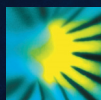


# *Plants, People, Planet* Symposium

Royal Botanic Gardens, Kew, London  
4–5 September 2019



New Phytologist  
Trust

**PPF**  
Plants People Planet

**Programme, abstracts and participants**

# ***Plants, People, Planet Symposium***

Royal Botanic Gardens, Kew

4–5 September 2019

## **Organising Committee**

Simon Hiscock, Editor in Chief, *Plants, People, Planet*

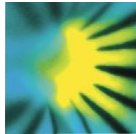
Sarah Lennon, Executive Editor, New Phytologist Trust

Paul Wilkin, Deputy Editor in Chief, *Plants, People, Planet*

Bennett Young, Managing Editor, *Plants, People, Planet*

# Acknowledgements

The *Plants, People, Planet* Symposium is funded by the New Phytologist Trust  
[www.newphytologist.org](http://www.newphytologist.org)



New Phytologist  
Trust

The New Phytologist Trust is a non-profit-making organisation dedicated to the promotion of plant science. It owns and produces the international journals *New Phytologist* and *Plants, People, Planet*. The Trust receives income through its publication activities and any excess revenue from publication of the journals is put straight back into supporting plant science. This is achieved by funding a wide range of activities: the organisation and sponsorship of symposia, workshops and meetings; numerous grant schemes; sponsorship of various awards for early-stage career scientists including the Tansley Medal; and ensuring that research published in the journals is as widely and openly available as possible. These actions have a common goal to promote emerging areas of plant science and to encourage continued progress and innovation in the field.

Programme, abstracts and participant list compiled by Freja Kärrman-Bailey  
'*Plants, People, Planet* Symposium' logo by  
Andy Crayston, Promotional Gods, Lancaster, UK

Contact email: [np-symposia@lancaster.ac.uk](mailto:np-symposia@lancaster.ac.uk)

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# Symposium Overview

Our complex relationship with plants has resulted in the world as we know it today, shaping not only the Earth's ecosystems but also its societies and cultures. As the human race continues to grow, the work of plant scientists to meet the global challenges of the 21<sup>st</sup> Century has never been more important. It is in this context that we welcome you to the inaugural *Plants, People, Planet* Symposium.

This exciting symposium will highlight outstanding plant-based research in its broadest sense and celebrate everything new, innovative and exciting in plant sciences that is relevant to society and people's daily lives.

The symposium is split into seven sessions that reflect the key themes of the journal: *Plants and society*, *Plant diversity*, *Plants and global change*, *Engaging people with plants*, *Plant natural assets*, *Plant genomics applications*, *Plant conservation*.

With such a broad range of important topics on offer, our aim is for this symposium to be of keen interest to all those interested in plant-based research and its impact on people, society and the world in which we live.

For more information on the journal, please visit [www.plantspeopleplanet.org](http://www.plantspeopleplanet.org).

# Information for Delegates

## **Symposium location**

The *Plants, People, Planet* Symposium will be held at the Jodrell Laboratory lecture theatre at the Royal Botanic Gardens, Kew. Please enter via the Jodrell Gate, which is at the end of Kew Road close to Kew Green. Maps and travel information can be found at the back of this abstract book.

Jodrell Laboratory  
Royal Botanic Gardens, Kew  
Richmond  
TW9 3AB  
UK

## **Catering**

All lunches and coffee breaks will take place in the Jodrell Laboratory 'Wolfson Atrium' on the 1<sup>st</sup> floor.

The symposium dinner on September 4<sup>th</sup> will be held in Cambridge Cottage, also in the Royal Botanic Gardens, Kew. The dinner will commence at 19:30. You will need to have registered for this option in order to attend. All grant awardees are welcome to attend the symposium dinner.

If you have special dietary requirements please do make yourself known to the catering staff or ask Freja/Bennett from the New Phytologist Trust. All our requirements have been provided to the catering team, and they will have meals prepared accordingly.

## **Posters**

Posters should be prepared so that they are no larger than A0 size, portrait orientation (118cm high X 84cm wide). Posters should be put up during registration (07:30–09:30 on Wednesday 4<sup>th</sup> September) and will be displayed for the duration of the meeting. Delegates are welcome to view posters

during coffee and lunch breaks, but there will be a dedicated poster session at 18:00–19:00 on Wednesday 4<sup>th</sup> September. Drinks will be served throughout this session in the Upper Atrium. Please stand by your poster during the poster session to chat and answer questions (we appreciate that you will also want to view and discuss other posters). Please note that there will be prizes for the best poster presentations. Posters will be assessed by your peers (the other delegates) and the posters that gain the most votes will receive prizes. A scoring sheet is included in your delegate pack. Please fill out and return this sheet to the registration desk by 13:00 on Thursday 5<sup>th</sup> September.

There will also be a prize awarded to the best selected poster speaker. The winner will be selected by a panel and will be announced at the end of the symposium.

### **Internet access**

Please select **Kew Visitors** to access free WiFi while in the Jodrell Laboratory.

Eduroam should also be available. To access this you must ensure that you are set up to access Eduroam via your home institution, this will allow you to connect to the Kew Eduroam network.

### **Social media**

We encourage all attendees to join in discussions on social media sites. Follow @plantspplplanet on Twitter and fb.com/plantspeopleplanet on Facebook for updates before, during and after the meeting. Please use the hashtag #PPP19 in all of your tweets.

### **Photography**

Photography will take place at the *Plants, People Planet* symposium. The resulting photographs will be used by the New Phytologist Trust for the purpose of promoting its activities, and may be published on the New Phytologist Trust's website and social media channels. If you do not wish to appear in the photographs, please speak to one of the organisers.

## **Code of conduct**

The New Phytologist Trust celebrates diversity and we expect participants in our meetings to be respectful, considerate and supportive of each other, to offer constructive critiques and embrace the variety of opinions on offer. The *Plants, People Planet* symposium is an opportunity to share, develop and broaden our viewpoints within a safe and inclusive setting, and we hope that you will enjoy the meeting. If you have any concerns or suggestions, please speak to one of the organisers.

## **Contact**

The main contact for the symposium is Freja Kärrman-Bailey, email: [np-symposia@lancaster.ac.uk](mailto:np-symposia@lancaster.ac.uk), tel: +44 7948 190448.



# Meeting Programme

**Wednesday 4<sup>th</sup> September**

7:30–9:30 Registration and refreshments

9:30–9:40 Welcome and Introduction

**Simon Hiscock, Paul Wilkin and Alexandre Antonelli**

9:40–10:20 **Keynote Lecture – Nicola Spence**

How the global threat of pests and diseases impacts plants, people and the planet

Session 1

**Plants and Society**

Chair: Simon Hiscock

10:20–10:40 **Alexandre Antonelli**

Testing traditional plant knowledge using genomic tools:  
Revisiting the fascinating history of the fever tree  
(*Cinchona*)

10:40–11:00 **Dawn Sanders**

Standing in the shadows of plants: New perspectives on  
plant blindness

11:00–11:20 **Crystal McMichael**

Late Holocene changes in Amazonian palm abundances

11:20–11:40 **Stephanie Smith**

Drops join to make a stream, ears combine to make a crop:  
multinational and multidisciplinary approaches to solving  
global challenges in plant science

11:40–12:00    Selected poster talk **Jessica Turner-Skoff**  
The benefits of trees for livable and sustainable communities

12:00–13:00    Lunch

Session 2  
**Plant Diversity**  
Chair: Pamela Diggle

13:00–13:20    **Simon Hiscock**  
Hybridization and polyploidy as drivers of rapid speciation in plants

13:20–13:40    **Susanne Renner**  
Narrowing down the early domestication history of the watermelon with ancient seeds and DNA

13:40–14:00    **Eric von Wettburg**  
The Queen of Sheba's chickpeas: post-domestication dispersal of crops along trade-routes

14:00–14:20    **Oscar Alejandro Pérez Escobar**  
Tracing date palm (*Phoenix dactylifera*) domestication through time, using whole-genome sequencing of archaeological remains

14:20–14:40    Selected poster talk - **Adriane Tobias**  
On the identity of *Rafflesia banoana*, a unique and magnificent flower of the Banao Indigenous Cultural Community

14:40–14:50    Group Photograph

14:50–15:20    Break

Session 3  
**Plants and Global Change**  
Chair: Alexandre Antonelli

- 15:20–15:40 **Katie Field**  
The roots of change: global change and mycorrhizal symbioses through the Phanerozoic
- 15:40–16:00 **Evan DeLucia**  
Farming with rocks: Using agriculture to reduce greenhouse gases in the atmosphere
- 16:00–16:20 **Rich Norby**  
Rapid loss of an ecosystem engineer: Sphagnum decline in an experimentally warmed bog
- 16:20–16:40 **Pamela Diggle**  
Does variation in flower development explain anomalous phenological responses to temperature?

16:40–18:00 Flash poster presentations

18:00–19:30 Drinks reception and poster session

19:30–22:30 Symposium dinner at Cambridge Cottage

**Thursday 5<sup>th</sup> September**

- 8:55–9:00 Announcements
- 9:00–9:40 **Keynote Lecture – William (Ned) Friedman**  
Mutants in our midst: Can botanical gardens do more to promote societal understanding of evolution?

Session 4

**Engaging People with Plants**

Chair: Dawn Sanders

- 9:40–10:00 **Jill Edmondson**  
Grow your own food security? Integrating science and citizen science to estimate the contribution of own-growing to UK food production
- 10:00–10:20 **Chris Thorogood**  
Engaging people with plants

10:20–10:50 Break

Session 5

**Plant Natural Assets**

Chair: Susanne Renner

- 10:50–11:10 **Paul Wilkin**  
Large scale phylogenomics of the yam genus (*Dioscorea*) to identify the origins of crops and their relationships to wild species
- 11:10–11:30 **Julie Hawkins**  
People and Medicinal Plants
- 11:30–11:50 **Colin Khoury**  
Developing meaningful indicators of the importance, interdependence with regard to genetic resources, and conservation status of socioeconomically valuable plants
- 11:50–12:10 **Olwen Grace**  
Water storage in succulent plants

12:10–12:30    Selected poster talk - **Katie Marfleet**  
Gathering evidence to meet gaps in Pest Risk Analysis  
evidence- The International Plant Sentinel Network

12:30–13:25    Lunch

Session 6  
**Plant Genomic Applications**  
Chair: TBC

13.25–13.45    **Ana Caicedo**  
Reinventing the wheel? The evolution of seed shattering in  
de-domesticated populations of weedy rice

13:45–14:05    **Richard Buggs**  
Genomics for future trees

14:05–14:25    **Andrew Groover**  
Understanding the genetic basis of quantitative trait  
variation in Populus

14:25–14:45    **Katherine Denby**  
Genetic improvement of leafy vegetables for sustainable  
production and livelihoods

14:45–15:05    Selected poster talk – **Zoë Migicovsky**  
The genomic consequences of apple domestication

15:05–15:35    Break

Session 7  
**Plant conservation**  
Chair: Paul Wilkin

- 15:35–15:55    **Toby Pennington**  
The dry tropics: science, conservation and restoration
- 15:55–16:15    **Cicely A. Marshall**  
Reconciling global and local priorities for plant conservation and economic development in the west African mining context: the case of Guinea’s bauxite
- 16:15–16:35    Selected poster talk **Jenny Williams**  
Madagascar drone survey mapping: illegal deforestation and early warning detection
- 16:35–16:55    **Antje Ahrends**  
The impact of rubber on forests in South East Asia
- 16:55–17:15    **Paul Smith**  
Integrated plant conservation. What can the botanic garden community do to prevent plant species extinctions?
- 17:15–17:30    Closing remarks and prize-giving

# Speaker Abstracts

S=speaker abstract, P=poster abstract

Antje Ahrends	<b>S7.3</b>
Alexandre Antonelli	<b>S1.1</b>
Richard Buggs	<b>S6.2</b>
Ana Caicedo	<b>S6.1</b>
Evan DeLucia	<b>S3.2, P52</b>
Katherine Denby	<b>S6.4</b>
Pamela Diggle	<b>S3.4</b>
Jill Edmondson	<b>S4.1</b>
Katie Field	<b>S3.1</b>
William (Ned) Friedman	<b>Keynote Lecture</b>
Olwen Grace	<b>S5.4</b>
Andrew Groover	<b>S6.3</b>
Julie Hawkins	<b>S5.2, P28</b>
Simon Hiscock	<b>S2.1</b>
Colin Houry	<b>S5.3, P35</b>
Crystal McMichael	<b>S1.3</b>
Cicely Marshall	<b>S7.2</b>
Richard Norby	<b>S3.3</b>
Toby Pennington	<b>S7.1</b>
Oscar Alejandro Pérez Escobar	<b>S2.4</b>
Susanne Renner	<b>S2.2, P18</b>
Dawn Sanders	<b>S1.2</b>
Paul Smith	<b>S7.4</b>
Stephanie Smith	<b>S1.4</b>
Nicola Spence	<b>Keynote Lecture</b>
Chris Thorogood	<b>S4.2</b>
Eric von Wettburg	<b>S2.3</b>
Paul Wilkin	<b>S5.1</b>

# Speaker Abstracts



## **How the global threat of pests and diseases impacts plants, people and the planet**

*Keynote  
Lecture*

NICOLA SPENCE

9:40–10:20

[Nicola.spence@defra.gov.uk](mailto:Nicola.spence@defra.gov.uk)

*Defra Plant Health, Sand Hutton, York, YO41 1LZ, UK*

The long-term trend of increasing volume and speed of movement of plants and plant material traded from an increasing variety of sources increases the chances of exotic pests arriving with imported goods and travellers, as well as by natural spread. The GB plant biosecurity strategy ensures activity is directed at priority pests and pathways and is informed by comprehensive risk assessment, which includes pest risk analysis, pathway analysis and trade intelligence plant pathology, population dynamics, and epidemiology, as well as social sciences to understand the values at risk. To respond effectively to new and emerging threats, GB as a whole must be resilient, capable and prepared to respond flexibly to new and emerging threats and everyone with an interest in plants must share responsibility for managing risks.

I will describe how plant and tree health impacts plants, people and the planet and how work with stakeholders improves plant health and biosecurity in the UK. I will describe key recent actions which have included: development of a prioritised plant health risk register to achieve better pest risk prioritisation and management; development and testing a plant health contingency plan to achieve better preparedness and control response; improving public access to plant and tree health information by developing a



digital information portal to provide comprehensive plant health information and addressing key skills shortages in plant health.



## Testing traditional plant knowledge using genomic tools: Revisiting the fascinating history of the fever tree (*Cinchona*)

# S1.1

ALEXANDRE ANTONELLI<sup>1,2</sup>, NINA RØNSTED<sup>3,4\*</sup>, CARLA MALDONADO<sup>5</sup>, NATALY ALLASI CANALES<sup>4</sup>, OSCAR ALEJANDRO PEREZ-ESCOBAR<sup>1</sup>, KIM WALKER<sup>1,6</sup>, ILIA LEITCH<sup>1</sup>, CHRISTOPHER J. BARNES<sup>4</sup>, CLAUS CORNETT<sup>7</sup>, MARK NESBITT<sup>1</sup>, and the CINCHONEAE WORKING GROUP

10:20–10:40

[a.antonelli@kew.org](mailto:a.antonelli@kew.org)

<sup>1</sup>Royal Botanic Gardens, Kew, Richmond, UK;

<sup>2</sup>Gothenburg Global Biodiversity Centre, Gothenburg, Sweden; <sup>3</sup>National Tropical Botanical Garden, Kalaheo, Hawaii, HI, USA; <sup>4</sup>Natural History Museum of Denmark, University of Copenhagen, Denmark;

<sup>5</sup>Herbario Nacional de Bolivia, Universidad Mayor de San Andrés, La Paz, Bolivia; <sup>6</sup>Royal Holloway University of London, UK; <sup>7</sup>Analytical Biosciences, Department of Pharmacy, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark

The fever tree (*Cinchona*) was discovered by local communities in South America and introduced to European empires in the 16th century. The tree produces quinine, which was the only effective medicine against malaria for several centuries and still remains an important anti-malarial drug today. Quinine and related alkaloids are known to be produced by many species in the genus *Cinchona* and its relatives in the Cinchoneae tribe of the coffee

family Rubiaceae. Considering this group's high species diversity and wide distribution, our group is trying to settle one of the long standing questions in the use of traditional plant knowledge: *"Did the indigenous populations, with no formal botanical knowledge and using only trial-and-error, succeed in locating the species with the highest concentrations of quinine, or are there still species to be discovered that produce more quinine or perhaps different alkaloids that are even more effective in treating malaria?"* To tackle this question, we are using genomic tools to understand how the different species of *Cinchona* are related to each other so we can target our search for the best quinine producing species more effectively. This project exemplifies how traditional knowledge, genomics, taxonomy and chemistry can be brought together to explore useful properties of wild plant species.



