



Cambridge University

**Botanic Garden**

# Plants and Climate Change Trail

Our climate is changing. How plants respond will depend on their adaptations and ecology. Some plants will adapt or expand their range; others will unfortunately go extinct.

The University of Cambridge has launched an ambitious new climate change initiative, Cambridge Zero, aiming to bring together the brightest minds to create a zero-carbon future. Plants – and the research on them facilitated by Cambridge University Botanic Garden – will play an important role in this endeavour.

This trail is focused on how plants are likely to respond to climate change, plantings that have been designed to cope with a changing climate, and plants that could be used in the battle against climate change and its impacts.

**See an online version of this trail  
at [www.botanic.cam.ac.uk/climatechange](http://www.botanic.cam.ac.uk/climatechange)**

# Plants and Climate Change

The global average surface temperature has increased by 1°C since the late 19th century. We are already seeing dramatic impacts across the world associated with this rise in temperature: extreme weather events such as floods and heatwaves, reduced snow and ice, and a rise in sea levels. In 2019, Cambridge broke the record of the highest temperature ever recorded for the UK: 38.7°C on 25 July here at the Botanic Garden. Since then, we have seen even hotter days, peaking at 39.9°C in 2022.

The scientific evidence shows that the dominant cause of the temperature rise has been the activities of people, which have increased the amount of carbon dioxide and other greenhouse gases in the atmosphere. These activities include the burning of fossil fuels, the clearance of forests, and agricultural practices that damage soils. Unless we dramatically cut our emissions, climate change will continue, threatening our food and water supplies, our health and our prosperity, as well as the biodiversity upon which we depend.

All the top ten warmest years for the UK in the records since 1884 have occurred since 2002. It is likely we will see hotter, drier summers in the future, with reductions in summer rainfall being more pronounced in the southwest. It is also likely we will see warmer, wetter winters, with increases in winter rainfall being most notable around the coast, especially in the very north and very south. The UK coastal flood risk is expected to increase as the sea level rises.

Cambridge is already one of the driest cities in Western Europe, getting an average of 557 mm of annual rainfall over the last 30 years. It is predicted to experience increased temperatures and shortage of water at certain times of the year, with prolonged periods of hot drought possible, especially in summer.

Plants are responding to these changes. Oak now comes into leaf nearly a month earlier than it did in the 1950s. Snowdrops appear almost two months earlier than they did in the 1950s.

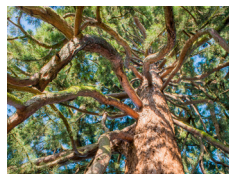
Plants and natural ecosystems can help mitigate the rise in global temperatures. In addition, natural climate solutions provide increased habitat for biodiversity, and increased resilience to the impacts of climate change.

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## Giant Redwood (*Sequoiadendron giganteum*)

### Can tree planting save the planet?

Trees lock away carbon in their wood and foliage as they grow and larger trees like this giant lock away more. Planting trees is becoming an increasingly popular tool for offsetting carbon dioxide emissions from flights. Only 13% of the UK is now wooded, down from almost complete coverage 8,000 years ago. Europe still has on average 37% woodland coverage, so there is much capacity to increase tree coverage in the UK. However, tree planting needs to be done sensitively and the right species needs to be planted in the right place. There is unfortunately not enough space to plant sufficient trees to offset all our carbon emissions. To meet climate reduction targets, we must not lose focus on reducing emissions by burning less fossil fuel and limiting deforestation. Find out how much carbon this tree locks away by visiting this point on the trail.



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## Lantana (*Lantana camara*)

### Innocuous garden plants primed for escape

*Lantana camara* is considered one of the most invasive species in the world. It has invaded more than 60 countries, causing major economic losses in many. In Europe it is still considered an attractive ornamental plant. Its range in countries such as Australia and South Africa is expected to increase under predicted climate change scenarios.



