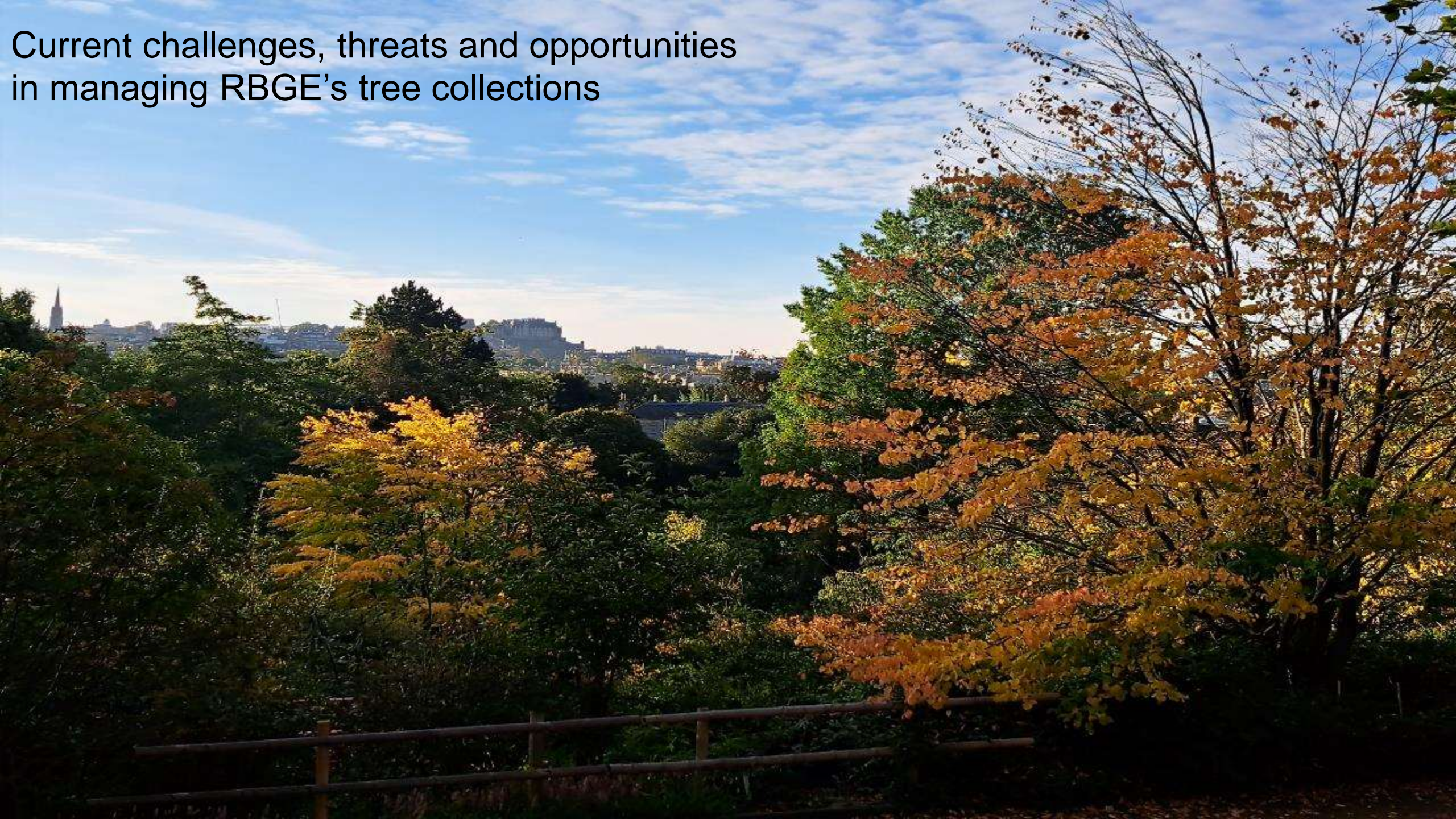


# Current challenges, threats and opportunities in managing RBGE's tree collections



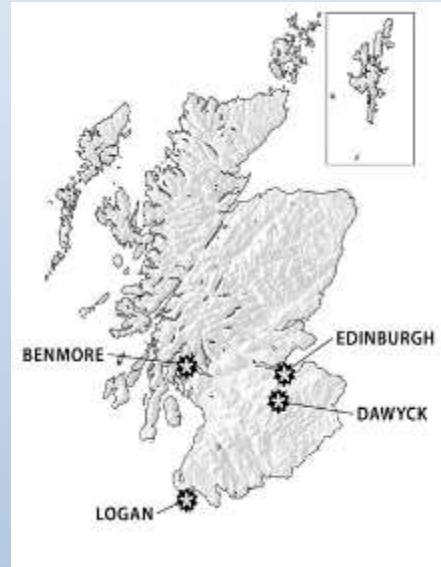


Benmore



Logan

## The Gardens



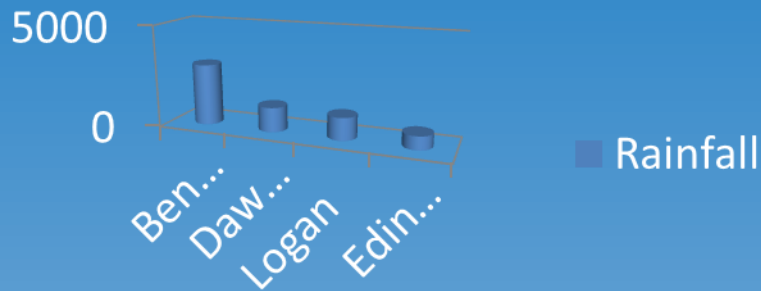
Dawyck



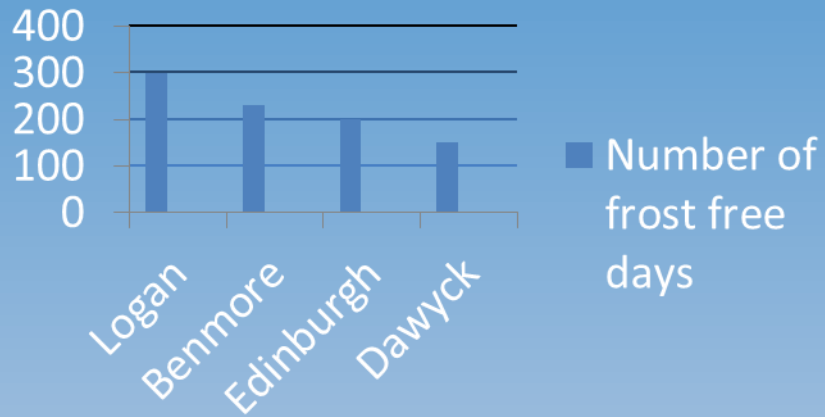
Edinburgh

# Climatic and Geographic data

## Rainfall



## Minimum Temperature



# The Living Collection

- 344 Families
- 2721 Genera
- 13 750 species
- 163 countries
- 60.8% wild origin
- 16 Plant Heritage collections
- With a significant number of trees....





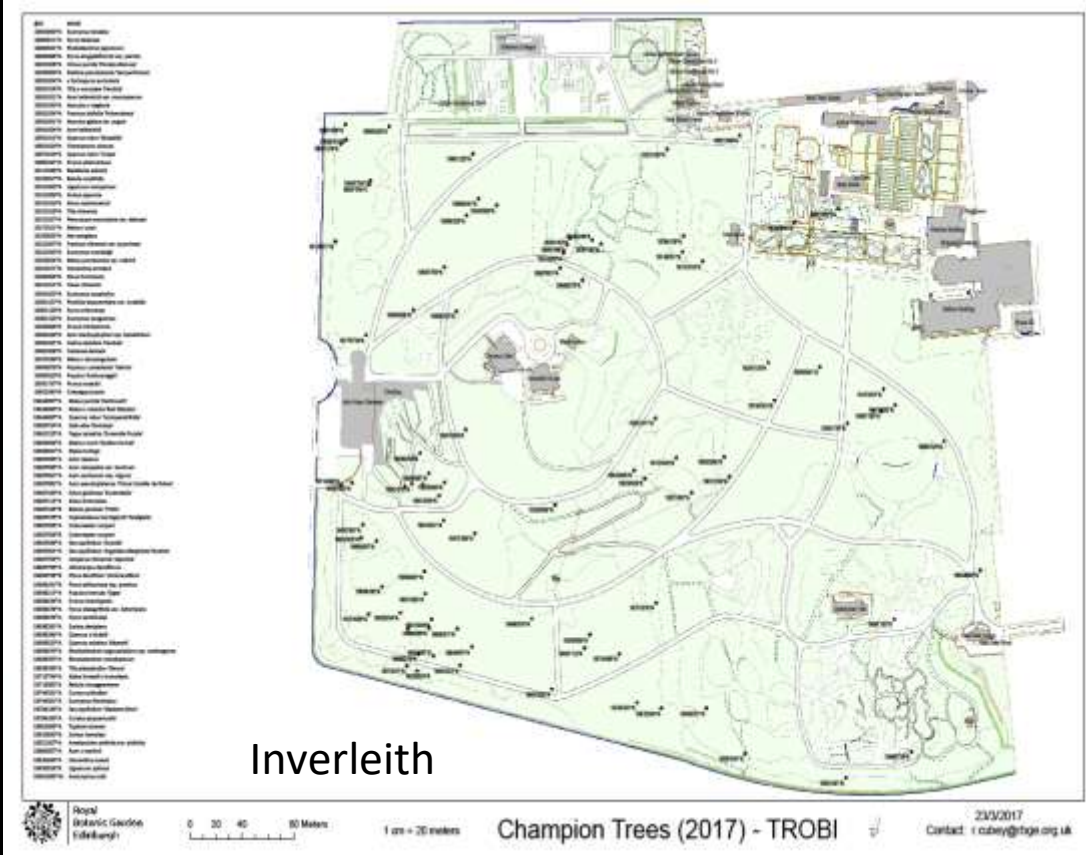
- **Inverleith**
- **Circa 3500 Trees**
- **6245 including accessed trees in conservation hedges and trees currently in the nursery.**
- **1319 Taxa**
- **250 Genera**
- **82 Families**



## Trees with the greatest number of individuals at Inverleith

- *Taxus baccata* 1277 - Conservation Hedge
- *Saxegothaea conspicua* 209 - Conservation Hedge
- *Prumnopitys andina* 163 – Conservation Hedge
- *Betula pubescens* 142
- *Pinus sylvestris* 103
- *Sorbus aucuparia* 100
- *Juniperus communis* 60
- *Magnolia stellata* 60
- *Betula utilis* 58
- *Betula pendula* 47
- *Corylus avellana* 45
- *Alnus glutinosa* 43
- *Pinus nigra* 40
- *Thuja plicata* 35
- *Chamaecyparis formosensis* 30

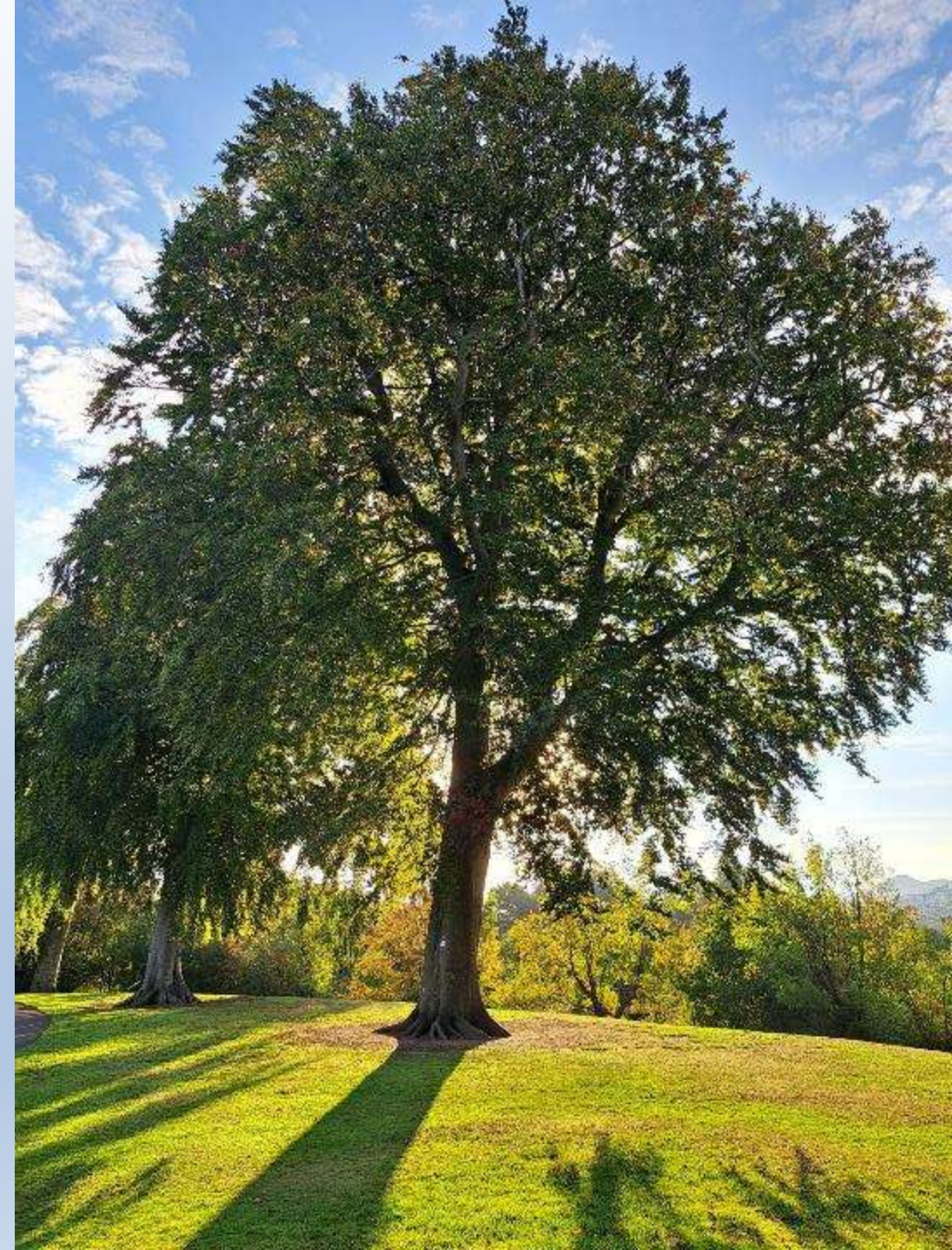
# Champion Trees



## Current Challenges –

### Climate change and the Living Collection

- In the last 15 years we have recorded the coldest, warmest, driest, wettest and windiest spells of weather
- Extreme and unseasonal temperatures both warm and cold throughout the year
- Longer drier spells, particularly in the spring/summer
- Conversely more intense rainfall events has led to flooding and to an increasing average rainfall.
- These subtle changes to the climate are and will undoubtedly have short, medium and long term impacts on the trees within the Living Collection.







## Current Challenges –

### Climate change challenges - Rainfall

- More rainfall extremes over the year.
- Drier springs.
- Wetter autumn/winter
- Above average winter rainfall.
- More intense/heavier rainfall throughout the year.
- Problems associated with fluctuating water table.
- Requires installation of more effective drains and SUDS
- Increased use of mulches to conserve water
- Increased need to irrigate
- Ensure that the right tree is in the right garden and location within each garden.