**Standing in the shadows of plants:  
New perspectives on plant  
blindness**

**S1.2**

DAWN SANDERS

10:40–11:00

[dawn.sanders@gu.se](mailto:dawn.sanders@gu.se)

*Faculty of Education, University of Gothenburg,  
Sweden*

In this presentation I will consider the social challenges in comprehending what it means for humans to perceive the importance of plants in a time of extreme anthropogenic change. In particular, the primary emphasis will concern the role of art in making the characteristics and capacities identified with 'plantiness' public, alongside the provocative potential of approaches from the humanities to move plants and people research beyond the original 20<sup>th</sup> century theory of 'plant-blindness'. The talk will draw on diverse research papers presented in the recent special issue of *Plants, People, Planet* (<https://nph.onlinelibrary.wiley.com/toc/25722611/2019/1/3>) and a completed research study funded by The Swedish Research Council (Dnr 2014-2013). This work is anchored in, and framed by, the belief that interdisciplinary work is critical to making the message 'plants= life' public and socially meaningful in the 21<sup>st</sup> century.



## Late Holocene changes in Amazonian palm abundances

# S1.3

CRYSTAL N. H. McMICHAEL

11:00–11:20

[C.N.H.McMichael@uva.nl](mailto:C.N.H.McMichael@uva.nl)

*Department of Ecosystem and Landscape Dynamics,  
University of Amsterdam, 904 Science Park, 1098 XH,  
Amsterdam, Netherlands*

In Amazonia, 227 of ca. 16,000 tree species account for half the individual trees (termed ‘hyperdominant’ species), and a disproportionate number of these species are palms. We assessed how and whether palm abundances have changed through time in northwestern Amazonia, using charcoal and phytolith analysis on soil cores. We obtained ages of past fires using  $^{14}\text{C}$  dating. I will present the results of this work, including a detailed reconstruction of fire and vegetation history from northwestern Amazonia.



**Drops join to make a stream, ears  
combine to make a crop:  
multinational and multidisciplinary  
approaches to solving global  
challenges in plant science**

**S1.4**

STEPHANIE SMITH<sup>1</sup>, TIRTHANKAR  
BANDYOPADHYAY<sup>3</sup>, VARINDERPAL  
SINGH<sup>4</sup>, STEPHANIE SWARBRECK<sup>2,3</sup>,  
MATTHEW MILNER<sup>2</sup>, ALEKSANDER  
LIGEZA<sup>2</sup>, SHAILAJA FENNELL<sup>6</sup>, ALISON  
BENTLEY<sup>2</sup>, TINA BARSBY<sup>2</sup>, HOWARD  
GRIFFITHS<sup>2</sup>, OTTOLINE LEYSER<sup>1</sup>,  
MANOJ PRASAD<sup>3</sup>

11:20–11:40

[stephanie.smith@slcu.cam.ac.uk](mailto:stephanie.smith@slcu.cam.ac.uk)

*<sup>1</sup>Sainsbury Laboratory, University of Cambridge, Cambridge, UK; <sup>2</sup>National Institute for Agricultural Botany, Cambridge, UK; <sup>3</sup>Department of Plant Sciences, University of Cambridge, Cambridge, UK; <sup>4</sup>National Institute for Plant Genome Research, New Delhi, India; <sup>5</sup>Punjab Agricultural University, Ludhiana, India; <sup>6</sup>Centre of Development Studies, University of Cambridge, Cambridge, UK*

As the Earth's population increases, the immediate needs of humans and the interests of the environment are increasingly coming into conflict. This is particularly apparent in the domain of agriculture, where human food security needs to be balanced against environmental needs. However, through careful use of agricultural policy and plant breeding, these interests can coexist harmoniously.

The Cambridge–India Network for Translational Research in Nitrogen (CINTRIN) takes a multidisciplinary approach to reduce the problem of nitrogen fertilizer overapplication and the severe environmental damage

this causes. Whilst of general global concern, the problem of nitrogen overapplication is a particular problem in India due to various scientific and sociopolitical aggravating factors. CINTRIN is thus a collaboration of researchers, agronomists and crop breeders from India and the UK; this multidisciplinary and cross-cultural approach facilitates better understanding of problems, improved knowledge exchange and access to resources, and more effective communication of solutions to shareholders. CINTRIN's sister project, TIG2RESS, further utilises experts in social science to understand how policy, agenda and technology can combine to solve various issues that are currently affecting Indian agriculture. A major agronomic success of the CINTRIN project has been the development and use of a cheap field tool for farmers to reduce their fertiliser inputs; the PAU-LCC, which has led to fertiliser application rate reductions of up to 50% in the Punjab village of Bassian. On the plant breeding side, researchers working on the model grass *Brachypodium distachyon*, wheat, and the Indian staple crop Millet (Foftail Millet/Pearl Millet) are narrowing in on genes which show promise as breeding targets for improved nitrogen use efficiency, allowing yields to be sustained (or even increased) on lower levels of nitrate.



## Hybridization and polyploidy as drivers of rapid speciation in plants

# S2.1

SIMON HISCOCK

13:00–13:20

[simon.hiscock@obg.ox.ac.uk](mailto:simon.hiscock@obg.ox.ac.uk)

*University of Oxford Botanic Garden and Arboretum, Rose Lane, Oxford, UK and Department of Plant Sciences, University of Oxford, South Parks Road, Oxford, UK*

Interspecific hybridisation is widespread in plants and is now recognized as an important mechanism of rapid speciation and generation of novel biodiversity, especially when associated with polyploidy (allopolyploidy) and changes in mating system. While examples of allopolyploid speciation are common in the literature, examples of hybrid speciation without a change in chromosome number (homoploid hybrid speciation) appear to be less common, probably because they are more difficult to detect. The daisy family (Asteraceae), one of the largest families of flowering plants, provides abundant examples of hybrid speciation, both homoploid and allopolyploid, and some genera have become, or are becoming, recognized as models for studying the genetic, phenotypic and ecological processes associated with hybrid speciation, most notably the genera *Helianthus* (sunflowers), *Senecio* (ragworts) and *Tragopogon* (goatsbeards/salsifies). Here I will review recent and ongoing studies of homoploid speciation and allopolyploid speciation in the Asteraceae with a particular focus on the genus *Senecio*, in which at least five new hybrid taxa have arisen in the UK in the last 150 years. This burst of speciation in the UK follows the introduction of plants from Mt Etna, Sicily as horticultural exotics in the early 18<sup>th</sup> Century. *Senecio* therefore provides an interesting insight into the unintended consequences of human-mediated plant dispersal around the globe. This has increased dramatically over the past 100 years due the rise of the global horticulture



industry, and in association with human-driven global change. These have created increased opportunities for hybridisation among previously isolated plant lineages with unknown consequences for native ecosystems and biodiversity.



## Narrowing down the early domestication history of the watermelon with ancient seeds and DNA

S2.2

SUSANNE S. RENNER<sup>1,6</sup>, OSCAR A. PÉREZ-ESCOBAR<sup>2</sup>, MARTINA V. SILBER<sup>1</sup>, MARK NESBITT<sup>2</sup>, MICHAELA PREICK<sup>3</sup>, MICHAEL HOFREITER<sup>3</sup>, GUILLAUME CHOMICKI<sup>4,5\*</sup>

13:20–13:40

[renner@lmu.de](mailto:renner@lmu.de)

<sup>1</sup>*Department of Biology, Institute for Systematic Botany and Mycology, University of Munich (LMU), Menzinger Str. 67, 80638 Munich, Germany.* <sup>2</sup>*Royal Botanic Gardens, Kew, Richmond, TW9 3AE, UK.*

<sup>3</sup>*Faculty of Mathematics and Natural Sciences, Institute for Biochemistry and Biology, University of Potsdam, 14476 Potsdam, Germany.* <sup>4</sup>*Department of Plant Sciences, University of Oxford, South Parks Road, Oxford OX1 3RB, UK;* <sup>5</sup>*The Queen's College, High Street, Oxford OX1 4AW, UK*

Domestication of the watermelon (*Citrullus lanatus*) has alternatively been placed in South Africa or in Northeast Africa (Sudan or Egypt), but the oldest seeds associated with human settlement come from Libya. Finding the closest wild relatives or surviving progenitor populations, and understanding the early domestication history of watermelons, is hampered by geographically-biased sampling of wild watermelons and the drastic climate change in Holocene Northern Africa. Our approach relies on nuclear and plastid genomic data from a 3,500-year-old *Citrullus* leaf from an Egyptian mummy's sarcophagus and genomic data for representatives of the seven extant species of *Citrullus*, including material from Darfur/Sudan. We found that modern cultivars and the ancient plant uniquely share mutations in a

lycopene metabolism gene (LYCB) affecting pulp colour and a stop codon in a transcription factor regulating bitter cucurbitacin compounds. This implies that Egyptians were cultivating red-fleshed and sweet watermelons 3,500 years ago. Extant Sudanese watermelons with white, sweet pulp are the closest relatives of ancient and modern domesticated watermelons, suggesting domestication in Nubia. However, we lack genomic data from Libya, a region from which Neolithic plant and animal use is well documented, especially from the Tadrart Acacus area where the oldest watermelon seeds were discovered.



## **The Queen of Sheba's chickpeas: post-domestication dispersal of crops along trade-routes**

# S2.3

ERIC VON WETTBURG

13:40–14:00

[Eric.Bishop-Von-Wettberg@uvm.edu](mailto:Eric.Bishop-Von-Wettberg@uvm.edu)

*University of Vermont, USA*

The geographical spread of crops from centres of origin is often clouded in mysteries, with linguistics and archaeology providing incomplete evidence of movement in times before written history. Increasingly disputes about the origins of crop varieties in different regions could be resolved with genomic data. Here we have developed new approaches to clarify several hypotheses on history and geography of chickpea, a pulse crop that occurs early in archaeological records of the Fertile Crescent, but disappears for a two thousand year period. Although a founding crop in Middle Eastern agriculture, chickpea is currently most widely grown and consumed in South Asia, and is also an important crop in the East African highlands. It has been postulated that the movement of chickpea occurred first from its known region of domestication in the northern Fertile Crescent to the Indus Valley, and then spread to other regions such as Ethiopia. However, the archaeological gap in the archaeological record opens the possibility of dispersal from the Fertile Crescent, abandonment, and subsequent replacement from South Asia. Furthermore, the Ethiopian genepool may be of Middle Eastern origin, as suggested by cultural lore, or of South Asian descent, consistent with the dark seeded phenotype of Ethiopian landraces.



**Tracing date palm (*Phoenix dactylifera*) domestication through time, using whole-genome sequencing of archaeological remains**

**S2.4**

OSCAR A. PÉREZ-ESCOBAR<sup>1,6</sup>,

14:00–14:20

SIDONIE BELLOT<sup>1</sup>, MURIEL GROS-BALTHAZARD<sup>2</sup>, JONATHAN FLOWERS<sup>2</sup>, TOM WELLS<sup>3</sup>, ROWAN SCHLEY<sup>1</sup>, MICHAELA PREIK<sup>4</sup>, MICHAEL HOFFREITER<sup>4</sup>, WOLF EISERHARD<sup>7</sup>; PETER M. PETOE<sup>1</sup>; MARK NESBITT<sup>1</sup>, PHILIPPA RYAN<sup>1</sup>, SUSANNE S. RENNER<sup>5</sup>, ALEXANDRE ANTONELLI<sup>1,6</sup>, ILIA J. LEITCH<sup>1</sup>, MICHAEL PURUGGANAN<sup>2</sup>, WILLIAM J. BAKER<sup>1</sup>

[o.perez-escobar@kew.org](mailto:o.perez-escobar@kew.org)

<sup>1</sup>Comparative Plant and Fungal Biology, Royal Botanic Gardens, Kew, TW93AE, Richmond, UK; <sup>2</sup>New York University Abu Dhabi Research Institute, Abu Dhabi, United Arab Emirates; <sup>3</sup>Department of Plant Sciences, University of Oxford, OX1 3RB, Oxford, UK; <sup>4</sup>Institute of Biochemistry and Biology, University of Potsdam, 14476 Potsdam, Germany; <sup>5</sup>Department of Systematic Botany and Mycology, Ludwig-Maximilians University, 80638, Munich, Germany; <sup>6</sup>Göteborg Global Biodiversity Centre, Göteborg, Sweden; <sup>7</sup>Department of Bioscience – Ecoinformatics and Biodiversity, University of Aarhus, 8000 Aarhus, Denmark

Accessing the DNA of plant archaeological material in principle allows to track crop adaptation through time. We are trying to disentangle the effects of domestication, hybridization and climatic change on the genetic diversity and genome architecture of the date palm. The date palm, *Phoenix dactylifera*, is one of the oldest and most economically important fruit crops worldwide, but its domestication history has remained enigmatic. Recent population-genomic studies on date palms suggest domestication in the Middle East, followed by diversification in Africa, possibly via hybridization with other *Phoenix* species. We have produced genomic data from the leaves of a  $\approx 3,500$ -years-old date palm specimen found in the necropolis of Saqqarah (Egypt) and are placing it in a phylogenomic context inferred from 51 modern accessions of date palms and other *Phoenix* species. The results show that the ancient date palm DNA shares nuclear and plastid mutations with modern date palms from North Africa, *P. atlantica* from Cape Verde, and the Asian *P. sylvestris*, the sister species of the date palm. Patterson' *D*-statistics derived from nuclear genomic SNPs indicate that the ancient date palm is more closely related to *P. dactylifera* and *P. atlantica* than to *P. sylvestris* and *P. theophrasti*. However, our introgression tests indicate that gene flow between the Saqqarah date palm and *P. theophrasti* might have occurred. Contrastingly, no evidence for introgression between the ancient date palm and *P. sylvestris* could be found. Taken together, our results suggest that hybridization of the date palm with *P. theophrasti*, a process that is thought to be responsible for the high genetic diversity of North African date palms, might have already taken place  $\sim 3,500$  yrs ago.



## **The roots of change: global change and mycorrhizal symbioses through the Phanerozoic**

# S3.1

KATIE FIELD

15:20–15:40

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*Centre for Plant Sciences, School of Biology, Faculty of Biological Sciences, University of Leeds, Leeds, LS2 9JT, UK*

Fungi and plants have engaged in intimate symbioses that are now globally widespread and have driven terrestrial biogeochemical processes since plant terrestrialisation >500 Mya. These associations, known as mycorrhizas, are usually considered to be nutritional mutualisms, whereby the plant benefits from greater access to soil nutrients in return for transfer of photosynthetic carbon to their mycorrhizal fungal partners. Enhanced access to soil nutrient pools is likely to have been critical for the success of the earliest plants on land and today forms the basis for the exploitation of soil fungi in sustainable approaches to agriculture.

Fossil evidence from the Rhynie Chert indicates that the earliest land plants, which evolved in a high CO<sub>2</sub> atmosphere during the Paleozoic Era, hosted diverse fungal symbionts. It is generally thought that the rise of early non-vascular plants and the later evolution of plant roots and vasculature drove the long-term shift towards a high-oxygen, low-CO<sub>2</sub> atmosphere and climate that eventually permitted the evolution of mammals and, ultimately, humans. Such shifts in atmospheric CO<sub>2</sub> concentration, together with biotic factors such as plant and fungal identity, have been shown to impact exchanges of carbon for nutrients between plants and their mycorrhizal fungi. Indeed, the effects of atmospheric CO<sub>2</sub> concentrations and cultivar on crop-fungal carbon-for-nutrient exchanges remain critical knowledge gaps in

the exploitation of mycorrhizas for future sustainable agriculture in a changing climate. We are investigating the impact of climate change-relevant shifts in atmospheric CO<sub>2</sub> concentrations in both wild and domesticated plant mycorrhizas. Our research suggests that mycorrhizas can contribute to sustainable crop production as part of a wider sustainable agriculture strategy and that there is substantial potential to improve future crop mycorrhizal receptivity, function and CO<sub>2</sub> responsiveness.





## Farming with rocks: Using agriculture to reduce greenhouse gases in the atmosphere

S3.2

EVAN DeLUCIA<sup>1,2,3,5</sup>, IISA B. KANTOLA<sup>1,2,3</sup>, ELENA BLANC-BETES<sup>1,2</sup>, MICHAEL D. MASTERS<sup>1,2,3</sup>, MARIA VAL MARTIN<sup>3</sup>, CARL J. BERNACCHI<sup>3,4,5</sup>, STEPHEN P. LONG<sup>1,2,3,5</sup>, DAVID J. BEERLING<sup>3</sup>

15:40–16:00

[delucia@illinois.edu](mailto:delucia@illinois.edu)

<sup>1</sup>*Institute for Sustainability, Energy, and Environment, University of Illinois at Urbana-Champaign, Urbana, IL, USA;* <sup>2</sup>*Carl R. Woese Institute for Genomic Biology, University of Illinois at Urbana-Champaign, Urbana, IL, USA;* <sup>3</sup>*Leverhulme Centre for Climate Change Mitigation, Department of Animal and Plant Sciences, University of Sheffield, Sheffield, UK;* <sup>4</sup>*United States Department of Agriculture Agricultural Research Service, Urbana, IL, USA;* <sup>5</sup>*Department of Plant Biology, University of Illinois at Urbana-Champaign, Urbana, IL, USA*

Reversing agriculture's contribution of greenhouse gases to the atmosphere can reduce the rate of planetary warming. Land-based enhanced rock weathering, the process of applying ground silicate rock to soils, is an UN-recognized geo-engineering strategy for sequestering CO<sub>2</sub> from the atmosphere. As a co-benefit to sequestering CO<sub>2</sub>, we hypothesize that increases in soil pH following basalt addition has a liming effect that may impact nitrogen cycle and shift the greenhouse gas balance by reducing emissions of N<sub>2</sub>O from soil. We show that application of basalt to heavily-fertilized annual *Zea mays* and the low-fertilizer perennial bioenergy grass *Miscanthus x giganteus* in Illinois over a period of 3 years significantly

increased soil pH in maize, and consistently reduced annual N<sub>2</sub>O production in both crops. N<sub>2</sub>O production in soils with surface applied and tilled-in metamorphose basalt was reduced by 4-14% compared to controls. Crop yields either increased or remained unchanged indicating enhanced weathering is compatible with conventional farming practices. The modeled response of N<sub>2</sub>O emissions to basalt was mostly driven by increases in soil pH with lesser contribution of P additions on N immobilization. Upscaling of our field-trial results indicates reductions from  $0.3 \pm 0.02$  Tg N<sub>2</sub>O-N yr<sup>-1</sup> flux by 6, 17, 27 and 43% across the US corn-belt following increases in initial soil pH by 0.1, 0.3, 0.5, and 1.0 units, respectively. The abatement of soil N<sub>2</sub>O emissions by rock dust could substantially lower the adverse impacts of US agriculture on climate. This study demonstrates that the effects of enhanced weathering extend beyond CO<sub>2</sub> sequestration, and may benefit both greenhouse gas mitigation and crop production in fertile, organic matter-rich US corn-belt soils.