Only a few ornamental plants escape the garden to establish themselves in the countryside ('naturalise'), and even fewer go on to negatively affect native biodiversity (becoming 'invasive'). However, in Britain in particular, non-native garden plants represent a huge pool of potential future invaders, and a warming climate increases the overlap between current cultivation areas of ornamental plants and their naturally suitable climatic conditions. Species such as the pink evening primrose (*Oenothera speciosa*) and the garden lupin (*Lupinus polyphyllus*) are amongst many on a watch list of potential garden plants primed for escape.

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### Larch (*Larix decidua*)

#### Plants out of sync with friends and enemies

Every year as spring advances, a complex dance unfolds. Trees burst into bud as frosts subside and hungry caterpillars hatch to feed on soft juicy new leaves. Bees and butterflies emerge to pollinate flowers. These species are in sync with each other by relying on environmental cues. As temperatures warm, plants flower and trees burst into bud earlier and a mismatch between interdependent species may occur. The sex lives of plants may become bleak due to the loss of a specialised pollinator, as in the case of the early spider orchid. *Larix decidua*, on the other hand, is benefitting from a mismatch with the emergence of its nemesis, the larch bud moth. Large historical outbreaks of the caterpillar have not recurred as the climate has started warming, and new leaves emerging earlier are escaping their attentions. Great for the plant, but perhaps not so great for the birds who depend on the caterpillar for food.

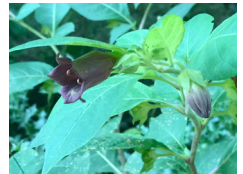


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### Deadly Nightshade (*Atropa belladonna*)

#### Plants bucking the trend

As the climate warms, spring arrives earlier. Germination, leaf emergence, flowering and fruiting, have all advanced in concert with these warming trends. However, there are some plants responding in unexpected ways. Timing of flowering is controlled by multiple, complex pathways related to temperature at different points in the plant's life cycle. Those bucking the trend seem to be responding to a lack of chilling occurring over the winter period due to warmer winters. Hence the sum of two opposing drivers results in some plants responding differently to the majority. *Atropa belladonna* now actually flowers later because of the lack of winter chilling, while *Acer pseudoplatanus* flowers at the same time as before, due to the two drivers cancelling each other out. Which other species have you spotted doing something different to what is expected?



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## Fen Display

### Wetlands as secret weapons in the fight against climate change

Natural wetland habitats like the peat bogs and fens in lowland England are a major carbon sink as they lock the carbon into the soil in the form of peat. Peatlands in the UK are thought to store more carbon than all the woodlands in the UK and France combined. Peat is formed due to waterlogged, anaerobic conditions inhibiting decomposition of plant matter. However, because of widespread fen habitat modification and drainage across the Fens to support agriculture and peat extraction, these habitats have been converted from natural carbon sinks into major carbon sources. Lowland peats under intensive arable agriculture in East Anglia are probably the UK's largest land-use derived source of carbon emissions. Our Fen Display recreates a typical lowland fen in miniature. Find out what you can do to reduce peat extraction by visiting this point on the trail.

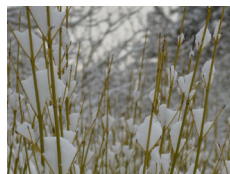


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## Dogwood (*Cornus sericea*)

### Supporting climate change research

With access to many species within a genus growing in one place, botanic gardens can study different responses of related plant species to climate change. For example, within the genus *Cornus*, most species avoid seasonal freezing of woody tissue by supercooling (where water is cooled below 0°C without solidifying), but there is a temperature below which this is no longer possible. Some species, like the red osier dogwood, have evolved to tolerate lower temperatures by recruiting special proteins in the cells to help prevent drying out when ice forms externally, which has allowed them to expand their range northwards (laboratory tests have shown that the red osier dogwood can survive down to the unnaturally low temperature of -269°C, the temperature of liquid helium!). Studies like these will help us to model shifts in species range in response to climate change. Botanic Garden staff also routinely identify species that used to grow well but no longer do, or those recently able to survive beyond the confines of the glasshouse due to less frequent frosts.



