in both areas.

As islands, these areas rely on the sea as an important source of food. There are more than 500 sea plants in the Pacific Islands, and perhaps over 100 of these are locally recognized as being edible (Novaczek 2001). A guide designed to meet the need for community fisheries training, particularly for women, describes some common edible sea plants of the Pacific Islands and compiles useful information about 26 genera, some containing more than one edible species (Novaczek 2001).

6.3 Wild Relatives of Crop Plants

A long transition from foraging to farming began with the harvesting of wild grains and underground organs (roots, tubers, rhizomes, and bulbs). Planting them in permanent mixtures of wild and domesticated types of the same species has been described in many sites of the world. Successful genetic and ecological approaches provide significant contributions to our understanding of plant evolution and domestication.

According to Harris (2005), "a worldwide distribution of agriculture was mainly the result of expansion from a few core regions where independent transitions from foraging to farming took place at different times, affected by many factors that varied from region to region."

In southern Asia, certain environmental and cultural conditions occurring simultaneously caused some groups of foragers to start cultivating and domesticating a limited range of wild plants. A small selection of seeds from wild legumes and grasses, as well as tubers and roots of some wild plants, were submitted to domestication. These people became the world's first farmers and produced the beginnings of agriculture and horticulture (Harris 2005).

Crop wild relatives (CWR) may be generally defined as wild plant species that are closely related to domesticated plants (Maxted *et al*. 2006). Such species present genetic diversity that has been used to increase crop yields, to obtain new varieties and hybrids, and can also be useful to improve resistance to pests, diseases, and stresses in a changing environment (Heywood *et al*. 2007; Maxted *et al*. 2006). Occasionally, CWR of cultivated plants are not easily determined. Domestication may have been a complex evolutionary process where the assignment of a unique ancestral wild gene pool is problematic (*Milla et al*. 2015). Some crops like leaf mustard (*Brassica juncea* (L.) Czern.) and bread wheat (*Triticum aestivum* L.) have no direct wild progenitors, having occurred via a process of hybridization, even though the origin of the hybrid is not always identified. However, other food species, such as watercress, blackberry (*Rubus* sp.pl.), hazel, carrot, and parsnip (*Pastinaca sativa* L.), are very similar to their wild ancestors, only varying in their edible parts that are particularly well developed (Vaughan & Geissler 2009).

In most regions, several inadvertently or intentionally domesticated wild plant species have become major complementary staples: barley (*Hordeum* L.) and wheat (*Triticum* L.) in south-western Asia; rice (*Oryza* L.) in China; maize (*Zea mays* L.) in North America; sorghum (*Sorghum bicolor* (L.) Moench) and pearl millet (*Pennisetum glaucum* (L.) R. Br.) in sub-Saharan Africa; herbaceous legumes from the Fabaceae family, represented by lentil, pea, chickpea, and other pulses in south-western Asia, soybean in China, common bean in Mesoamerica, cowpea and groundnuts in West Africa, south of the Sahara. Taro (*Colocasia esculent*a (L.) Schott), yams (*Dioscorea* sp. pl.), bananas (*Musa* sp. pl.), sugarcane (*Saccharum officinarum* L.), and breadfruit (*Artocarpus altilis* (Parkinson) Fosberg) were independently domesticated in New Guinea and south-eastern Asia (Harris 2005).

Zohary (2004), writing about unconscious selection and the evolution of domesticated plants, pointed out that cultivated crops ordinarily maintained by seed propagation (sexual reproduction) and thus passing through consecutive cycles of selection, such as grains and numerous vegetables, diverged considerably from their wild progenitors, being distinguished by complex syndromes of morphological and physiological traits.

But, vegetative or clonal propagation (e.g. cutting and grafting), used for perennial fruit trees or corm and tuber crops, taking into account the grower's preferences, fixes desired types of plants/clones that remain relatively close to their wild progenitors. With rare exceptions, selection is completed once a given clone is picked up and most valued genotypes are frequently kept for long periods of time, exhibiting impressive resemblance to the wild forms (Zohary 2004).