### Rapid loss of an ecosystem engineer: *Sphagnum* decline in an experimentally warmed bog

S3.3

RICHARD NORBY<sup>1</sup>, JOANNE CHILDS<sup>1</sup>,  
PAUL HANSON<sup>1</sup>, JEFF WARREN<sup>1</sup>

16:00–16:20

[rjn@ornl.gov](mailto:rjn@ornl.gov)

<sup>1</sup>*Environmental Sciences Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN, USA*

Human alteration of the atmosphere and climate will compromise critical services provided by terrestrial ecosystems. One such ecosystem service is carbon storage. Peatland ecosystems hold significant quantities of carbon that is vulnerable to be released to the atmosphere as atmospheric and climatic conditions change. The chemical and physical conditions that retard decomposition of the large carbon pools in peatlands are maintained by *Sphagnum* mosses, the keystone component of this ecosystem; hence, the responses of *Sphagnum* to climate change are critical to the future trajectory of peatland ecosystems. We measured the growth and productivity of *Sphagnum* in an ombrotrophic bog in northern Minnesota, where ten 12.8-m diameter plots are being exposed to a range of air and soil warming treatments (+0 to +9°C) in ambient or elevated (+500 ppm) CO<sub>2</sub>. Dry matter increment of *Sphagnum* increased with modest warming to a maximum at 4.9°C above ambient and decreased with additional warming. *Sphagnum* cover declined from close to 100% of the ground area to less than 50% in the warmest enclosures. After three years of warming, annual *Sphagnum* productivity declined linearly with increasing temperature, resulting in the loss of 13 to 29 g C m<sup>-2</sup> per degree of warming. Productivity was less in elevated CO<sub>2</sub> enclosures, which we attribute to increased shading by shrubs. *Sphagnum* desiccation and growth responses were associated with the effects of warming on hydrology. The rapid decline of the *Sphagnum* community with sustained warming, which appears to be

irreversible, can be expected to have many follow-on consequences to the structure and function of this and similar ecosystems, with significant feedbacks to the global carbon cycle and climate change....and hence to People and our Planet.



## Does variation in flower development explain anomalous phenological responses to temperature?

S3.4

PAMELA DIGGLE<sup>1</sup>, CHRISTA P. H. MULDER<sup>2</sup>

16:20–16:40

[pamela.diggle@uconn.edu](mailto:pamela.diggle@uconn.edu)

<sup>1</sup>*Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs CT 06269, USA;*

<sup>2</sup>*Institute of Arctic Biology and Department of Biology and Wildlife, University of Alaska Fairbanks, Fairbanks, AK 99775, USA*

Climate change has resulted in increased temperatures across the globe. Although many angiosperms flower earlier in response to rising temperature, a substantial number of species either do not appear to respond or even delay flowering in, or following, warm years. Existing phenological models cannot explain such exceptions to the common association of advancing phenologies with warming temperatures. The phenological events that are typically recorded (e.g., onset of flowering) are but one phase in a complex developmental process that often begins one or more years previously, and flowering time may be strongly influenced by temperature over the entire multi-year course of flower development. Preformation, the initiation of flower primordia one or more years prior to anthesis, is characteristic of temperate forest trees, shrubs, and many herbaceous perennials, and ubiquitous for high elevation and high latitude species. We explore conceptual models of the effects of temperature on the entire year-long process of flower preformation that incorporates changes in developmental rates, timing of onset and offset of individual stages, as well as plant and inflorescence architecture. Understanding these developmental process could dramatically improve our ability to predict the timing of flowering in temperate environments and may also give insights

into how temperate trees and shrubs, the majority of which preform flowers, will respond as the climate continues to warm.



**Mutants in our midst: Can botanical gardens do more to promote societal understanding of evolution?**

*Keynote  
Lecture*

WILIAM (NED) FRIEDMAN

9:00–9:40

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*Department of Organismic and Evolutionary Biology  
and The Arnold Arboretum, Harvard University,  
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Although often overlooked as such, many of the horticultural varieties and cultivars that grow in botanical gardens are premier examples of the ongoing process of evolution. Indeed, Charles Darwin, as well as a number of other early evolutionists drew heavily from late 18<sup>th</sup> and early 19<sup>th</sup> century botanical and horticultural knowledge to gain critical evidence for and insights into the process of evolution. Botanically and horticulturally inclined early evolutionists made use of an ever more extensive understanding of plant hybridization, domestication history, horticultural sports, and biogeography to piece together key facets of the evolutionary process. In the end, botanical and horticultural knowledge provided a unique set of perspectives complementary to those derived from the zoological world that, in Charles Darwin's hands, saw fruition in an overwhelmingly synthetic and complete argument for descent with modification in *On the Origin of Species*. Thus, botanical gardens present powerful opportunities to teach the public about the underlying and diverse processes of descent with modification. I will argue that botanical gardens can and should become a stronger voice for the promotion of evolutionary thinking in society by highlighting the very kinds of botanical sports, hybrids, and cultivars studied by Darwin and other early evolutionists.



## Grow your own food security? Integrating science and citizen science to estimate the contribution of own-growing to UK food production

# S4.1

JILL EDMONDSON<sup>1</sup>, ROSCOE S.  
BLEVINS<sup>1</sup>, HAMISH CUNNINGHAM<sup>2</sup>,  
MIRIAM C. DOBSON<sup>1</sup>, JONATHAN R.  
LEAKE<sup>1</sup>, DARREN R. GRAFIUS<sup>1</sup>

9:40–10:00

[j.edmondson@sheffield.ac.uk](mailto:j.edmondson@sheffield.ac.uk)

<sup>1</sup>*Department of Animal and Plant Sciences, University of Sheffield, Sheffield, S10 2TN, UK;* <sup>2</sup>*Department of Computer Sciences, University of Sheffield, Sheffield, S10 2TN, UK*

More than half of the world's population now live in urban areas and so are physically detached from the conventional agricultural system. However, globally ~800 million people practice urban agriculture, the majority driven by necessity for subsistence in the Global South. In recent decades there has been a resurgence in interest in urban agriculture in the Global North, as evidenced by the rise allotment waiting lists in the UK or the increase in community gardens in vacant lots in the USA. Indeed, own-grown production of fruits and vegetables in urban areas is increasingly recognised by policy-makers at local to transnational levels of governance as an important contributor to food security. Despite this recognition the evidence-base to support this assumption is lacking. Here, we integrate spatial analysis in a GIS, fieldwork and a citizen science project (MYHarvest.org.uk) to provide an estimate of current levels of UK own-grown fruit and vegetable production and how this could be increased if more urban land was made available for own-growing. A key challenge to this research was to understand the yield achieved by own-growers for



typical UK fruit and vegetable crops. This aspect of the research relied entirely on the own-growing community participating in MYHarvest. We used press releases (with resultant newspaper articles, radio and TV interviews), collaboration with the National Allotment Society and the Royal Horticultural Society, and stands at regional gardening shows to engage own-growers and maximise recruitment. Over two growing seasons >1,300 people signed up to the project with 441 going on to submit data for >20,500 individual crop harvests. This research will provide the first comprehensive UK dataset on own-grown production for use by scientists, policy-makers, and the public, and will highlight the importance of urban horticulture to local and national food security.



## Engaging people with plants

S4.2

CHRIS THOROGOOD

10:00–10:20

[Chris.thorogood@obg.ox.ac.uk](mailto:Chris.thorogood@obg.ox.ac.uk)

*University of Oxford Botanic Garden, Rose Lane,  
Oxford. OX1 4AZ*

Given the sharp decline in public interest with plant sciences, identifying new pathways to engagement has never been more important. Flora Obscura is a platform of *Plants, People, Planet* which puts a spotlight on astonishing plant biology in the digital landscape. Flora Obscura articles published to date – for example on unworldly *Hydnora*, or the underground orchid *Rhizanthella* – have seen unprecedented engagement scores in the field of plant biology, including Altmetrics ranked in the 99th percentile of all research outputs ever tracked. Together, they show that combining unique and intriguing plants to new demographics using multimedia is a powerful success mechanic for exciting people with plant biology. Furthermore, there is significant scope for botanic gardens to engage more people digitally with the collections they hold and the work they do. Whilst 300 million people visit botanic gardens every year, and engage with the plant collections they hold, in the Information Age, even more people can ‘visit’ online. This offers endless opportunities for communicating messages about the importance of plants to people. Oxford Botanic Garden has put focus on public engagement with remarkable ‘wow plants’, to challenge people’s perception of plants as inanimate or irrelevant. Plants can excite people. Within the context of a declining engagement in plant sciences, this talk explores innovative ways of elevating plants to the front and centre.



**Large scale phylogenomics of the  
yam genus (*Dioscorea*) to identify  
the origins of crops and their  
relationships to wild species**

**S5.1**

PAUL WILKIN<sup>1</sup>, FELIX FOREST<sup>1</sup>, SEAN  
W. GRAHAM<sup>2,3</sup>, BARBARA  
GRAVENDEEL<sup>4, 5, 6</sup>, MICHAEL B.  
KANTAR<sup>7</sup>, ILIA J. LEITCH<sup>1</sup>, MARYBEL  
SOTO GOMEZ<sup>2,3</sup>, JUAN VIRUEL<sup>1</sup>

10:50–11:10

[p.wilkin@kew.org](mailto:p.wilkin@kew.org)

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3DS, United Kingdom; <sup>2</sup>Department of Botany,

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<sup>5</sup>Institute Biology Leiden, Leiden University, Sylviusweg  
72, Leiden 2333 BE, The Netherlands; <sup>6</sup>Science and  
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<sup>7</sup>Department of Tropical Plant and Soil Sciences,  
University of Hawai'i at Manoa, Honolulu, Hawai'i,  
96822, USA

The principal cultivated yams (guinea yams, *Dioscorea rotundata*-*D. cayenensis* and winged yam, *D. alata*) had global yield of 73M tonnes in 2017, supplying dietary starch, protein and micronutrients, especially in West and Central Africa where the feed ca 100M people. They form part of a global consumption of tropical root and tuber crops of about

365kg/capita/year. Despite this productivity, they remain orphan crops with limited development via breeding and limited international trade. Their role is supported by at least five regionally or nationally important starch staples and many more niche crops and wild-exploited species among ca 625 species with a global temperate to tropical distribution. The two main crop species have significant pest and disease issues and guinea yams in particular a notably narrow climatic niche.

Yam breeding efforts to date have almost exclusively relied upon cultivated genepools, due in significant part to lack of understanding of cultivated-wild plant relationships. Previous phylogenetic research was too limited in both sampling and depth of genomic coverage to deliver this information effectively. The YAMNOMICS project used over 750 accessions, including herbarium and seed bank collections. Via Hybseq methods and using a customised target capture kit, 303 nuclear genes plus the plastome were sequenced for 450 species from the yam genus to estimate phylogeny. This unprecedented breadth and depth of research provided clear evidence for both of the principal crops and the more minor cultigens with which to identify species on which breeding programmes using crop wild relatives could be based. The same dataset was also used to estimate ploidy for each accession, including those from herbarium specimens, as a further resource for yam breeders. It will also be used for research on steroid synthesis through transcriptomics, trait evolution and phylogeography.



## People and medicinal plants

JULIE HAWKINS

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*School of Biological Sciences, University of Reading,  
Whiteknights, Reading RG6 6AS, UK*

# S5.2

11:10–11:30

Plants are a living repository of pharmacologically active chemicals. They meet health care needs directly, and provide natural products for drug development. How people have selected medicines from the plants around them is a question of great interest, with relevance to health-care strategies and to bioprospecting. With cultural, biological and linguistic diversity under threat, gaining a deeper and broader understanding of the variation of medicinal plant use cross-culturally and through time and space is pressing. In this talk I outline research directions in medicinal plant research, highlighting comparative methods as an approach to address several salient questions.



**Developing meaningful indicators of the importance, interdependence with regard to genetic resources, and conservation status of socioeconomically valuable plants**

**S5.3**

COLIN KHOURY

11:30–11:50

[c.khoury@cgiar.org](mailto:c.khoury@cgiar.org)

*International Center for Tropical Agriculture (CIAT),  
Recta Cali-Palmira, Apartado Aéreo 6713, 763537 Cali,  
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In recognition of the tremendous value of plants and of the increasing threats to their persistence, international agreements including the Sustainable Development Goals, the Convention on Biological Diversity, and the International Treaty on Plant Genetic Resources for Food and Agriculture have created ambitious conservation and sustainable use targets which must be measured through quantitative indicators. Gaps in the current indicators for these targets suggest that the development of effective measurements of the state of conservation and use of valuable plants is a major challenge. Here I present two current efforts that aim to contribute to filling these knowledge gaps. The first is a gap analysis indicator methodology that provides a pragmatic estimate of the comprehensiveness of conservation of the genetic diversity within 7,000 useful wild plant species, both ex situ and in situ. The methodology enables a prioritization of species for immediate conservation action, and, when measured periodically, can quantify progress toward comprehensive conservation of these plants at global, regional, and national scales, including determining when that goal has been reached. The second effort focuses on the compilation of useful metrics with regard to the importance of 350 food and agricultural crops, as well as interdependence among countries, the current status of demand and supply, and threats with regard to their genetic resources. Both projects hopefully represent advances in the state of

knowledge on valuable plants, through the mobilization of large and diverse data sources and state of the art indicator methodologies, and are available for use for those concerned with plants and their persistence around the world.



## Water storage in succulent plants

S5.4

OLWEN M. GRACE

11:50–12:10

*Royal Botanic Gardens, Kew, Surrey  
TW9 3AE, UK*

Specialised water-storing tissue, hydrenchyma, has evolved many times as an adaptation to drought among flowering plants. So-called ‘succulent’ plants comprise a phylogenetically diverse assemblage of thousands of species occurring in drought-prone habitats. The apparently simple hydrenchyma tissue is mechanistic complexity of the tissue and its function in regulating drought stress in xeric succulent plants. Considered in an evolutionary framework, these traits help to target attention towards the species and genes that could be useful bioresources to meet the challenges of environmental change. However, risks of species extinction and invasiveness indicate that this is not straightforward. Here, I will discuss recent advances in the understanding of water-storing tissues in plants and their future value.





## Reinventing the wheel? The evolution of seed shattering in de-domesticated populations of weedy rice

S6.1

ANA L. CAICEDO<sup>1</sup>, XIANG LI<sup>1</sup>,  
VERÓNICA HOYOS<sup>1,2</sup>, SHULIN  
ZHANG<sup>3</sup>, IGNACIO AMARO BLANCO<sup>4</sup>

13:25–13:45

[caicedo@bio.umass.edu](mailto:caicedo@bio.umass.edu)

<sup>1</sup>*University of Massachusetts, Amherst, MA, USA;*

<sup>2</sup>*Universidad Nacional, Bogotá, Colombia;* <sup>3</sup>*Anyang Institute of Technology, Anyang, China;* <sup>4</sup>*Instituto de Investigaciones Agrarias Finca La Orden, Valdesequera, Extremadura, Spain*

The invention of agriculture by humans created a dynamic environment which opportunistic weeds are constantly invading and in which they are evolving. These agricultural weeds are currently one of the largest constraints on crop productivity. Weedy or red rice is a conspecific weed of cultivated rice (*Oryza sativa*) that infests rice fields worldwide, aggressively competing with the crop and decreasing yields. Prior studies by us and others have shown that weedy rice has evolved independently multiple times, and it has done so from a diversity of ancestral backgrounds, which include several cultivated rice varieties. Various traits such as rapid growth, herbicide resistance, efficient seed dispersal, and seed dormancy are common in weed species and may help their adaptation to the agricultural environment. Seed shattering, a mechanism that aids in seed dispersal, is the most broadly convergent trait across weedy rice populations. The shattering trait is not present in cultivated rice ancestors, due to strong selection during domestication to facilitate harvesting, giving rise to questions about how weedy rice groups have reacquired the shattering trait. Seed shattering is dependent on the development of a functional abscission zone (AZ), a layer of densely cytoplasmic and non-lignified cells, at the base

of the flower where it attaches to the pedicel. We are dissecting the morphological and genetic basis of the seed shattering trait in three independently evolved populations of weedy rice. Preliminary mapping in weed x crop crosses suggests that different genetic mechanisms underlie the shattering trait across weed populations. I will present our recent findings on the morphology of the AZ in weed crop ancestors our efforts to determine how ancestral background may influence the evolutionary trajectory of the shattering trait in different weedy rice populations.



