LEVEL 2

PRINCIPLES OF HORTICULTURE

Charles Adams, Mike Early,
Jane Brook & Katherine Bamford

ROUTLEDGE

Principles of Horticulture: Level 2

This colourful guide will introduce you to the fundamentals of horticulture, whether you are taking a Level 1 or 2 RHS, City and Guilds or BTEC course, are a keen amateur or a seasoned gardener. Written in a clear and accessible style, this book covers the principles that underpin growing plants for the garden and on the allotment, with reference to how these are tackled by professionals. With highlighted definitions, key points and illustrated in full colour, this book will be a useful companion as you progress in the study and practice of horticulture.

Complete with a companion website which includes extended horticultural information, powerpoint slides, questions and exercises to test your knowledge, syllabus cross-referencing and downloadable tutor and student support materials. Available at www.routledge.com/cw/adams

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Preface

Horticulture involves the growing of plants: from the production of flowers, fruit and vegetables outdoors, to the more tender plants under protection. It includes the establishment and maintenance of plants for our enjoyment right through the landscape industry and the provision of sports turf. Those beginning their study of horticulture are often familiar with growing in gardens in order to create an attractive area around them, and to provide leisure facilities such as lawns and sitting out areas. Many embark on the outdoor production of fruit and vegetables in their garden or on an allotment. In some instances the use of greenhouses or other protected areas enables these enthusiasts to extend the growing season, and also to grow tender plants not normally possible in their garden. This background makes an appropriate starting point for an introduction to the principles of horticulture.

There are many techniques involved in horticulture and some familiarity with them is gained through our own experience of gardening. By studying the **principles of horticulture**, you will see how plants grow and develop. In this way, a better understanding of the plant's requirements and its responses to various conditions enables us to grow plants more effectively. The trained horticulturist is able to manipulate plants to suit their own ends, including optimising their growth, fitting them into a pleasing planting scheme or decorative arrangement, or to benefit wildlife.

In the introductory chapter, the many and varied sectors of the horticultural industry serving the gardener are introduced. Gardens do not exist in isolation, so some of the current issues surrounding **sustainable practice** and the importance of **conservation** of our garden plant heritage are explored, including some of the organisations which help to bring this about.

The early chapters introduce **the plant** to the reader. The gardener currently selects from an enormous range of plants that have been collected from all over the world and are adapted to a wide range of climates and habitats. Having acknowledged the work of **plant collectors** in providing such a cornucopia, the challenge of growing the plants they introduced in situations local to us is explored, along with the way these plants relate to each other and to other organisms in the garden through the study of **ecology**. The means of **classifying** and **naming** plants as an important way of communicating accurately with others in gardening and horticulture is established, after which the **internal** and **external features** of the plant and the many and varied ways in which they are adapted to different environments are described. The significance of these features is explained in relation to plant processes such as **photosynthesis, respiration** and **transport**, an understanding of which helps create opportunities for optimising and manipulating plant growth, development and behaviour to the grower's advantage. Along with details of plant reproductive methods including **pollination** and **fertilization**, the nature of **plant propagation** is then described in some depth to illustrate the various means by which plants can be multiplied efficiently.

Growing media include soils and soil substitutes such as composts, aggregate culture and nutrient film technique. Usually the plant's water and mineral requirements are taken up from the growing medium by roots. Active roots need a supply of oxygen, and therefore the root environment must be managed to include aeration as well as to supply water and minerals. The growing medium must also provide anchorage and stability, to avoid soils that 'blow', trees that uproot in shallow soils or tall pot plants that topple in lightweight composts.

The **physical characteristics of soil** are described to help explain how satisfactory root environments can be produced and maintained. **Organic matter, water** and **nutrients** are analysed in detail because they play such an important part in management of productive soils along with **soil pH** which has a major effect on the availability of nutrients. Soil conditions are modified by cultivations, irrigation, drainage and liming, while fertilizers are used to adjust the nutrient status

to achieve the type of growth required. **Alternative growing media** and the management of plants grown in pots, troughs, peat bags and other containers are discussed in the context of the restricted rooting volume that makes it very different to growing in soil.

