# Plants in natural and managed communities

The behaviour of individual plants to climate change can be anticipated with some degree of confidence, because plants function in accordance with well established principles of plant physiology (see Chapter 3). However, when plants grow in close association with other plants, the outcome of any change in the environment will be subject to the complex science of ecology. As a very simple example, use of fertiliser in 1970s public planting schemes resulted in poor tree growth. The grass around the tree was stimulated by the fertiliser and competed more strongly with the tree roots for water, so tree growth suffered.

In examining the effects of climate change on plants in gardens, it is therefore necessary to consider the character of the garden and the extent to which the plants in it exist as individuals or as parts of a community. Gardens vary greatly in this respect. Some ‘wild’ gardens or ‘wild’ parts of gardens, and many of the18th century parklands and woodlands, were planned and planted to be gardened and managed as natural landscapes. Indeed, many landscape parks are now valued and managed as much for their nature conservation value as for their aesthetic appeal.

At the other extreme, a garden may be a collection of individual specimens, whether prizewinning delphiniums, North American conifers, or old apple varieties. In such cases, management intervention is more intense with pruning, staking, spraying and other maintenance practices aimed at fostering the growth of the individual and protecting it from external threats.

There are important differences between plants in the natural environment and plants in the highly cultivated garden in relation to the impacts of climate change. It is, therefore, necessary to consider, in each garden, the extent to which the particular garden resembles a natural community or, in J C Loudon’s words, “a work of art and a scene of cultivation” (Loudon, 1838).

## 4.1 Plants in the natural environment

The survival of a plant in nature depends on its fine adjustment to many components of the habitat, and the ability to exploit a niche more effectively than any potential competitor. It is not a matter of how it will respond to higher carbon dioxide levels, but whether it will respond to higher carbon dioxide levels more or less successfully than its neighbour. Very subtle changes in soil moisture levels, light levels (as nearby plants grow, for example), or nutrient levels can make the difference between a plant dominating its surroundings, or becoming eliminated. Increased susceptibility to, or prevalence of, pests or diseases will also have long term impacts on the success or failure of a species, and hence affect the composition of the plant community as a whole.

The static nature of a plant, being literally rooted to the spot, is a challenge to its survival in a changing environment. In natural, as in managed forests, there is some evidence that trees are capable of surviving (Myking, 2000) and even benefiting from (Saxe *et al*., 2000) the higher mean temperatures experienced to date. However, the current rate of change in annual mean temperature is unprecedented. As is already apparent in the Chiltern beechwoods, for example, some trees have adapted to 150 years of moderate climate change, but continuing increases in temperature and particularly the more taxing extremes of temperature and drought, are resulting in widespread decline (see section 6.3).

In nature, plant species have responded to climate change by physiological changes in the individual plant (fewer stomata for example), and by changes in distribution of the species as seeds are dispersed to more or less favourable sites and flourish or perish accordingly.

Experience in nature conservation suggests that dispersal of many species will be too slow to respond to the changes anticipated in the climate change scenarios. Van de Geijn *et al*. (1998) equate a 1°C rise with a geographical shift of 150-200km, and Ciesla (1995) with a 100km shift, or a 170m rise in altitude. Given the 3-5°C rise in temperature anticipated by the high emissions scenario by the 2080s for the UK, a plant species would need to migrate 4-7km each year to stay in the 'same' climate, assuming of course that the terrain permitted this.

Harrison *et al*. (2001) have simulated the response of 34 terrestrial plant species to climate change using the UKCIP98 climate scenarios (a previous generation of climate change scenarios that have since been updated and replaced by the UKCIP02 scenarios). Their results show that the distribution of some species such as Beech (*Fagus sylvatica*) and bog rosemary (*Andromeda polifolia*) declines (Figure 14), but the distributions of others, such as cross-leaved heath (*Erica tetralix*), remains unchanged.

Another factor in the potential risk to natural plant communities to climate change, is the very limited mobility of many plant species, and thus their inability to migrate from one area to a more favourable one if there are discontinuities in the landscape because of habitat fragmentation. A species may be able to spread northwards to escape or exploit higher temperatures, but it will rarely be able to move from one mountain top to a higher one across a valley, or even from one damp hollow to a nearby wetter one across dry ground, so it may be eliminated as the local or microclimate changes. In mountainous areas of Europe, plant communities are moving to higher altitudes as temperatures increase (Ciesla (1995) estimates 1-4m higher each year in Austria), but local extinctions are anticipated as plants are unable to relocate from a previously favourable area to a new area, because of habitat discontinuity (Gottfried *et al*., 1999). Management and selection – human intervention – will be needed if substantial components of natural ecosystems are to be conserved.