## Genomics for future trees

# S6.2

RICHARD BUGGS<sup>1,2</sup>

13:45–14:05

[r.buggs@qmul.ac.uk](mailto:r.buggs@qmul.ac.uk)

*<sup>1</sup>Queen Mary University of London, UK; <sup>2</sup>Royal Botanic Gardens, Kew, UK*

Broad-leaved trees stand to disproportionately benefit from advances in genomics. Their long-lifecycle and large size make them unsuitable subjects for classical genetic research and conventional breeding methods. But their small genome sizes - smaller than most crop, livestock or conifer genomes - makes them highly suited to genomic research. I will outline three methods that my research group is applying to enhance the future of broad-leaved trees. (1) Phylogenomics to find genes for resistance to the emerald ash borer in worldwide ash tree species. (2) Genome-wide association study and genomic prediction of ash dieback resistance in European ash. (3) Genome-environment associations to help dwarf birch populations in Scotland adapt to climate change. These methods allow rapid progress towards the solution of threats to trees, and give potential for future rapid breeding programmes.



## Understanding the genetic basis of quantitative trait variation in *Populus*

S6.3

ANDREW GROOVER<sup>1,2</sup>, HELOISE BASTIAANSE<sup>1</sup>, DANIELA RODRIGUEZ-ZACCARO<sup>1,2</sup>

14:05–14:25

[andrew.t.groover@usda.gov](mailto:andrew.t.groover@usda.gov)

<sup>1</sup>US Forest Service, Pacific Southwest Research Station, Davis CA, USA; <sup>2</sup>Department of Plant Biology, University of California Davis, USA

The majority of ecologically and economically important traits in forest trees are quantitative. Examples of such quantitative traits include biomass yield, phenology, and water stress physiology traits. Understanding the genetic basis of variation for such traits is a fundamental need for applications ranging from directed tree breeding, to predicting how different tree populations will respond to climate variation. A fundamental assumption of most quantitative genetic analyses is that DNA sequence variation among alleles for many individual genes is the ultimate source of quantitative trait variation. However, in practice, our ability to predict important tree traits based on allelic variation is often disappointing.

Recent comparative sequencing of plant genomes has revealed that structural variation, including gene copy number variation, is surprisingly common in plants, including poplar. Such variation results in alteration of relative gene dosage of the affected genes, but previously the significance of such variation on quantitative trait variation was unclear. In the presented work, we will show results from systematic genome-wide analysis of the effects of copy number variation on biomass yield, phenology, and wood anatomy traits associated with water stress in poplar. In general, a large proportion of poplar genes are dosage sensitive, and cumulatively gene dosage variation can account for a significant proportion of trait variation. Our results suggest consideration of copy number variation and dosage

variation could significantly improve our ability to predict phenotypes based on genotypic information.



## Genetic improvement of leafy vegetables for sustainable production and livelihoods

# S6.4

KATHERINE DENBY

14:25–14:45

[katherine.denby@york.ac.uk](mailto:katherine.denby@york.ac.uk)

University of York, UK

*Botrytis cinerea* and *Sclerotinia sclerotiorum* are fungal pathogens of global importance, each causing multi-million pound annual crop losses pre- and post-harvest on many dicotyledonous crops including field-grown and protected lettuce (the highest value vegetable crop in the UK). Chemical control is problematic with restrictions on spraying and fungicides being medium-high risk for development of resistance. Development of host resistance is a more sustainable solution, but has been an intransigent problem for breeders.

We have taken a novel approach to breeding for disease resistance against *B. cinerea* and *S. sclerotiorum* in lettuce combining systems biology and quantitative genetics. Genetic variation in susceptibility to these pathogens was identified in a set of diverse lettuce accessions with susceptibility to both pathogens correlated across different accessions, increasing the potential of identifying alleles conferring broad resistance. Disease resistance QTL have been identified in mapping populations. We developed a transcriptome-based network modelling strategy to predict genes conferring disease resistance against *B. cinerea* and *S. sclerotiorum*. These candidate genes are prioritised and tested by examining expression in diversity set lines showing a range of resistance phenotypes, by overexpression in *Arabidopsis*, and by DNA-free gene editing of target genes in lettuce. Co-localisation of these key regulators with resistance QTL could predict causal genes and associated markers for integration into lettuce breeding programmes.

We are also working on genetic improvement of leafy Amaranths – a widely eaten plant in Sub-Saharan Africa usually harvested from the wild – to

develop lines suitable for cultivation by smallholder farmers. This will not only enhance dietary diversity but also provide increased income as leafy vegetables are in demand at formal and informal markets. We are sequencing the genome of *A. cruentus* in association with the African Orphan Crop Consortium, and resequencing and phenotyping a diversity collection of 100 lines. Metabolite profiling, genomics, transcriptomics and participatory breeding are being used to select high quality lines that perform well under low input agriculture.



## The dry tropics: science, conservation and restoration

# S7.1

TOBY PENNINGTON<sup>1,2</sup>, LUCY ROWLAND<sup>1</sup>, DRYFLOR NETWORK

15:35–15:55

[T.Pennington@exeter.ac.uk](mailto:T.Pennington@exeter.ac.uk)

*<sup>1</sup>Department of Geography and Global Systems Institute, University of Exeter, Laver Building, North Park Road, Exeter EX4 4QE, UK; <sup>2</sup>Royal Botanic Garden Edinburgh, 20a Inverleith Row, Edinburgh EH3 5LR, UK*

Up to one third of the global population lives in seasonally dry areas of the tropics. This includes some of the world's poorest people, who rely upon tropical savannas and dry forests for ecosystem services including water, food and fuel. Despite this societal importance, tropical dry forests and savannas have been relatively neglected by science, conservation and, crucially, policy makers. This 'biome blindness' is exemplified by recent suggestions that savannas could be targets for afforestation, which would risk maintenance of species-richness that rivals that of rain forests. Neglect by conservation and policy makers is demonstrated by the extensive destruction of tropical dry forests and savannas coupled with representation in protected areas that does not meet Aichi targets. A sustainable future for the dry tropics will depend on ecosystem restoration. However, successful restoration in times of climatic change will require a much improved knowledge of plant functional trait diversity in tropical dry biomes in order to understand their value for carbon storage, water cycling and biogeochemical cycling.





## Reconciling global and local priorities for plant conservation and economic development in the west African mining context: the case of Guinea's bauxite

# S7.2

CICELY MARSHALL<sup>1</sup>, OOU OOU HABA<sup>2</sup>, DAVID BILIVOGUI<sup>2</sup>, FAYA SIMBIANO<sup>2</sup>, KOI KOI BILIVOGUI<sup>2</sup>, WILLIAM HAWTHORNE<sup>3</sup>

15:55–16:15

[cm997@cam.ac.uk](mailto:cm997@cam.ac.uk)

*<sup>1</sup>Department of Plant Sciences, University of Cambridge, Cambridge, UK; <sup>2</sup>Université de Nzérékoré, Nzérékoré, Guinea; <sup>3</sup>Department of Plant Sciences, University of Oxford, Oxford, UK*

Tropical Africa is home to around 30,000 plant taxa. Protecting these wild plants is important because we rely on this biodiversity to provide our livelihoods, not only in the places where these wild plants grow, but indirectly across the world. Protecting plant biodiversity is important, but so is economic development. The west African nation of Guinea (Conakry), ranked 175<sup>th</sup> of 190 by the Human Development Index, holds 40% of the world's bauxite, the main source of aluminium. The Government of Guinea is keen to increase production of bauxite, which has the potential to bring economic development and relative wealth to the country at a significant environmental cost.

Using a botanic baseline survey we carried out as part of an Environmental Impact Assessment for a Guinean bauxite mine as a case study, I aim to demonstrate that a) Rapid Botanic Survey allows biodiversity conservation requirements to be fine-tuned at local scales, for example to maintain corridors and local biodiversity benefits in increasingly fragmented landscapes, supplementing and supporting larger scale networks of protected areas; b) the Star rating system, whereby species are categorized

by their global rarity, offers a useful way to identify conservation priority species and landscapes, especially for areas where few species have been assessed for the IUCN Red List; c) direct provisioning ecosystem services provided by plants can and should be recorded as part of baseline surveying, as locally important medicine and food species are not necessarily restricted range or endangered species; d) modelling patterns of plant endemism at continental scales throws up some important challenges, such as a preponderance of globally rare species in areas with unusual geology, so often the focus of mining operations.



## The impact of rubber on forests in South East Asia

S7.3

ANTJE AHRENDTS

16:35–16:55

[AAhrends@rbge.org.uk](mailto:AAhrends@rbge.org.uk)

*Royal Botanic Gardens, Edinburgh, UK*

The para-rubber tree *Hevea brasiliensis* is the world's major source of natural rubber. It is used in the production of tens of thousands of products, including over one billion tyres annually. Following a price boom in the first decade of the new millennium this industry has expanded dramatically in South East Asia, where over 97% of the global natural rubber are produced. Rubber was traditionally planted in the humid tropics, however, with many areas in insular South East Asia being converted to the even more lucrative oil palm, the production of rubber has been pushed further north. Most of the new plantations have been established in areas that are sub-optimal for the crop. While rubber production is possible in these areas thanks to the development of hardy clones, this does not necessarily equate to long-term sustainability. Rubber has replaced many natural forests, and there is potential for loss-loss scenarios whereby high-biodiversity land is cleared for economically unsustainable plantations – ultimately compromising livelihoods when rubber prices fall or plantations fail.

Given the volatile nature of rubber prices and the global search for alternatives the future impact of this crop on forests in South East Asia is hard to predict. Recent studies have given a mixed picture, with an apparent slow-down of rubber planting in China while others report continued expansion in countries such as Cambodia. This talk summarises the past, present and potential future impact of rubber plantations on forests in South East Asia.



**Integrated plant conservation.  
What can the botanic garden  
community do to prevent plant  
species extinctions?**

**S7.4**

PAUL SMITH

16:55–17:15

[paul.smith@bgci.org](mailto:paul.smith@bgci.org)

*Botanic Gardens Conservation International, Kew,  
Richmond, UK*

Botanic gardens offer the opportunity to conserve and manage a wide range of plant diversity ex situ, and in situ in the broader landscape. The rationale that botanic gardens have a major role to play in preventing plant species extinctions through integrated plant conservation action is based on the following assumptions:

- There is no technical reason why any plant species should become extinct. Given the array of ex situ and in situ conservation techniques employed by the botanic garden community (seed banking, cultivation, tissue culture, assisted migration, species recovery, ecological restoration etc.) we should be able to avoid species extinctions.
- As a professional community, botanic gardens possess a unique set of skills that encompass finding, identifying, collecting, conserving and growing plant diversity across the taxonomic spectrum
- Botanic Gardens Conservation International (BGCI) is a membership organization representing a network of 600 botanic gardens in 100 countries, and around 60,000 scientists, horticulturists and educators - the largest plant conservation network in the world. This network already conserves and manages more than 90% of plant families, 50% of genera and 30% of species in its living collections and seed banks. Following the example of the crop conservation community, BGCI's botanic garden-

centered Global System for the conservation and management of plant diversity aims to prevent species extinctions by deploying plant conservation skills, knowledge and resources in a cost-effective, rational way. Using tree conservation as an example, the speaker will set out the approach, methodologies and milestones being employed by botanic gardens and arboreta to ensure that no rare and threatened plant species becomes extinct.

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# Poster Abstracts

Poster abstracts are ordered alphabetically by presenting author (underlined).

**P1**

## **Bombs and cocaine: detecting nefarious nitrogen**

C. ADAMS, D. LANGTON, O. WINDRAM

*Imperial College London, Silwood Park Campus, Buckhurst Road, Ascot, SL5 7PY, UK*

Synthetic or organic nitrogen sources applied to soils or plant tissue provide essential nutrients to enhance the growth of plants. However, some of these sources can be used nefariously. Ammonium nitrate is a detonatable oxidiser that is a primary ingredient in explosive devices. Ammonium sulphate is used in cocaine manufacture. Techniques that enable us to distinguish plant exposure to these different nitrogen sources could allow us to monitor illegal activities and improve our understanding of nitrogen usage in plants. Here I present a fast-non-invasive remote sensing method to identify plant exposure to different nitrogen sources. I will present how I can distinguish leaves from plants exposed to different nitrogen compounds using a combination of hyperspectral sensing, regression analysis, multispectral imaging and machine learning. Untargeted metabolomics reveals that exposure to variable nitrogen sources induces shifts in plant leaf biochemistry. Overall, the approach highlights how exposure to different nitrogen sources induces detectable changes in plant leaf reflectance, likely driven by shifts in plant leaf biochemistry. These results also highlight the potential to develop remote sensing tools that could be used to monitor the usage of nefarious nitrogen compounds.



## P2

### **Nomad Garden: conservation of biodiversity of Kyrgyzstan through ethnobotanical knowledge**

K. ADYLBKOVA

*“Archa Initiative” Public Foundation, Kyrgyz Republic*

Plant biodiversity across Kyrgyzstan is endangered: nearly the entire country is part of biodiversity hotspot.

According to the Kyrgyz Republic Biodiversity Strategy, overgrazing, overharvesting, unsustainable land use and climate change are the most important drivers of biodiversity loss. Simultaneously, changing lifestyles and rural to urban migrations threaten traditional knowledge and biodiversity values to be forgotten, as a knowledge gap appears between generations. These threats are also identified by the Gareev Botanic Garden staff and rural community leaders.

To solve this problem by the support of Garden and local communities the concept of the Nomad Garden was developed, the goal of which is to collect and conserve the wild flora of Kyrgyzstan in the Botanical Garden for present and future generations and providing trainings on plants conservation in rural communities. In our work we combine different target groups: Citizens who live far from nature but on their decisions and actions depends on the preservation of nature; Community residents and townspeople who have suburban areas that directly use ecosystem services; Children and adolescents who are interested in plants and which are attracted to botanical science.

# P3

## **Multifaceted valorisation of single-country endemic plants of Crete, Tunisia and northern Morocco for sustainable exploitation in the agro-alimentary, horticultural-ornamental and medicinal-cosmetic sectors**

I. ANESTIS<sup>1,4</sup>, M. EL HAISSOUFI<sup>2</sup>, A. KHABBACH<sup>2</sup>, M. LIBIAD<sup>2</sup>, S. BOURGOU<sup>3</sup>, W. MEDICHE-KSOURI<sup>3</sup>, N. KRIGAS<sup>1</sup>

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Mediterranean Basin is a biodiversity hot-spot, including numerous wild edible greens, commercially appreciated ornamental species and valuable aromatic-medicinal plants, many of which are local endemics. MULTI-VAL-END project brings focus on unique, neglected and underutilised plants (357 single-region endemics) of Crete (Greece), northern Morocco and Tunisia, with the aim to: (a) Provide solid documentation for these plants in selected economic sectors; (b) Explore and evaluate their existing potential in economic sectors using multiple attributes; (c) Identify basic opportunities, main barriers and steps needed to build and establish new product supply chains in the selected regions; (d) Facilitate the sustainable exploitation of selected endemic plants by bridging gaps with targeted actions. The MULTI-VAL-END project will deliver by 2020: (i) 357 species-specific assessment reports with valorisation per selected sector; (ii) A road map for the successful conservation and sustainable exploitation of the targeted plants, identifying barriers, opportunities and

perspectives for the development of innovative agricultural products; (iii) Seed banks per country with stored material for the top-evaluated plants; (iv) New documentation on propagation, natural compounds and properties of selected top-evaluated plants to boost their sustainable exploitation; (iv) Awareness raising activities involving citizens, target groups, farmers, consumers, stakeholders and scientific audience.

S. BÁRRIOS<sup>1</sup>, A. ROBERTS<sup>1</sup>, K. GRANT<sup>2</sup>, L. VARLACK<sup>2</sup>, M. DANI SANCHEZ<sup>1</sup>, N. HARRIGAN, N. WOODFIELD-PASCOE<sup>2</sup>, T. HELLER<sup>1</sup>, J. SMITH ABBOTT<sup>3</sup>, T. SMITH<sup>3</sup>, C. CLUBBE<sup>1</sup>, M. HAMILTON<sup>1</sup>

<sup>1</sup>*Conservation Science Department, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE, UK;* <sup>2</sup>*National Parks Trust of the Virgin Islands, Road Town, Tortola, BVI;* <sup>3</sup>*Ministry of Natural Resources and Labour, Government of the Virgin Islands, Road Town, Tortola, BVI*

Kew and partners in the British Virgin Islands (BVI) undertook the first Tropical Important Plant Areas (TIPAs) project in the Caribbean between 2016-2019 using the newly revised criteria developed to incorporate tropical regions. The biggest knowledge gap in BVI in order to apply TIPAs criteria A and B was the lack of a list of threatened plants and a list of plant species of national importance, including those of cultural and social importance. To address this deficit, data were mobilised from specimens held at several herbaria (K, MAPR, MO, NY, SJ, US), online databases and published literature. Fieldwork in poorly explored areas filled data gaps. Distribution, population number, habitat and threat data were compiled for each species to apply the IUCN Red List categories and criteria. Data from the compiled conservation assessments not only identified 25 threatened species, but also allowed us to identify 35 species of national conservation importance, including one range restricted endemic species and one highly restricted plant species. This work has raised the profile of these globally and nationally recognized species of conservation concern as well as providing a conservation tool for species management at national level and stimulated local interest in plants.