In growing plants for our own needs, we create a new type of community that introduces competition for environmental factors between one plant and another of the same species, between the crop plant and a **weed**, or between the plant and a **pest or disease organism**. These bring about the need to address the challenge of maintaining plant health. It is only by the identification of the competitive organisms (weeds, pests and diseases) and an understanding of their life cycle and biology that the gardener may select the correct approach to keeping them under control. With larger pests recognition is a relatively easy affair, but the smaller insects, mites, nematodes, fungi and bacteria are invisible to the naked eye and, in this situation, the grower must rely on the **symptoms** produced (type of damage) in order to discover the problem. For this reason, the pests are covered under major headings of the organism (most of which are large enough to recognize), while the diseases are described under symptoms. In this section the symptoms of physiological disorders such as frost damage, herbicide damage and mineral deficiencies that may be confused with pest or disease damage are also addressed.

The indexing and key word cross-referencing is to help the reader integrate the subject areas and to pursue related topics without laborious searching. It is hoped that this will enable readers to start their studies at almost any point, although it is recommended that an overview of the subject is gained by reading the early chapters first. Essential definitions are picked out in red boxes alongside appropriate parts of the text. Further details of some of the science associated with the principles of growing have been included in the grey boxes and specialist areas of the horticulture industry are picked out in green boxes. Each chapter concludes with a further reading section on the subjects covered. The companion website is also available at www.routledge.com/cw/adams with extended horticultural information, questions to test your knowledge, syllabus cross-referencing, downloadable tutor and student support materials and all the colour artwork from the text.

This book provides the ideal support for those studying horticulture up to Level Two and is organized to align with the very popular RHS 'Certificate in the Principles of Plant Growth, Propagation and Development' whilst providing the principles underpinning Level 1 and 2 Practical Certificates. In addition it covers the plant science, plant/crop protection and soils units in the Level 2 **Certificate, Subsidiary Diploma, Diploma and Extended Diploma and Work-based Diplomas in Horticulture.** It is also intended to be a comprehensive source of information for the keen gardener, especially for those taking City and Guilds Land-based Services Certificate in Gardening modules.

Charles R. Adams
Jane E. Brook
Michael P. Early

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CHAPTER 1

Level 2

Horticulture and gardening

Figure 1.1 Decorative border

This chapter includes the following topics:

- The nature of horticulture and gardening
- The horticultural industry
- The plant
- Ecology and gardening
- Sustainability
- Organic gardening
- Conservation

Figure 1.2 A garden idyll

The nature of horticulture and gardening

Most of us are familiar with plants through our **gardens** and **gardening**. Around us are examples of gardens that are little more than surrounds to houses with the priority being to provide standing room for the car, utility areas and a place to sit out when the weather is good enough; the owners' emphasis is probably on minimizing the workload with much hard surface. For others, the area is an opportunity to provide an attractive view, to enhance the look of the property or to have a safe playing area, but without wanting to be more involved with the plants than necessary. Again the emphasis is likely to be on minimizing their input, with a person brought in considered to be a good solution to dealing with the time required and complications to keep good order. In contrast, gardeners consider their garden to be where they fulfil their wish to work with plants and seek to create their 'paradise on earth' (see Figure 1.2).

We learn quickly that gardening is not a simple process because it is a dynamic situation that we face. Plants and plantings change over time. Over the year there are seasonal changes; and as time passes the plants grow in size. Both these have significant consequences in attaining and maintaining what we wish to achieve. We can choose between rigorously maintaining our planned garden or allow it to evolve. There are many skills and techniques associated with both ways forward: planting and replanting; controlling the size of the plant; allowing plants to spread by seed or vegetative means such as runners or placing plants according to carefully devised plans; but, probably above all, selecting the right plant for the situation in the first place. It is an ongoing job for the gardener to hold at bay the undesirable plants and weeds while protecting their chosen ones from the attack of pests and diseases.