**When plants grow together in communities it is much more difficult to anticipate the impacts of climate change than when they grow as individuals or as a crop of one plant type. Survival of a plant in a natural community will depend on how much more or less able it is to respond to climate change than its competitors, rather than on its innate response.**

**Because plants are static, those in natural communities, in particular, need to be closely adapted to their environment. Changes in that environment are likely to threaten their survival. In natural communities, plants will respond to higher temperatures and reduced water availability by migrating to cooler, wetter areas (north and west in the UK) and/or to higher altitudes – by about 1-200km, or 170m in altitude per degree Celsius. This migration can only occur if there is a continuum of suitable environment across which migration can take place. Plants with patchy, localised distribution, such as those in heaths, bogs or mountain tops, could be threatened with extinction.**

### 4.2 PLANTS IN THE GARDEN ENVIRONMENT

In a garden, the 'habitat' is often extensively modified prior to planting, by soil cultivation and fertiliser addition, for example. This modification continues with mulching, feeding, irrigation, pest and disease control and, most importantly, removal of potentially competing plants, often throughout the life of a plant. Even in supposedly 'wild' gardens, grass is cut and bracken, brambles, sycamore and other potentially dominant plants are controlled periodically. Competition seldom plays a major part in determining the fate of individual garden plants.

In gardens, plants are not necessarily required to flower (especially in the case of vegetables) or to set seed. Plants do not require pollinating insects because, if an increase in numbers is required, seed can be obtained from suppliers in warmer climates or plants can be propagated vegetatively. Under natural conditions, plants are especially vulnerable during seed germination and early growth, which is why a plant may produce tens of thousands of