D. BRÖDERBAUER, N. RAUCHBERGER, M. KIEHN

*Core Facility Botanical Garden of the University of Vienna, Rennweg  
14, 1030 Vienna, Austria*

The Green School Program at the Botanical Garden of the University of Vienna offers guided tours and workshops for pupils of all ages. In order to improve knowledge of science and botany in pupils, the garden trains students that prepare to become biology teachers and thus will play an important role in engaging pupils in science. The objective is to improve the students' skills by combining the potentials of university education for future biology teachers with the demands for educative activities at the garden. To achieve this goal, university courses are designed to improve students' involvement with and knowledge of the Botanical Garden and its collections. Students are asked to develop appealing program units on plants and environmental sciences for pupils. After finishing the courses, the students are able to work as guides and gain experience in communicating science to pupils. Moreover, students have the opportunity to develop templates for new programs as a part of their bachelor or master thesis, resulting in more than 30 finished theses so far. In conclusion, involving future biology teachers in the outreach activities of the botanical garden is a successful approach to engage teachers and pupils in science.

D. P. BUENAVISTA, S. WYNNE-JONES, M. MCDONALD

*School of Natural Sciences, Bangor University, Bangor, UK*

An ethnobotanical study was carried out to investigate the cultural transmission and traditional uses of food plants among the Higaonon tribe, a distinct group of indigenous peoples living in the uplands of Bukidnon, Philippines. With prior and informed consent, we conducted 89 semi-structured interviews from five upland villages surrounding the Mount Tago Range. A total of 64 species of food plants belonging to 34 plant families was recorded. Results showed that learning and acquisition of ethnobotanical knowledge start from childhood to adolescence. The transmission strategy is predominantly through vertical transmission (81.3%) through observation and imitation, and instruction coupled with the oblique transmission (16.2%). Horizontal transmission occurs in early adolescence (2.3%). The tribes' collective social memory of food plants is mainly associated with homegardens (55 species), farm (47 species), communal area (21 species) and riparian vegetation (2 species). The indigenous community is less dependent on forest resources. Most of the species were consumed as vegetables (39 species) and fruit snack (24 species). Other plants were used as a seasoning (2 species) and beverage (1 species). Our findings suggest that food plants are essential biocultural elements in the resilience and food security of the marginalised and remote communities in the Philippine uplands.

C. CARRIZO GARCÍA<sup>1,2</sup>, N. PALOMBO<sup>1</sup>, H. SCHNEEWEISS<sup>2</sup>

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The hot chile *Capsicum pubescens* is cultivated mainly in the highlands of Central-South America. Unlike other cultivated chiles, *C. pubescens* is known only as a cultigen and not in the wild. The affinities and origin of this species are puzzling; the ‘purple species’ from central Andes have been proposed as its ancestors but *C. pubescens* forms an isolated monotypic clade in phylogenetic reconstructions. To better understand *C. pubescens* origin and affinities, the RAD-sequencing approach was followed using samples from *C. pubescens*, the ‘purple species’, and other species across *Capsicum*. The data filtered were analysed by Maximum Likelihood methods. A highly resolved phylogenetic reconstruction was obtained. *Capsicum pubescens* samples are resolved as a monophyletic group, sister the ‘purple species’, which in turn form a strong monophyletic group; this assemblage is sister to the clade that includes the other cultivated chiles and their wild relatives, altogether in the most derived branches of *Capsicum*. In contrast to previous studies, by using data from the whole genome it is proposed that *C. pubescens* is not an isolated lineage but closely related to the ‘purple species’, although they are clearly distinct clades, therefore none of the latter or any extant species would be its ancestor.

CHRISTOFIDES, S.R.<sup>1</sup>, HART, E.<sup>2</sup>, ROGERS, H.J.<sup>1</sup>, MULLER, C.T.<sup>1</sup>, KINGSTON-SMITH, A.<sup>2</sup>

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The rumen is a stressful environment for plant cells: dark, anoxic, hot and full of microbes. Up to 50% of grass cells survive mastication in the animal's mouth, but upon arrival in the rumen they start to undergo stress-induced autolysis. The consequent rapid protein breakdown creates a resource mismatch for the rumen microbiota: nitrogen becomes available more rapidly than carbohydrate, so the excess is converted to ammonia and excreted by the animal. This process is thought to contribute to the N-inefficiency of ruminant animals.

The present project investigates how this stress response upon entering the rumen is altered when grass has been subject to environmental stress whilst growing. Extreme weather events such as floods, droughts and heatwaves are predicted to increase in frequency under climate change. These stressors produce characteristic responses in plants, which are frequently reflected in altered emission of volatile organic compounds (VOCs). Ten commercial or pre-commercial varieties of *Lolium* and *Festulolium* were grown under different environmental stresses, then harvested and incubated in an artificial rumen for 24 hr. Here we present the VOC profiles (as analysed by GC-MS) to characterise variety- and stressor-specific fingerprints.



LIU U., KENNEY S., BREMAN E., COSSU T.A.

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We propose a prioritisation process which is integrative, adaptable, straightforward and transparent, and open to refinement by interested parties. Using the principles of multicriteria decision making approach, we produced a conservation priority list for 25,025 vascular plant taxa that accounts for their geographic rarity or endemism, taxonomic rarity or uniqueness, vulnerability to extinction and natural capital value. Results were validated against existing prioritisation schemes with a global or continental focus. Prioritised list represents about 4.47% of pteridophyte, 36.12% of gymnosperm and 7.41% of angiosperm global diversity. The list consisted of a high percentage of taxa from South America (30%), Africa (23%) and North America (22%) followed by Asia-Temperate and Europe (each 15%) and Asia-Tropical (14%) with a low percentage from Australasia (6%), the Pacific (5%) and Antarctic (~2%). We found 573 taxa (2%) with high priority, 21,707 (87%) with medium priority and 2745 taxa (11%) with low priority status for conservation. The resulting list of plants with priority status along with their geographical distribution patterns should complement, not replace, existing conservation plans. Our method can be used as a rapid and preliminary assessment technique in prioritising vascular plants and has the scope to be used globally across various conservation activities.

# P10

## **Investigating the uptake and nanoparticle formation of gold and palladium in the plant species, *Arabidopsis thaliana***

J. A. DOBSON, E. L. RYLOTT, F. J. M. MAATHUIS, N. C. BRUCE

*Centre for Novel Agricultural Products, Department of Biology,  
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Copper transporter 2 (COPT2) is a plasma membrane located, high-affinity copper uptake transporter in *Arabidopsis thaliana*, and has recently been implicated in the uptake of gold in plants. The ability of this transporter to function with both copper and gold is likely due to the chemical similarity of these elements. Other metals, such as palladium and platinum, share similar chemistry and may be additional targets for this transporter. To examine the uptake of palladium by the protein, an optimised *COPT2* gene (*COPT2y*) was heterologously expressed in a number of *Saccharomyces cerevisiae* mutants, and grown in the presence of palladium. Qualitative analysis of growth on solid media, alongside analysis of the elemental concentration in liquid grown strains (ICP-OES), demonstrate that the transporter may also take up palladium. This discovery could be utilised for plant mediated synthesis of palladium nanoparticles with advantages over chemical production methods, such as the phytostabilisation of mine tailings and accumulation of palladium from low-level contamination. Following a pyrolysis of the plant biomass, nanoparticles could be used *in planta* to release platform chemicals for industrial use.

# P11

## **Multi-stemmed trees in subtropical forests: Species characteristics and Survival strategy in response to chronic disturbance**

S. FAN

*Botanical Garden Division, Taiwan Forestry Research Institute, No. 53, Nanhai Rd., Taipei City, 10066, Taiwan (R. O. C.)*

The Nanjenshan forest in southern Taiwan is a wind affected forest, with low canopy and multi-stemmed trees. We are curious that trees show the relationship between multi-stemmed characteristics and the micro-environment. Therefore, this analysis was carried out using the survey data of the Lanjenshan Forest Dynamic Plot.

There were 21,535 single stemmed individuals and 5,216 multi-stemmed trees in study plant. We used torus analysis to test whether any species perform different spatial patterns between single-stemmed and multi-stemmed groups. Seventy-eight species (number of individuals > 10) were tested and most species (43 species) showed concentration of their multi-stemmed individuals in northeast-facing and lower-elevation slopes. It suggests most species in Nanjenshan grow branches to respond to disturbance (chronic northeast monsoon).

We also found species grow multi-stems in bigger size DBH. The K-S test showed the multi-stemmed and single-stemmed population had the different size distribution. There are fewer individuals in smallest size class in multi-stemmed population, but had most individuals in smallest sized class in single-stemmed population. However, Tree multi-stemmed individuals did not show more damage in their primary stems.

# P12

## Urban horticulture for the improvement of food security and nutrition in selected refugee camps in Jordan.

A. GALLONE, A. MALHOTRA

Multi-storey gardening is a high-efficiency and low-space method that can be used for growing horticultural crops. The feasibility of using it to improve food security and nutrition in selected refugee camps in the Kingdom of Jordan has been evaluated. Three crops that are traditional to the area were chosen: *Coriandrum sativum* L. (coriander or cilantro), *Spinacia oleracea* L. (spinach) and *Allium fistulosum* L. (spring onion). Plants were grown in sacks (volume: 40 litres each) in a protected environment, using the tops and sides of the bags as the planting area. In addition, interviews with experts on camps and food security and field visits to refugee camps were conducted. Four camps were examined: Zaatari, Azraq, and King Abdullah Park camps for Syrian refugees, and Jerash camp for Palestinians. Multi-storey gardening proved to be a valuable tool to increase both food security and nutrition in low-space and resource-constrained environments: an average of 1.00 kg of fresh biomass could be produced in each sack over a six-week trial. Moreover, differences in the way Syrian and Palestinian camps are managed may affect the potential implementation of this or similar projects.

# P13

## Functional traits of mangrove trees and the potential impact in the sediment carbon storage

A. GARDNER<sup>1</sup>, J. PRITCHARD<sup>1</sup>, A. R. MACKENZIE<sup>2</sup>

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This study investigates the effect of elevated carbon dioxide (eCO<sub>2</sub>) on leaf physiology in a mature oak woodland. Rising CO<sub>2</sub> is expected to stimulate photosynthesis, but limited studies have been conducted on mature temperate forests. This experiment has been conducted at the Birmingham Institute of Forest Research Free Air Carbon Enrichment Experiment (BIFoR-FACE). BIFoR-FACE is set in a mature oak (*Quercus robur*. L) woodland manipulated to simulate future atmospheric conditions (+150ppm) to experimental plots. This study used a paired plot design (n=3) of elevated CO<sub>2</sub> plots (eCO<sub>2</sub>) (550ppm) and ambient control plots (aCO<sub>2</sub>) (400ppm). *In situ* instantaneous leaf gas exchange measurements were taken in the upper oak canopy (June to October 2018) using a Li-6800 portable photosynthesis system. Preliminary results suggest a) increased photosynthetic rates (A) b) decreased stomatal conductance (gsw) and c) increased intrinsic water-use efficiency (iWUE) under eCO<sub>2</sub> treatment. The strength of the treatment effect was influenced by both seasonal and diurnal fluctuations of environmental variables such as; light intensity, air temperature and water availability. The next steps will include developing models to understand the relationships between the data and the environmental parameters, in addition to scaling up from the leaf-level to the canopy-level.

# P14

## Analysis of Phenotypic Diversity in Sorghum (*Sorghum bicolor* (L.) Moench) Landraces *in situ* in Tigray, northern Ethiopia

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This study was conducted with the aim of estimating the extent and patterns of phenotypic diversity, identifying sorghum race type, locating potential areas for *in situ* conservation and breeding of sorghum in Tigray, northern Ethiopia. A total of 358 sorghum landraces were collected from farmers' field at maturity and evaluated for twenty qualitative characters. Percentage frequency and Shannon-Weaver diversity index ( $H'$ ) were calculated for each character, zone of origin, and altitude class. Variation was common in varying degree for most of the measured characters signifying the availability of diversified sorghum landraces in the Tigray region. This can be due to the existence of different agro-climatic landscapes in the region and farmers' crop diversity management including selection for different end use of the crop. The  $H'$  varied from 0.48 for race type to 0.93 for seed color with an overall mean of 0.79. The high value of  $H'$  for seed color shows that farmers in the study area use diverse seed colors of sorghum for different end use. The average high level of sorghum diversity in the region suggests the likely availability of sorghum landraces having candidate genes for sorghum improvement against the ever-increasing effect of climate change. A maximum ( $H' = 0.68$ ) and minimum ( $H' = 0.57$ ) diversity index was estimated in western and south-east zones, respectively. The highest  $H'$  (0.64) was recorded in lowland while highland had relatively lowest  $H'$  (0.54). Races durra, bicolor, caudatum and durra-bicolor were documented in which durra sorghum was dominantly occurred in the region. The high frequency of durra sorghum supports the fact that this race is widely adapted to low precipitation, which is one of the

typical characteristics of the study area. Other reason for the wide spread of race durra is because in the region sorghum is largely used for food consumption in which farmers prefer durra type as it usually has no pigmentation on its pericarp and yields high quality white flour which is preferred for making *injera*, Ethiopian flat bread.

Considerable amounts of wild type of sorghum were also recorded. Population structure showed that the 358 sorghum landraces were clustered into seven distinct classes. It can be concluded from the current study that high degree of morphologic variation was detected among the evaluated sorghum landraces. Hence, this great diversity has to be considered in the sorghum conservation and improvement strategy and policy of the region. Although the phenotypic markers gave us insight into the level of diversity of sorghum in the region, this alone cannot reveal the detailed polymorphism among the landraces. Hence, it has to be supported by genome wide polymorphism data (work is undergoing).

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Forest genetic resources (FGRs) provide a wide range of benefits such as better protection of ecosystems, additional sources of food, timber, medicinal plants and other. The availability of FGRs relies from the diverse forest formations. Application of the use and conservation of FGRs is interrelated with the management and implementation of science-based forest restoration activities. However, the rapidly changing climate and continuous forest degradation, the FGRs are at risk of being depleted. This paper aims to discuss the effects of the existing factors to the country's forest, as well as to FGRs. Ultimately, the author hopes to provide a new perspective in FGR conservation with respect to human behavior as the main driver of change. Human, being the think tank of the planet who creates solutions and causes problems, is the main driver of change. Hence, the need to conserve the FGR and effective management of forests is in parallel equated with the need to shape the human behavior. Changing the human behavior that favors actions towards the conservation, sustainable use and management of FGRs should be a challenge to, and priority of the government, academe and non-government organizations.



# P16

## Identifying Tropical Important Plant Areas (TIPAs) in the British Virgin Islands

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TIPAs are identified using internationally accepted criteria and robust scientific data on threatened and restricted plant species distribution, areas of botanical richness and location of threatened habitats. The British Virgin Islands (BVI), a UK Overseas Territory in the Caribbean Biodiversity Hotspot, lacked a TIPAs network and comprehensive botanical data to inform local plant conservation and habitat management. A collaborative project between Kew, NPTVI and BVI Government (2016-2019) bridged the data gap and identified a network of TIPAs for the BVI. A total of 3688 geo-referenced high-resolution (+/-10m) records from herbarium specimens and field observations of BVI's priority species and a vegetation map were imported into a GIS to map distribution of globally threatened species, highly restricted and range restricted endemics, areas of botanical richness and threatened habitats. A series of workshops in the BVI applied the TIPAs criteria to available data and identified the world's first network of 18 TIPAs across 13 islands in the BVI. The identification of sites for botanical richness and threatened plant species and habitats across the BVI by applying benchmarked criteria to robust data is an important tool for long-term species and habitat management to ensure the future of the BVI's unique flora.

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The three criteria used to identify Tropical Important Plant Areas (TIPAs) focus, in turn, on (A) Threatened Species, (B) Botanical Richness and (C) Threatened Habitats. With no formal list of globally or regionally threatened habitats applicable to the British Virgin Islands (BVI) to refer to, the BVI TIPAs National Team have developed a list of nationally threatened habitats to apply under sub-criterion C(iii) of the TIPA guidelines. Published land cover data and field data collected by the team were combined in a Geographical Information System (GIS) and refined to produce a simplified classification of the terrestrial habitat types. Nine broad vegetation classes were defined, and spatial coverage of each type was calculated. Threatened terrestrial habitats were defined as those comprising <10% of terrestrial land cover or occurring on <3 islands and a continuing decline in spatial extent observed or inferred. Five vegetation types were identified following this definition: Mangroves, Upland evergreen forest, Semi-deciduous gallery forest, Coastal shrubland and Dry salt flats. Identification of threatened habitat types has enabled sub-criterion C(iii) to be used in the identification of 12 of the 18 TIPAs defined as part of this collaborative project between Kew, NPTVI and BVI Government (2016-2019).