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Contributions to the content of this trail have been made by Cambridge Zero and GFS.

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**ZERO**







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## ***Eucalyptus* spp.**

### **Climate change-enhanced wildfire and drought – and the plant making it worse**

*Eucalyptus* species have an amazing suite of adaptations. They are fast growing and well adapted to fire. They have volatile, highly flammable oils in their leaves making them more likely to catch fire. They are also extremely thirsty plants, causing major problems in climate change-induced, drought hit regions like Cape Town where it is invasive. They are also known to release chemicals which inhibit the growth of plants growing nearby. Finally, they are one of the highest emitters of isoprene, and have been shown to increase these emissions when stressed. Isoprene emissions from plants substantially affect the physical and chemical properties of the atmosphere through their influence on greenhouse gases. All in all, despite their renowned economic value in timber plantations, these are trees that will become less and less appreciated in certain regions of the world as temperatures rise.



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## ***Oryza sativa***

### **Food plant under threat from climate change**

Rice is a cereal that provides food for half the world's population. This vital crop is seriously threatened by climate change and disease. Around 40% of rice is grown at higher altitudes in rain-fed fields; decreased rainfall due to climate change will reduce productivity. A larger proportion of rice is grown in rice paddies in lower lying and coastal areas, especially in Asia. Here, rising sea levels could flood rice-growing areas and increase soil salinity, preventing rice cultivation. The effects of climate change on rice will be complex – increased atmospheric carbon dioxide will tend to increase production, but rising temperatures will negate this. Meanwhile, changes in humidity and carbon dioxide concentration will affect rice's susceptibility to rice blast and other fungal diseases, and increasing temperatures will enhance reproduction of insect pests, including the leafhoppers that spread many rice-infecting viruses.



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## Banana (*Musa acuminata*)

### Food plant under threat from climate change

Bananas and their starchier relatives, plantains, are cultivated in over 100 tropical countries. Most are consumed locally and, in some regions, for example East Africa, are vital food crops. The familiar 'Cavendish' dessert banana dominates commercial cultivation and became predominant after the popular 'Gros Michel' bananas succumbed to the Panama disease fungus in the 1950s. All Cavendish bananas descend from plants raised at Chatsworth in Derbyshire in the 19th century. Unfortunately, this genetic uniformity renders them highly susceptible to disease epidemics, including novel Panama disease fungus strains. Meanwhile, black sigatoka fungus threatens banana and plantain production, especially in East Africa. Remarkably, since the 1960s, climate change has increased banana productivity. But, as we move towards the mid-21st century, temperatures in several major banana-growing regions may rise to levels that will lead to declining yields.

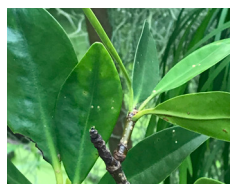


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## Mangrove (*Rhizophora mangle*)

### Mangroves as secret weapons in the fight against climate change

Located where the sea meets land, mangroves provide a natural barrier for coastal communities and whole ecosystems from storm surges, flooding and erosion. Alongside their living biomass, mangrove soils are carbon-rich, sequestering and storing carbon at great depths. Mangroves are incredibly efficient carbon stores, locking away up to 3–4 times more carbon on an area basis than their terrestrial counterparts, and act as nurseries for fish. Mangrove trees have amazing adaptations to their salty and flooded habitat. There are approximately 70 true mangrove species - *Rhizophora mangle* is just one of the mangrove tree species that make up mangrove forests. Mangroves are unfortunately highly threatened and largely overlooked by the global community for their potential role in climate change mitigation.

