# Oxford Plant Systematics

**With news from Oxford University Herbaria (OXF and FHO), Department of Plant Sciences, Oxford**

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# Foreword

Plant collections, living or dead, combined with field and laboratory work, are important for botanical research. Some of the diverse uses of the Oxford collections are described in the current issue of OPS. Robert Scotland and his colleagues describe how collections support their work on the sweet potato and its relatives. Caroline Pannell illustrates the use of collections in picking apart complex patterns of variation. John Wood highlights how collections and fieldwork are important for the identification of areas of conservation importance in the tropics.

Historical specimens, and their associated documentation, are a continual source of interest to researchers. Richard Mulholland describes his research to understand the material and methods used by Ferdinand Bauer in the late eighteenth century to produce the watercolours for the *Flora Graeca*. Zoë Goodwin describes her research to understand the processes of species discovery and completing the global inventory of plants. The global plant inventory was also a preoccupation of the eighteenth-century botanist William Sherard as he tried to complete his *Pinax*. Collections may stimulate the search for apparently lost species, as described by Keith Kirby.

Research by new generations of students who use collections fill the pages of OPS. Juan David Beltrán uses collections for ecological modeling, Cicely Marshall for understanding biological hotspots, Claudia Havranek for understanding species diversity in agricultural landscapes and Pablo Muñoz Rodríguez for investigating the systematics of sweet potato. It is also important to recognize that if collections are to be useful for future generations they must be looked after. The appointment of James Ritchie as a Herbarium Apprentice is a particularly exciting development in the Department of Plant Sciences commitments to the botanical collections in its care.

Finally, the tremendous, half-century-long achievements of Rosemary Wise as a botanical illustration have been formally recognized by the Department of Plant Sciences and at a meeting at the Linnean Society in January 2015, organized by Robert Scotland.

***Stephen A. Harris***
*Curator of Oxford University Herbaria*

Department of Plant Sciences,
University of Oxford, South Parks Road, Oxford, OX1 3RB, U.K.
Tel. +44 (0) 1865 275000
http://herbaria.plants.ox.ac.uk

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# Contents

**Foreword**
*Stephen A. Harris* ……..… 2

**News**
Sibthorp Medal awarded, Publication of book on Mark Catesby, Appointments & joining the herbaria ……..……..… 3

**Expeditions and visits**
*Robert Scotland, John R.I. Wood, Caroline Pannell & Cicely Marshall* ……... 3

**Publications 2014** ……... 5

**Student reports**
**Ecological and evolutionary significance of CAM in the montane genus *Puya* (Bromeliaceae)**
*Juan David Beltrán* …….. 5

**Completing the global inventory of plants – Species discovery and diversity**
*Zoë Goodwin* ……... 6

**Agriculture and conservation in Oxfordshire: finding the perfect solution to the perfect storm**
*Claudia Havranek* ……..… 6

**Do hotspots of species endemism promote novel lineage diversity?**
*Cicely Marshall* ……..…. 7

**Systematics of the sweet potato and wild relative species**
*Pablo Muñoz Rodríguez* …….. 7

**A lost plant re-discovered**
*Keith Kirby* ……...…. 7

***Luehea* morphometrics**
*Caroline Pannell* …… 8

**News from the Herbaria**
**Fielding-Druce (OXF) and Daubeny (FHO)**
*Serena Marner* ……..…..… 9

**Identifying Ferdinand Bauer's materials and methods**
*Richard Mulholland* ……..…….. 11

**William Sherard: his herbarium and his *Pinax***
*Stephen A. Harris* ……..……. 13

**Tropical important plant areas – deep, dry isolated valleys**
*John R.I. Wood* ……..... 15

***Front cover images:***
Oxford University Herbaria holds a significant number of specimens collected by the eighteenth-century botanist and travelling artist Mark Catesby. These collections have been included in an account of Catesby's life, work and importance, *The Curious Mister Catesby* (2015), edited by Charles Nelson and David Elliott. The cover shows a specimen of *Liatris squarrosa* (L.) Michx. (Asteraceae) raised at Eltham Palace in 1726 from seed collected by Catesby in the Carolinas and illustrated in Jacob Dillenius's *Hortus Elthamensis* (1732, t.71; Sherardian Library of Plant Taxonomy, Bodleian Libraries). This is compared with a modern specimen collected by Dixie Damrell in 2011. Images © Oxford University Herbaria

# News



Rosemary Wise receiving the Sibthorp Medal from Professor Liam Dolan, Head of the Department of Plant Sciences.

## Sibthorp Medal awarded

**Rosemary Wise**, Botanical Artist, received the Sibthorp Medal for lifetime contributions to botany, on 22 January 2015 after first coming to work in the Department of Plant Sciences in January 1965. Professor Sir Ghillean Prance FRS gave a lecture to mark the occasion and Professor Liam Dolan presented Rosemary with the medal. During the last 50 years Rosemary has produced over 12,000 botanical illustrations and is currently working on illustrating plants in the genus *Ipomoea* (Convolvulaceae) for Robert Scotland and his colleagues Foundation Monograph Project.

## Publication of book on Mark Catesby

A magnificent book entitled *The Curious Mister Catesby a "truly ingenious" naturalist explores new worlds,* edited by Charles Nelson and David J. Elliott (2015) has been published by the University of Georgia Press. Oxford University Herbaria has the single largest collection of Catesby specimens (http://herbaria.plants.ox.ac.uk/bol/catesby).