In contrast, wild species of direct use for food, in addition to many other purposes (e.g. fodder, medicinal, ornamental, and industrial), did not pass through the genetic limitation of domestication and maintain important genomic features that ensure adaptation to different habitats and biotic and abiotic stresses. Therefore, such wild resources have extended application in plant breeding and are fundamental for improving agricultural and food production, human nourishment, and maintaining sustainable agroecosystems. Nevertheless, some potentially valuable species are threatened in the wild, due to habitat destruction, degradation and fragmentation, conversion of farming systems, overexploitation, invasive flora, and climate change. Survival of many wild plant species that are CWR is at risk from a wide range of drivers of biodiversity loss, experiencing extensive genetic erosion and even extinction as a result of direct or indirect environmental changes (Heywood 2008, 2011; Heywood *et al*. 2007).

An outstanding contribution to wild and cultivated species germplasm collection and to comprehensive information and use of CWR in plant breeding was achieved by J. R. Harlan (1917–1998) (Hymowitz 1999; Khoury *et al*. 2013). This scientist established the level of domestication of a crop, its perceived genetic vulnerability, as well as the availability of CWR for use, the usability of CWR in research and breeding programs, and the financial, technical, and political circumstances or constraints pertaining to their use (Khoury *et al*. 2013).

Harlan and de Wet (1971) developed a framework for rational classification of cultivated plants. They considered that formal plant taxonomy was not satisfactory for classifying cultivated plants and their wild relatives because taxonomists tended to overclassify and standard botanical categories did not work at infraspecific levels. They studied the total existing set of all genes of a cultivated plant and assigned taxa to one of three gene pools, defining the gene pool concept (Harlan & de Wet 1971). Consequently, close relatives are included in the primary gene pool (GP1), more remote ones in the secondary gene pool (GP2), and very remote ones in the tertiary gene pool (GP3) (Harlan & de Wet 1971).

The gene pool concept has some limitations because in many cases, crossing ability and patterns of genetic diversity between crops and their wild relatives do not exist. Therefore, where crossing and genetic diversity information is lacking, the taxon group concept, using the existing taxonomic hierarchy to recognize the degree of relatedness of a wild species to a crop, may be introduced, although such concept is a more subjective assessment than direct comparison of genetic diversity (Maxted *et al*. 2006).

Nowadays, the most efficient usage of CWR and of wild native or semidomesticated species has an accepted vital role in food security and economic stability and is a matter of global concern, for both more industrialized and the poorest developing regions. A significant number of plant species have been overlooked or undervalued although they have the potential to provide increased commercial opportunities and improved nutritional status for the population, particularly in Africa, Asia, and Latin America.

Meeting the demands of agriculture, nutrition, and enhancing livelihoods in the twenty-first century involves an appropriate focus on neglected or underutilized species, many of them CWR species, all over the world. International policies and treaties, such as the Convention on Biological Diversity (CBD 2015a), the International Treaty on Plant Genetic Resources (FAO 2009), and the Global Strategy for Plant Conservation (GSPC) (CBD 2015b), recognize CWR conservation as a worldwide priority. The GSPC has a well-defined strategy that includes 16 outcome-oriented global targets set for 2011–2020. Within GSPC Objective II: Plant diversity urgently and effectively conserved, Target 9 specifically proposes "by 2020, 70% of the genetic diversity of crops including their wild relatives and other socioeconomically valuable plant species should be conserved, while respecting, preserving and maintaining associated indigenous and local knowledge" (CBD 2015b). Hence, the essential framework to develop national and regional inventories is already available, as well as networks and information systems to enable the exchange of data related to plant genetic resources for food and agriculture (CBD 2015a,b).

6.3.1 CWR Inventories and Checklists

Crop wild relatives' inventories and checklists of taxonomic diversity and prioritized taxa, at the global, national or regional level, are systematic approaches comprising useful tools for surveying and collecting genetic resources of crop species and wild plants, and also encompassing fundamental strategies for CWR conservation and future use (Maxted *et al*. 2007; Vincent *et al*. 2013).

Maxted *et al*. (2007) describe some of the first global and regional lists of CWR. The preliminary list of European CWR was produced in 1994 by the World Wide Fund for Nature (WWF) and the International Union for Conservation of Nature (IUCN) and extended a year later by Heywood and Zohary who organized a checklist of 206 species and subspecies, focusing on the primary gene pool of major cultivated species. The following Crop Wild Relative Catalogue for Europe and the Mediterranean (Kell *et al*. 2005) addressed the gene pools of all European socioeconomically important species (Maxted *et al*. 2007), which comprised about 23 483 CWR and 2204 crop taxa (Brehm *et al*. 2008).