A gardener benefits from knowing about the factors that may improve or harm their plant's growth and development. The main aim of this book is to provide an understanding of how these factors contribute to the ideal performance of the plant in particular circumstances. For many gardeners, their intention is to apply the knowledge to improve their garden or allotment. Many others are seeking to build on what can be learned in the private garden in order for them to widen their interests, or seek professional or semi-professional employment.

What goes on in our gardens gives us all an insight into the wider world of horticulture.

The horticultural industry

Most of us are familiar with the products of the horticultural industry in terms of the fruit, vegetables, plants and flowers that we buy. The orchards and the fields of vegetables and flowers that we see on our travels give us some idea of the area over which **outdoor production** is undertaken (see Figure 1.3). The huge blocks of polythene tunnels or greenhouses indicate that **protected cropping** is being undertaken on a scale very different from the greenhouse in the garden (one of the largest tomato producers in Britain and Ireland has a block of 18 hectares, i.e. it could contain 36 football pitches). Even from the road we are able to note, in general terms, the work being done over the year and the wide range of equipment being used in the fields. Less obvious is what exactly is being done and the technology involved, especially with the protected crops. Protected cropping enables plant material to be supplied outside its normal season and to ensure high quality – for example, chrysanthemums all the year round, tomatoes to a high specification over an extended season, and cucumbers from an area where the climate is not otherwise suitable. Also out of sight is all the work being done with specialist equipment in the packing sheds where so much is undertaken, including the processing and grading as well as the packaging of what we see in the shops.

For many, leisure time will be spent in parks, the stately homes or the great gardens of the country where professionals, and some skilled amateurs, are employed in establishing and maintaining what we are more familiar with on a small scale: borders and lawns. Those of us whose leisure includes sport, playing or watching all too easily take for granted the preparation of the surfaces and surrounds of the field of play. **Turf culture** is a specialist part of horticulture that is concerned with the establishment and maintenance of decorative lawns and sports surfaces for football, cricket, golf and so on.

Parts of the industry also come close to our own gardens. **Garden construction** involves the skills of construction **(hard landscaping)** together with the development of planted areas **(soft landscaping)**. Closely associated with this sector is **grounds maintenance**, the maintenance of trees and woodlands **(arboriculture** and **tree surgery)** and **jobbing gardeners** who do so much to maintain and improve our domestic gardens.

The garden centre is where most gardeners see the work of the industry in more detail. But again, this is only the shop front of a large sector that specializes in producing plants in containers for us to put into our garden. A few have some plant production on site, but stock is usually bought in. The **hardy ornamental nursery stock (HONS)** sector is concerned with supplying not just the garden centres, but also all the other sectors of horticulture including the production of soil-grown or container-grown shrubs and trees (see Figure 1.4) and the young stock of **soft fruit** (strawberries etc.), **cane fruit** (raspberries etc.) and **top fruit** (apples, pears etc.). These plants are supplied in the following ways (see Figure 1.5):

Figure 1.3 Bulb field

Figure 1.4 A Hardy Nursery Stock area

Figure 1.5 a) bare root b) root-balled c) containerized d) container grown

- **Bare-rooted** plants are taken from open ground in the dormant period. These are cheaper but only available for a limited period and need to be planted out in the autumn or spring when conditions are suitable. In practice, this is mainly October and March. Roots should be kept moist until planted and covered with wet sacking while waiting. Plants received well before the time for permanent planting out should be 'heeled in' (i.e. temporary planting in a trench to cover the roots).
- **Root-balled** plants are grown in open ground, but removed with soil and the root ball secured by sacking (hessian). This natural material does not need to be removed at planting and will break down in the soil. This reduces the problems associated with transplanting larger plants.
- **Containerized** plants are also grown in open ground, but transferred to containers. Care needs to be taken to ensure that the root system has established before planting out unless treated as a bare-rooted stock.
- **Container-grown** plants, in contrast, are grown in containers from the time they were young plants (rather than transferred to containers from open ground). This makes it possible to plant any time of the year when conditions are suitable. Most plants supplied in garden centres are available in this form.