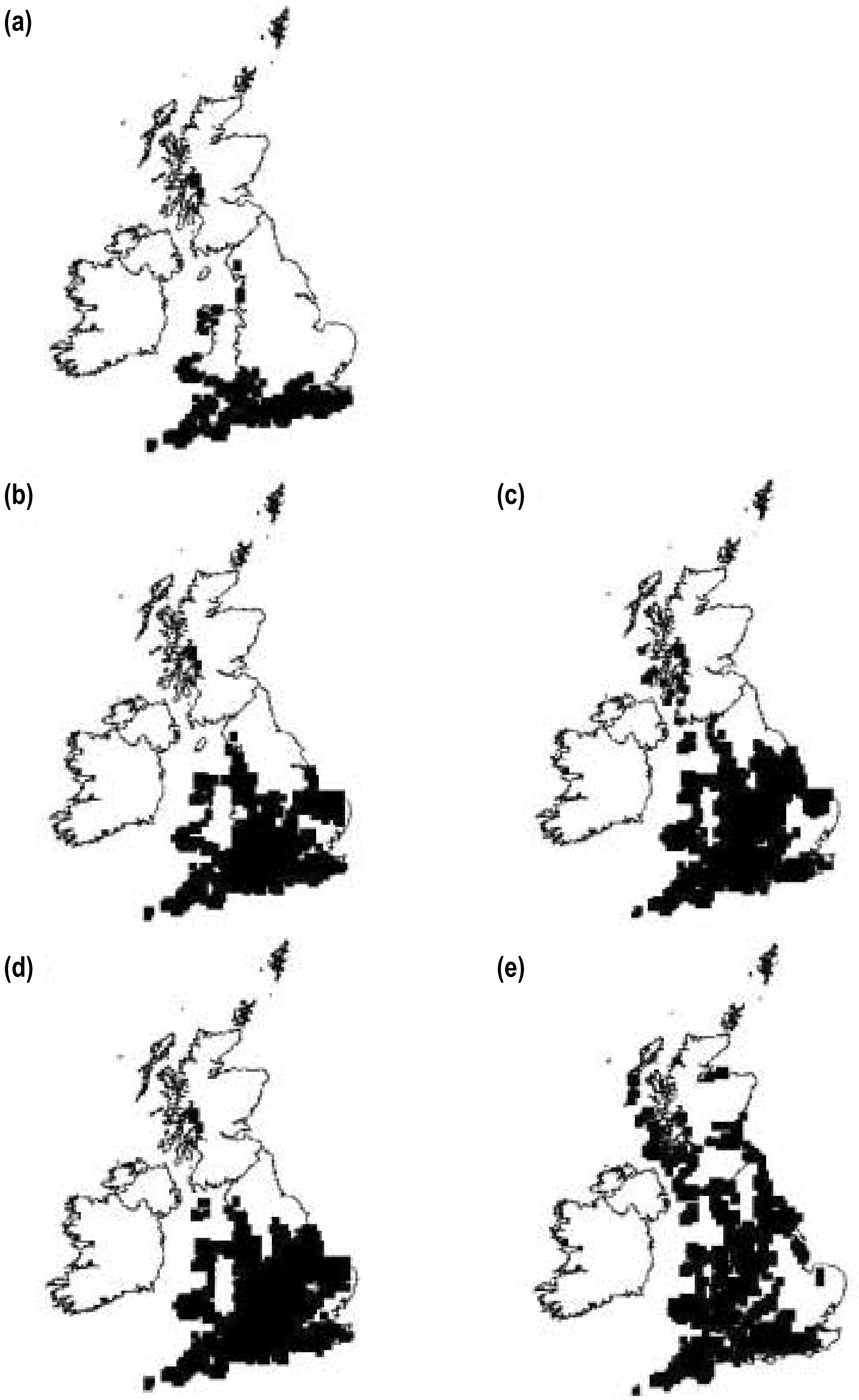


**Figure 14a: Current and future distribution of beech (*Fagus sylvatica*) using the SPECIESv1 model and the UKCIP98 climate change scenarios:** (a) simulated current distribution (1961-90); (b) 2020s low scenario; (c) 2020s high scenario; (d) 2050s low scenario; and (e) 2050s high scenario. *Source: Harrison et al. (2001)*