At a national level, Maxted *et al*. (2007) cited lists from different European countries provided by several authors: the first CWR inventory for Italy with 163 taxa; a list of 130 CWR taxa for France and another of 44 French wild species representing 23 genera that justified priority conservation; the first comprehensive database of 1603 CWR taxa occurring in Russia; the preliminary list of United Kingdom CWR in 1995, which was expanded in 1999 to include 57 taxa from 26 genera of minor crops that had wild populations present in the UK, but not comprising their wild relatives.

The UK national inventory of CWR contains 413 genera and 1955 species. Approximately 65% of the 2300 UK native taxa are CWR, and of these, 85% are wild relatives of medicinal and aromatic plants, 82% of agricultural and horticultural crops, 15% of forestry plants, and 30% of ornamentals. The botanical families Poaceae, Rosaceae, Fabaceae, Brassicaceae, and Asteraceae present a high level of CWR taxa richness (Maxted *et al*. 2007). A recent publication refers to the English national inventory of priority CWR that contains 148 taxa (126 species and 22 subspecies) (Fielder *et al*. 2015). This number represents 10% of the taxa listed in the checklist of English CWR (reporting 1471 native and introduced taxa) that was developed by matching the

previous mentioned UK inventory (Maxted *et al*. 2007), the Catalogue of Crop Wild Relatives for Europe and the Mediterranean, and a list of the English flora, extracted from the Vice County Census (Fielder *et al*. 2015).

Brehm *et al*. (2008) performed a case study on the Portuguese mainland to inventory CWR and wild harvest plants (WHP). They reported 2319 taxa distributed across 524 genera and 122 families. Of the total number, 97.5% are CWR, 21.4% are WHP, 19.0% are both CWR and WHP, and approximately 6.1% are endemic. In Portugal, the top five families of CWR are the Fabaceae, Asteraceae, Poaceae, Lamiaceae, and Caryophyllaceae, accounting for almost 40% of the total number of CWR taxa. Genera including the highest number of taxa related to food and medicinal use are *Silene* (41 taxa), *Centaurea* (32), *Vicia* (30), *Thymus* (12), *Rumex* (7), *Malva*, *Mentha* and *Polygonum* (6) (Brehm *et al*. 2008).

Wild plant species (CWR and wild utilized species (WUS)) occurring in the United States territory with potential value in crop research and directly used for food and other purposes were compiled from North American databases and floras (Khoury *et al*. 2013). The inventory reported 4596 taxa, representing 3912 species from 985 genera and 194 plant families. CWR (54% of the total taxa) correspond to 1905 species from 160 genera and 56 families; WUS (46%) are represented by 2101 taxa from 2007 species, 833 genera, and 182 families. The botanical families comprising the highest number of species of CWR are Fabaceae (693 species), Poaceae (448), Asteraceae (182), Rosaceae (163), and Amaranthaceae (137) (Khoury *et al*. 2013).

A recent article published by Kell *et al*. (2015) highlights the significant impact of CWR on agriculture, horticulture, and the world economy. Referencing several researchers and using the example of China (one of the most important centers of plant diversity, with more than 30 000 native higher plant species), they emphasize the crucial role of such species in food security and economic stability and report that high-priority native wild relatives are threatened. They also provide a list of 871 high-priority species of the CWR China inventory, within the gene pools of 28 socioeconomically relevant crops to be used for future conservation programs.

Vincent *et al*. (2013) argued that a more systematic and targeted use of CWR is a currently underdeveloped option that could potentially make a significant contribution to increasing food security. The authors described a global priority CWR inventory and list 92 genera of the most socioeconomically important global food crops. Moreover, using preestablished criteria (socioeconomic relevance, potential use, and threatened status) and three main concepts (gene pool, taxon group, and provisional gene pool), they were able to prioritize CWR species covering over 150 crops. They estimated CWR relatedness for priority crops, documented taxonomy, geographic distribution, potential use, seed storage strategies of valuable CWR, and designed a database available online searchable by crop, gene pool, individual CWR species, country or region (http://www.cwrdiversity.org/checklist/). This checklist is named the Harlan and de Wet CWR Inventory in honor of the scientists who originally proposed the crop gene pool concept (Vincent *et al*. 2013).

The first global list of priority CWR species comprised 1667 taxa, divided between 37 botanical families, 108 genera, 1392 species and 299 subspecific taxa. The families with the most CWR are Fabaceae (253), Rosaceae (194), Poaceae (150), Solanaceae (131), and Rubiaceae (116) while the genera with the most CWR are *Solanum* (124), *Coffea* (116), *Prunus* (102), *Ficus* (59), and *Ribes* (53). CWR numbers in these lists concern botanical taxa of the major biodiversity and availability of the most important wild edible plants known and consumed by many people worldwide (Vincent *et al*. 2013).