Fluctuating water table has impacted on trees both young and old

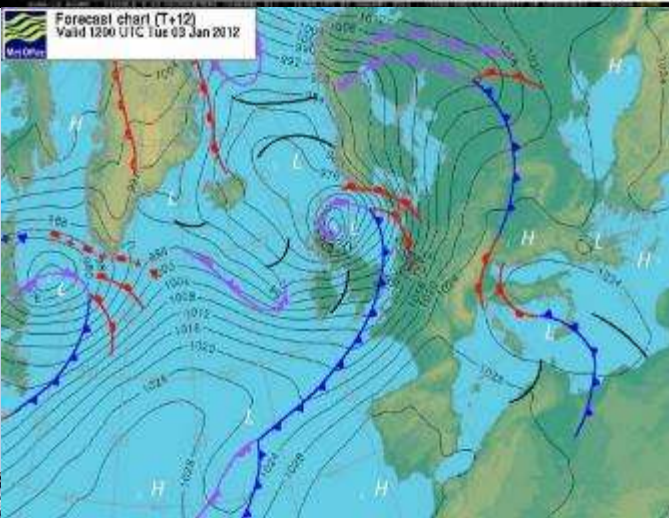
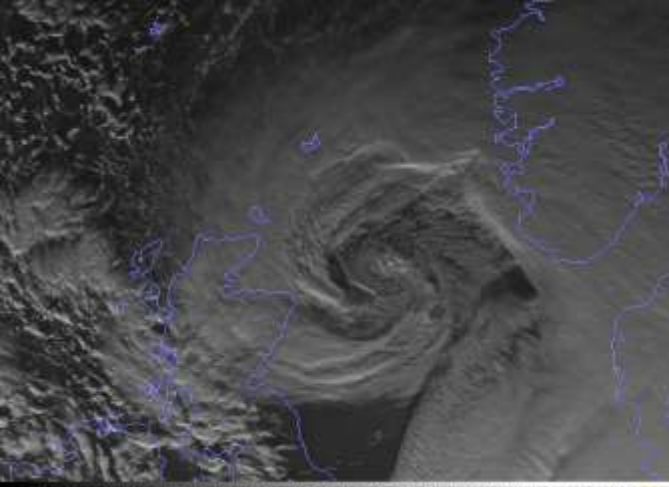




## Current Challenges

### Climate change- Temperature extremes.

- Mild winter/springs then unseasonal late frosts.
- Milder winters.
- Warmer summers – record July 2022
- Fluctuating temperatures throughout year but particularly in spring and autumn.
- Extremes of temperature can now be experienced at any time of year.
- Extended periods of hot weather [ 30C plus ] are now anticipated more frequently



## Current Challenges

### Climate change challenges -Wind

- Severe wind events are happening more frequently throughout the year, not just over the winter months but also during the spring, summer and autumn.
- Increasing damage to the plants within the Living Collection particularly trees.
- Scale and extent of devastation.
- Damage to infrastructure.
- Resultant garden closures.
- Associated additional clearance costs and loss of income.

January 2012 Inverleith



January 2012

Benmore



Storm Malik January 2022



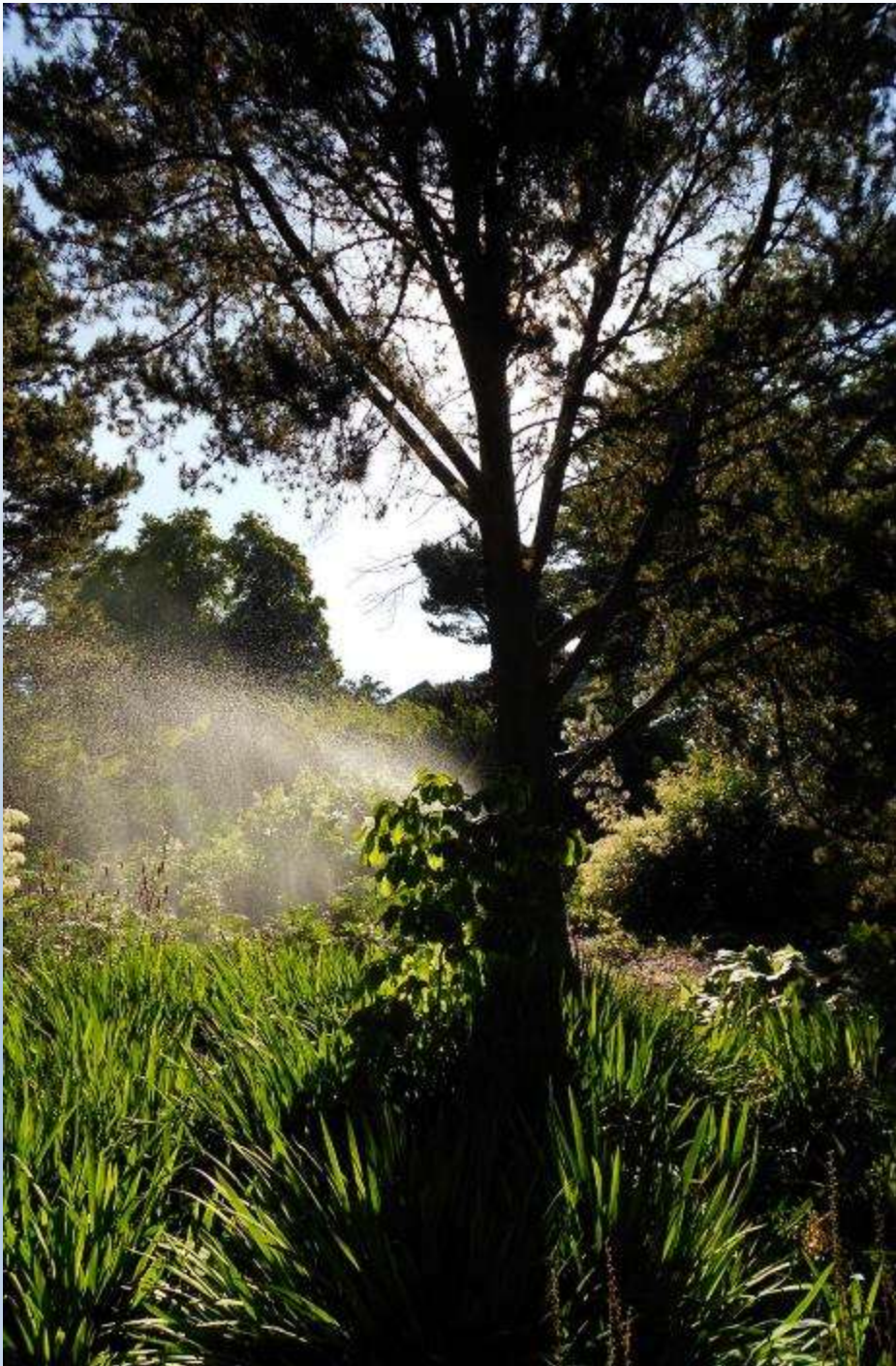






6 June 2022

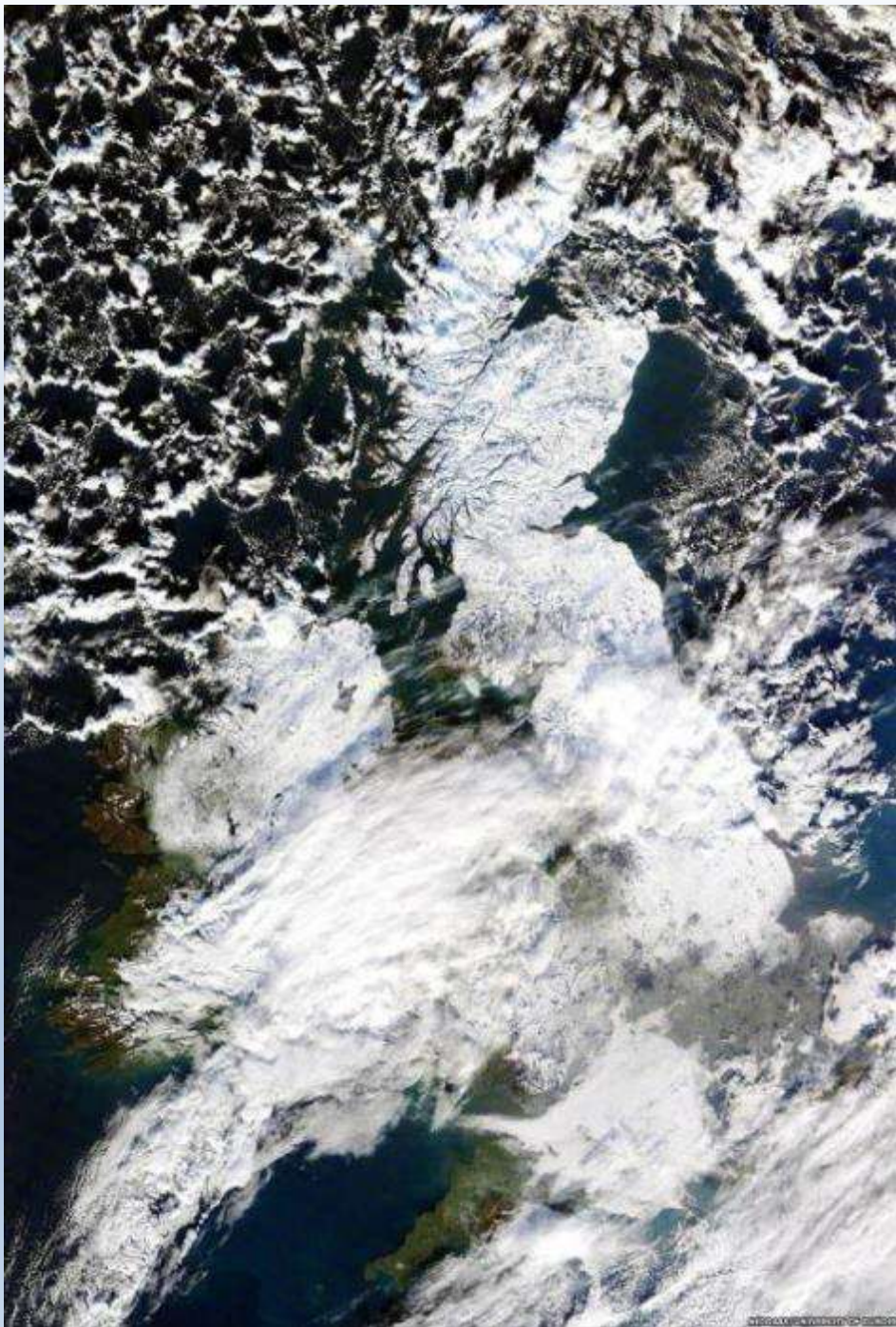




## Climate change challenges –increasing Temperature

- Short, medium and long term consequences of prolonged dry weather and record high temperatures – 30C July 2022 – Edinburgh and Dawyck
- Plants particularly mature trees begin to suffer and require sustained irrigation – potential to hasten long term decline
- Visitor numbers increase until it gets too hot....





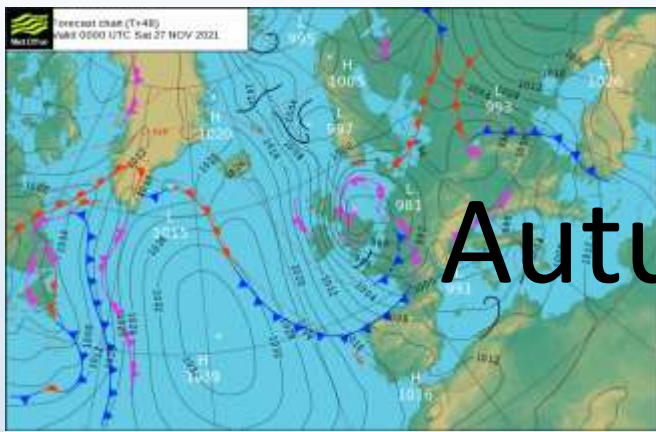
## Climate challenges – Severe Winters

- The recent cool weather in December 2022 and with the winters of 2009/10 and 2010/11 perhaps two of the coldest winters in living memory.
- Resultant damage and loss of ‘tender’ plants.
- Damage to infrastructure i.e. freezing pipes and associated repair costs.
- Additional heating costs.
- Additional operational costs in keeping garden open.

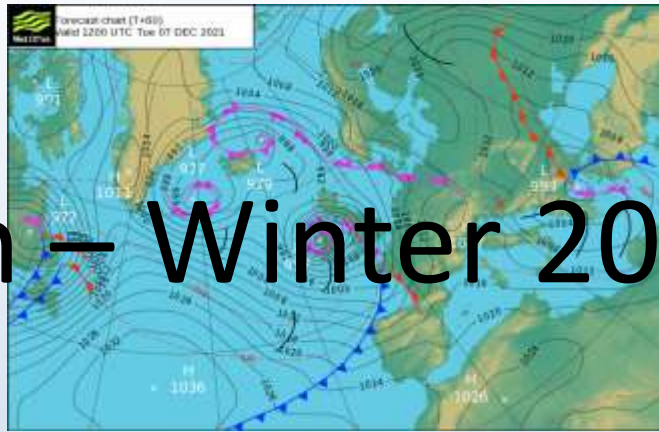
Picturesque but potentially damaging  
to trees