# P18

## Studying UV sex chromosomes in liverworts with a focus on repetitive DNA

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Bryophytes comprise hornworts, liverworts, and mosses and based on recent molecular data appear to be monophyletic. Of the estimated 7500 species of liverworts, 68% are thought to have separate-sexed gametophytes (dioicous), while the remaining 32% produce both sperm and eggs (monoicous). Phylogenies imply repeated evolutionary switches between these two systems, but their genetic regulation is not understood. Microscopy, however, shows that many dioicous liverworts have visibly distinct pairs of chromosomes, which are referred to as U/V sex chromosomes. The UV chromosomes must coexist in every cell of the diploid sporophyte and presumably pair at meiosis, but without recombining. A lack of recombination is expected to lead to chromosome-specific accumulation of repetitive sequences. To test this hypothesis, we are using *Frullania dilatata*, the female gametophytes of which have  $n = 7 + UU$ , while the males have  $n = 7 + V$ . We performed low-coverage Illumina sequencing on a male and a female and used the RepeatExplorer pipeline to detect repetitive elements suitable for designing FISH probes for in *in situ* analyses of the sex chromosomes. Graph-based clusters revealed 3.7% repetitive elements to the male genome and 13.7% to the female genome. The female genome has 6x more Ty3/gypsy elements and 8x more satellites than the male genome, and Ty1/copia elements are only present in the female genome, while microsatellites were found exclusively in males. Our data also show that the male genome is enriched in organellar DNA. So far, the leafy moss *Physcomitrella patens*, which does not have distinct sex chromosomes, is the only other bryophyte whose transposable elements have been

characterized. Our analysis is therefore a first step to pinpoint the genomic causes of UUV sex chromosome differentiation.

# P19

## **Capturing the genetic diversity of UK trees: sampling strategies and a partner network**

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The UK National Tree Seed Project (UKNTSP) was established in 2013 with the aim of creating a genetically representative seed collection of the UK's bankable woody flora. With increasing threats facing UK woodlands from environmental change, including plant pests and pathogens, the project focused on creating a resource that would be of use for conservation, restoration and scientific research projects. Two key questions arose, 1) how to optimally sample our target species to capture as much genetic diversity as possible, in most cases without an understanding of its distribution, and 2) logistically, what is the best way to undertake seed collecting on this scale? The first involved implementing a sampling strategy focused at three levels: national, local and population. The second involved the creation of a partner network spanning the UK. By June 2019 1,200 seed collections had been made across 75 species, totalling over 15 million seeds. Over 80% of the seed collections were made by partners and/or volunteers, involving staff from over 30 partner organisations and over 400 trained volunteers. Research looking at the genetic diversity of some of the collections suggests this approach has been successful. The UKNTSP collections are available to conservation and research practitioners.

## P20

### Down to the roots: how foliar herbivory affects roots and root-feeding insects

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Plants must defend themselves against a multitude of attackers, both aboveground and belowground. By defending against herbivores, plants change their phenotype systemically, for instance by producing toxins, which affects the quality of their tissues for later arriving herbivores. This way, insects separated in space and time can interact via plant defense. We study how foliar herbivory affects defence in plant roots, and the performance of root-feeding insects. Here, we investigated the effects of foliar herbivory on root defences against root herbivores. We induced Brussels sprouts plants (*Brassica oleracea* var. *gemmifera*) with either diamondback moth caterpillars, *Plutella xylostella*, or cabbage aphids, *Brevicoryne brassicae*. Two days later we added cabbage root fly larvae, *Delia radicum*, to the roots and assessed their performance on plants with different induction treatments. Foliar herbivory affected *D. radicum* performance, depending on the identity of the inducing insect. We investigated the defence responses in primary roots to the various treatments in terms of phytohormonal pathways, secondary metabolite production, and transcriptomics. Our study provides insight into the effects of shoot herbivory on belowground interactions of plant roots with root herbivores.

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With increasing concerns about UK and global plant biosecurity and continued demands for rewarding career prospects, now is a good time to build the plant health profession. We understand the range of careers in the healthcare sector for medically-related jobs; why don't we think professionally about plant healthcare in the same way? Clear presentation of training and professional recognition in plant health appeals to students interested in biological sciences and complements recruitment efforts from established professions such as agriculture, horticulture and forestry to help build the skills base. We present work on two schemes administered by The Royal Society of Biology to increase opportunities in plant health. 1) **Plant Health Undergraduate Studentships**<sup>1</sup>: In its third year, a competitive scheme for research addressing Defra's priorities has funded nine studentships (from Defra, BSPP, N8 Agrifoods and the David Colegrave Foundation). 2) **Plant Health Professional Register**<sup>2</sup>: In its fourth year this scheme recognises plant health competencies in the workforce. Now with over 90 government registrants and extending to the horticultural trade, we are working with the HTA to link professional registration to the new Plant Health Management Standard<sup>3</sup>.

<sup>1</sup><https://www.rsb.org.uk/get-involved/grants/plant-health-ug-studentships>

<sup>2</sup><https://www.rsb.org.uk/careers-and-cpd/registers/plant-health-register>

<sup>3</sup><https://planthealthy.org.uk/assets/downloads/Plant-Health-Management-Standard-v1.0-Published-240119.pdf>

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Between conventional and organic market farming lies a fertile field for sustainable innovation. We propose smart robotic platforms developed for small organic market gardening farms. They are intended to improve the working conditions of farmers while respecting the complexity of diversified agriculture. Our main contributions rely on imaging techniques using computer vision. We develop a multitask robot aimed at maintaining crops by regular weeding and 3D-monitoring. The tools we develop can also be used in academic research. The robot is able to distinguish weeds from crops with imaging techniques, and compute a path to mechanically remove the weeds. We also investigate state-of-the-art generative networks to predict plant development and improve the movement of the robot arm. This last method could have great interest for plant and growth modelling in research.

To fulfil the monitoring task of the mobile platform, the robotic arm scans the plants in 3D to oversee their state and morphology precisely. The development of the scanner is currently limited to laboratory use, where we are demonstrating its potential to offer an alternative to highly jammed phenotyping platforms. Indeed we are testing it on the phyllotaxis of *Arabidopsis thaliana*. We are now preparing the robot for in-field phenotyping.



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*Varronia bellonis* (Boraginaceae) is a threatened (Critically Endangered) species, endemic to the Caribbean island of Puerto Rico where it is restricted to the island's western zone. Ongoing international collaboration is researching key aspects of the species phylogenetic placement, biogeography and conservation status to inform its conservation. Desk and field-based studies have provided the data (occurrence records, geology and land cover maps, protected area boundaries) necessary to develop a GIS and enable the study of population distribution, geology and land cover preferences. We found the species only occurs on three types of geology (Serpentine, Lares Formation and Montebello Limestone) and predominantly occurs in four land cover types. There is strong preference for Evergreen Forest on Serpentine with 66% of project records occurring on this land cover type. Extant individuals were found in and around Maricao, Susúa and Río Abajo State Forests, the three historical areas of distribution, as well as individuals in previously unrecorded locations in Arecibo, San German and Utuado. Within the extant preferred land cover types (area = 331km<sup>2</sup>) overlying the serpentine and limestone geology (area = 479km<sup>2</sup>) that support the species, 186km<sup>2</sup> is within protected areas. This work provides information necessary to develop an effective species conservation plan.

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In recent years, scientific investigations on the effectiveness of Protected Areas (PAs) in conserving biodiversity under the impact of climate change have increasingly received more attention. Here, we used a combination of species distribution modelling (SDM) and Zonation technique to delineate and prioritize areas for endemic plant species conservation under current and future (2050s, 2070s) climate conditions in Sikkim Himalaya. We found that the existing PA network in the region was inadequate in conserving the endemic plant diversity either in the current or future climate scenarios. Based on our results, we propose addition of 896 square kilometers to the existing PA network in the study area to ensure meaningful conservation goals. Additionally, we propose creation of 3 new PAs and the need for expanding the boundaries of three existing PAs. Our analyses show that to mitigate the effects of ensuing climate change, a single large PA with wide geographic and elevational extents instead of several smaller PAs would be a more prudent strategy for conserving the plant diversity in the Himalaya.

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The Utilitarian Redundancy Model (URM) has been widely used in ethnobotany. Two concepts are associated to it: redundant species - species that perform the same function, and redundant targets - uses performed with several species. We argue that URM can be applied to access use-pressure on plant species, resilience of socioecological systems (e.g. local medical systems), cultural keystone species, and the role of exotic species in socioecological systems. Based on previous URM studies we also emphasize the need to differ actual (considering plants and uses that are currently employed) and general (considering both currently employed and potentially employed plants and uses). Based on the main applications of the URM we propose a new index to access redundancy of a target (e.g. therapeutic indication): the URIt, so that  $URIt = \sum Si / N$ , where URIt is the Utilitarian Redundancy Index for the target; Si represents the number of people who mentioned the species i for the target t, and N represents the total number of people interviewed. The maximum value that the URIt could reach is exactly the number of species employed for the target. We believe that this theoretical and methodological improvement in the model can improve comparisons of redundancy in different social-ecological systems.

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The apple (*Malus domestica*) is one of the most commercially important perennial crops. We characterized over 1,000 accessions of apple from the United States Department of Agriculture (USDA) germplasm collection in Geneva, New York using over 30,000 single nucleotide polymorphisms. We found that both cider and dessert apples derive ancestry from two wild ancestors, *Malus sieversii* from Central Asia and the wild European crab apple, *Malus sylvestris*. However, cider apples derive more ancestry from *M. sylvestris* than do dessert apples, which suggests they get their acidic and tannic character from *M. sylvestris*. Within the domesticated apple, we find extensive inter-relatedness: over half of the USDA germplasm collection is inter-connected by a series of first-degree relationships, and can thus be understood as a large pedigreed population. Several commercially successful apple cultivars were repeatedly used in apple breeding. For example, 'Golden Delicious' and 'Red Delicious' both have over 60 putative first degree relatives. We detect the signature of intense selection for red skin during apple improvement and provide evidence that breeders have selected for late-ripening, firm apples. Ultimately, our genome-wide analysis of the USDA apple germplasm collection allowed us to determine the consequences of domestication and breeding on apple diversity.

## P27

### Climate change impacts on sweet potato in Uganda: a causal network approach to reduce uncertainty capturing diverse knowledge sources

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Sweet potato is a mainstay of household food security across Sub-Saharan Africa, as a major drought-resilient food crop and a major source of provitamin A. However, sweet potato is an under-researched crop, with great model uncertainties that make robustly characterising and predicting the impacts of climate change a challenge. We aim to investigate and model the factors impacting sweet potato crop yield and quality in Uganda, with a focus on the specific vulnerabilities to drought and pests. We develop an approach based on causal networks to integrate knowledge from multiple sources of understanding, including insights from experts, crop and pest models, to provide information on likely crop yield and quality under different scenarios. These scenarios, or 'storylines' through the network, can be based for example, on different climate change scenarios, or agricultural management decisions. Instead of the usual large uncertainties associated with climate change impacts on agriculture, this methodology instead characterises possible futures through distinct, physically grounded storylines based on key decisions at different points. These can therefore represent policy choices and their impacts in a transparent way, providing policymakers with a means to evaluate interventions to promote food security and resilience in the context of a changing climate.



## P28

### The Big Botany Challenge: how to promote passion for plants in our schools?

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Plants are regularly undervalued across society and often poorly represented in our school and university teaching resulting in the low perception of plants by many students. This has knock-on implications for a critical botanical skills shortage in ecology, conservation, taxonomy, botanic gardens and other plant-related industries. This theme, often referred to as “Plant Blindness”, also means young people lose out on developing relationships with plants as an integral part of their daily lives with amazing stories to tell. This poster provides details of our symposium on the state of botany teaching in UK secondary schools (Friday 8th November 2019 at University of Reading) which aims to bring together scientists, teachers, education and industry specialists and associated organisations to present and debate the most effective ways to enhance the coverage of plants in UK secondary biology education. Our symposium will provide a forum to debate these ideas and to discuss the most effective ways to encourage and nurture the next generation of botanists and plant-aware scientists.

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As biodiversity professionals, we are keenly aware of the extraordinary biodiversity that surrounds and inhabits us. However, despite interacting with and depending on biodiversity on a daily basis, much of society does not notice it. Of the many components of biodiversity to which society is blind, plants are a special and severe case. Food is a powerful and effective medium for biodiversity outreach because our diets are largely composed of plants and plant-derived products, and food plays a special role in bringing people together and catalyzing connections with the natural world in positive ways.

We introduce our innovative, cross-institutional, cross-disciplinary food-based science outreach project, Taste of Life. Our meals have reduced plant and biodiversity blindness in the lives of hundreds of campus and community members in southeast Michigan, USA. We summarize our events and describe the planning process, event structure, and impact on participants, with particular emphasis on our commitments to community partnerships, affordability, adaptability, and accessibility. We also discuss plans for future directions, including expanding our collaboration geographically and creating shareable curricula that can be easily adapted based on factors such as audience, resources, and cultural context.



## P30

### **Useful plants in Tropical Andean mountain summits: Distribution, phylogenetics and climate change vulnerability**

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Plants provide goods and services to humans, but may be vulnerable to climate change, especially on mountain summits due to habitat reduction. We aim to assess climate change vulnerability for useful plants in the tropical Andes, South America. 208 out of the 520 plant species recorded on 49 Andean summits (Venezuela-Argentina), were identified as useful in literature and their thermal traits, distribution and phylogenetics were analysed. Medicine is the most highly represented use (146 species), followed by animal food (86 species). Plants with these uses have among the lowest median thermal optimums (8.4°C and 7.7°C, respectively), making them vulnerable to an increase in temperature due to the potential partial loss of their niche space. This is particularly worrying as maximum likelihood analysis indicates that these uses are phylogenetically conserved, along with human food and fuel plants. Moreover, 44% of recorded useful summit species are restricted to Andean alpine zones and 32 species are endemic to the Puna region, indicating endemism of useful Andean plants. The Andean population depend on useful plants for their livelihoods, particularly for health care and thus, urgent conservation actions are needed to mitigate potential climate change impact on useful plants.

# P31

## Fruit and nut conservation in rural communities of Armenia

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Rural communities in Armenia receive limited education, especially on the importance of sustainability and the impact of natural ecosystems on livelihoods. Funded by the Darwin Initiative, Nature Heritage (NH) and RBG Kew are collaborating in a project targeting the Khachik community, a rural village based in a mountainous area of Armenia, which is rich in biodiversity.

The “*Enhancing Rural Caucasian Community Livelihoods through Fruit and Nut Conservation*” project aims to support rural communities by raising awareness and facilitate knowledge exchange on the sustainable use of wild fruit and nut resources. Training on plant diversity, IUCN Red List and sustainable use of species has been carried out over the last year. The team also engaged with the local school through sustainable plant collecting activities. Alongside the community engagement activities, the team will assess important fruit and nut species under the IUCN Red List methodology and collect seeds of targeted species for *ex situ* conservation. Additionally, we have engaged with an MSc student from a local university who will conduct research on the molecular phylogenetics and antibacterial potential of 8 *Rosa* species.

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2,4-Dinitroanisole (DNAN) is an explosive compound and potential replacement for 2,4,6-trinitrotoluene (TNT) in military munitions due to its more favourable shock tolerance. TNT is known to be a toxic, environmental pollutant, and though currently few studies have assessed the long-term toxicity of DNAN, it may also have significant implications on the environment. Here, we have characterised the effects of DNAN on the plant model species *Arabidopsis thaliana*. Through root-length studies, we have determined concentrations of DNAN that induce significant phytotoxic effects, and in hydroponic growth studies, we have monitored the removal of DNAN from media and subsequent biotransformation *in planta*. Transcriptomics and T-DNA knockout library screens have identified genes with putative roles in DNAN detoxification pathways, including nitroreductases, glutathione transferases and glycosyltransferases, which are currently undergoing heterologous expression and further characterisation. By resolving the detoxification pathways employed by plants to mediate the toxicity of DNAN, we aim to modify relevant field species capable of remediating DNAN from the natural environment.

# P33

## Engaging communication of knowledge & research: CSI mystery as a tool

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The Botanic Garden TU Delft is a 'technical' garden set up over 100 years ago as a training facility for university students studying microscopic anatomy. Since its founding ground breaking research has taken place, which has been and still is communicated to the public, but mostly to adults. Today we aim to reach a broader audience and also involve children, teenagers and families in learning about plants, their products and plant science. We explored a game approach to highlight the importance of trees, how to determine wood and related new DNA research. A CSI mystery scenario was created where customs suspect wood from a protected species was being smuggled. Through interactive assignments the audience had to determine if that was the case. The game was used for different age groups in slightly adapted versions. We found that especially mixed age group teams, mostly parents with their children in various ages, enjoyed the game as a family activity. Children liked the game element, parents enjoyed learning new things and the teamwork. Based on this outcome we will continue use the game approach as a framework to address other topics in the future.

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The genus *Rosa* L. (*Rosaceae*) includes more than 300 species globally, 24 of them are native to Armenia. Under the project “*Enhancing Rural Caucasian Community Livelihoods through Fruit and Nut Conservation*”, we are studying the phylogeny of eight *Rosa* species potentially used by rural Armenian communities: *R. canina* L., *R. sosnovskyana* Tamamsch., *R. corymbifera* Borkh., *R. iberica* Stev., *R. pimpinellifolia* L., *R. klukii* Bess. and 2 additional species to be confirmed later in the year. DNA leaf samples were collected from seven sites across Armenia.