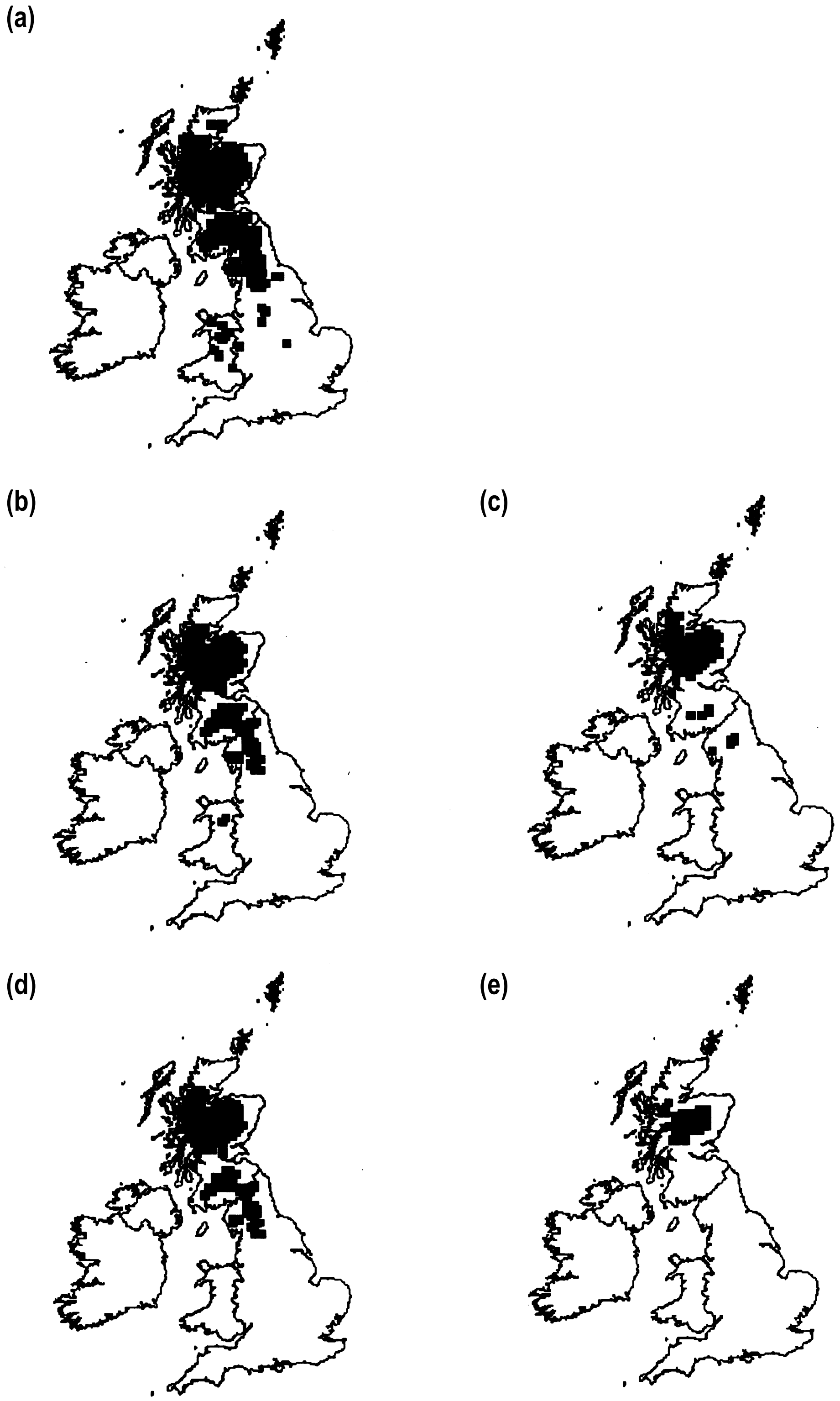


**Figure 14b: Current and future distribution of bog rosemary (*Andromeda polifolia*) using the SPECIESv1 model and the UKCIP98 climate change scenarios:** (a) simulated current distribution (1961-90); (b) 2020s low scenario; (c) 2020s high scenario; 2050s low scenario; and (e) 2050s high scenario. *Source: Harrison et al., 2001.*

seeds in order to continue the survival of the species by establishing one successor. In the garden or nursery, seedlings and young plants are grown in carefully controlled conditions, using sterilised compost for example, and are only planted in the open ground at a later, more robust stage of the life-cycle, into carefully prepared sites. It is unusual to see natural seeding of the great majority of our garden plants in gardens.

The effectiveness of all these cultivation practices is clearly evident when one compares the very poor native flora of the UK, estimated at 1500 species, with its immensely rich garden flora of 10000-15000 species (Royal Horticultural Society, 1992) or the 70000 taxa (species, subspecies, varieties and cultivars) listed in *The RHS Plantfinder* (Lord, 2002). The very wide geographical distribution of many garden plants throughout England, Scotland and Wales, and the ability of plants produced in Italian, German or Dutch nurseries to acclimatise more or less successfully to British gardens, all testify to the ability of plants to tolerate a much wider range of conditions in cultivation than they would normally experience in the natural environment.

Because of these advantages, garden plants are very elastic in their response to environmental conditions, and are likely to display a similarly elastic response to climate change. However, some changes in the garden flora will undoubtedly occur as a result of increasing temperatures and, especially, changing patterns of precipitation. Where conservation of the existing plant population of a garden is a high priority, for example in historically important designed landscapes or in gene banks of particular species, careful management will be required to accommodate and adapt to changing conditions.

Two key factors influencing the tolerance of garden plants to climate change will be their hardiness and their water requirements.

**In gardens, plants grow in very favourable conditions. They are usually propagated in controlled conditions, planted into carefully prepared ground and protected to a greater or lesser degree from pests and diseases and especially from competing plants. In such conditions, the elasticity of response to climate change is very much greater than in nature. Two factors are particularly important in determining climate change impacts: hardiness and water availability.**

#### 4.2.1 HARDINESS OF GARDEN PLANTS

Low temperature tolerance varies greatly amongst garden plants. Some plants, for example dahlias and *pelargoniums*, will not survive even short periods below freezing, while others will tolerate temperatures of -40°C or lower.

The United States Department of Agriculture (USDA) developed a system for defining plant hardiness by dividing the United States into ten hardiness zones based on 6.25°C bands of average annual extreme minimum temperatures (the lowest temperature recorded in each year averaged over a number of years). These bands extend from zone 1 (eg, central Alaska) where the average annual extreme minimum temperature is below -46°C to zone 10 (eg, southern Florida) where the annual extreme minimum temperature is between -1°C to 4°C. In the context of the large land mass of the United States, the zones run in more or less parallel east-west bands across the country, curving southwards across the major mountain ranges and northwards as the moderating influence of the Atlantic and Pacific Oceans on winter temperatures is felt along the coasts.