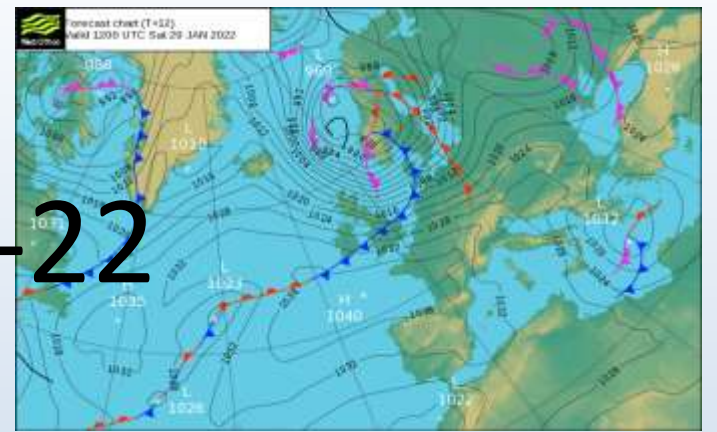
# Autumn – Winter 2021 -22



Arwen



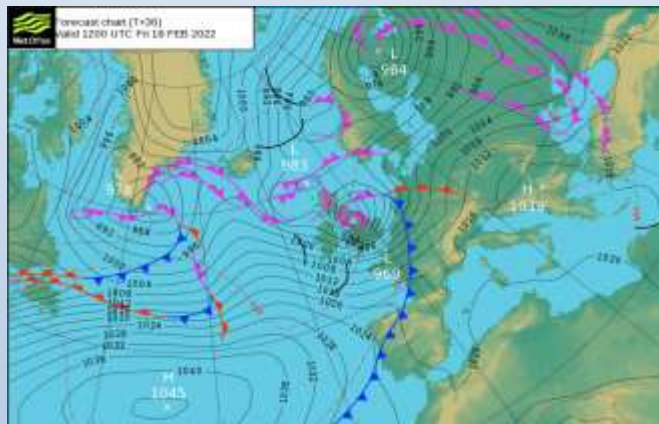
Barra



Corrie



Dudley



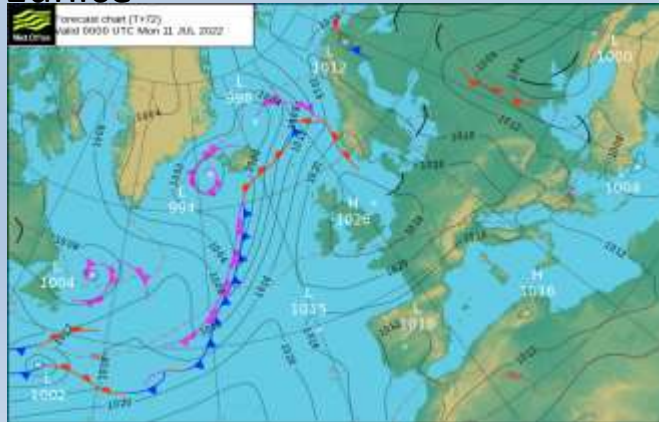
Eunice



Franklin



Dry mild January



Warm dry July –record breaking 31C



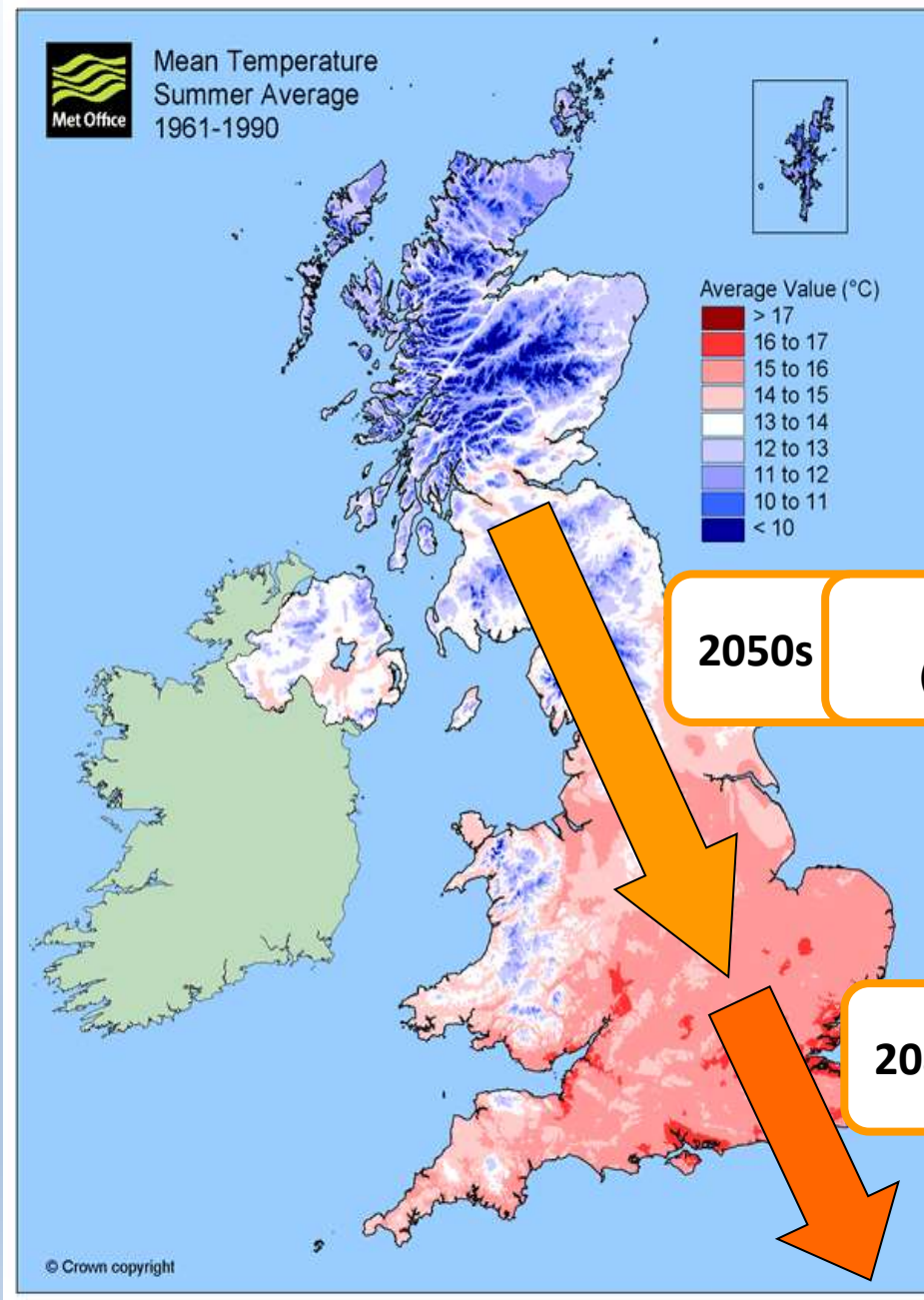
Warm dry August

The key long-term climate change trends for Scotland are:

- Weather will remain variable, it may become even more variable
- Typical summer will be **hotter** and **drier**
- Typical winter / autumn will be **milder** and **wetter**
- Significant variation

We can also expect to see:

- Increased summer heat waves, with extreme temperatures and drought
- Increased **frequency** and **intensity** of extreme precipitation events
- Reduced occurrence of frost and snowfall
- Sea level rise



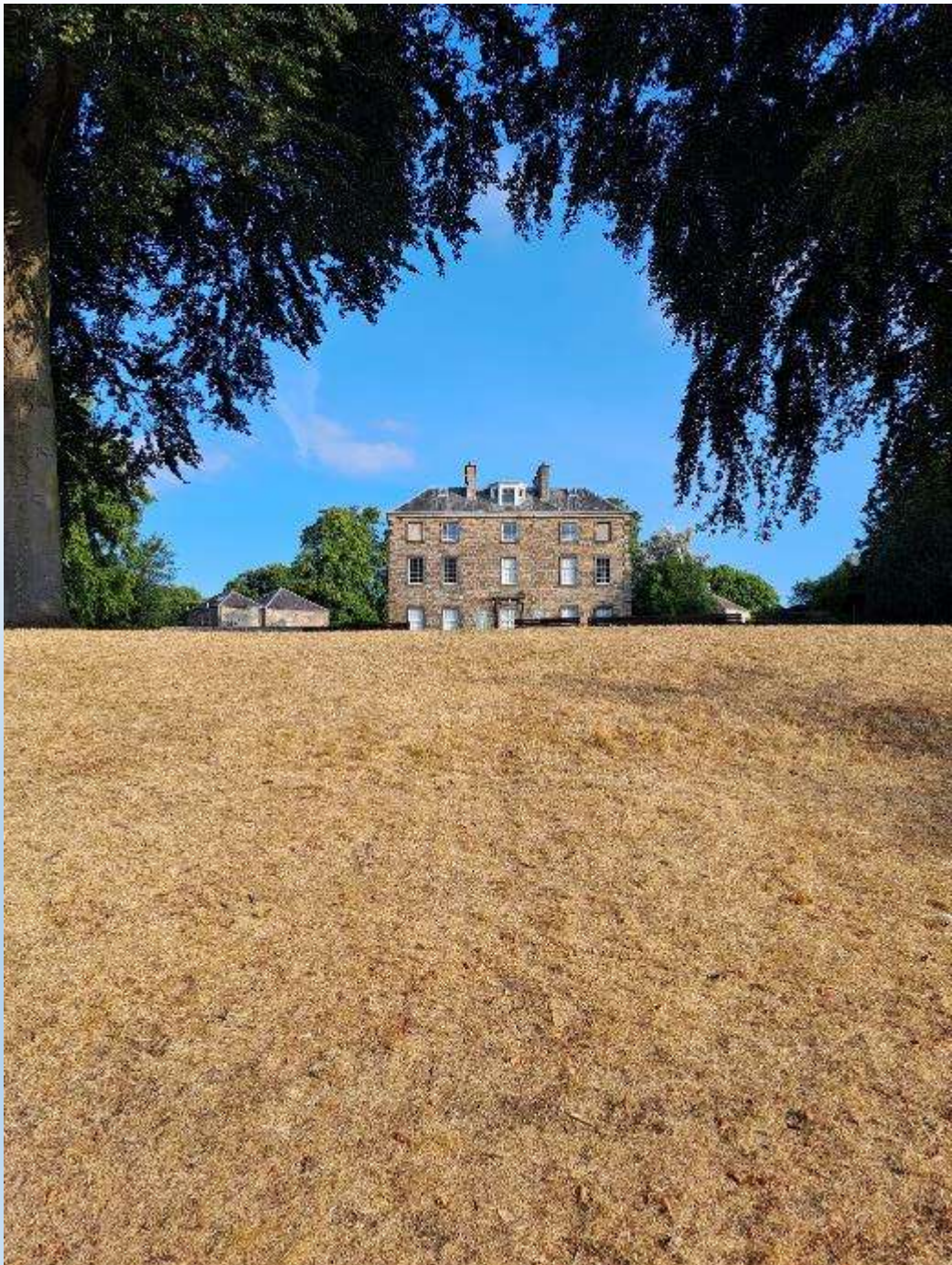
# What difference does a few degrees make?

London was **3.0°C** warmer than Glasgow (in baseline 1961-1990)

So summer temperatures may be more similar to those in south of England by the 2050s...

... and potentially more like those currently experienced in Southern Europe (>4°C)

\*The projected values are for summer mean temperature under high emissions scenario



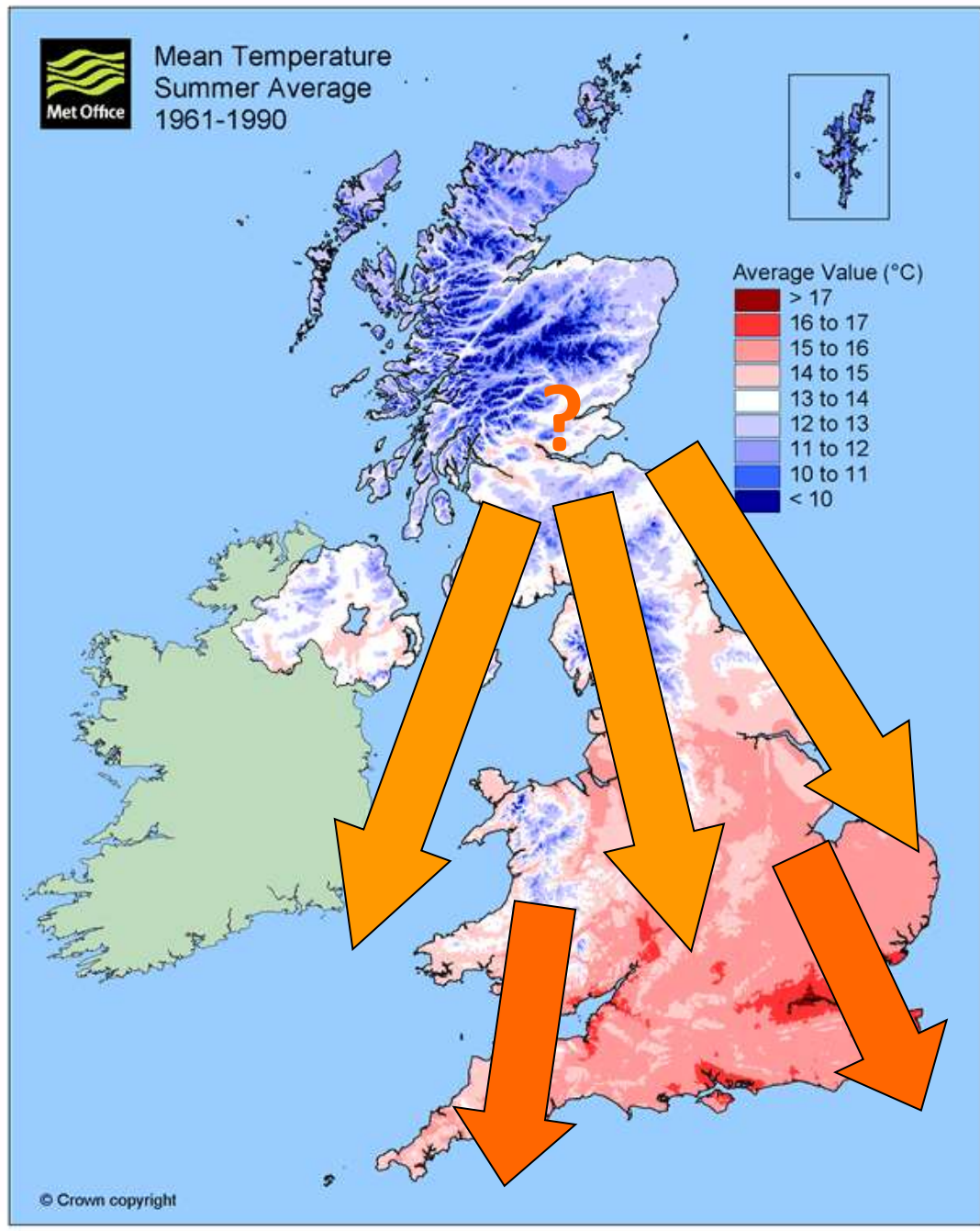
# Drought

There is some evidence suggesting in future, there will be less drought on the west coast and more drought in the central highlands of Scotland.

However:-

- Uncertainty is high – models used define drought basically as a precipitation deficit, but temperature plays a role too, so they may underestimate summer drought.
- Models use quite long droughts (3-18 months) so the summer decrease and winter increase in rainfall will be having opposite effects, so summer droughts might not get picked up. Only one model tries to separate dry (Apr-Sep) and wet (Oct-Mar) seasons. The one study that looks at 2020s, 2050s and 2080s only finds increase in central Scotland drought intensity in the 2080s.

In conclusion- it is quite uncertain. This mostly reflects uncertainty in rainfall projections, but also in what is meant by a drought, for example, how long a period of low rainfall is needed before the 'system' of interest is under stress.



A word of caution however we will also need to consider rainfall and several other climate variables.