Western Asia with 262 taxa is the region with the highest number of priority CWR, followed by China with 222 taxa and south-eastern Europe with 181. Calculating the unit area per CWR, within the nations with over 80 priority CWR inventoried, the countries with the highest concentration of all priority CWR are Lebanon, Israel, Greece, Portugal, Azerbaijan, Bulgaria, Syria, Italy, Spain, and Turkey. Overall, the countries identified as the highest priority for further CWR targeted conservation initiatives are China, Mexico, and Brazil (Vincent *et al*. 2013).

6.4 Enhancing Biodiversity and Plant Genetic Resources Conservation

Biological diversity or biodiversity is the basis of a sustainable environment and global wellbeing. Biodiversity contributes directly and indirectly to the provision of ecosystem goods and services that correspond to four main categories according to MEA (2005): (i) provisioning services; (ii) regulating services; (iii) supporting services; and (iv) cultural services. Plant use, food strategy and fair, culturally appropriated, ecofriendly, sustainable diets are intrinsically biodiversity based.

Campbell *et al*. (2012) identified the interlinkages between biodiversity and human wellbeing, i.e. between ecosystems functions and elementary material for good health, security, social relations, and freedom of choice and action. They argued that the recognition of the relations between biodiversity, sustainability, human life and human welfare is a major challenge to contemporary paradigms and support the urgent need for action at national and international levels.

"Plant genetic resources for food and agriculture (PGRFA) consist of diversity of seeds and planting material of traditional varieties and modern cultivars, crop wild relatives and other wild plant species" (AGP 2015). Erosion of these resources contributes to biodiversity loss and poses a severe threat to the world's food security in the long term. Increased environmental awareness of PGRFA erosion has led to a greater demand for conservation measures and transdisciplinary joined-up approaches to assess the implications of global changes and to improve conservation efficiency.

Plant diversity is suffering erosion and extinction at different degrees, which involves both taxonomic and genetic diversity. The level of genetic erosion is not easily estimated as it may go unnoticed because it occurs not only when species become extinct but also in living species. Thus, conservation should focus on local ecosystems protection, as well as on the safeguarding of genetic diversity within the component plant populations (Maxted 2003).

Maintaining PGRFA both in nature (*in situ*) and in gene banks and botanic gardens (*ex situ*) is one of the strategies used to meet conservation goals. It is important to raise public awareness about PGRFA conservation and its contribution to sustainable development of agriculture and the safeguard of biodiversity and agroecosystems.

6.4.1 Conservation Strategies

Conserving plant genetic resources (i.e. PGRFA and wild species) and sustaining biological populations and plants productivity encompasses technical, ecological, socioeconomic, and cultural factors, and requires successful strategies and appropriate policies.

Technical issues relate to maintaining the full range of genetic variation within a particular species while ecological topics, besides species and populations, are more concerned with natural habitats and agroecosystems, ensuring the ongoing processes of evolution and adaptation within native species' own environments. Plant genetic resources can be conserved both *in situ* and *ex situ*. *In situ* conservation corresponds to the maintenance and recovery of viable populations of species in their natural surroundings. *Ex situ* conservation maintains biological diversity components outside their natural habitats and involves procedures like sampling, transferring, and storing samples of the target taxa (e.g. seeds, propagules, explant cultures, specimens) (AGP 2015). *In situ* management approaches include genetic reserve conservation (e.g. protected areas, such as biosphere reserves, national parks, and wildlife sanctuaries), on-farm conservation (conserving within local farming systems, as farmers have been doing for millennia), and homegarden conservation (crops grown in gardens as small populations and produce used primarily for household consumption). *Ex situ* examples are botanical gardens, gene banks, and field gene banks as living collections. The highest proportion of landraces and CWR diversity is actively conserved *ex situ* (Maxted *et al*. 2011).