A specialist area within this sector is the **propagation** of plants. Part of this will be the multiplication of seeds and material to grow on until ready for sale but within this sector are the **plant breeders** who specialize in the creation of new cultivars.

It is essential that care is taken when buying plants. Besides ensuring that the best form of the plants are being purchased and correctly labelled, the plants must be healthy and 'well grown': plants should be compact and bushy (see etiolated p. 68), free from pest or disease and with appropriately coloured leaves (no signs of mineral deficiency see p. 270). The roots of container plants should be examined to ensure that they are visible and white rather than brown (see Figure 1.6). The contents of the container should not be root bound and the growing medium not too wet or dry.

The plant

At the heart of our garden is the plant. In order to discuss them, we need to have an unambiguous means of naming and ideally a way of seeing how they relate to each other (see Chapter 4). While they come in a great variety of shapes and sizes, they do have some fundamental similarities in their life cycles (see Chapter 5) and how they grow (Chapter 6).

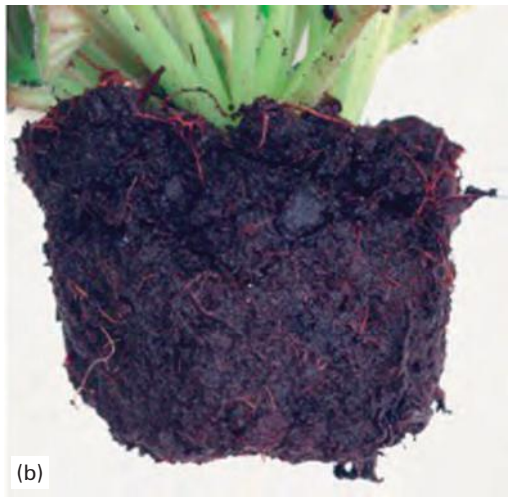

Figure 1.6 a) healthy white roots b) poor roots in waterlogged pot

It is important to have a clear idea of what a **healthy plant** is like at all stages of its life. The appearance of abnormalities can then be identified at the earliest opportunity and appropriate action taken. This is straightforward for most plants, but it is rather important to be aware of those plants whose healthy leaves are not normally green, that is, variegated, yellow, silver, purple and so on (see p. 114). Many 'stunted' plants are, often expensive, dwarf forms such as *Betula nana*, *Berberis thunbergeii* 'Atropurpurea Nana'. Some appear 'monstrous' – for example, those with contorted stems such as *Salix babylonica* var. *pekinensis* 'Tortuosa' and the corkscrew hazel *Corylus avellana* 'Red Majestic' (see Figure 1.7).

It should be noted that **physiological disorders** account for many of the symptoms of unhealthy

Figure 1.7 Corylus avellana 'Red Majestic' (Corkscrew hazel) with insert showing detail of the contorted twigs

growth, which include nutrient deficiencies or imbalance (see Chapter 14). Damage may also be attributable to environmental conditions. These disorders are examined in Chapter 19 along with the problem of plant diseases, the symptoms of which may look similar. The problems that plant pests bring and how to deal with them is the theme of Chapter 18.

The incorrect functioning of any one factor may result in undesired plant performance. Factors such as the soil conditions, which affect the underground parts of the plant, are just as important as those such as light, which affect the aerial parts. The nature of soil is dealt with in Chapter 12. Increasingly plants are grown in alternatives to soil such as peat, bark, inert materials and water culture, which are reviewed in Chapter 15.