- Including; – cloud cover, fog, wind and lightning incidence
- Wind speed values are particularly uncertain, in part due to the low confidence in projecting future North Atlantic winter storm tracks





Current threats

Plant Health  
at RBGE

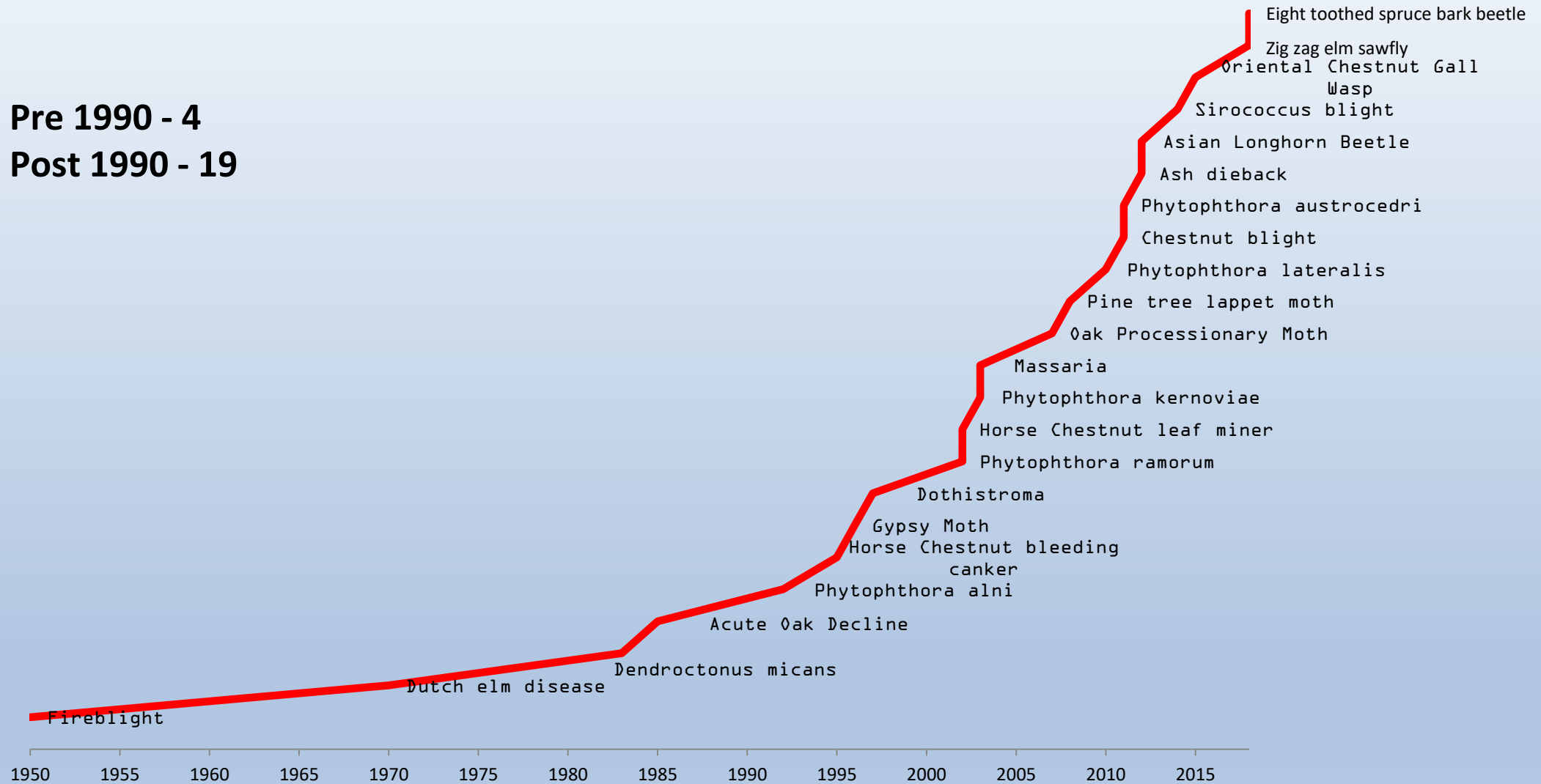
# Kalopanax septemlobus

- Armillaria sp.



# The incidence of tree pest and disease introductions 1950 - 2018

Pre 1990 - 4  
Post 1990 - 19



# Phytophthora at RBGE

- *Phytophthora* spp. are extremely concerning.
- *P. ramorum* in particular is likely to impact all our gardens for many years to come.
- Species already infected and removed since 2008 at Benmore include *Magnolia*, *Rhododendron*, *Kalmia* and *Osmanthus*.
- *P. ramorum* confirmed on larch this year at Benmore.
- Recently first finding of *P. ramorum* on *Sciadopitys verticillata* (Japanese umbrella pine).
- New *Phytophthora* species are being discovered (e.g., *P. pluvialis* at Benmore).
- *P. austrocedri* having an impact on juniper and exotic conifers (*Xanthocyparis vietnamensis*) at Edinburgh.
- First finding of *P. cactorum* on *Araucaria araucana*.
- *P. pseudosyringae* on *Nothofagus* at Logan and Edinburgh.
- Many more *Phytophthora* species out there...



*P. pluvialis* infecting a mature *Tsuga heterophylla* (c.130 y.o.) at Benmore.





The now familiar use of LFD's





*X. vietnamensis* infected with *P. austrocedri* at Edinburgh site



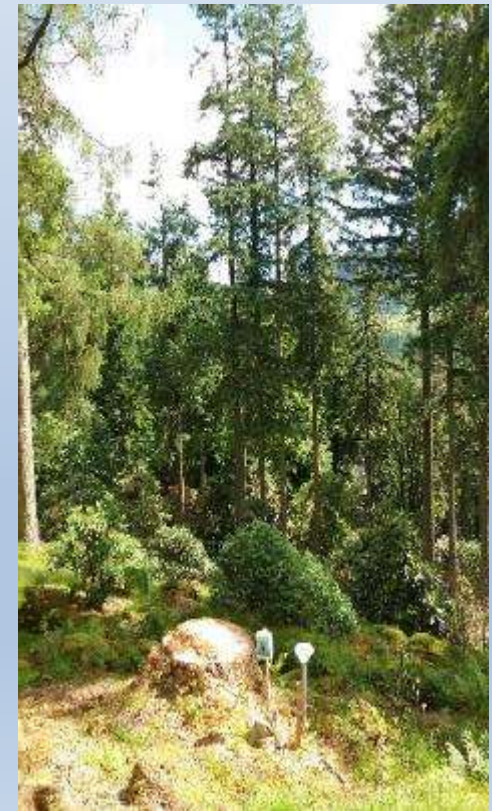
*S. verticillata* infected with *P. ramorum* at Benmore site.

**Impact - removal of *Juniperus rigida* infected with *P. austrocedri* in the Rock Garden Edinburgh**



# *Phytophthora ramorum* on the Larch at Benmore

- Currently large areas of Larch being felled in the forests surrounding Benmore due to being infected with *Pr*
- There have been and are a number of *Pr* positive cases found in the Larch and other plants at Benmore
- Current plan is to remove all shelter belt Larch over the next 5 years to mitigate the risk to Living Collection
- Logistical challenge of removing circa 350 trees, many of which are over 25m tall without damaging the Living Collection
- RBGE Team is working closely with Forestry and Land Scotland and Forest Research





**Current impact - removal of *Larch* infected with *P. ramorum* at Benmore**

**Future impact – scale and cost of the required removal of *Larch* infected with *P. ramorum* at Benmore and surrounding area**



## Emerging issues

*Dendroctonus micans* Spruce Bark Beetle on *Picea* – Spruce at Dawyck

**Impacts** – First detected in 2020 with noticeable damage –see image below- to mature *Picea* species at Dawyck.

**Action** - Forest Research working with Dawyck team have released relatively low numbers [25] of biological control *Rhizophagus grandis* in 2021 in key locations.

**Future Action** – Monitoring control and condition of trees particularly *Picea*



*Picea breweriana* 19795151 – planted at Dawyck 1909 and unfortunately a TROBI Champion Tree



## Case Study

# *Cedrus libanii*

- Planted 1849
- Canopy damaged under weight of snow 2010
- Tree reduced 2011
- Subsequently infected with *Sirococcus conigenus*
- Removed 2021



*Sirococcus conigenus*





## Plant health threats

Ash Dieback – *Chalara fraxinea*

Relatively new disease

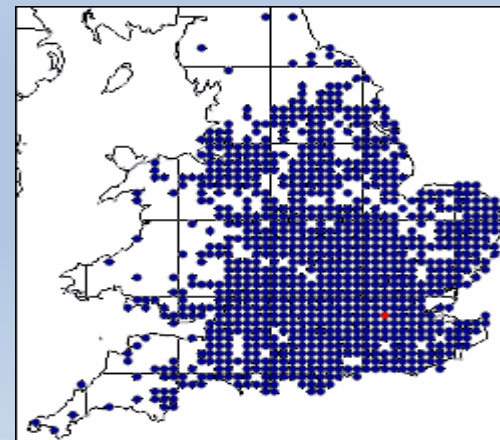
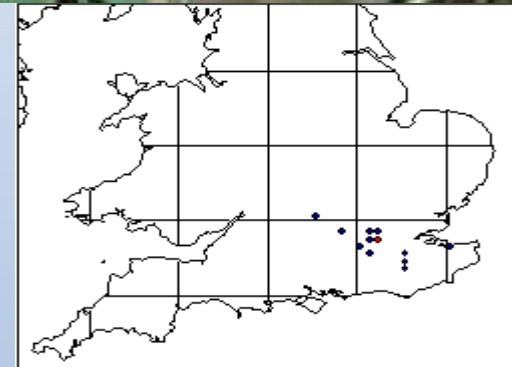
Impacts including tree removal increasing

Horse Chestnut Leaf Miner  
*Cameraria ohridella*

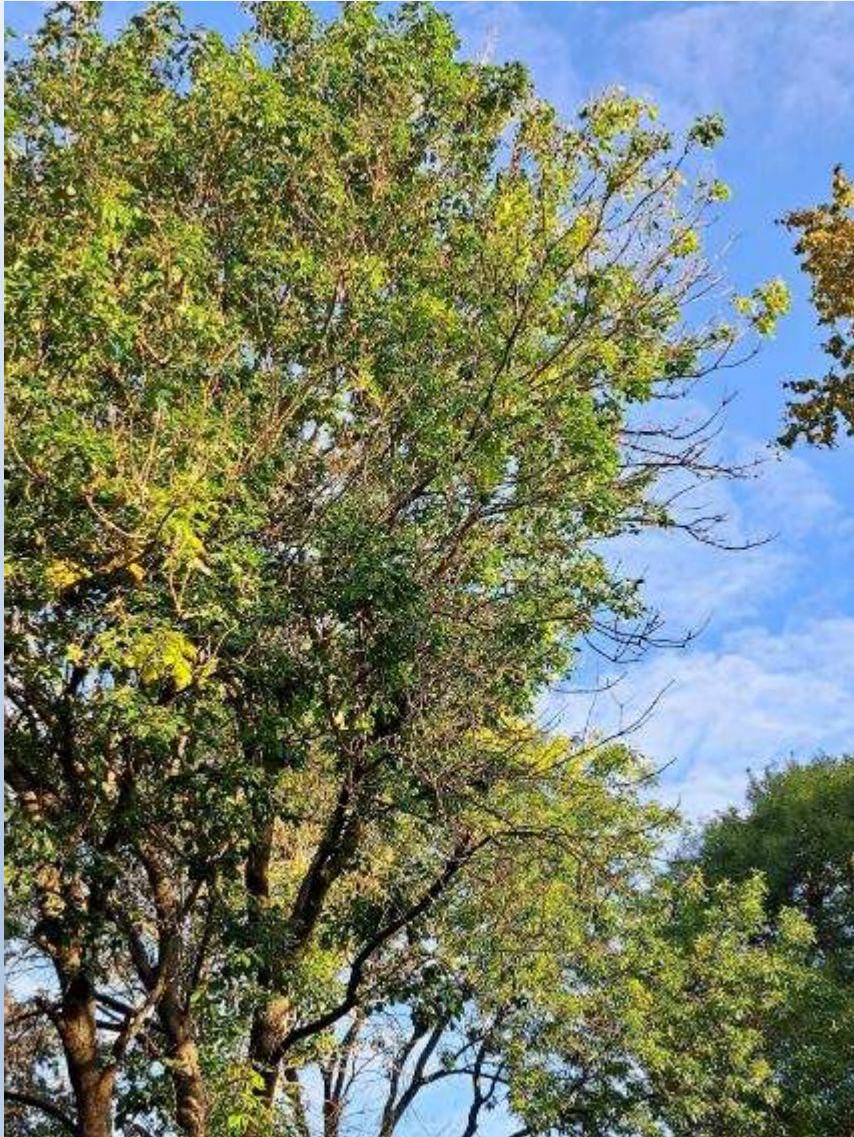
Found in the UK 2002

Rapid movement north since 2010

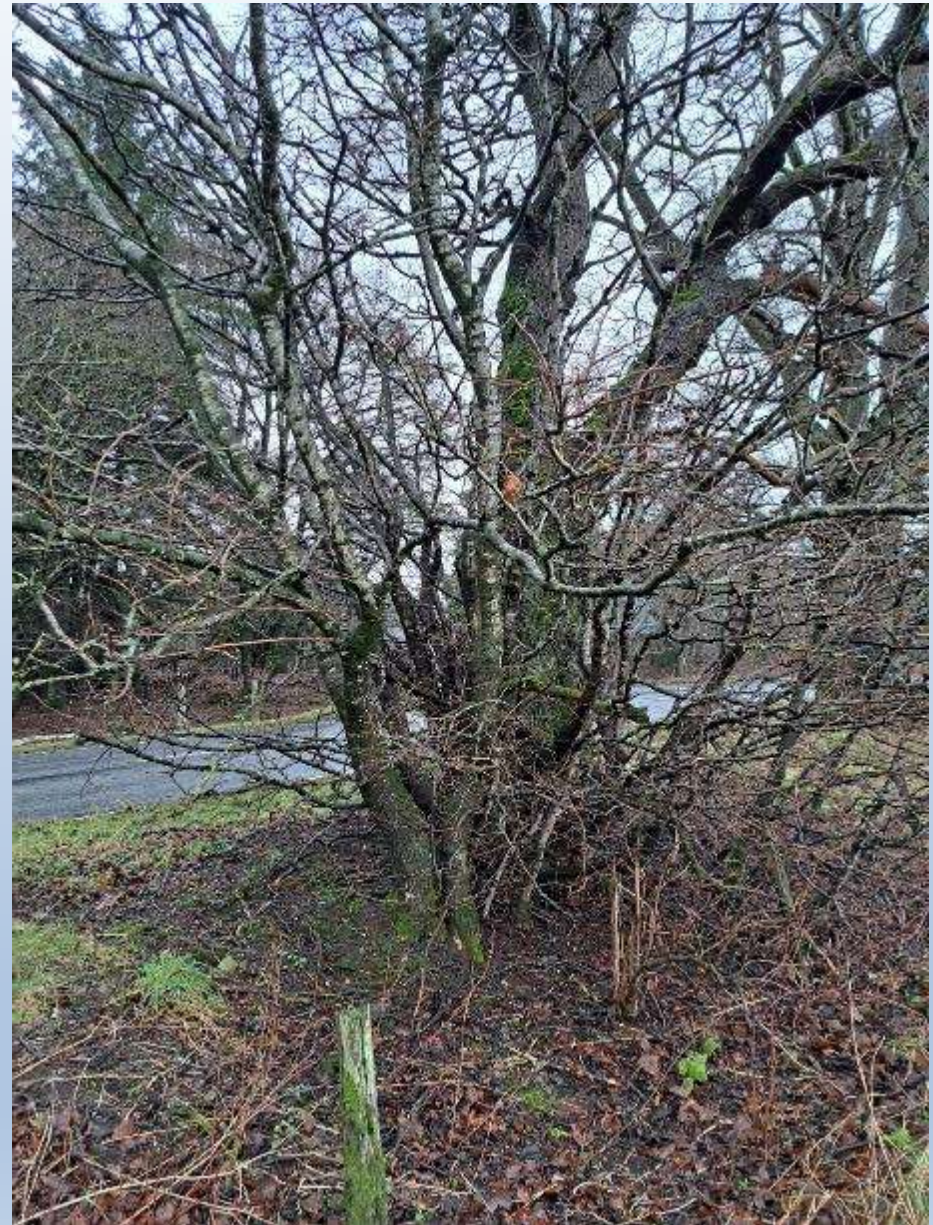
‘Arrived’ Inverleith 2018



Are there parallels between Ash Dieback and DED?



Ash – RBGE 2022



Wych Elm – Borders 2023



# Future plant health threat

## Emerald Ash Borer – *Agrilus planipennis*

This beetle was introduced into the US and Canada in the 1990's probably on wood packing material from Asia.