The FAO Commission on Genetic Resources for Food and Agriculture (www.fao.org/nr/cgrfa/cgrfa-home/en/) was created in 1983 to deal specifically with issues related to PGRFA. Two important assignments were accomplished during the 1990s: the first report on the State of the World's Plant Genetic Resources for Food and Agriculture, a periodic assessment that delivers a broad overview on the status and trends of conservation and use of plant genetic resources at national, regional, and global levels; and the adoption in 1996 of the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture, involving 150 countries (AGP 2015). Over the past 20 years, extensive information has become available on genetic erosion and vulnerability of plant genetic resources. Moreover, taking in account the growing demand for new products, the main drivers of biodiversity loss (e.g. climate change), and major advances in key areas of science and technology (e.g. development of information and communication technologies and of molecular and genomic methods), a second edition of the report on the State of the World's PGRFA (www.fao.org/wiews/en/) was published in 2010. This provided a concise assessment of the status of plant genetic resources and identified the most significant developments, gaps, and needs that were the basis for updating the Global Plan of Action, which was adopted in November 2011 (AGP 2015).

Considering that 2010 was the International Year of Biodiversity and also the year in which the Convention on Biological Diversity failed to meet its major conservation goal of a significant slowdown in biodiversity loss (Heywood 2011), the Second Global Plan of Action, addressing new challenges such as climate change and food insecurity as well as novel opportunities, including information, communication, and molecular methodologies, was fundamental in setting priorities for the effective management of plant genetic resources for the future (AGP 2015). The plan defines 18 priority activities grouped in four main areas: (i) *in situ* conservation and management; (ii) *ex situ* conservation; (iii) sustainable use; and (iv) building sustainable institutional and human capacities (AGP 2015).

Despite significant progresses being made, enhancing biodiversity and plant genetic resources conservation (crops, CWR, and wild species) needs huge commitments to embrace initiatives undertaken under the umbrella of treaties and plans, in order to foster conservation strategies and sustainable use of resources.

At global, national, and regional levels, a number of initiatives have been designed to address conservation issues. Some examples are listed below (AGP 2015).

- *2002: Globally Important Agricultural Heritage Systems (GIAHS)*: such systems are rich in agricultural biodiversity and associated wildlife, linked with local knowledge and experience, reflecting the evolution of humankind and its profound relationship with nature, and are important resources of indigenous knowledge and culture. The GIAHS initiative aims to identify and ensure global recognition of the importance of these unique traditional agricultural systems for food security and sustainable development, providing dynamic conservation of heritage systems and their multitude of goods and services. GIAHS has project interventions in Algeria, Azerbaijan, Bangladesh, Chile, China, Ethiopia, India, Indonesia, Iran (Islamic Republic), Japan, Kenya, Mexico, Morocco, Peru, Philippines, Sri Lanka, Tanzania, Tunisia, and Turkey (http://www.fao.org/giahs/en/).
- *2004: Global Crop Diversity Trust (GCDT)*: to ensure the conservation and availability of crop diversity for food security worldwide.
- *2005: European Crop Wild Relative Diversity Assessment and Conservation Forum, the PGR Forum Crop Wild Relative Information System (CWRIS)*: the first information management system specifically designed to facilitate CWR conservation and use, developed for Europe and the Mediterranean. It includes taxa (a searchable database of crop species and their associated wild relatives), site and population information, descriptors and links to data on individual species held within other online systems (Heywood 2008; Heywood *et al*. 2007).
- *2006: The Svalbard Global Seed Vault*: an international legal framework for conserving and accessing crop diversity, storing duplicates (back-ups) of seed samples from the world's crop collections. The Vault holds more than 860 000 samples, originating from almost every country in the world.
- *2013: The Millennium Seed Bank of the Royal Botanic Gardens of Kew and the Global Crop Diversity Trust*: a global long-term effort to collect, conserve, and use wild relatives with the characteristics required for adapting the world's most important food crops to climate change. The project Adapting Agriculture to Climate Change is focused on the wild relatives in the gene pools of 29 focal crops (Dempewolf *et al*. 2014).
- *2013: LIBERATION*: linking farmland biodiversity to ecosystem services for effective ecofunctional intensification. Main objectives are to identify general relationships between seminatural habitats, on-farm management, and biodiversity. Moreover, to link farmland biodiversity to ecosystem services, to value the contribution of ecosystem services for different land-use scenarios, and diffuse information to a wide range of stakeholders.
- *GCP/RAS/240/JPN*: capacity building and regional collaboration for enhancing the conservation and sustainable use of plant genetic resources in Asia.

6.4.2 Promoting and Strengthening Biocultural Heritage

Biocultural heritage is a broad concept overlapping quite a few common interests in understanding the relationship between biological, linguistic, and cultural diversity (Davidson-Hunt *et al*. 2012). It concerns the interactions between people and the

natural environment; it is linked with biological resources, from genes to landscapes; it also encompasses long-standing traditions, practices, and knowledge enabling adaptation to different drivers of changes (e.g. environmental, cultural) and challenges (e.g. socioeconomic, demographic). It supports local people's initiatives and dynamic adjustment to meet their own needs and may provide sustainable use of biodiversity.