The USDA system has also been adopted in Europe (Krussmann, 1984; Royal Horticultural Society, 1992; Schacht and Fessler, 1990) but in Europe as a whole, and especially in the UK, the zones are much less neatly defined (Figure 15). The patchy influence of changing altitude on temperature and the moderating influence of the sea are greater than the smooth influence of latitude is in Europe, compared with the United States.

The relationship between hardiness zones and plant survival is also less clear, because milder winter temperatures in the UK are not currently accompanied by high summer temperatures. In particular, the uncertain progression from autumn to winter to spring in the UK frequently leads to winter damage of young twigs which were not sufficiently matured or 'ripened' in the previous summer, and to frosting of premature growth in spring. Plants such as sugar maple (*Acer saccharum*), redbud (*Cercis canadensis*) and flowering dogwood (*Cornus florida*) tolerate very low temperatures in the northern United States but are much more temperamental in the UK.

As a broad generalisation, however, much of the UK equates to zone 8 (-12°C to -7°C), the Scottish highlands to zone 7 (-17°C to -12°C), and the southern and western coastal fringe to zone 9 (-7°C to -1°C) (Figure 15). Significantly, zone 9 plants include *Abutilon vitifolium*, *Callistemon*, *Carpenteria californica* and *Phlomis fruticosa*, which can now be found thriving in many gardens in the south west and in sheltered locations much farther north.

The 1-4.5°C rise in mean temperature anticipated by the 2080s by the UKCIP02 scenarios equates to about half a zone in the USDA scheme. Although mean *annual* temperature and mean *annual extreme minimum* temperature are very different, this comparison does serve to put the temperature effect of climate change in the UK into some kind of context. Most plants currently growing in UK gardens would be expected to survive a temperature lift of this magnitude, especially as it has been estimated that 85% of plants grown in UK gardens originate from areas with warmer climates (Thoday, *pers. comm.*).