**The emerald ash borer,**  
*Agrilus planipennis* (Linnaeus), is a wood-boring beetle first detected in the United States in 2002. Evidence suggests that the beetle was introduced to Michigan by a number of ash trees in all shipments. Emerald ash borer has since been detected in Ohio, Indiana, Virginia, Maryland, and Ontario, Canada. In addition to spreading by natural means, Emerald ash borer can be transported to new areas by infested nursery stock and nursery stock. The beetle is responsible for deaths of more than 1 million ash trees in Michigan alone.

**Host:**  
In North America, Emerald ash borer is known to feed on several species of ash trees and be transported by the movement of nursery stock. Emerald ash borer is a pest of ash trees and several species of the subgenus *Fraxinus*.

**Signs and Symptoms:**  
New infestations are difficult to detect as symptoms do not show until several years after they first appear. Signs of other infestations are not visible through dieback in the upper canopy. Considerable mortality has been reported in the New York, United States and Michigan nurseries.

**Biology:**  
Eggs are laid in dense layers of 1-5 and in both summer and winter. Eggs are laid in the bark and hatch in late spring. The larvae feed on the cambium and phloem, creating "S" shaped galleries. The larvae go through three instars. They pupate in the cambium and pupation occurs in late spring, and adults begin to emerge through 10-15 mm diameter holes in late summer and fall. Adults will emerge in the next fall and lay eggs.

**Not EAB:**  
This commonly misidentified beetle (EAB) has several green spots on its back. It is a pest of ash trees and is a pest of ash trees and is a pest of ash trees and is a pest of ash trees.

**Other Stressors:**  
Ash trees can be stressed by drought, winter dieback, soil erosion, nutrient deficiency, and other factors. Emerald ash borer can be introduced to ash trees by nursery stock and other factors.

It is now widely distributed across central and eastern US and Canada. It has devastated native and cultivated populations of North American ashes.

Currently the only reported location outside of Asia and North America is in Russia just outside Moscow.

Increased vigilance required with all importations of wood packing material from Asia and Fraxinus imports from Europe.





Future plant health threat

## Processionary moths

- Management nightmare! Hazardous to human and animal health.
- Nests have to be removed in public areas.
- Oak processionary moth (OPM) now widespread in Greater London.
- Has been intercepted in Scotland and could survive here, particularly at Edinburgh site.
- Pine processionary moth (PPM) is in Europe and has been intercepted by UK Plant Health Authorities.





Future plant health threat

## *Xylella fastidiosa*

- Bacterial disease with over 600 known hosts many of which are horticultural staples (e.g., *Acer*, *Fraxinus*, *Platanus*, *Quercus*, *Ulmus*, *Vaccinium* and *Vitis*).
- High risk hosts include *Coffea*, *Polygala myrtifolia*, *Lavandula*, *Nerium oleander*, *Rosmarinus officinalis*, *Prunus dulcis*, *Olea europaea*.
- Causes wilts, die-back and leaf-scorch (due to blocked xylem).
- Transmitted by sap-sucking insects (e.g., meadow froghopper).
- Not yet in the UK but has been found in a number of European countries.
- Plant health enforcement is significant with *Xylella*; potential loss of trees and exclusion of visitors.

So what are we doing?



Raising  
Awareness -

Education

Skills

Training



Visitor interest and awareness

### Sweet chestnut: the afterlife of a tree

This mature sweet chestnut (*Castanea sativa*) was one of the oldest trees in the Garden when it started to die back. Rather than completely removing the tree, we decided to make it safe and keep as much of the wood on site as possible. Over time, this will become a valuable habitat.

**Deadwood**  
Fungi and bacteria will decompose the wood over the next few decades. We will be able to use the wood for other purposes. In fact, woodpeckers will be using the wood to build their homes and we hope that bats will return to roost in the tree.

**Roosting bats**  
We have created artificial roost structures using a technique to help cut down on the tree as a habitat. Bats are a protected species in the UK and conservation measures protect their populations.

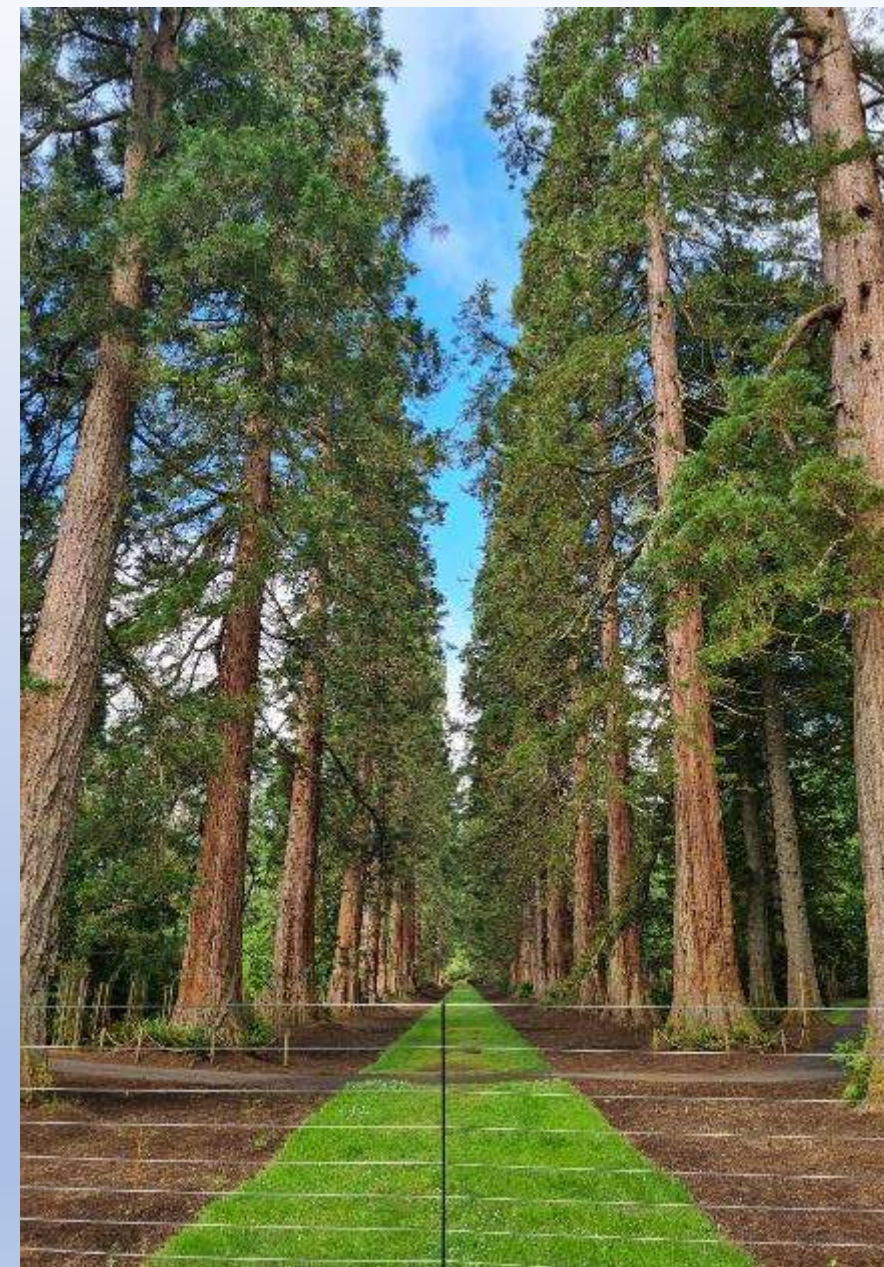
**Our helpers**  
The Great Tit Team (led by the King of the Wood) and the Woodpecker Team (led by the King of the Wood) will be working to maintain the site.

For more information visit [www.rhs.org.uk](http://www.rhs.org.uk)



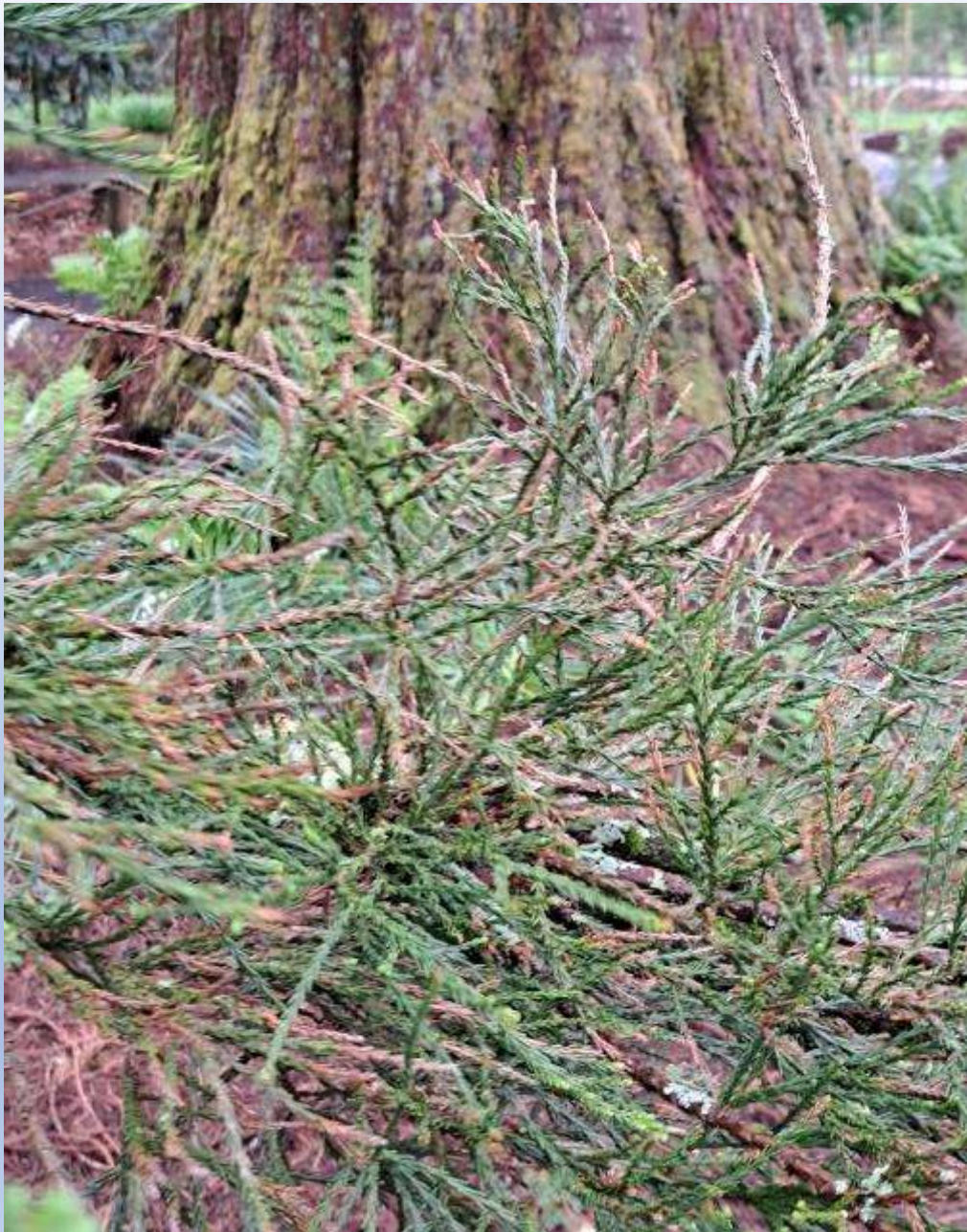


**Improving resilience of  
the tree collection**

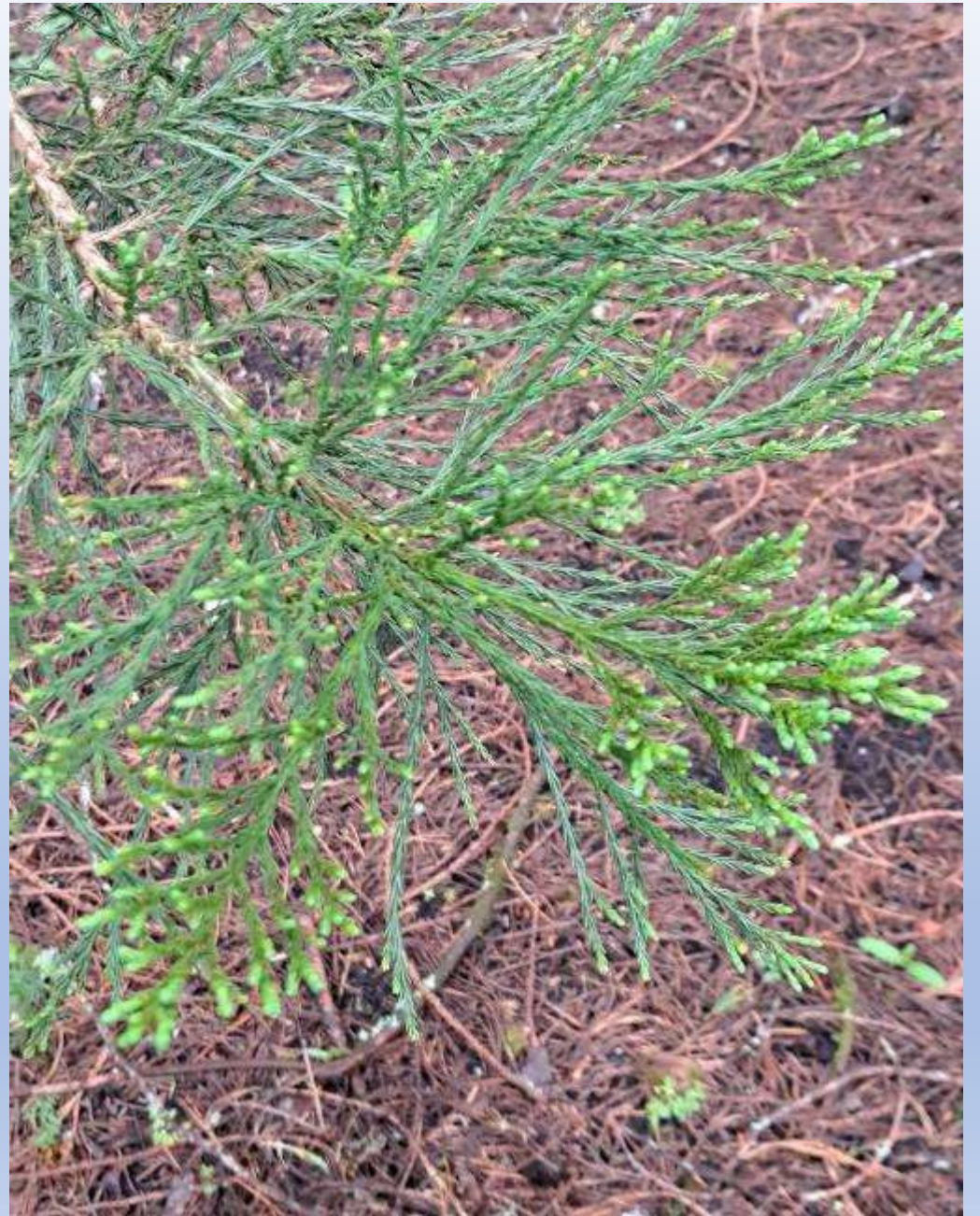


Improving the resilience of the tree collection – Benmore Avenue

Before



After....



# Research

- RBGE Staff are working closely with the Scottish Plant Health Centre to provide evidence for biosecurity improvements.
- At RBGE we are conducting research on:
  - Plant waste management
  - Biosecurity concerns with peat-free and reduced peat components
  - Biosecurity related to visitors, equipment and machinery
  - Alder health
  - *Phytophthora* diversity, survival and spread (*P. pluvialis* and others)
- Further research planned to look at pest risk assessment and the use of biological controls.