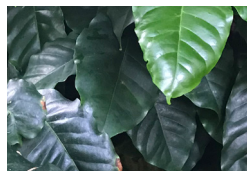


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## 11 Coffee (*Coffea arabica*)

### Food plant under threat from climate change

Coffee is grown as a cash crop by 100 million farmers, who are mostly resource-poor smallholders. Although over 120 wild coffee species exist, commercial coffee cultivation is dominated by just two species: Arabica (*Coffea arabica*), and Robusta (*Coffea canephora*). Coffee plants grow best within narrow ranges of temperature and rainfall, but around half of the land now suitable for cultivation is projected to be too hot and dry for coffee plants by 2050. Another threat is the coffee rust fungus, which affects Arabica in particular. Ideally, plant breeders would turn to wild species as sources of valuable genetic diversity to develop crops with increased resilience to drought or disease. Unfortunately, around 60% of wild coffee species, which grow in small, specialized habitats, are close to extinction due to rising temperatures and human activity.



## 12 Saxifrage (*Saxifraga berica*)

### Running to keep up

Alpine plants grow at high altitudes above the tree line. As the climate warms, alpine plants could migrate upwards to cooler temperatures. Whether plants are able to migrate up mountains to track the climate to which they are adapted will depend on their ecology and the physical characteristics of the mountain they are on, such as height. They will need to be good at colonising new areas. It will also depend on which other species they are racing against; some lowland species are outcompeting true alpine species with limited altitudinal refuges to retreat to. Mountains have many species that occur nowhere else and there is the potential for many rare, mountain species to go extinct with climate change. *Saxifraga berica* is a plant only found in the Veneto area of North Italy. It grows on very shady cool rock faces, often on cave entrances and overhangs. It hates warm weather and quickly dies if exposed to the sun's hot rays. It is threatened with extinction.



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### 13 Olive (*Olea europaea*)

#### A triple whammy! Climate change, pests and diseases

The combined effects of pests, disease and climate change on olive trees is resulting in a perfect storm. Olive trees across the Mediterranean have been hit by freak events that mirror climate change predictions- erratic rainfall, early spring frosts, strong winds and summer droughts. Olive trees are weakened by these events and even if they recover, they are also facing a deadly disease caused by a bacterium *Xylella fastidiosa* and an olive fly pest infestation in some areas. *Xylella*, originally from America, causes disease in many important crops including citrus, coffee and grapes. Outbreaks in Europe since 2013 have resulted in the death of many olive trees. The disease has not yet reached the UK, but temperature increases in southern England make it now possible to grow olive trees commercially here.



### 14 Mediterranean Beds

#### Gardening in a changing climate

In a time of climate change, our gardens can help in many ways, from reducing our emissions and storing carbon, to providing safe havens for wildlife. We should carefully consider our plantings to make them resilient to climate change. As one of the driest parts of the UK, Cambridgeshire is well suited to the cultivation of Mediterranean plants, and the predicted increase in summer drought stress because of climate change will make it even more so. Mediterranean plants, like lavender and rosemary, are renowned for their blue grey waxy leaves that reduce water loss and reflect light. *Santolina chamaecyparissus* has hairs that trap moisture and reflect heat. Med plants are represented by a high proportion of evergreen dwarf shrubs, such as *Erica* and rosemary, as well as bulbous plants that escape summer drought like the autumn flowering *Sternbergia lutea*.



## Climate Change and Biodiversity

Climate change and biodiversity loss are intertwined global issues both requiring equal attention. We are in the throes of the sixth mass extinction event, and climate change is making things worse. In turn, the loss of biodiversity is degrading the planet's capacity to regulate natural processes, exacerbating climate change.



Our understanding of global climate change has been facilitated by the Intergovernmental Panel on Climate Change since 1988, but the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (PBES) was only established in 2012. The importance of biodiversity loss is now starting to be recognised with the recent publication of the first global assessment.

Addressing climate change and biodiversity loss in isolation will fail and one can often have negative effects on the other. An integrated approach is essential. Happily, addressing climate change appropriately will have positive effects on biodiversity. Protecting biodiversity will help mitigate climate change through nature-based solutions, some of which have been explored in this trail, all underpinned by plants.

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