Ecology and gardening

As well as understanding how individual plants operate and having a knowledge of their requirements, it is important for gardeners to appreciate how they relate to their surroundings and the organisms that live there, whether this is other plants, the animals that live with them and on them, or the non-living parts of their environment. The subject of ecology

deals with the interrelationships between all three of these groups, although it is the plants which are the focus of horticulturists. Some of these interactions are explored in Chapter 3.

Although the principles of ecology were developed in relation to the natural world, they can also be applied to artificial situations such as gardens. As in nature, a garden is made up of **population**s of plants and other organisms that form a **community** occupying a particular **habitat**. The community together with its non-living components form an **ecosystem** (p. 36). In terms of plant choice, it is useful to have a knowledge of the ecology of a plant's natural habitat, to try to match this to the environment they experience in the garden. Suitable levels of temperature, water and light, soil type and pH need to be considered on the basis of a plant's origin (Chapter 2). Ecologists have categorized and described a range of global geographical zones in which plants grow in the wild called **biomes** (p. 37) that give a broad idea of a plant's environmental requirements.

Choice of plant spacing directly relates to the ecological concept of **competition** between plants for essential environmental resources such as light, water and nutrients. Gardeners need to choose spacings suitable for individual plant species in, for example, a border, taking into account future growth. They can also space plants to harness the effects of competition, or lack of it, for specific purposes (p. 44).

Plants do not exist in isolation and their **interactions** with other organisms in the community are significant for the well-being of the whole community. Some of these organisms might be detrimental to plant health (e.g. pests and diseases) but many will be beneficial, such as natural pest predators and those which recycle nutrients within the garden ecosystem. One of the most important relationships between all garden organisms is how they feed on each other. Complex **food chains** and **food webs** (p. 38) exist through which energy and matter flow and these need to be kept in balance to support the whole community. Successful garden management takes account of these interactions.

The ecological concept of **succession** (p. 40) describes how plant communities change with time. Gardeners need to manage this change whether it is by controlling weeds on a newly prepared plot or halting succession by interfering with natural progression through, for example, pruning or harvesting.

Finally, paying attention to the ecological processes in gardens and using that knowledge to inform planting and management has an added advantage. Gardens are becoming increasingly recognized as an important **habitat for wildlife** providing suitable habitats for organisms to feed, shelter and breed. Again, an understanding of the ecology of gardens helps us to manage them appropriately to encourage wildlife (see Figure 1.8), which has also been shown to be good for our well-being too.

Figure 1.8 A bumble bee feeding on a *Scabeous* flower

Beyond the garden gate, the importance of protecting and maintaining ecosystems, both locally and globally, is recognized because they provide humans with many useful '**ecosystem services**'. These include the supply of food, medicines and water, climate and disease control, nutrient cycling and crop pollination, flood control and prevention of soil erosion and also cultural benefits both spiritual and recreational. Gardeners as well as professional horticulturists, whether producing food, providing amenity planting on a large scale or simply growing plants in a domestic garden, can contribute to maintaining these ecosystem services through thoughtful design and management.

Sustainability

There are many ways to define the word '**sustainable**' but essentially this mean that, if an action or process is sustainable, it provides the best for the environment and people, socially and economically, both now and indefinitely into the future. Environmental sustainability means making decisions and taking actions that do not degrade the natural world irreversibly. The end result of most environmentally unsustainable practices is **loss of**

biodiversity, that is, a reduction in the number of habitats and species present in the wild, less genetic variation in the wild and fewer cultivated species (p. 45). Threats to biodiversity include habitat destruction, pollution, introduced species, global warming and overexploitation of natural resources.

When focusing on environmental sustainability, there are many issues that have relevance for gardeners and horticulturists. Some of these are:

- peat
- invasive non-native species
- 'greenhouse gas' emissions
- waste
- removal of rare species from the wild.