The infographic features logos for the Plant Health Centre (Scottish Centre of Excellence) and the Scottish Government (Riaghaidh na h-Alba gov.scot) at the top. The main image shows a large pile of brown, mulched plant waste. Below this, a green banner contains the title. The text is organized into two columns. The left column discusses the risks of untreated waste piles and provides practical advice. The right column focuses on minimizing waste and risk by sourcing plant stock to high standards. A smaller image at the bottom right shows a person in a white protective suit handling waste. A disclaimer at the bottom left notes that the guidance is for Scotland and that national licensing authorities should be contacted for use elsewhere.

**Plant Health Centre**  
Scottish Centre of Excellence

**Scottish Government**  
Riaghaidh na h-Alba  
gov.scot

## Biosecurity best practice for safe disposal of plant waste and spent growing media

Research has shown that plant waste and spent growing media can harbour pests and pathogens, including quarantine-regulated species such as *Phytophthora ramorum*. These organisms have the potential to spread from untreated waste piles to cultivated plants and the wider environment. This guidance aims to help the horticultural sector understand and mitigate these risks by providing some practical advice on waste management.

**Minimise waste and risk of infected waste material by growing clean plants**

The best way to limit waste volumes and to minimise the risk of pests and pathogens proliferating in waste is to ensure that plant stock is sourced and grown to high standards of biosecurity and is monitored frequently to ensure that plants remain visibly healthy/symptom-free. Various types of growing media ingredients and mulches (e.g. pot tops) can also harbour and be sources of pests/pathogens.

*Waste and environmental legislation is a devolved issue so please note that if you are using this guidance outside Scotland, the relevant national licencing authorities will need to be contacted.\**

1



# Biosecurity measures

**1 Plants coming in:** this is the way that most pests and disease-spreading pathogens enter a garden!

## What can you do?

- Use reputable suppliers who have been 'checked out'
- Source locally if possible
- Avoid cheap imports and semi-mature specimen trees from abroad

**2 Plants on arrival** need careful inspection.  
**Remember to:**

- Check paperwork for compliance with purchase order form and plant passport if needed (eg EC Plant Passport UK/EW 12345)
- Only accept delivery if you are sure that the plants are healthy

**3 Quarantine areas** should be isolated from the main garden and the public.

## What more can you do?

- Restrict access to the area
- Be scrupulous about hygiene
- Use dedicated tools
- Hold new arrivals for 2-6 weeks and monitor frequently

**4 Day-to-day hygiene:** many pests and pathogens are carried on boots!

## It's important to:

- Wash all soil and plant material from footwear, and disinfect them
- Clean and disinfect tools and machinery

**5 Basic path maintenance** can help too.

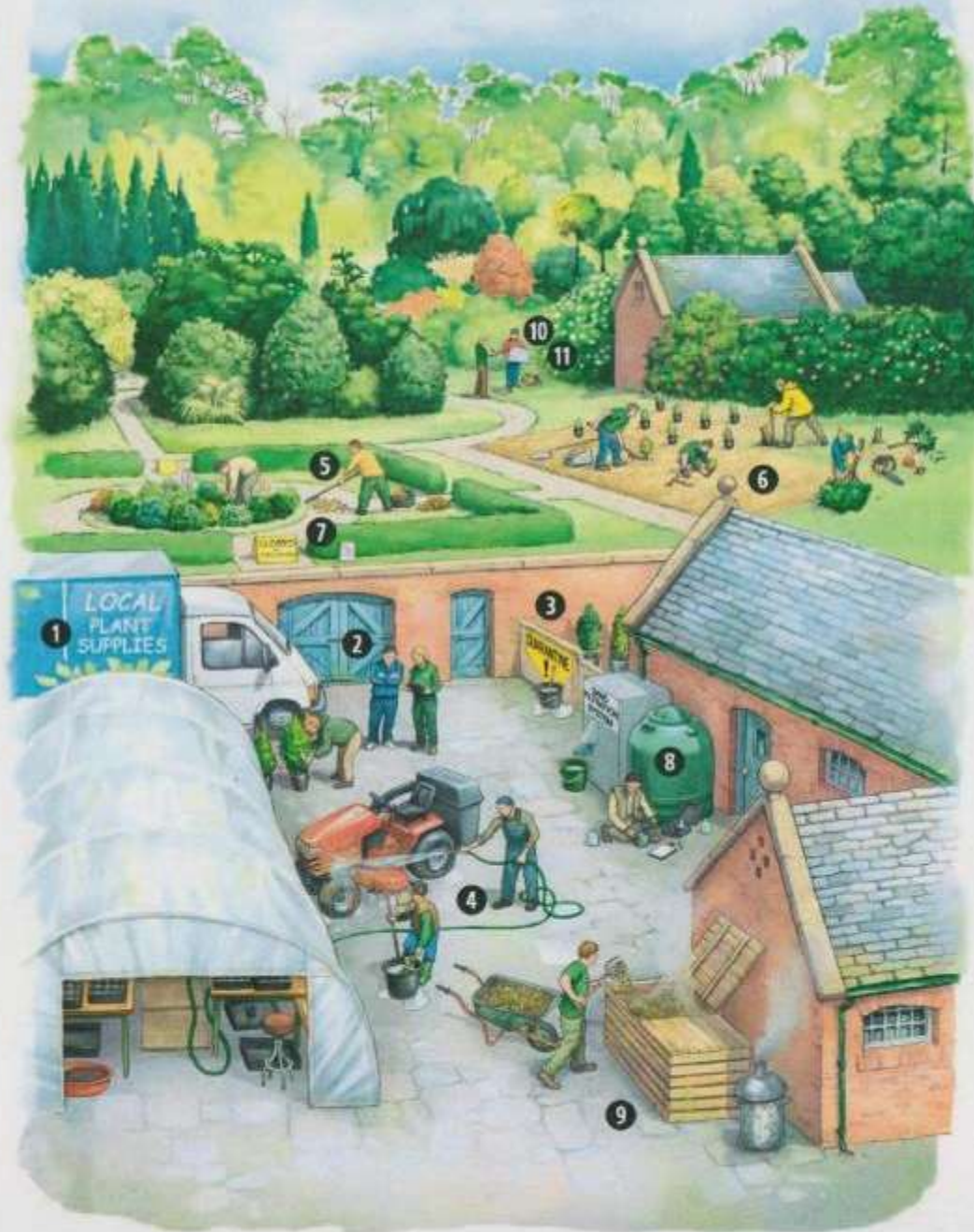
## How?

- Surfacing and levelling avoids puddles
- Cleaning and clearing removes leaves and plant debris that can harbour pests and pathogens

**6 Good plant husbandry** also matters.

## What can you do?

- Use the right plant in the right place
- Mulch when planting perennial ornamentals to prevent soil splashing onto foliage
- Use space to help ventilation and reduce humidity
- Manage plants to encourage vigorous, healthy growth
- Prevent plants such as *Rhododendron panticum* from choking the garden



**7 Clear information** helps keep visitors informed and aware.

## Why put up a notice?

- To inform visitors of serious outbreaks
- To restrict access to ground under repair
- To suggest responsible behaviour eg clean shoes, not taking cuttings, keeping to paths, dogs on leads etc

**8 Irrigation water** should be clean and free from plant pathogens.

## How can you ensure this?

- When using recycled water, eg collected off roofs, try to clean it before use (sand filtration works well)
- Cover water tanks to prevent leaves blowing in
- Regularly test water to check for pathogens

**9 Organic waste** can harbour pests and pathogens.

## What should be done with it?

- All dead plants, prunings, fallen leaves etc should be collected and disposed of safely
- Composting is the best way, as it kills most pests and pathogens
- Or you could collect waste in a covered skip for removal to an approved landfill site
- Small amounts can be burnt where they lie

**10 Plant collections** know what you've got.

## What can you do?

- Make a record of the plants in the garden
- Develop a management plan to conserve important plants
- Propagate important plants through the Plant Conservation Programme

**11 Regular monitoring** of the health of your plants lets you spot problems early and take prompt remedial action.

## What can you do?

- Familiarise yourselves with the main pests and diseases of plants in your garden
- Get problems identified
- Report all suspicious symptoms to your Garden Adviser
- Notify suspect findings of quarantine pest and diseases to Plant Health authorities

# Plant Healthy

- A plant health certification scheme based on the Plant Health Management Standard.
- Governing body is the Plant Health Alliance.
- Businesses and organisations that join are subjected to an in-depth audit to examine the processes in place across the site to identify and address potential plant health risks.



Understanding, risk assessing and recording all goods and supplies entering the garden.



## Wider UK biosecurity context



The UK Plant Biosecurity Strategy 2023 -2028 published January 2023, has four planned “outcomes”

The four overarching themes proposed in the strategy are:

1. A world-class biosecurity regime.
2. A society that values plant health.
3. A biosecure plant supply chain.
4. An enhanced technical capability.

Greater collaboration with the industry to facilitate safe trade and to reduce the risks posed by pests and diseases.

Increase awareness of the importance of plants as well as improving plant health understanding at educational level.

Ash Dieback was a landmark moment, triggering a step change in public awareness that led to the original plant biosecurity strategy for Great Britain being published in 2014.



The strategy describes how more than a third of the 454 native tree species in Europe are considered threatened and also highlights how plant trade poses a significant threat to the entry of pest and diseases, though the strategy does not go far enough to mitigate this threat. Since 1990, more than 20 serious tree pest and diseases have been imported to the UK which are now wreaking havoc on our wildlife populations and stripping our landscape of trees

This year marks 10 years since ash dieback was discovered in the UK, a disease that stands to wipe out up to 80% of the nation's second most common tree at an estimated cost of £15bn

The evidence tells us the most common pathway for the entry of certain pest and diseases is through international plant trade

For example, the UK has one of the most diverse populations of chestnut blight fungus in Europe, despite it being a relatively recent addition with limited distribution, reflecting multiple imports of the fungus.

# Potential future Biosecurity measures?



# Assessing the Tree Collection



# New Planting is always an opportunity!

Current key considerations are however;

- Genera and species selection for future planting
- Current and future plant health considerations
- Climate projections 2050 onwards
- Using climate assessment tool to map tolerances of existing genera and species –
  - <https://cat.bgci.org/> and <https://www.rbg.vic.gov.au/initiatives/landscape-succession-strategy/>.
- Climate envelope mapping for future planting provenance
- Location i.e. which garden
- Soil type within each garden
- Microclimate within each garden
- Future biosecurity requirements and considerations







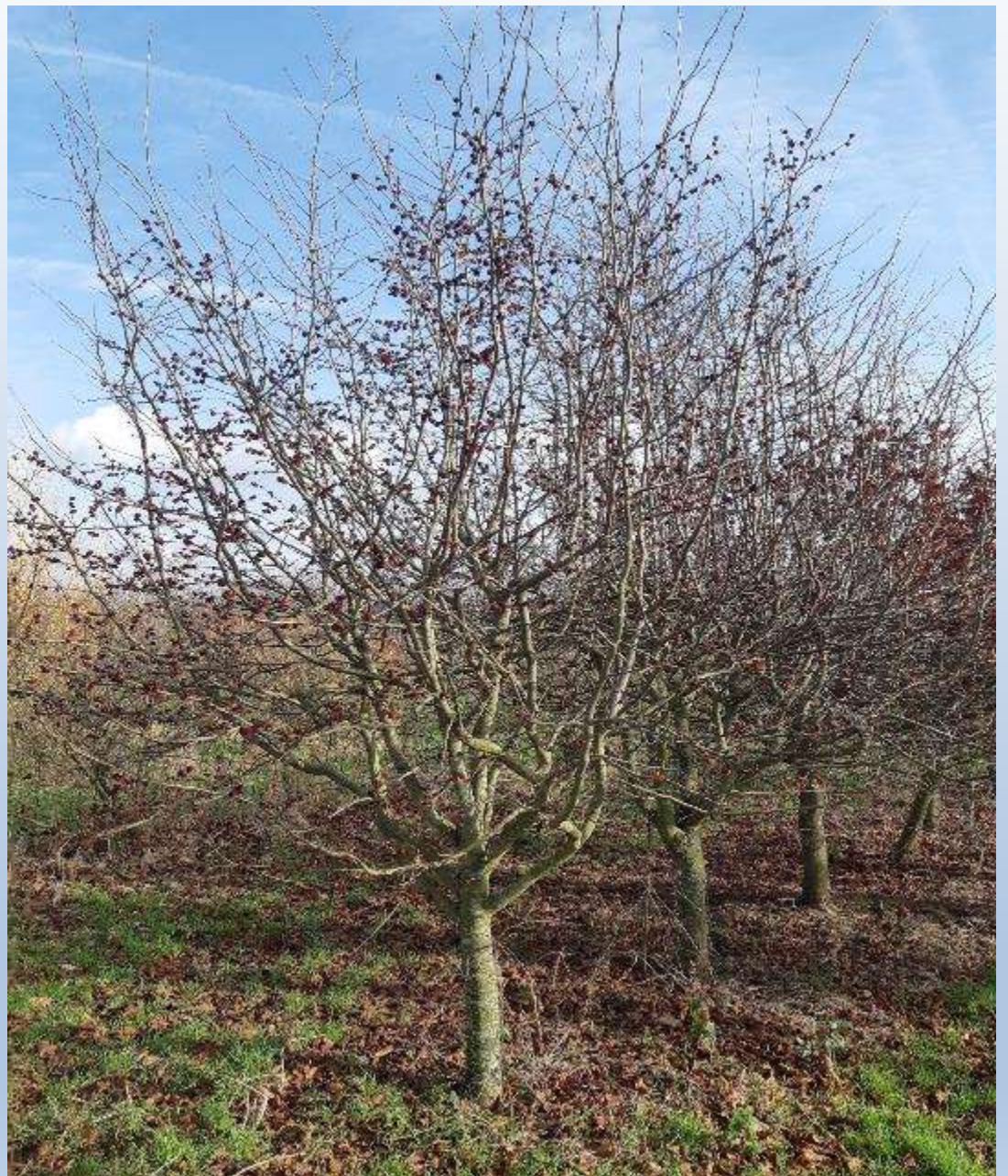
Future planting - Where in the World?