DNA of four species from seven collections was isolated for molecular phylogenetic research and the following primers were used during PCR analysis: Trnk-F/ RosmatK655R, psbA-781F/trnH, CATmH, PYRpetN-F/PYRpsbm1-R and ndhC-F/PYR-trnv-150R. Our results show that these primers worked well for two species (*R. canina* – 4 samples, and *R. corymbifera*), but no amplification occurred for *R. sosnovskyana* and *R. iberica*. Further work is needed to resolve this issue. The data obtained will help to understand the peculiarities of these species and could be helpful in making adjustments in the rules of the genus in the future.

## P35

### **Environmental shifts of crops: A global niche comparison of domesticated plants and their wild relatives**

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Crop Wild Relatives (CWRs) present a source of plant genetic resources for modern cultivar trait improvement. CWRs may provide food system resilience, supporting food security as the world faces environmental pressures and population growth. While little is known about the environmental shifts that occurred during the domestication of these CWRs, there is also lack of ecology, geography and taxonomy knowledge, with little conservation practice in place for CWRs.

We explored the geographic distribution and environmental requirements of 72 crops and 1, 506 associated wild relatives, across the world. By using 1, 040, 344 unique occurrence records from multiple online databases (e.g. GBIF, GENESYS, etc.), climatic, topographic and soil data, and ecological niche analysis; we tested whether more closely related wild species' environmental requirements are more similar to their cultivar and if crops are more productive in conditions similar to their progenitors.

Our results highlight widespread environmental shifts associated to plant domestication, and identify the CWRs that could benefit crop production through breeding programmes, e.g. CWRs persisting in warmer climates than their domesticated cultivars, may offer a genetic source of resistance to future climate warming. Finally, the study highlights the need of CWR management practices for conservation and maximising possibilities to increase crop yields.

## P36

### Evaluating the sustainability of forest use: A case study from Dashtijum Nature Reserve, Tajikistan

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The fruit and nut forests of Central Asia are home to five globally threatened tree species and numerous ancestral species of domestic cultivars. As part of the Global Trees Campaign, FFI has been supporting conservation of the fruit and nut forests of Tajikistan for 13 years, working in partnership with government and other local partners. There is critical need for more information on the status of forests in Central Asia to inform conservation management. To help fill this gap an assessment of the state and use of the fruit and nut forests within Dashtijum Nature Reserve was undertaken. A rapid forest inventory and socioeconomic survey were conducted. Thirty-three tree species were recorded and most tree species exhibited healthy stable population structures. Resource use was prevalent throughout the community where most households harvest at least one fruit or nut species (78%), firewood (88%) and grazed livestock (85%). Most respondents noted declines in availability of fruits, nuts and firewood and reported a decrease in the overall area and quality of grazing. Our results suggest that conservation management by the government and NGOs is partly effective but there is a clear need for increased enforcement of grazing practices to prevent further forest degradation. This study's findings will augment stakeholder engagement strategies in Dashtijum and Childuchtaron Nature Reserves and specifically, will inform reforestation site selection for 250,000 native trees to enhance forest diversity and resilience to climate change.

## P37

### The effects of different tropospheric ozone concentrations on oilseed rape growth, morphology and volatile emissions

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*Brassica napus*. L (oilseed rape) is the third most important oilseed crop worldwide, and the most valuable in Europe. *B. napus* is moderately sensitive to the secondary air pollutant ozone, with exposure to elevated concentrations reducing yield by 14% at an agricultural scale. There is considerable concern over future harvests, as background tropospheric ozone concentrations have increased by ~15% in many areas of the Northern Hemisphere since 1990, and are projected to increase by a further 10% by 2030. It is therefore important to fully understand the implications of rising ozone levels on the growth, physiology and biochemistry of *B. napus*. We grew two varieties of *B. napus* (spring and winter) in state-of-the-art solardome facilities. Plants were exposed to four different O<sub>3</sub> concentrations: 30ppb (~ambient), 55ppb, 80ppb and 110ppb (June-August 2019). Leaf gas exchange, stomatal conductance, and crop phenology were recorded regularly and we collected samples of biogenic volatile organic compounds (bVOCs) emitted from the leaves. bVOCs are synthesised and released as a defensive response to oxidative stress, and may protect plant functioning under ozone exposure. We report here on our findings and the implications for breeding programmes to ensure ozone-hardy *B. napus* crops in the future.



## P38

### Exploiting a mutualist toolkit: Using effectors to activate beneficial plant pathways

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The fungal symbiont *Serendipita indica* has shown to confer improved growth and stress resilience to a broad range of host plants, including important crops such as rice, wheat and barley. *S. indica* secretes specific proteins (termed ‘effectors’) to aid in plant root colonisation. Interestingly, effectors specific to *S.indica* can confer increased stress resilience in crop lines by targeting and thereby modifying, plant signaling in a highly specific manner. Determining how effectors secreted by *S. indica* function at a molecular level to increase stress resistance, could aid in the future manipulation of underlying pathways to improve crop yields. We have shown increased growth and stress resistance in stably transformed *Arabidopsis thaliana* expressing *S. indica* effectors. Using a protoplast screen of promoter activity, we have also determined which hormonal and immune signaling may be controlled by these effectors. By employing X-ray crystallography, I aim to elucidate effector structure and, as some protein targets have been discerned, to uncover the molecular interactions between these partners. Transitioning this research to crops will involve full understanding of the pathways and proteins involved, the key role of my research.

## P39

### **Food security in north-east Africa: ethnobotanical approaches to traditional agricultural systems**

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Traditional agricultural practices are rapidly changing in many parts of Africa due to intensified cropping systems, socio-economic and environmental changes. Preserving indigenous knowledge about local agri-systems, cultivation and cuisine, has implications for future food security through offering unique insights into local adaptive solutions. Recent research in northern Sudan has highlighted dramatic shifts in crops grown, cultivation practices and cuisine since the middle of the twentieth century (Ryan 2018). This poster will consider the advantages or disadvantages of the local crops versus newer cash crops from the perspectives of the farmers. Fieldwork during early 2019, as part of a field work project entitled 'A holistic view of plant uses within traditional agroecological settings in the middle Nile valley' has further explored the impact of changes in crops grown and farming practices on natural capital within traditional agroecosystems, including about useful wild plants. Preliminary new data will be presented, and how temporal changes to both traditional agri-systems and wild plant exploitation practices can be interlinked discussed. The poster highlights the value of situating studies of biodiversity within traditional agri-systems within a temporal and cultural context through the documentation of endangered local knowledge and oral histories.

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The diversity of medicinal, spice (aromatic) plants (MAPs) is important from the scientific and practical point of view (WHO traditional medicine strategy: 2014-2023). WHO estimated that 80 percent of people worldwide rely on herbal medicine for some aspect of their primary health care needs. In the twenty-first century specific attention is paid to conservation, preservation and cultivation of MAPs and to the evaluation of their quality and quantity (The Global Strategy for Plant Conservation 2011-2020).

The aim of research is the introduction and phytochemical investigation of *Asteraceae* Bercht. & J.Presl family spice (aromatic) plants. Complex interdisciplinary research on *Asteraceae* family spice (aromatic) plants by modified methods of collection and phytochemical analysis in 2017-2018 was carried out in two bases: in Spice – Melliferous plants collections in Scientific sector of Medicinal and Aromatic Plants of Botanical Garden at Vytautas Magnus University (VMU) and in The Instrumental Analysis Open Access Center in Faculty of Natural Sciences at VMU.

The primary introductory study of *Asteraceae* family spice (aromatic) plants has enabled following conclusions:

1. Phenological observation, phytochemical investigation of *Asteraceae* family plants revealed that new species from foreign geographic regions can be successfully introduced in Lithuania.

2. *Asteraceae* is a large family of spice (aromatic) plants and sources of raw material, used for pharmacy, phytotherapy, veterinary and food industry practice.

# P41

## Gathering evidence to meet gaps in Pest Risk Analysis evidence- The International Plant Sentinel Network

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The International Plant Sentinel Network (IPSN) consists of botanic gardens & arboreta and plant-health scientists who collaborate to provide an early-warning system for new and emerging plant pests/diseases. A research project was conducted to provide new scientific evidence to support UK Pest Risk Analyses as well as raising awareness about important emerging pests and pathogens. A number of target pest/host relationships were identified for surveying, including European oaks in the US for susceptibility to three beetle pests. Using BGCI's databases, botanic gardens with the target host species in their collections within the pest ranges were identified and information to support surveying for these pests provided. Surveys were conducted in 10 botanic gardens in California and initial findings suggest that of the three oak pests *Euwallacea whitfordi* (Polyphagous Shot Hole Borer) poses the greatest threat to European *Quercus* spp. This pest was found to be particularly prevalent on *Q. robur*. This finding will inform future plant health activities. In this initial phase of surveying no records of the other pests were found, however it is clear that these pests could pose a severe threat to UK plants and a more prolonged period of surveying over a wider geographic range is planned.

## P42

### Neighboring Land Use Increases Pathogen Spillover to Threatened *Hexastylis* Gingers in Southeast US

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Diseases will increase in rare and threatened plants as changes in habitat promote pathogen spillover from introduced to threatened species. This spillover will complicate efforts to preserve plants because safeguarding methods, like *ex situ* propagation or assisted migration, rarely consider disease susceptibility of targeted populations. We investigated how disease impacts *Hexastylis*, a rare genus of wild gingers in the Southeast US that are also related to *Magnolia*, a popular plant in the ornamental trade. *Hexastylis* are most diverse within this region, with most member species listed as threatened by state and federal agencies, and a recently-identified bacteria has diminished reproductive output for these plants. We measured pathogen movement from ornamental *Magnolia* to threatened *Hexastylis* through molecular markers observed in plant populations, and subsequently, used habitat modelling to understand what ecological factors may contribute to pathogen spillover. Results demonstrate that proximity to urban areas may not be as significant as local herbivorous insect diversity, which harbors disease vectors and depends on surrounding land use.

## P43

### **Do socioeconomic variables qualitatively and quantitatively explain knowledge on medicinal plants and the diseases they treat? A case study in the Boa Vista community, Alagoas- Northeast of Brazil**

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Local knowledge on medicinal plants varies in relation to factors such as age, gender, schooling, and income. Understanding this variation identify weaknesses in local medical systems. The influence of socioeconomic variables on the quantity of known medicinal plants, there can be a qualitative variation in the plant and disease repertoire of different social groups. Thus, we aimed to identify if socioeconomic variables influence the set of known medicinal plants and diseases treated by the people of the Boa Vista community, São José of Tapera, Alagoas. A total of 33 semi-structured interviews were conducted, using the free-listing technique for data collection. There were no significant differences between the knowledge of men and women from a quantitative point of view ( $p = 0.24$ ). It was observed that older people know more medicinal plants than younger ones ( $p = 0.04$ ), and there was a significant difference between the group of medicinal plants known to older and younger people ( $p = 0.01$ ). As for the diseases mentioned, there was no difference between gender ( $p = 0.37$ ) or age ( $p = 0.06$ ). Thus, making inferences about qualitative-quantitative aspects of knowledge on medicinal plants and diseases requires understanding the social structure of the studied community, since people with similar social roles tend to have homogeneous knowledge.

## P44

### **Relative contribution of ancient woodland indicator and non-indicator species to herb layer distinctiveness in ancient semi-natural, ancient replanted, and recent woodland.**

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The floristic distinctiveness of ancient woodland relative to recent woodland is commonly measured by Ancient Woodland Indicator (AWI) species richness at the alpha scale. However, focusing on a pre-defined subset of species means that distinctiveness in non-AWI species, or at wider biodiversity scales (beta and gamma) may be overlooked. Herb layer AWI and non-AWI species presence was surveyed in a total of 45 ancient-semi natural, ancient replanted, and recent woodland sites in southern England. Ancient semi-natural woodland was significantly distinguished from both ancient replanted and recent woodland at the alpha and gamma scales. A modelling approach showed AWI species richness was a stronger predictor than non-AWI at the alpha scale. Beta ordination analyses revealed significant differences among woodland ages for both AWI and non-AWI communities. Our results have revealed previously undetected complexity in the contributions of AWI and non-AWI species to floristic distinctiveness of ancient woodland. The non-AWI community also exhibited a sensitivity to habitat continuity that: (a) adds weight to the argument that ancient woodland is floristically distinct from recent woodland; and (b) provides a useful measure of success for woodland restoration.



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The Mediterranean diet consisting of fresh fruit and vegetables, olive oil, and limited in meat and dairy, is associated with health benefits. In 2010, UNESCO recognised it as an intangible cultural heritage of humanity. In Jordan and Lebanon, their traditional East Mediterranean diet includes wild collected edible plants. We aim to understand which wild edible plants are important to local communities, and where these species occur to collect seeds for their conservation. Some of these species are at risk from over-exploitation and over-grazing but also from knowledge loss of traditional uses. These species could be key to help achieve local food security goals in Jordan and Lebanon. Therefore, our research on seed germination and dormancy will pave the way to bringing some of these important species into cultivation. Our research also includes analysis of nutritional and high value chemicals in these edible plants, relevant to health, supporting livelihoods and providing incentives for sustainable cultivation. We are focusing primarily on the popular wild edible species 'Akkoub', (*Gundelia tournefortii*) but are also collecting seeds, collating use information and gathering initial data for four other wild edible species important in the Mediterranean diet in both Jordan and Lebanon.

## P46

### **From treetops to tabletops: a preliminary investigation of how plants are represented in popular modern board games**

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Plant blindness is the inability to appreciate plants in one's own environment, in the biosphere as a whole and their relationship to human affairs. Here we discuss a community of interests in which we suggest that an appreciation of plants is vital for success: namely the world of modern board gaming. We present a classification system for the presentation of plants in the 500 most popular modern board games, where games are categorised based on their complexity, and representation and portrayal of plants. This initial mapping exercise defines a potential scope for the future analysis of how modern board games may offer a novel and interactive entertainment mechanism to challenge plant blindness and a framework for future analysis work in this area.

Plants have been elements in board games throughout history. In an era where 'digital pushback' is becoming more common, the impressions that representations of plants in board games have on an audience is not to be overlooked. By acknowledging the importance, beauty and history of the botanic world and its considerable impact on the daily lives of human beings connected to it, modern board games may offer an entertainment route towards awareness as well as an educational resource to challenge plant blindness.

## P47

### **Exploring natural variation in silicon accumulation in wheat landraces to improve plant stress tolerance**

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Wheat is one of the most important crops worldwide, but yields are increasingly threatened by climate change. Silicon fertilisation can be used to improve tolerance to abiotic and biotic stresses, such as drought and insect pests, but the effectiveness of this stress mitigation strategy depends on the ability of crops to accumulate high levels of silicon. Cereals have this ability, although in rice and barley, silicon accumulation differs significantly between cultivars. However, whether similar variation exists in wheat has not yet been established. We have used a diverse panel of wheat landraces to investigate variation in silicon accumulation in wheat, as well as the potential causes of this variation. Shoot silicon concentration varied significantly between landraces, and preliminary work suggests that differences in the expression levels of silicon transporter genes may partly be responsible. This knowledge could be used in crop breeding programs to develop wheat varieties with a higher silicon content that are more stress tolerant.

# On the identity of *Rafflesia banoana*, a unique and magnificent flower of the Banao Indigenous Cultural Community

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*Rafflesia banoana* Malabrigo was described in 2010 from the Banao Protected Landscape in the Kalinga Province of the Philippines. The species was later treated as conspecific with the species *R. leonardi*, which was described in 2009 from low elevation forests (270 to 300 m.a.s.l.) in Luzon Island in the Cagayan Province. Barcelona *et al.* (2011) treat *R. banoana* as a form of *R. leonardi*, suggesting that the unique characters of the former species are a result of habitat-related variation. We examined specimens from the type locality. Using stable yet neglected characters (anther size, the number and length of processes, colour and markings of the disk under-surface, and annulus structure), we demonstrate unequivocally that populations growing in Kalinga are morphologically distinct from those in Cagayan. Hence, *R. banoana*, named in honour of the Banao tribe, in recognition of their exemplary indigenous forest management practices, requires taxonomic recognition at the species rank. The Philippines is now considered to be the center of diversity for the genus *Rafflesia*, with 15 species described to date. Further work should explore the extent of genetic divergence in the genus in the region. A combined approach focusing on careful examination of morphological features, ecology, and genetic divergence among species will be essential for

informing conservation priorities for the world's most enigmatic genus in the Philippines.

## P49

### **Blue-green roofs as an ecological tool for combating urbanisation, improving biodiversity and providing wildlife stepping stones**

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In urban environments green roofs provide additional habitat, enhancing biodiversity and habitat connectivity. Green roof designs vary, they can be broadly categorised into extensive, intensive and semi-intensive or hybrid systems. Intensive green roofs with deeper substrates can support a wider diversity of plants including trees. They are however heavier and unsuitable for retrofitting. Extensive green roofs are a lower cost, low maintenance solution, more suited to retrofit. Normally composed of low-growing sedum mats, these extensive systems are popular with planners as they are tried and tested and able to withstand summer droughts. They are however relatively poor habitat with limited ability to enhance local biodiversity. Blue-green roofs offer an alternative, constructed with a reservoir base they are suitable for retrofit and support a more diverse flora. The project aimed to evaluate blue-green systems as an option for enhancing biodiversity and habitat connectivity in urban environments. Plant and insect surveys were carried out on several blue-green roof systems, some constructed for the project. Initial results were encouraging, indicating that even very new, establishing blue-green roofs are rapidly colonised. In conclusion, blue-green systems can enhance biodiversity, but further work is needed to evaluate their performance over time and promote their wider use.