According to the International Institute for Environment and Development, 370 million indigenous people in the world depend directly on natural resources and still rely on their biocultural heritage for survival (IIED 2015). Since most of the cultural landscapes, wild habitats, agroecosystems, natural resources, crops, and landraces have inherent human management and long-term use, conserving plant genetic resources is highly dependent on the safeguarding of biocultural heritage.

International authorities for nature conservation have been engaged in comprehensive resource networks and operational regulations for protected areas, combining efforts to include local knowledge and skills in contemporary strategies for conserving cultural and ecological diversity. Progress towards greater recognition of indigenous societies and local communities and their right to reproduce particular knowledge systems and practices differs across the globe. For instance, some European protected areas were legally created to preserve and maintain biological diversity, unique natural features, and associated cultural heritage. However, in some instances the main objectives of such protected areas (e.g. conservation, sustainable development, public use, and community involvement) were not fulfilled, because communication was lacking and participatory approaches were not applied (Carvalho & Frazão-Moreira 2011). Other countries like the United States of America, New Zealand, and Australia have also defined an array of policies and programs to enhance indigenous involvement. Nevertheless, to integrate different priorities and achieve greater inclusion of local people and values is a substantial challenge (Ens *at al.* 2015). In Australia, despite significant contributions to national biological conservation priorities, especially about fire management, threatened fauna and water rights, a general lack of awareness about indigenous history and culture, problems with accepting different knowledge systems, and insufficiently respectful partnerships are the main reasons for limited indigenous involvement in contemporary environmental conservation, with benefits for ecosystem science and management (Ens *at al.* 2015).

To successfully address the loss of both cultural and biological diversity and to achieve effective and fair conservation outcomes, it is fundamental to focus on biocultural approaches to conservation which include new attitudes and integrated programs to balance biodiversity conservation priorities with sustainable human livelihoods.

Gavin *et al.* (2015) argue that the study of biocultural diversity has emphasized the interdependence of biological and cultural diversity via co-evolution processes, common threats, and geographic overlap. They have proposed a set of guidelines and designed a conceptual model for biocultural approaches to conservation assuming that such methodologies are developed within complex social–ecological systems and benefit from previous work on different models of conservation (co-management, integrated conservation and development, and community-based conservation).

It should be stressed that local ecological knowledge and practices are the result of co-evolution over time between humans and their natural environment and are vital to manage resources now and in the future. Plant genetic resources conservation planning and strategies need to respect and combine multiple perspectives and knowledge systems as manifested in many worldviews, languages, and sources of information.

However, one of the most important demands within biocultural approaches to conservation is "to connect local realities with regional and global institutions, bridging gaps and promoting synergies among different sets of knowledge and interests, as well as supporting partnership and prioritizing joint responsibility, active relation management, environmental justice, and the sharing of governance and stewardship responsibility" as accurately suggested by Gavin *et al*. (2015).

6.5 Culturally Significant Wild Edible Plants

Many different botanicals have been used worldwide since ancient times. Within particular geographical and cultural contexts, some species play a role in people's way of life that sometimes is difficult to estimate. Researchers have attempted to develop methodologies for evaluating the cultural significance of biological taxa in a particular group or culture (Medeiros *et al*. 2011; Pieroni 2001; Reyes-García *et al*. 2006; Tardío & Pardo de Santayana 2008). These approaches measure different dimensions of plants that are relevant to society and provide a more comprehensive evaluation of the significance of floras for humans, avoiding bias and reducing researcher subjectivity (Medeiros *et al*. 2011; Reyes-García *et al*. 2006).

Several surveys within the ethnobotanical literature focus on culturally significant wild plants and associated traditional knowledge, highlighting that local use depends more on the cultural importance of each plant and on the transmission of knowledge and practices needed for using such species than on resource distribution, availability or abundance.

Much of this significance is shaped in local diets, gastronomic traditions, and recipes. Moreover, many edible species also have medicinal properties and spiritual and aesthetic values which strengthen their use. Therefore, as it is an impossible task to mention all culturally significant wild edible species, selected examples from the literature are cited here, trying to give a general overview of some interesting case studies carried out in different geographic regions.