Mediterranean influence - *Arbutus andrachne* and or *x andrachnoides*



*Platanus orientalis* - Turkey



*Parrotia persica* - Iran



*Liriodendron tulipifera* – North America





*Liriodendron Chinese* – south west China





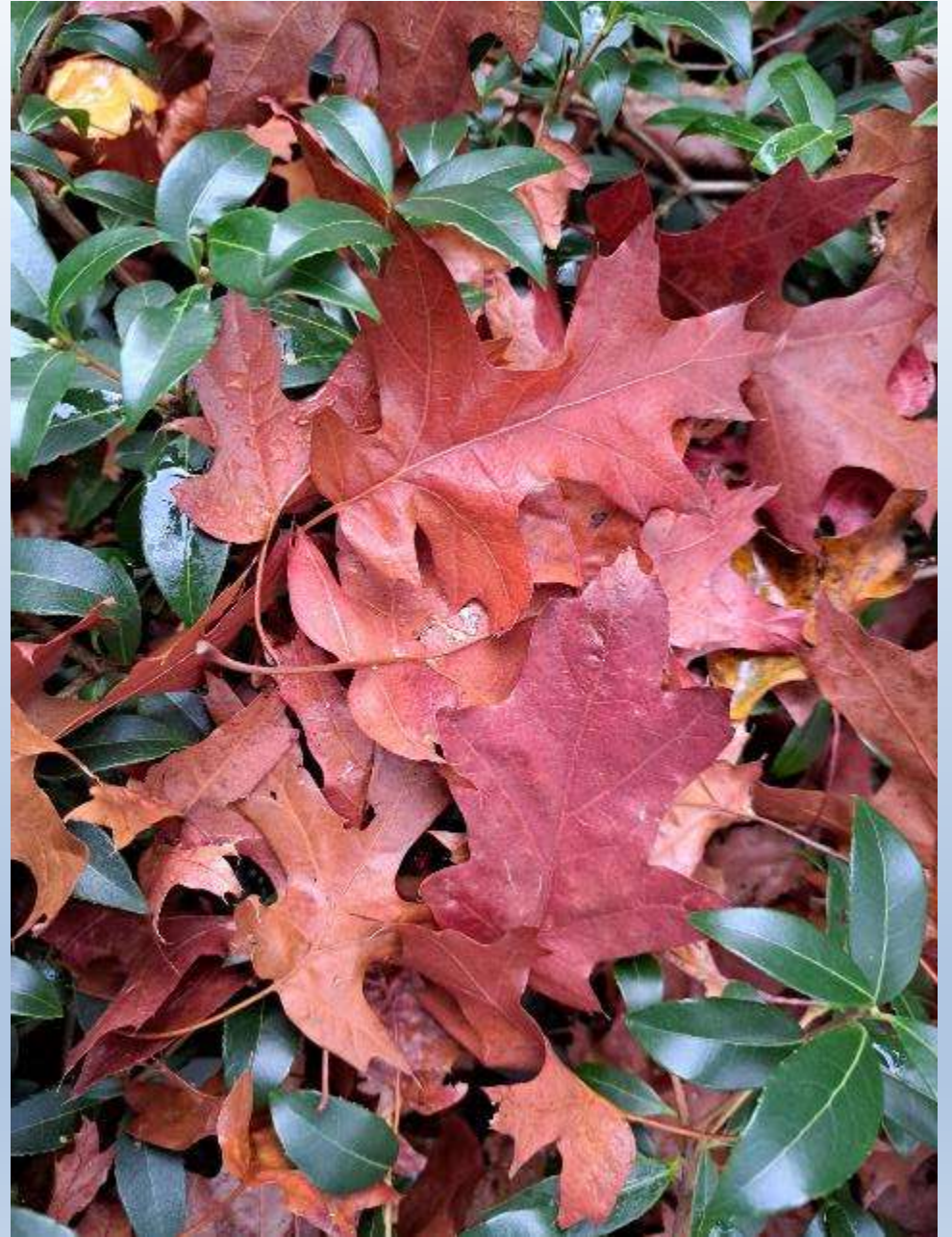
*Liquidamber styraciflua* – North America



*Liquidamber acalycina* - China



*Quercus rubra* – North America





*Carya cordiformis* – North America



*Taxodium distichum* – North America





*Ostrya virginiana* North American Hophornbeam

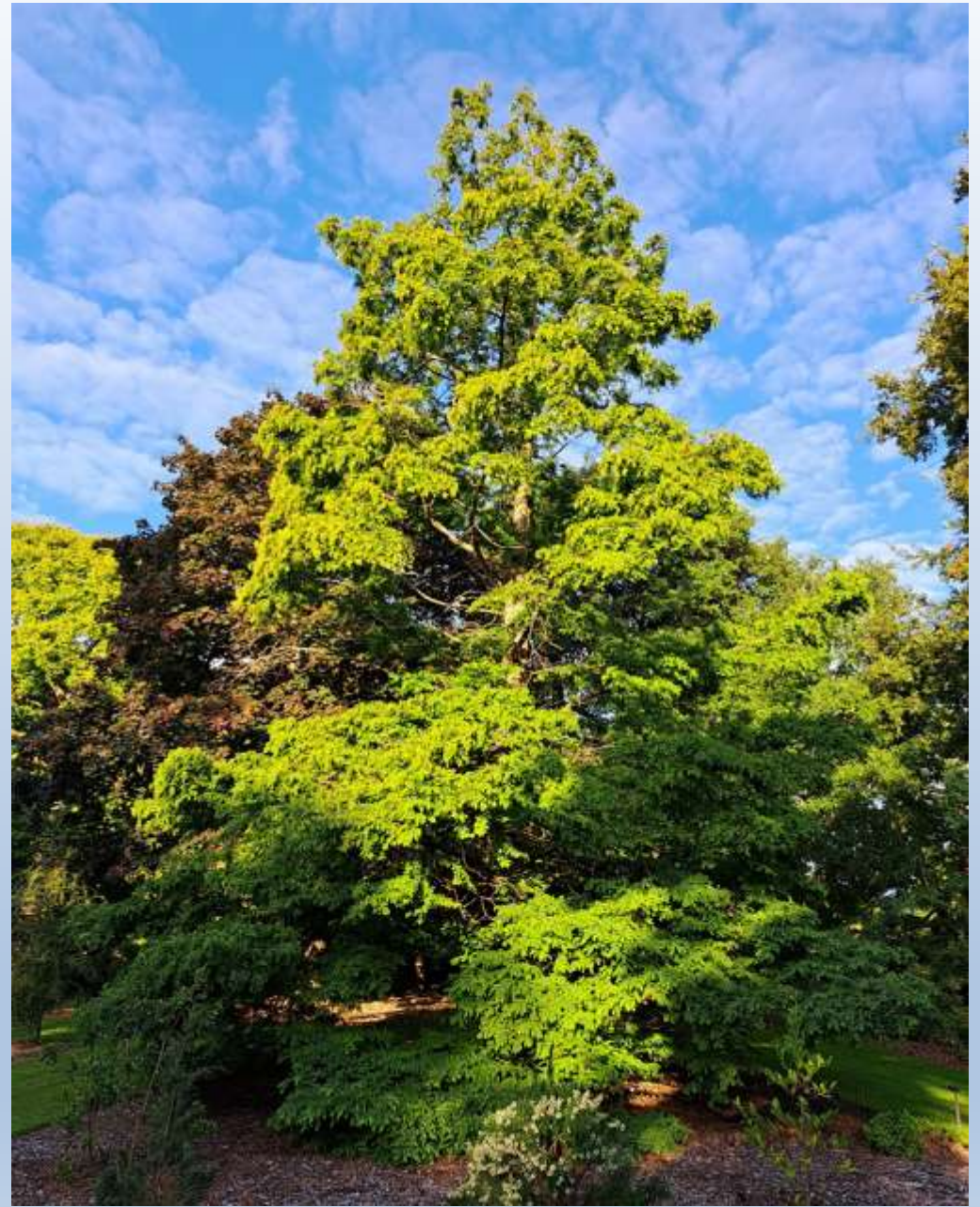




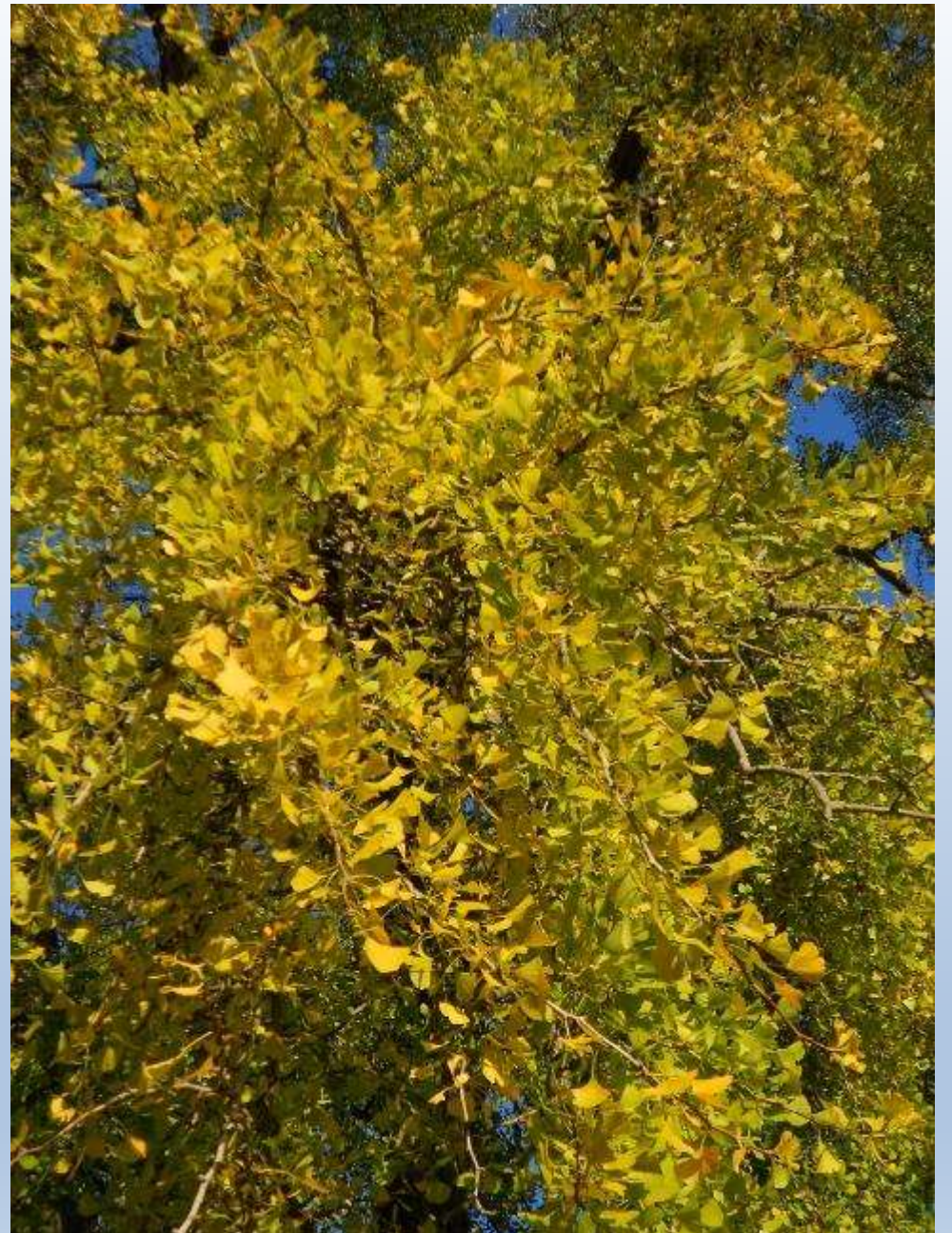
*Ostrya carpinifolium* European Hophornbeam



*Corylus jacquemontii* – western Himalaya



*Metasequoia glyptostroboides* - China



*Ginkgo biloba* – Japan and China



*Cecidiphyllum japonicum* – China and Japan



*Sorbus alnifolia* - Japan



*Paulownia tomentosa* - Empress or Foxglove Tree - China



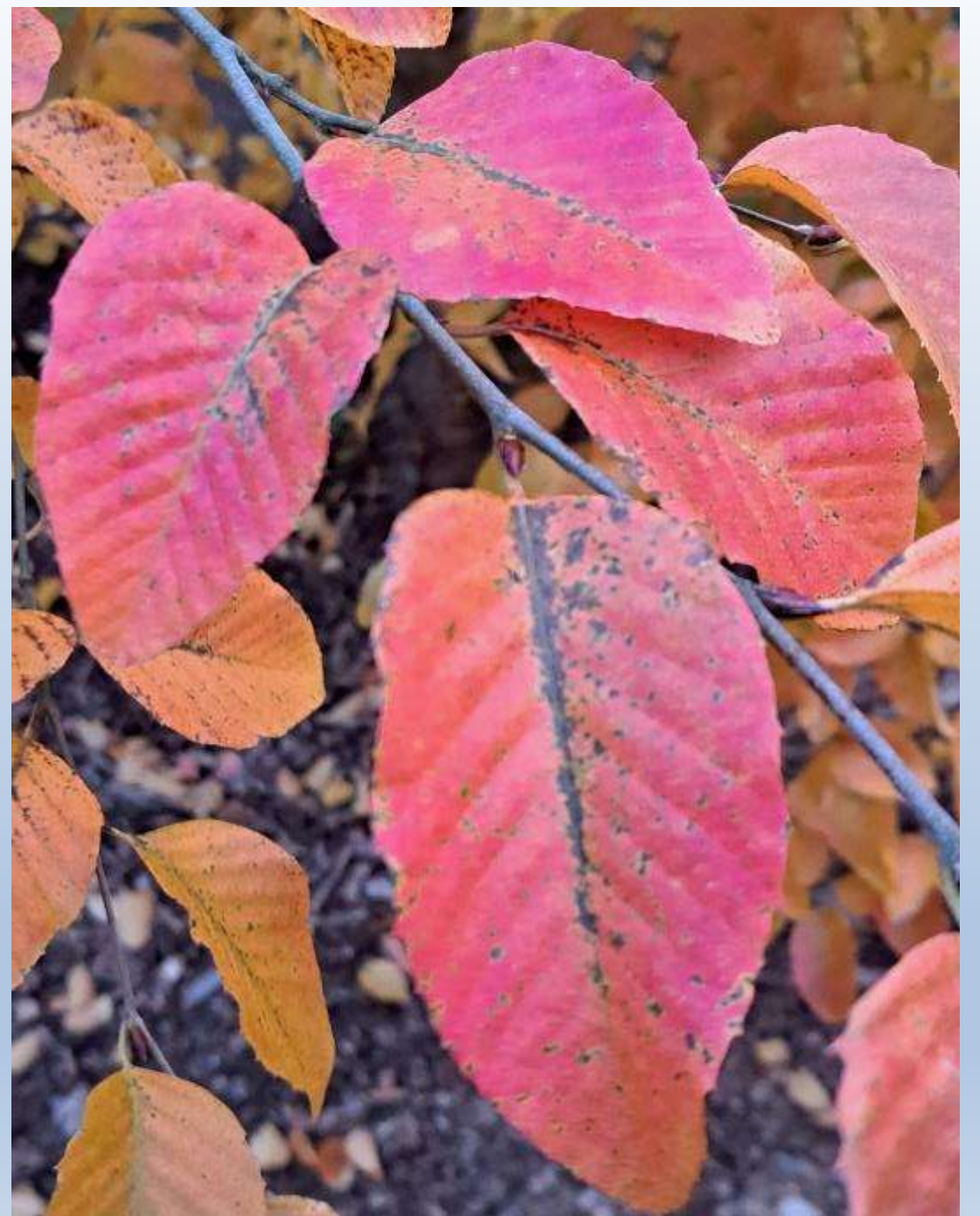
*Paulownia kawakamii* – Dragon Tree - Taiwan



*Emmenopterys henryi* – China - George Forrest collection planted 1925 – still to flower at RBGE!