Peat is used in composts (Figure 1.9), and sometimes as a soil conditioner too. It has unique characteristics which make it ideal as a growing medium (see Chapter 15). Peat is extracted from peatlands mainly in the north temperate zone in areas of high rainfall and low temperature and is formed of the incompletely decomposed remains of sedges, mosses, grasses and reeds. Peatlands are important for four main reasons:

- They form a unique natural habitat supporting many rare species.
- They are an important carbon sink, locking up about a third of the world's soil carbon.
- They are an archive containing archaeological and geochemical historical information going back hundreds of years.
- They play an important role in the water cycle contributing to flood prevention, water quality and quantity of freshwater.

Peatlands form very slowly at a rate of only 1 mm a year. A 10 m deep layer of peat has taken around 10,000 years to form, so when peat is extracted, the damage is irreparable. Outside the European Union the importance of peatlands is recognized but legislation to protect them varies. Within the EU, most peatlands are now so rare that they are being designated as Special Areas of Conservation and member states are now required to protect them rather than permit them to be mined and then restored. To tackle the problem, targets have been set to phase out peat in bagged composts by 2020 for amateur gardening and by 2030 for professional growers. The main difficulty with reducing peat usage is finding suitable alternatives which are themselves sustainable, consistent, the right cost and deliver similar results to peat-based composts. Acceptable peat alternatives for seed sowing and some groups of plants such as acid-loving plants have been difficult to develop. Some of these alternatives are discussed in Chapter 15.

Figure 1.9 Bags of compost at a garden centre containing peat

Invasive non-native species include many weeds, pests and diseases which have arrived in this country from elsewhere. Their impact is second only to habitat destruction in reducing biodiversity. In the heyday of plant collecting (see Chapter 2), little thought was given to the effects on native wildlife of foreign plants. While most were well behaved, some garden escapees are now causing increasing problems for native plants and habitats and also pose a challenge to forestry, tourism, agriculture and construction. Since they originated in countries far removed from Britain and Ireland, they were not accompanied by their natural diseases and predators that might have kept them in check. Three examples of invasive plant species are:

- ***Fallopia japonica*** (**Japanese knotweed**) was introduced in the nineteenth century by E.A. Bowles as an attractive ornamental (Figure 1.10a). It can grow at an alarming metre or more a month, penetrating tarmac and concrete and is highly resistant to weedkillers. The annual cost to the construction industry for removal is significant (it cost £70 million to remove it from the London Olympic site).
- ***Rhododendron ponticum*** is a familiar weed in woodlands with attractive purple flowers in spring (Figure 1.10b). It is one of nature's most successful plants, spreading readily by seed and rooted branches, and its dense evergreen canopy cuts out the light and produces poisons and a deep leaf litter which suppress the growth of everything beneath it including woodland tree seedlings. It was introduced as an ornamental garden shrub in 1763 and also used as a

Figure 1.10 Three invasive non-native plant species; (a) *Fallopia japonica* (Japanese knotweed) at Myddleton House where E.A. Bowles first planted it in his garden; (b) Clearing *Rhododendron ponticum* from a woodland, note the lack of other plant species in the cleared area; (c) *Impatiens glandulifera* (Himalayan balsam) along a river bank.

rootstock for grafting. It was first recorded in the wild in 1893 and has spread to woodland and moorland, particularly on acid soils. The toxins in its leaves mean that it is undamaged by insects and can also harbour fungal diseases such as *Phytophthera ramorum* and *P. kernoviae* (see p. 44) which can spread to oaks, beech and nursery stock.

- ***Impatiens glandulifera*** (**Himalayan balsam**) can grow to 3 metres tall and is a serious problem along riverbanks (Figure 1.10c). It was introduced in 1839 from Northern India and grown for its attractive pink and white slipper-shaped flowers. Its seed pods can project the seed explosively up to 7 metres away and the seeds are carried downstream to colonize new areas. The dense stands shade out other species and it produces more sugary nectar than any other European plant species, attracting pollinating insects such as bees away from native plants. When it dies back in late autumn, it leaves riverbanks exposed and liable to erosion.