## P50

### **The benefits of trees for livable and sustainable communities**

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We live in an era influenced by humans to the point that the Earth's systems are now altered. In addition, a majority of the world's population lives in cities. To meet the needs of people in a changing world, The United Nations General Assembly created the United Nations Sustainable Development Goals (UN SDG) to improve the quality of life for people. These broad goals outline the greatest challenges of our time. An effective strategy to assist in meeting these goals is to plant and protect trees, especially in cities where the majority of people live. Numerous studies have demonstrated that the presence of trees and urban nature can improve people's mental and physical health, children's attention and test scores, the property values in a neighborhood, and beyond. Trees cool our urban centers. Trees are essential for healthy communities and people. As we navigate this human-dominated era, we need skilled people who understand the nuances of the built environment and trees as we strategically plan the cities of the future. The overwhelming evidence from the scientific literature suggests that investing in trees is an investment in meeting the UN SDG, and ultimately an investment for a better world.

# P51

## **Asian Mountain Garden: a dialogue between townspeople and nature**

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Our Foundation was established in 2016 with the main goal of helping to restore and revive the Botanical Garden named after E.Z Gareev in Kyrgyzstan which is the largest Botanical Garden in Central Asia. For 26 years of independence of our country, the Garden’s infrastructure is almost destroyed, a whole generation of townspeople has grown up who do not know what the Botanical Garden is, its role and significance for science and society. We, the citizens, have united under a common idea to revive the Botanical Garden. We work closely with the staff of the Garden, government agencies, the Government, business and international organizations. During two years of work we held a large number of events in the Botanical Garden: art and thematic festivals, master classes, open lectures, workshops and open-air cinema, restored information infrastructure, held Saturday cleaning works and planting activities. More than 10,000 citizens visited our events, more than 2,000 people / hours worked in the garden. Our experience has shown that education programs have a great response among the citizens. Thanks to the events, we managed to inform the citizens in an open and accessible manner about the activities carried out by the staff of the Garden.

Owing to the educational materials of other gardens that we receive through BGCI newsletters, the web and our intuitive approach, we made it possible to develop a variety of approaches to working with the population that are far from botanical science. We also attracted plant lovers to the Garden by organizing the Resource Center which became the center of knowledge, the center of experience exchange and the center for warm meetings of plant friends. We want to share our experience, as well as pass on to our colleagues the achievements and discoveries that we have made.

However, we understand that it is time to systematize the approach to work with the public. We want to participate in this event with the expectation to get the knowledge and experience of other countries in engaging public in the world of plants.



## P52

### Separation of autotrophic and heterotrophic soil respiration with $\delta^{13}\text{CO}_2$ and root exclusion methods in an annual bioenergy cropping system

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Root- and microbial- derived soil respiration are integral components of plant and soil carbon balances, respectively. However, separating these two sources of soil respiration *in situ* is a technical challenge. Our objective was to compare and evaluate the  $\delta^{13}\text{CO}_2$  and root exclusion methods of partitioning soil respiration *in situ* over a full growing season. We used high-frequency automated soil respiration measurements with  $\delta^{13}\text{CO}_2$  to separate soil respiration in a bioenergy sorghum cropping system during the 2018 growing season in central Illinois, USA. With the root exclusion method, microbial respiration exceeded root respiration during the early growing season, but this pattern was opposite during the peak growing season. Rates of root and microbial respiration were similar throughout the late growing season. Good agreement between the root exclusion method and the  $\delta^{13}\text{CO}_2$  method was achieved when the microbial respiration endmember was held constant at -18.0‰ VPDB. Root respiration contributed an average of 55% and 46% to the seasonal soil respiration flux using the root exclusion and  $\delta^{13}\text{CO}_2$  methods, respectively. While both methods have intrinsic pros and cons, our data suggest that both methods can provide similar estimates of root- and microbial- derived soil  $\text{CO}_2$  fluxes.

***De novo* genome assembly of an endangered maple species with extremely small populations: *Acer yangbiense***

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*Acer yangbiense* is a critically endangered endemic maple tree confined to the Yangbi County in Yunnan Province of China. It is included in a programme for rescuing the most threatened species in China ‘plant species with extremely small populations (PSESP)’. However, not much research had been conducted on this species, which hinders understanding of its evolution and conservation. We used a combination of PacBioSMRT, Illumina HiSeq X, and Hi-C mapping, and generated 64 Gb, 94 Gb and 110 Gb of raw DNA sequences respectively and obtained a chromosome-level genome assembly of *A. yangbiense*. The final genome assembly was approximately 666 Mb, with 13 chromosomes covering ~97% of the genome. BUSCO analysis recovered 95.5% complete BUSCO genes. Genome annotation generated 28,320 protein-coding genes, assisted by a combination of prediction and transcriptome sequencing. In addition, nearly 1:1 orthology ratio of dot plots of longer syntenic

blocks revealed a similar evolution history between *A. yangbiense* and grape, indicating that the genome has not undergone a whole genome duplication (WGD) event after the core-eudicot-common hexaploidization (ECH). *A. yangbiense* assembly will provide a fundamental genomics resources to get insight into the demographic history as well as conservation of this critically endangered species of maple lineage.

## P54

### Stamping out weakness: investigating the use of mechanical stress to improve crop resilience

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Climate change pose a huge threat to crop production, and significant increases in yield are required to meet the needs of our growing population. In Japan, mechanical conditioning has been used for centuries to improve the resilience and yield of wheat and barley. Mechanical stimulation is known to lead to changes in plant growth and development and has been shown to improve general stress resilience. The potential agricultural benefits of mechanical conditioning in other crops is being investigated using the East African crop plant *Eragrostis tef* (tef). Preliminary results suggest that this treatment significantly reduces root lodging and increases the number of tillers per plant, potentially leading to increased yield and resilience to adverse weather. I am also using the model plant *Arabidopsis thaliana* to investigate the effect of repeated controlled mechanical stress on plant growth and gene expression. This was shown to increase expression of marker genes for touch- and drought-stress, and repeated treatment did not appear to lead to desensitisation. Future work includes dissection of the molecular response to mechanical stress in tef and working with farmers in Ethiopia to develop treatment protocols suitable for application in the field.

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Genotoxic effects of environmental contaminants on plants at molecular level can be used as indicator to quantify the risk of environment. This research compared the genotoxicity of rice exposed for 10 mg/kg Cd for one month using random amplified polymorphic DNA (RAPD) assay. In this study, nine Sri Lankan rice varieties (*Suwandel*, *H4*, *BG350*, *BG352*, *BG357*, *BG359*, *BG360*, *BG450*, and *LD356*) and reference *indica* rice variety cultivar 93-11 were assayed using five RAPD primers. These primers produced a total of 49 reproducible polymorphic bands ranging from 225 – 2072 bp. All rice varieties showed altered RAPD profiles for 10 mg/kg Cd for every primer compared to its control. *BG350* had the highest average polymorphism to Cd, while, *BG352* had the least. Based on the band sharing index, *BG352* and *BG359* are identified as the varieties with the highest Cd tolerance. Rice varieties ranked against the Cd tolerance as *BG352* > *BG359* > *LD356* > *BG357* > *Suwandel* > *Cultivar 93-11* > *BG450* > *BG360* > *H4* > *BG350* based on the genomic template stability.

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Illegal deforestation identified from Unmanned Aerial Vehicles (UAVs), drone photography or satellite image monitoring, can be restricted or stopped in near-real time by forest rangers on the ground.

Madagascar is the 4th largest island in the world and contains some of the highest numbers of endemic plants found anywhere on earth. Unfortunately, the tropical rainforests of Madagascar have been devastated by illegal deforestation for many years predominantly due to the “18 million people [who] are dependent on it for their subsistence needs” (CBD, 2019). Our drone survey mapping expedition was designed to collect detailed aerial photographs of a large ‘at risk’ area of forest in central Madagascar. The protected forest area in Ambohimahamasina municipality is classified as a “Natural Resource Reserve” and comprises 20,000 hectares of biodiversity-rich rainforest. Nevertheless, mass immigration has resulted in an unprecedented increase in illegal deforestation in this area, and despite individual forest-cuts generally being small-scale (used for irrigated rice-farming) they are now so prevalent that this once intact contiguous primary forest is now highly fragmented. Our images highlight location and extent of deforestation for near real time forest service intervention and allow in some instances the calculation of exact forest stand loss.

**The genus *Cistanche* (Orobanchaceae) in the Arabian Peninsula and adjacent countries: taxonomy, evolution and use.**

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The taxonomy and evolution of genus *Cistanche* are poorly known due to unstable morphological characters which caused a nomenclatural proliferation. An example of this issue, the Chinese Pharmacopoeia recognizes *Cistanches herba* as the dried fleshy stems sourced from either of two plant species, *Cistanche deserticola* or *Cistanche tubulosa*. *Cistanche tubulosa* is included in the Chinese Pharmacopoeia as an official alternative to *Cistanche deserticola* because of the rarity of *C. deserticola* and because the plants cultivated in China are thought to be *Cistanche tubulosa*. However, there is doubt about whether the cultivated plants are *C. tubulosa*. The recent volume by Christine Leon (Kew) and Lin Yu-Lin (IMPLAD), “Chinese Medicinal Plants, Herbal Drugs and Substitutes: an identification guide”, refers to *C. ‘Tamarisk’* as the 2nd official source species of Rou Cong Rong, noting that there is a taxonomic problem that needs to be resolved. Here I will present a framework that needed to resolve the taxonomic and evolutionary questions. I also will present the diverse of ethnobotany use of *Cistanche*.

## P58

### What's killing juniper? High microsite soil moisture leads to increased infection by *Phytophthora austrocedri*

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*Phytophthora austrocedri* is now endemic in the UK, further threatening juniper (*Juniperus communis* s. l.): a keystone species already undergoing long-term population declines. With little existing knowledge about the specific host-pathogen-environment interaction and few resources dedicated to disease detection, where should conservation effort for this keystone species be prioritised?

As juniper management is primarily conducted at local level, we undertook the first field investigation of abiotic and biotic predictors of *P. austrocedri* infection at three, geographically separate, juniper populations with different infection histories. We measured the proportion of juniper showing symptoms - discoloured or dead foliage – and potential predictors of infection including altitude, slope, watercourse proximity, soil moisture, browsing damage and associated vegetation in quadrats distributed across each population. Bayesian Generalized Linear Mixed Models revealed that - despite differences in predictor gradients – juniper infection increased with soil moisture in all three populations.

Our results show that management for juniper - such as grazing regulation, scrub clearance and creation of sites for natural regeneration - should be prioritised for stands growing in drier microsites. Disturbance of soil in wetter microsites should also be controlled, to maximise the resilience of existing juniper populations and limit disease spread.



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The lower Himalayan regions of Azad Jammu and Kashmir are richly distributed with the variety of medicinal flora. These plants possess bioactive compounds with therapeutic properties to combat various ailment. Three plants were identified including *Elegnus umbellata*, *Taraxacum Species* and *Adhota vasica*, for their medicinal use using local knowlegde and evaluated for antimicrobial, antidiabetic, anticoagulant and antioxidant effects. Antimicrobial activity of *Taraxacum officinale* and *T.compylodes* was tested against three different bacterial strains *Stphylococcus aureus*; *E.coli* and *klebsiella* with leave extracts in different solvents. The maximum inhibition zone observed was 32 mm for *staphylococcus aureus*. The berries of *Elaeagnus umbellata*, were tested for hypoglycaemic and anticoagulant effects and the most significant results were obtained with acetone extract on glucose reduction with the value of 14.5, 16 and 18 mmol/L. Similarly, the acetone extract of the berries delayed coagulation up to 30, 32 and 34 minutes. The nectar extracted from the flower of *Adhota specie* was found to contain significant antioxidative properties. These plants were found to be very effective, against different microbes, to reduce blood glucose level, prolong blood coagulation, and scavenge free radicals. This research provides an insight for identification and isolation of the particular pharmaceutical compounds associated with therapeutic effects and further development of pharmaceutical products.

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We can perceive with our human senses some floral features such as colour or smell. Some other features are imperceptible to us, but also play important roles in the interaction between flowers and their animal pollinators. I investigate one of these floral traits, hard to detect for people, but crucial for flowering plants and their pollinators: the texture of the petal at a microscopic scale. This texture is defined by the shape of the cells on the petal surface. Conical cells may increase grip for insect pollinators and enhance flower colouration compared to non-conical cells (that velvety shine of some roses and petunias is given by conical cells on their petals!). The wild tobaccos, genus *Nicotiana*, present a diverse range of petal cell shapes. Interestingly, sister species in the genus have contrasting petal cell shapes (conical vs. non-conical). This provides a unique opportunity to explore the evolution of conical cells. Using a combination of molecular, morphological and behavioural ecology tools I studied the development, evolution and function of petal cell shape in *Nicotiana*. My investigation gave insights to understand the genetic mechanisms involved in defining contrasting cell shapes in sister species of wild tobaccos. Additionally, I performed flower choice experiments with bumblebees, using biomimetic replicates of petals. These experiments provided new evidence on the optical effect of conical cells and how the intense velvety gloss of some petals might help flowers to be perceived by flying pollinating insects. Understanding floral features important for pollination in this integrated way, allows us to contribute tackling current problems of our changing planet. We can inform the design of strategies to conserve plants and their animal pollinators and collaborate with plant breeders to optimize crop pollination and ensure food security.

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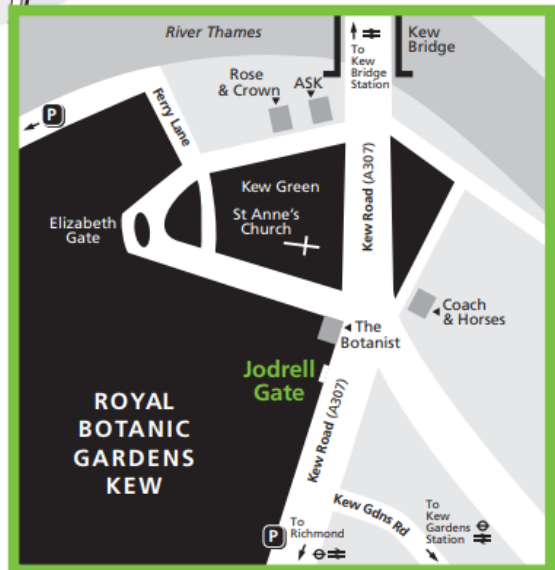
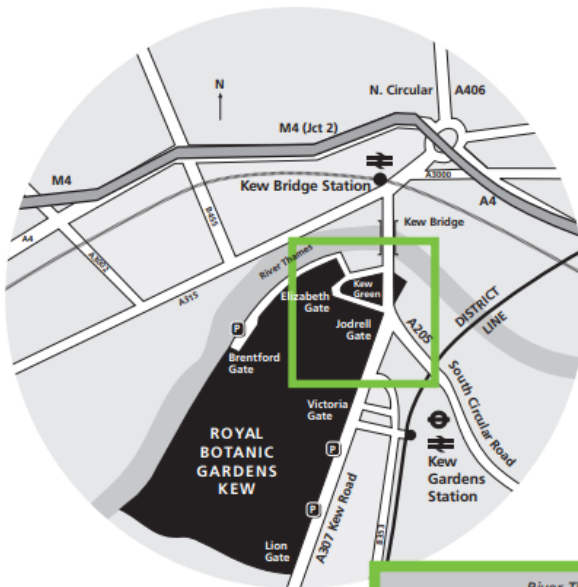
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## Venue Map



# Travel information

The symposium will be held at the Jodrell Laboratory in Kew Gardens. Please enter the gardens via Jodrell Gate, which is located at the end of Kew Road close to Kew Green.

## By tube

**Kew Gardens Station** is approximately a 10 minute walk from Jodrell Gate via Lichfield Road and Kew road. It is in Zone 3 and is served by the District Line (Richmond branch) and London Overground.

There is no level access from the Westbound platform. You can travel one stop to Richmond and return to use the eastbound platform, which does have level access.

## By train

**Kew Bridge Station** is approximately a 10 minute walk from Jodrell Gate via Kew Bridge. Services run from Waterloo via Vauxhall and Clapham Junction. There is no level access at Kew Bridge.

**Richmond Station** has a lift and level access. Please take the 65 bus (in the direction of Ealing Broadway) from Richmond station to Mortlake Road Kew (Stop B).

## By car

Kew Gardens car park (TW9 3AF)

Ferry Lane, near Brentford Gate

There is only limited parking available in the car park. Parking costs £7 per day. The car park is a short walk from Jodrell Gate. Please note, the car park closes at 19.30.

There are three disabled access parking bays and a drop-off area at Elizabeth Gate (TW9 3AB). Jodrell Gate is to the right of Elizabeth gate.