Wild greens with a circum-Mediterranean distribution are highly prized and consumed. Many of the species used belong to the Asteraceae and Brassicaceae families, due to their bitter and pungent taste which is very much appreciated (Biscotti & Pieroni 2015). Golden thistle, *Scolymus hispanicus* L. (Asteraceae), locally known as *cardillo*, is one of the most valued wild vegetables in central Spain (Polo *et al*. 2009). Other thistles also eaten are *Sonchus oleraceus* L. and *Silybum marianum* (L.) Gaertn. (Biscotti & Pieroni 2015; Tardío *et al*. 2006). *Arctium lappa* L., *Cichorium intybus* L., and *Cynara cardunculus* L. are also widely consumed too (Biscotti & Pieroni 2015; Łuczaj 2012; Pieroni *et al*. 2005; Tardío *et al*. 2006). Frequently reported Brassicaceae in Europe are watercress, *Rorippa nasturtium-aquaticum* (L.) Hayek, *Capsella bursa-pastoris* (L.) Medik., wild rucula, *Eruca sativa* L., wild mustard, *Sinapsis arvensis* L., and wall-rocket, *Diplotaxis tenuifolia* (L.) DC. (Biscotti & Pieroni 2015; Tardío *et al*. 2006).

Herbal teas or tisanes are very popular in many countries across central Europe as observed in a survey conducted in 29 different areas (Sõukand *et al*. 2013). Tisanes are drunk in a food context, apparently without any medicinal purpose. Results highlight that representative botanical families used to prepare herbal teas are Lamiaceae and Asteraceae in all studied areas, and Rosaceae only in eastern and central Europe. The

main taxa are *Matricaria*, *Mentha*, *Origanum*, *Tilia*, *Thymus*, and *Rubus*. At a regional level, *Rubus idaeus* L. is the most used in eastern Europe, *Chamaemelum nobil*e (L.) All. in southern Europe and *Rosa canina* L. in central Europe (Sõukand *et al*. 2013).

Amaryllidaceae and Asparagaceae are mostly perennial bulbous or rhizomatous herbaceous plants. Several species from these families are of great importance as wild food in the Mediterranean and Asia; for instance, wild specimens from the genus *Allium* (Kang *et al*. 2013; Pieroni *et al*. 2005; Tardío *et al*. 2006), *Leopoldia comosa* (L.) Parl. (Biscotti & Pieroni 2015; Pieroni *et al*. 2002) and *Asparagus acutifolius* L. (Biscotti & Pieroni 2015; Tardío *et al*. 2006).

According to most recent taxonomical approaches supported by both morphological and phylogenetic analyses, the Amaranthaceae is a broadly defined botanical family that includes plants formerly treated as Chenopodiaceae (APG III 2009; Chase & Reveal 2009). The new Amaranthaceae family comprises approximately 180 genera and 2500 species, mainly from tropical Africa and North America (APG III 2009). Genera including *Amaranthus*, *Gomphrena*, *Beta*, *Chenopodium*, *Atriplex*, *Salsonia*, and *Spinaca* are spread throughout the world in wild and domesticated forms. Wild amaranth seeds (genus *Amaranthus*) were gathered by many Native American people for food and ritual purposes. Leaves and seeds are sources of high-quality protein and the plants grow like a weed in many different environments in the Americas, Africa, and Asia (Vaughan & Geissler 2009).

Six endemic species of wild yam (*Dioscorea* sp. pl.) were identified as potential food resource in the Mahafaly region, south-western Madagascar. Wild yam tubers are used as a staple food by 42% of households close to forest areas, where daily plant collection is accessible. Cassava, maize or sweet potato may be substituted. Different types are identified by local people who prize their sweet taste, size of tubers, and claimed nutritional value. Wild yams have a central role in local food security in the Mahafaly region, especially for poor farmers (Andriamparany *et al*. 2014).

Based on a literature survey, in South Africa Bvenura and Afolayan (2015) found several plant species with great potential to reduce food insecurity at a regional scale. Despite some toxicity problems, the fruits are edible and tender shoots and leaves may be eaten raw or cooked or dried for later use. These species were Spanish needle, *Bidens pilosa* L. (Asteraceae); bastard mustard, *Cleome gynandra* L. and *C. monophyla* L. (Brassicaceae); Jew's mallow, *Corchorus tridens* L. and *Corchorus olitorius* L. (Malvaceae); balsamina, *Momordica balsamina* L. (Cucurbitaceae); and black nightshade, *Solanum nigrum* L. (Solanaceae).