Invasive species are particularly troublesome along and in waterways where it is difficult to use chemical control. Aquatic species such as water fern, Australian swamp stonecrop, floating pennywort, Canadian pondweed and parrots' feather are particularly invasive. Others include *Buddleja*, *Cotoneaster*, some broadleaved bamboos and some exotic honeysuckles. Gardeners can best prevent the spread of these damaging weeds by knowing precisely which plants they are buying, choosing non-invasive species and disposing of plant material carefully. See 'Invasive Plants' on the companion website.

The global trade in plants has also led to the introduction of many new '**alien**' **pests and diseases** (see Chapters 18 and 19). Ash dieback (*Chalara fraxinea*) is just the latest in a series of fungal diseases affecting our trees.

'**Greenhouse gas**' **emission**, largely due to the burning of fossil fuels and conversion of land for agriculture, has been identified as the major cause of global warming. The fruit and vegetables we eat and the plants we grow will all have a **carbon footprint** made up of the

Figure 1.11 Plastics waste at a nursery

Figure 1.12 *Encephalartos ferox*

'greenhouse gas' emissions incurred in their production and supply. Fossil fuels are used directly for cultivation, heating and transport of produce and plants. They are also used indirectly to supply energy for lighting, refrigeration, water treatment and manufacture of materials such as plastics, fertilizers and pesticides. Issues such as the sale of all-year-round produce which involves heating and lighting in winter and long distance transport ('air' and 'road miles') are all hotly debated. Growers can reduce their 'carbon footprint' by reducing their energy use or using alternative 'green' energy. For example, combined heat and power generated from green waste can be used for tomato production in the winter and wood chip burners are used by *Alstromeria* growers to heat their greenhouses in areas where gas is not readily available. Some major greenhouses are located beside power stations to make use of 'waste' heat. A new greenhouse production area generates all its energy from crop waste and exports the remainder to the National Grid. A successful scheme in Suffolk uses 'waste' carbon dioxide produced in an adjacent factory to boost photosynthesis (see p. 113) in its greenhouse-grown tomatoes, thus reducing the amount lost to the atmosphere.

Waste is an issue because of the damage to the environment from landfill and the energy used to collect, dispose of and recycle it. Horticulture uses many types of plastic from trays and pots (see Figure 1.11) to the polythene used to cover polytunnels, fleece to insulate crops and packaging for sale of fruits and vegetables, cut flowers and plants. Growing also generates green wastes such as plant material, including unsaleable produce which is not harvested, and composts.

Removal of rare species from the wild is a result of our demand for new and ever more interesting plants. In particular, overcollection of wild bulbs has been an issue in recent years. Many of these are now protected to some extent by CITES (Convention on Trade in Endangered Species) which monitors and issues quotas for imports and exports of threatened species. CITES produces a checklist which can be downloaded from its website, most of the plants listed are orchids, cacti, cycads (Figure 1.12), some succulents and some carnivorous plants.

Sustainable gardening practices

Gardeners can help reduce their environmental impact in many ways including the following:

- **Cut down on water** use by planting drought-tolerant plants and mulching (see p. 160). Use rainwater to water plants (purification of mains water is energy intensive) or reuse household water where appropriate. Water only when necessary and do this efficiently, that is, thoroughly and less frequently (see Chapter 12).
- **Reduce energy use** by, for example, heating and lighting in glasshouses or power tools such as air blowers outdoors. Insulate greenhouses as an alternative to heating. Source garden materials and plants locally if possible to reduce fossil fuels used in transport.
- **Limit the use of fertilizers, pesticides** and other garden chemicals and use manures correctly. Only treat pests and diseases when necessary and follow the instructions carefully using only approved products. Incorrect and excessive use might kill beneficial insects and pollute soil, ponds and groundwater.
- **Waste management** – good practice can be summarized as **Reduce**, **Reuse**, **Recycle**.
  - **Reducing waste** is the most sustainable approach to waste **management – for example**, by avoiding excessive packaging.
  - **Reuse** items such as plastic pots and trays (Figure 1.11), which should be thoroughly