

Research and further actions

This desktop study has brought together material from a wide range of sources to explore the potential impacts of climate change on gardens. Of necessity, its focus has been wide more than deep, and in many areas its conclusions have raised as many questions as they have provided answers.

One of the main objectives of this report was to identify gaps in our information on the impacts of climate change on gardening, heritage gardens and the garden industry and, from these gaps, to define a future research agenda. While this is not an exhaustive list, several areas for further investigation have been identified. These are outlined below.

9.1 Climatological research

9.1.2 CLIMATE CHANGE SCENARIOS

Climate impacts on particular gardens will be strongly influenced by their regional climate. Scenarios at a higher spatial resolution would facilitate climate impacts assessments for gardens.

9.2 Horticultural research

9.2.1 FROST SENSITIVITY

There is some doubt as to whether plants will be more or less damaged by frost with climate change. Further research is required to establish whether plants will be more likely to suffer damage as a result of frosting of precocious growth, or less likely to suffer damage because of reduced frequency and severity of frosts.

9.2.2 THE EFFECTS OF WARMER WINTERS ON DORMANCY AND PLANT DEVELOPMENT DURING DORMANCY

There is a substantial literature on dormancy, but the impacts of higher winter temperatures on growth, flowering and fruiting of garden plants needs more attention, as does its effects on winter hardiness. The possible interactions with elevated

carbon dioxide concentrations also merits further study. Defra is looking towards funding research in this area.

9.2.3 AUTUMN COLOUR

Summer drought may result in premature leaf senescence and higher autumn temperatures in delayed leaf fall. The potential impacts of climate change on these precursors of winter dormancy have not been studied in any detail, unlike spring emergence from dormancy, but they could have considerable implications for the appearance of gardens in the autumn.

9.2.4 PLANT HARDINESS

Hardiness is determined not just by innate tolerance to freezing temperatures, but also by the conditioning of the plant in the previous summer or autumn. More refined maps of hardiness zones would enable informed judgements to be made on appropriate adaptations to climate change.

9.2.5 CARBOHYDRATE CONCENTRATIONS IN PLANTS

The effects of increasing carbohydrate concentrations in plants on flowering, autumn colour, and susceptibility to pests and diseases needs further investigation.

9.2.6 PESTS AND DISEASES

The incidence and virulence of pests and diseases in future, needs further investigation, with particular emphasis on phenology, monitoring and environmentally sensitive control.

9.2.7 WEEDS AND POTENTIAL WEEDS

The introduced plants which are currently causing concern in the UK, notably Japanese knotweed (*Fallopia japonica*) and *Rhododendron ponticum*, were in cultivation for a century or more before they became problems. It is important to understand why this should be, to review the various

causes of exotic plant infestations in other parts of the world, and to establish which plants have the propensity to become problems in the UK as a result of climate change.

9.2.8 THE RELATIONSHIP BETWEEN PLANTS AND SYMBIOTIC SOIL FUNGI AND BENEFICIAL MICRO-ORGANISMS

Climate change may have significant impacts on mycorrhizal and other symbiotic associations, both directly and indirectly by influencing the host plant. A greater understanding of these relationships may result in the ability to offset adverse effects of climate change on trees, for example, by increasing mycorrhizal activity.

9.2.9 LAWNS

Lawns already receive considerable research input, mainly because of the importance of grass surfaces for sports. Most of this research is focused, however, on highly managed surfaces such as golf greens and football pitches. More research is needed, and the results of previous research on agricultural grassland and ecologically important grassland communities need to be reinterpreted, to meet the needs of gardeners seeking to adapt to the particular conditions imposed by climate change. Ways of managing lawns in wet conditions during late autumn, winter and early spring require specific investigation.

Mower manufacturers would do well to look at possible changes in mowing technology, to reduce compaction risk and perhaps to reduce the impacts of mowing on the environment.

9.3 Research on soils and water

9.3.1 SOILS

Soil is, in every sense, fundamental to the garden. Research into the fluctuations and fate of soil nitrogen and the dynamics of the relationship between nitrate release and uptake by plants or loss by leaching will have far reaching implications for gardens. Research into the dynamics of gain and loss of soil organic matter should also be considered a priority.

Mitigation of climate change is not within the scope of this present study, but it must not be forgotten that management of soil carbon (as organic matter) will have impacts on mitigating the effects of climate on gardens *and* on the mitigation of climate change itself.