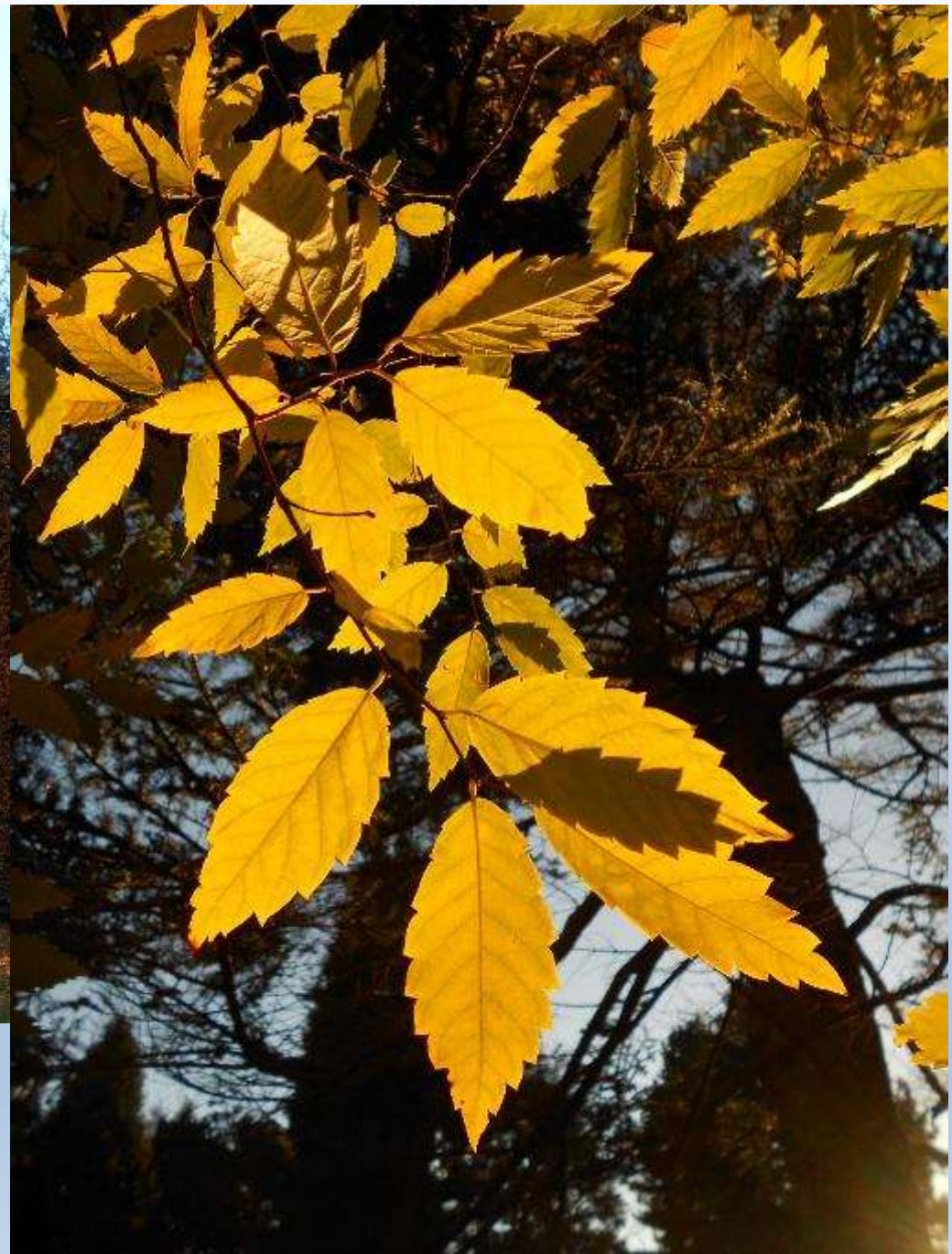
*Nothofagus nervosa* - Chile

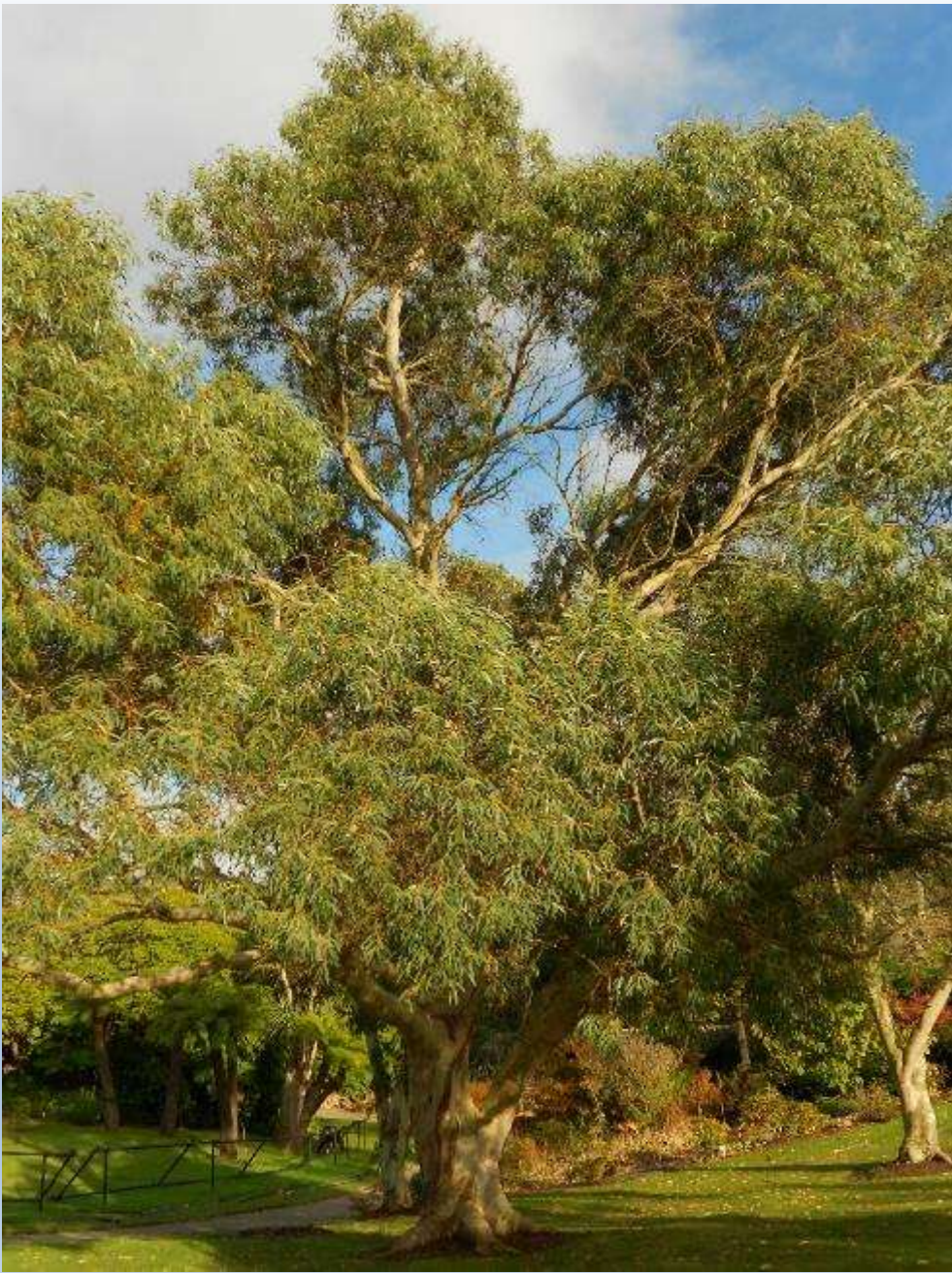




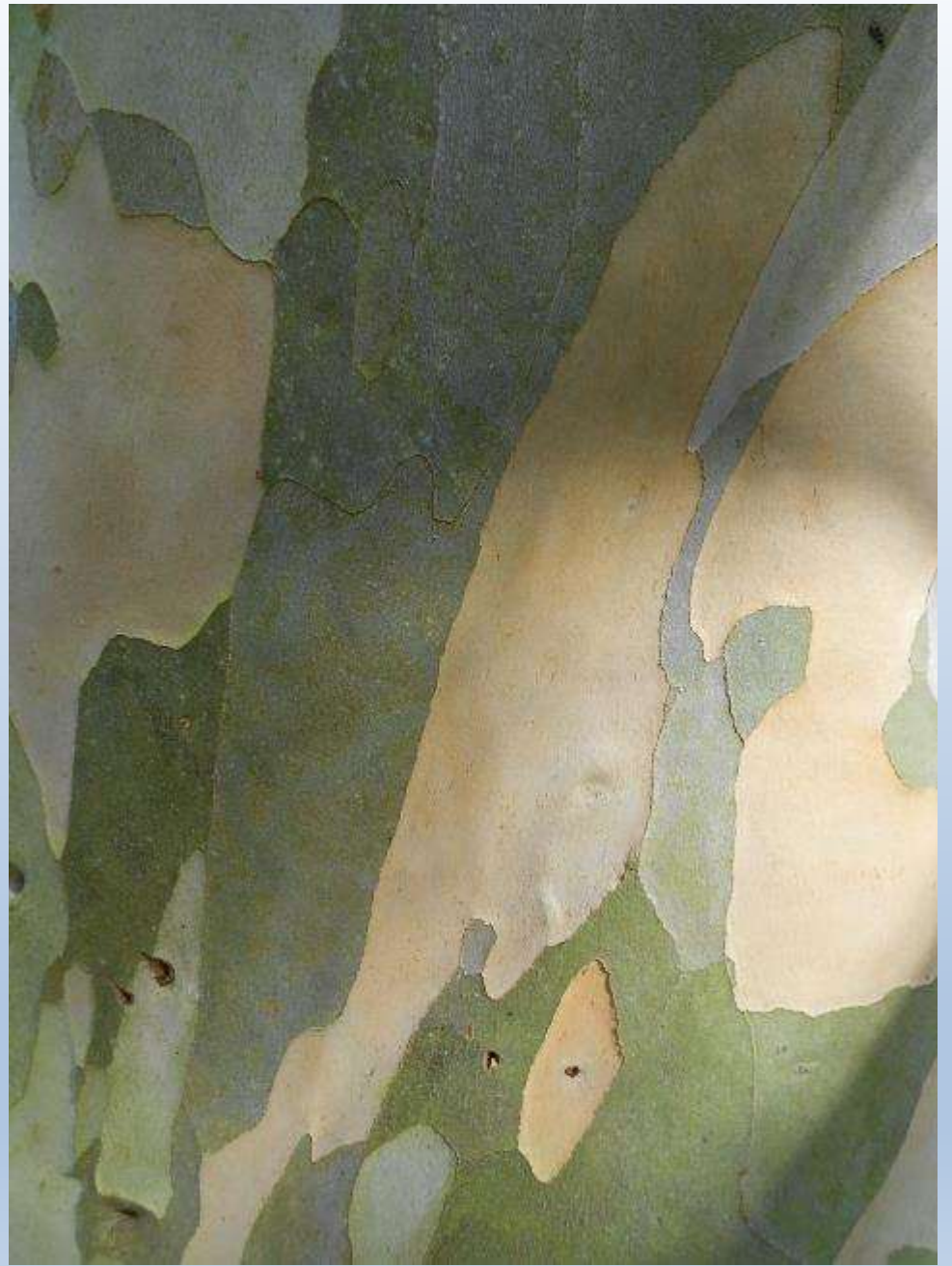


Zelkova x verschaffeltii – Z. carpinifolia x serrata





*Eucalyptus coccoifera* – Tasmanian Snow Gum





*Tilia tomentosa*





*Tilia oliveri*



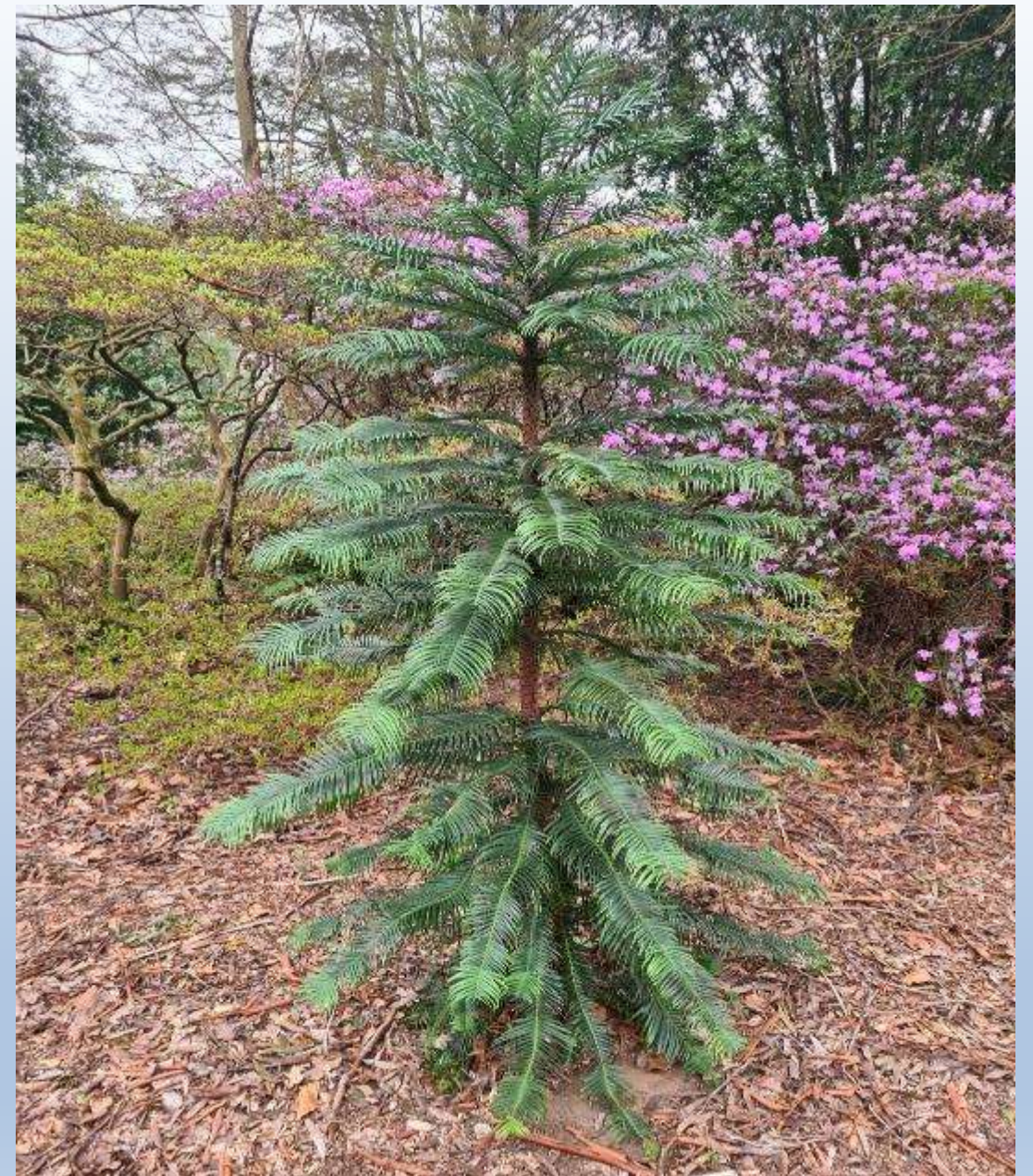


Tilia americana



Tilia endochrysea –  
although other species deserve to more widely planted

## Failures and successes – lessons learned



*Wollemia nobilis* first planted at RBGE 2008



There is currently never been a greater understanding of the importance, value and benefits of all the different components of parks, gardens, greenspace and the wider natural environment

Partly linked to C19 but also to the two biggest challenges we –humankind- face - climate change and significant biodiversity loss

The challenges we face -working in nature based professions - will be ensuring that we continue to sustain this level of appreciation against a backdrop of the many challenges, threats and opportunities we face.

# Thank you for listening

## Any questions?

- Acknowledgements:

- Will Hinchliffe, RBGE Arb
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