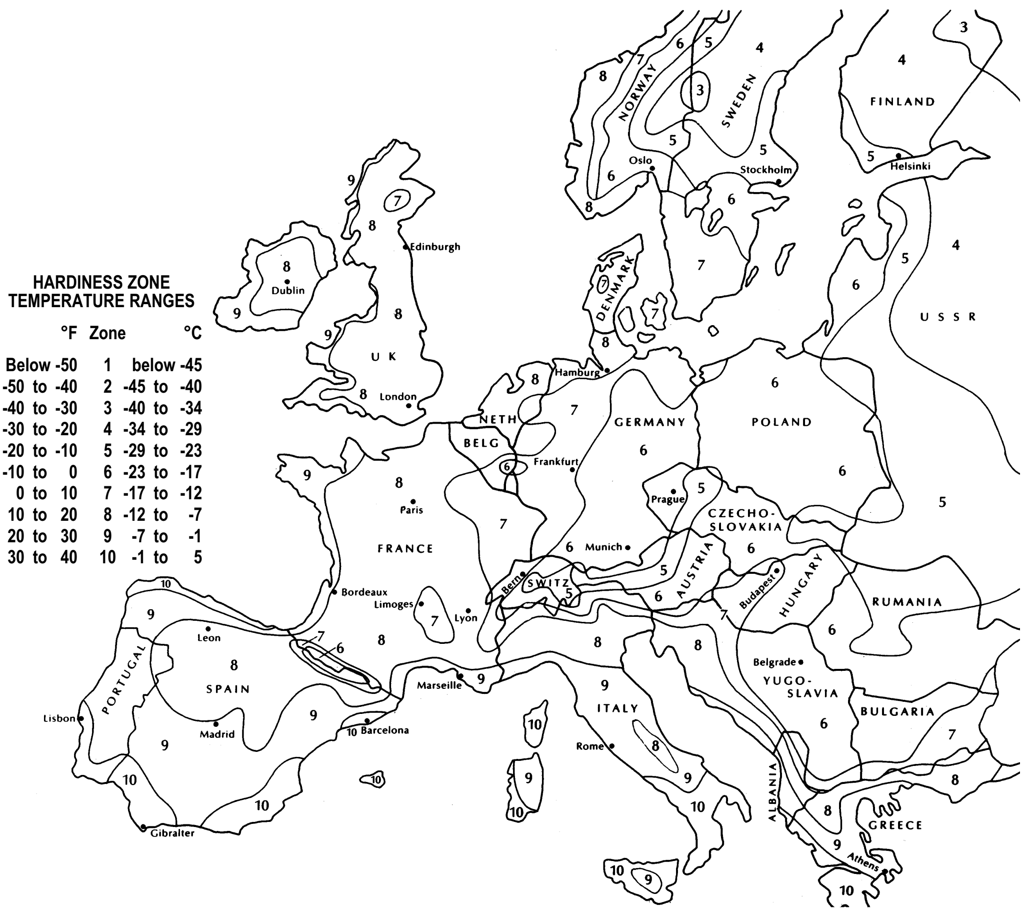


**Figure 15: The USDA hardiness zones applied to Europe.** *Source: Schacht and Fessler, 1990.*

Sukopp and Wurzel (2000) suggest that the heat island effect of major cities also lends support to the conclusion that many plants will adapt readily to the increasing temperatures predicted by the climate change scenarios. Native and exotic plants survive at least as well in cities, where the mean temperature is often 2-3°C warmer, than they do in surrounding rural areas.

The response to temperature is further complicated because the variations in microclimate within a single large garden are probably equivalent to the variation occurring on the macro scale across at least half of England. If there is a great desire to grow a particular plant, much of the change anticipated in plant tolerance as a result of climate change could, for several decades at least, be compensated for by moving plants to more sheltered or more shaded situations for example, though of course only if the plants are small enough and tolerant enough to be moved. This might also apply in special circumstances to heritage gardens where a particular plant needs to be conserved, but it would not apply, of course, if the particular plant had an historically determined particular place.

**A scale of hardiness developed initially in the United States, from zone 1 (Alaska) to zone 10 (Florida), has also been adopted in Europe. On this scale, most of the UK falls into zone 8, with the Scottish highlands falling into zone 7, and the southern and western coastal fringe to zone 9. The average annual temperature change anticipated by the UKCIP02 low and high emissions scenarios by the 2080s is equivalent to about half a zone.**

**Hardiness and satisfactory growth and flowering are more complex than the ability to withstand a particular minimum temperature. Some North American plants, in particular, are tolerant of low temperatures, but will not grow well in Britain because of cool summers and an erratic transition from autumn to winter to spring. Climate change will favour the growth of some of these plants and will encourage good autumn colour in these and many other plants.**

#### 4.2.2 WATER AVAILABILITY AND GARDEN PLANTS

Although higher temperatures anticipated by climate change scenarios are, in themselves, unlikely to have a major impact on the garden flora, the relationship between temperature and water availability will be of critical importance to survival of many plants. If the expected climate changes were limited to higher temperatures and drier summers, it would not be at all difficult to find plants tolerant of the climate conditions suggested by the UKCIP02 scenarios for the 21st century. A rule of thumb of looking for parallels about 150km further south for each °C could be used (see Ciesla, 1995; van de Geijn, 1998).

However, most of the plants used in ‘dry’ or ‘waterwise’ or ‘xeriscape’ gardening are intolerant of the winter wet, and increased winter rainfall is a component of all the UKCIP02 scenarios. By the 2080s winter precipitation is likely to increase by 10-30% across the UK with regional variations. But increased winter precipitation will not necessarily lead to wetter soils. This is because the warmer, drier summers and autumns expected could substantially reduce soil moisture content before the onset of winter, particularly in the south and east where soils may become some 20-50% drier by the 2080s. By the 2080s, winter soil moisture contents are expected to increase by around 4% in parts of Wales and south west England, and by 4-10% in Scotland, while parts of south east and north east England could see a 10% reduction in winter soil moisture. Annual soil moisture content is expected to decrease by 10-20% across the UK by the 2080s with regional variations. The impacts of increasing winter rainfall may, therefore, not be as serious as the figures of precipitation change imply.