9.3.2 WATER SUPPLY AND DEMAND

Further analysis of the potential demand for water in gardens on a regional basis will highlight problems of supply, and foster examination of possible methods of reducing or meeting water demand

Further research and dissemination of good practice is also needed to prevent loss of water quality in ponds and lakes as a result of climate change and to explore the possibilities of storage and recycling of rain and 'grey' water in domestic gardens.

9.3.3 WATERLOGGING

Amelioration and/or remediation of winter waterlogging and its effects on the growth of mediterranean plants requires further investigation. Predicted warmer winters and hotter, drier summers will encourage gardeners to grow more mediterranean plants, which are increasingly popular, but wetter winters will pose problems for these plants, which are generally intolerant of winter waterlogging. The suggested topic is a particular aspect of the wider issue of water management and one which is a practical issue for amateur gardeners, who will want to exploit the opportunities to grow a wider range of exotic plants in an environment of increasingly variable water supply.

9.4 Economic research

9.4.1 GARDEN VISITOR PATTERNS

Greater awareness is needed of visitor behaviour in a garden, so that gardens may better cater for visitors' needs. Better understanding of the factors influencing visiting is also required to inform marketing strategies in present and future climates.

9.4.2 INDUSTRY RELEVANT RESEARCH

Technical investigations into improved production systems, including improved water management, ventilation or cooling systems for greenhouses, management and timing of production of novel crops, is required. Market research is also needed to gain a better understanding of customer behaviour and requirements.

9.4.3 HERITAGE SECTOR

More research on climate change effects for heritage gardens and landscapes is needed. English Heritage has commissioned UCL's Centre for Sustainable Heritage to undertake a scoping study to investigate likely risks and potential mitigation and adaptation strategies for the historic environment. The scoping study will be published in 2003. Climate change impact monitoring is also identified in the heritage sector's forthcoming annual *State of the Historic Environment* report.

Specific heritage garden research will also be needed to identify resources and level of investment required to maintain the quality and integrity of these gardens and the criteria for the management of significant plant collections on a national basis. The National Trust, for example, plan to assess the climate change risks facing its own parks and gardens. The value of conservation management plans as tools for managing change needs to be promoted; and the training and education of professional gardeners needs to be supported to ensure the availability of skilled staff to manage these sites in the future.

9.5 Networks

9.5.1 A GARDEN NETWORK

The literature reviewed for this study suggests that the outcomes of much of the research outlined above will be varied and dependent on complex interactions. Interdisciplinary research at the level of the whole plant and plant community is needed. More needs to be understood about the role of gardens and parks in relation to biodiversity, nationally and internationally and how they

might provide 'connectivity', in the form of green corridors, to ensure wildlife migration as climate zones shift.

A garden network is needed to exchange and coordinate observations, ideas and actions, and to communicate the effects of climate change on gardens widely. The network should highlight solutions to management problems and identify areas for further research relating specifically to the impact of climate change on gardens.

9.5.2 TOWARDS A *HORTUS EUROPEUS*

Flora Europea (Tutin *et al.*, 1964) maps the natural distribution of plant species in Europe (see Figure 17 for examples). The parallel development of distribution maps for selected garden plants as a basis for (and result of) phenological mapping would provide a valuable resource in determining the actual and potential response of garden plants to climate change. It would also facilitate studies of plant hardiness and refinements to the concept of hardiness zones referred to in section 9.2.4 above.

There is clearly scope for, and great benefit in, relating garden plant phenological records with those of native plants, many of which contribute to gardens as well as to the wider landscape. Links with the International Phenology Garden Network, established in 1957, would be particularly useful in enabling comparisons with countries which currently have climates similar to those anticipated for the UK by the UKCIP02 climate change scenarios.

Data on responses of garden plants to changes in weather and climate are continually collected by UK gardeners. Systematic gathering of even a small proportion of this information through professional organisations would add significantly to our understanding of what will grow, and where.

9.5.3 AN INDICATOR SPECIES LIST

A list of genetically uniform plants which can be grown in a wide range of gardens should be developed to monitor the effects of climate change in gardens. The survival (tolerance of low and perhaps of high temperatures) and phenological data

of these species should be collected. Plants which might not be expected to survive the winter in many situations should be included in the list to investigate hardiness.

9.6 Policy development

The garden network (above) should be used to disseminate an understanding of the importance of gardens in the national culture, so that they receive a rightful place in policy formulation. Nature conservation is achieved by a range of statutory designations and controls, but garden conservation does not receive such attention. The environmental and cultural benefits inherent in sensitive management of the garden heritage underline the importance of gardens in responding to the impacts of climate change. It is, therefore, important to ensure that gardens in all their diversity receive proper attention when matters of national and European policy are being developed.