Several authors have described particular usages of some edible wild plants that highlight specific issues in addition to dietary or nutritional interest.

- Ertug (2000) gave information about vegetables for preparing *yufka* (greens eaten raw with salt and bread) and *cacik* (vegetables chopped and cooked with onions and bulgur, usually eaten with yogurt) in Anatolia, Turkey.
- Pieroni *et al*. (2002) analyze the use of *liakra* (leaves of weedy greens) by Albanian descendants in southern Italy and discuss a rich heritage under the multidisciplinary perspectives of ethnobotany, ethnotaxonomy, ethnoecology, and ethnopharmacology.
- Nabel *et al*. (2006) document the uses of *ta chòrta* (wild edible greens) in southern Calabria, Italy, where local inhabitants regularly gather more than 40 wild food species.

- Dogan *et al*. (2012) identify 87 botanical taxa, mainly wild and belonging to 27 families, used to prepare *sarma* (cooked leaves for wrapping rice or meat) in Turkey and the Balkans.
- Cruz *et al*. (2014), through 12 species in a rural area of the Caatinga, Brazil, evaluated people's perceptions regarding the use of wild edible plants and found that cultural acceptance, flavor, and emergency food were significantly associated with consumption.
- Kang *et al*. (2014) record the use of *cai* by the Tibetans of Gongba Valley, China. Wild vegetables are usually boiled and/or fried and served as side-dishes (*cai*) but they are also dried for further use or lacto-fermented in wooden barrels.
- Hong *et al*. (2015) describe processing procedures of *jiuqianjiu* liquor, made from water, rice, and a special starter of wild plants known as *xiaoqu* in Sandu Shui County of Guizhou, China. They report 103 wild-harvested plant species used as starters for preparing fermented alcoholic beverages.
- Sõukand *et al*. (2015) report botanical diversity (116 taxa from 37 families) used to make fermented foods and beverages in seven eastern European countries, upon which further microbiological, nutritional, and pharmacological studies may be developed to address their rational use. Moreover, the authors also list the most uncommon and endangered preparations.

6.6 Conclusion

The consumption of wild edible plant species is not easy to estimate. There have been some attempts to assess the real macro- and micronutrient intake of such components of several food systems, but detailed systematic transdisciplinary studies on edible wild plants are still required, contributing to overcome the world's nutrition problems and to understand the remaining unknown roles of wild edible plants in food security, local diets, and within many groups and societies worldwide.

Wild plant foods have been important sources of nutrients in the past. However, even now, many people rely on these foods to satisfy basic nutritional needs, particularly in underdeveloped regions where undernourishment prevails, due to wide socioeconomic differences persisting in many areas of the world.

Many countries have failed to reach the international hunger targets. Natural disasters and sociopolitical instability have resulted in prolonged crises with increased vulnerability and food insecurity for large parts of the world population (FAO 2015).

Research on wild edibles use goes beyond dietary approaches. Wild foods and local gastronomies are representations of traditional ecological knowledge locally managed and transmitted over centuries by many generations. This knowledge encompasses skills in managing habitats and using resources in a sustainable way.

In indigenous territories, as well as in isolated mountain areas or rural agricultural landscapes, wild edibles are a symbol of precise identity and cultural heritage. Wild edible plants are versatile and thus are used within cultural environments, as foods and medicine in addition to many other purposes, such as building, fibers, wood, fodder, dye, rituals, and religious festivals.

Technical entities and governance have undervalued wild edible plants; they have been considered minor species or weeds to be eradicated from cropland. This

perspective, along with global societal changes, has led to loss of the ability to identify and consume the available diversity of wild plant resources. Moreover, deforestation and overexploitation, conflicts, climate changes, and natural disasters have also threatened natural resources worldwide.

Different conservation strategies are required to address erosion of both cultural and biological diversity. Sustainability in wild plant gathering is also a relevant topic to overcome in some specific cases (e.g. underground organs and massive harvesting).

Biocultural approaches to conservation can achieve effective outcomes and successfully deal with cross-cultural awareness and communication challenges, bridging local communities and biologists, environmental managers and policy makers.

Food systems embody resources, ingredients, culture, values, and identity. This chapter does not intend to be an exhaustive approach, but to enhance the perception of the many dimensions of edible wild plants, while emphasizing the conservation of biocultural heritage and stressing the importance of undertaking further transdisciplinary research.

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