The local setting of the garden will be important in determining the impact of hydrological changes. Clearly, only coastal gardens or those in low-lying areas near the coast will be affected by increases in sea level, although gardens farther inland may suffer from increasing salt spray damage. Low-lying areas inland, such as the Bedfordshire Plain, may suffer from increasing flood risks in periods of heavy rain. Most larger gardens from the early 18th century onwards were consciously sited on eminences for the prospect which that afforded

(Bisgrove 1978), and so should be at lower risk of inland flooding as winter rainfall increases, though they will be at risk from summer drought.

Soil type will also be important. On light, sandy soils, increased winter precipitation is likely to be advantageous, replenishing the water resources depleted in hotter and drier summers. There will, though, be some increased leaching of nutrients from the soil. On heavier soils and in low-lying areas (the two situations are often linked, because clay deposits occur on flood plains and old lake beds), higher winter rainfall could lead to an increased risk of waterlogging. Improved soil drainage and careful positioning of plants (perhaps in raised beds) may assist in countering wetter winters but the effects of long periods of higher humidity, surface wetness and low light conditions will not be so easily remedied. Plants in raised beds will also be more susceptible to summer drought.

Another important factor in relation to increased winter rainfall is its intensity. A greater proportion of winter rain is expected to fall in more intense downpours. If the soil is capable of absorbing large amounts of water quickly, the garden will benefit fully from the higher rainfalls anticipated by climate change scenarios. If it is not, water will run off across the surface, causing erosion and possibly flooding, and it will be lost as a resource to the garden. Dawson *et al*. (2001) (using the UKCIP98 scenarios) suggest that by the 2050s run-off could increase by up to 20% in the winter and decrease by as much as 20% in the summer, with the largest changes in the south and east. Good soil husbandry will play a very important role in allowing plants and gardens to adapt to this aspect of climate change.

Given the continued survival of traditional gardening skills, it will be possible for the garden plants to survive fairly substantial changes in climate. Indeed, the lessons offered by long established garden maintenance techniques are being recognised increasingly as analogous to techniques which could be required in the wider aspects of landscape and nature conservation, if fragile habitats such as relict alpine meadows, lowland heaths and fens are to survive and adapt to climate change.

**Winter precipitation is expected to increase across the UK. However, increased precipitation will not always lead to increased soil moisture content. By the 2080s, slight increases in winter soil moisture content are expected in south west England, Wales and Scotland, but annual soil moisture content may decrease by 10%-20%, with regional variations. Rainfall intensity is likely to increase in winter, increasing the risk of flooding. It may be difficult to find plants that will tolerate hotter drier summers but also survive wetter winter conditions, particularly in gardens with heavy soils.**

### 4.2.3 CLIMATE AVERAGES VERSUS WEATHER EXTREMES

Although plants may survive significant changes in average temperature and average precipitation rates, it is important to realise that climate change will not come as a smooth gradient of change, but as the accumulation of a very large number of fluctuations about a mean. Weather will remain variable in future, and extreme conditions will occur. These would have more immediate impact on the garden than average changes in climate would. A week-long heat wave, a night of severe frost, drought, floods and very high winds, for example, will stress most garden plants and kill the more sensitive ones.

As part of this study, fourteen garden managers were asked to cite any examples of extreme weather events in the past five years that had affected their gardens. All ten respondents listed events ranging from heavy or prolonged rain (7 responses), through frosts and prolonged cold spells (5), high winds (5), floods (2), drought (2), variable rainfall (1), mild winters(1), very warm springs (1), unusually high/low temperatures (1) and deep snow (1).

Eight respondents thought that extreme weather events had become more frequent during their careers (two of these adding the qualification, “without doubt”). Another thought that extreme weather events were now so common that they no longer justified the term ‘unusual’. These responses do not constitute hard evidence for the existence of climate change: not all of the phenomena listed are necessarily associated with climate change and the recollections might well be biased by the freshness of recent events. However, they do offer some indication of recent climatic impacts on gardens and, by analogy, illustrate the effects and reactions which many of the components of climate change anticipated by the UKCIP scenarios are likely to create.

**Climate change – long term changes in temperature and precipitation, for example – is the result of averaging widely variable daily, monthly and annual weather conditions. Short term weather events will have more immediate impact on the garden than will long term changes in climate.**

**Plants in gardens will be less vulnerable to climate change than plants in natural habitats, because of the management they receive. However, climate change will have significant impacts on garden plants and additional management inputs will be required to reduce adverse impacts.**