## Appointments

**Dr Stephen A Harris**, Curator of Oxford University Herbaria, became Acting Director of Oxford Botanic Garden and Harcourt Arboretum (part time) in February 2015. He remained in the post until the new Director, Professor Simon Hiscock arrived in July 2015.

**Mr James Ritchie** was appointed as Herbarium Apprentice in Plant Specimen Conservation (see below). The University of Oxford is currently promoting and developing apprenticeships across the University. At present there are about twenty apprentices but is hoped to increase these to about one hundred over the next couple of years.

## Joining the herbaria

After finishing my GCSEs at the end of June 2014, I joined the herbarium on the first day of the following month as a full-time Apprentice. I am one of 23 apprentices across the University and will be on the scheme for three years.

Working in the herbarium has been extremely enjoyable and interesting. My post is unique; very few people have the opportunity to work in such a fascinating and history-rich place such as Oxford University Herbaria. My duties in the herbarium involve curatorial work such as specimen conservation and generally contributing to the care of the items within the collection as well as mounting and data basing specimens that will later be incorporated into the collection. I have also been involved with plant verification sessions at the Oxford Botanic Garden and exhibition curation at the Museum of Natural History.

I am becoming increasingly familiar with the collection, such as its numerous classification systems. I have gained a very wide range of knowledge and skills from working in the herbarium, for example, I now have a much better understanding of plants in general and the importance of Herbaria.

I am currently studying at the Victoria and Albert Museum in London with five other apprentices from venues such as The Tower of London and Hampton Court. The course is to achieve a level 2 NVQ in Cultural Heritage. However I am the only one working towards a level 3 diploma in Cultural Heritage after successful completion of the level 2 qualification.

***James Ritchie***
*Herbarium Apprentice*

# Expeditions and visits

## Robert Scotland

Reader in Systematic Botany

During August 2014, John Wood and I visited the International Potato Centre in Lima Peru. The purpose of our trip was to give a research seminar on our ongoing monographic studies of *Ipomoea* and to examine living and herbarium collections of *Ipomoea batatas* (sweet potato) and its closest relatives. We spent some time in Lima in the herbarium and travelled to San Ramon over - what CNN refer to as one of the world's top ten ultimate drives (http://travel.cnn.com/explorations/play/worlds-10-ultimate-drives-468834) - the Ticlio Pass, to the field station where the living collections are housed. The trip was funded by the John Fell fund as a pump-priming grant to develop international contacts for future research in relation to the domestication and evolution of sweet potato.

*Ipomoea batatas*, the domesticated sweet potato, is an important global crop, particularly in Africa as it can tolerate marginal growing conditions such as dry spells and poor soil. It demands fewer inputs and less labour than other crops. It is now the third most important food crop in seven eastern and central African countries. Sweet potatoes are a good source of carbohydrates, fibre and many micronutrients. Orange-fleshed varieties are also very rich in beta-carotene, the precursor to vitamin A. As a result, sweet potato is well placed to address both under-nutrition and micro-nutrient malnutrition. The more widespread consumption of orange-fleshed sweet potato can have a significant impact on Vitamin A deficiency which threatens an estimated 43 million children under the age of 5 in Sub-Saharan Africa and contributes to a significant incidence of blindness, disease and premature death in children and pregnant women. As little as 125 grams of orange-fleshed sweet potato can supply the recommended daily allowance of vitamin A.

Breeding programs of sweet potato have two immediate aims, to breed weevil-resistant varieties and varieties with a combination of traits suited to cultivation under diverse environmental conditions. Genes from crop wild relatives have real potential for an important role in ongoing sweet potato breeding programs. However knowledge of these relatives of domesticated sweet potato is rudimentary at best, hindering their potential use in ongoing breeding programs and research on domestication. What is known is that *Ipomoea batatas* belongs to the large, globally distributed genus *Ipomoea* that contains approximately 800 species. It is also agreed that the sweet potato belongs to a small group of some 13 currently accepted







Images: Top left: Road from Lima over the Andes to San Ramon. Middle: *Ipomoea trifida*, the presumed sister species of *Ipomoea batatas*. Bottom : Different races of the domesticated sweet potato, *Ipomoea batatas*. All photos © Robert Scotland

species within *Ipomoea*. This small group of species almost certainly contains the relevant wild relatives involved in the domestication of sweet potato. However, the species in this group are poorly defined, have been interpreted differently over the years and little credence can be given to the currently accepted species definitions. In summary, in order to maximise future crop breeding efforts for sweet potato it is imperative to identify and characterize its crop wild relatives by producing a taxonomic revision of these species.

## John R.I. Wood

Research Associate

During 2014 John Wood made two visits to Europe and two to South America.

Supported by Synthesis grants, John spent a week at the Royal Botanical Garden in Madrid in September and another in Paris in October to look at *Ipomoea* collections in both herbaria. This also enabled him to reinforce contacts with Dr Thierry Deroin at Paris and Dr Jose Luis Fernandez at Madrid, who also shares a long-standing interest in Colombian salvias.

The first visit to South America in January and February involved field work in Bolivia and visits to the herbaria in Bolivia, Corumbá (Brazil) and Tucuman in Argentina. Three new species of *Ipomoea* were identified as a result of the herbarium visits. The second trip involved field work in Bolivia and Brazil, visits to herbaria in five Brazilian cities and a week in Lima at the CIP (Centro Internacional de la Papa) with Robert Scotland (see report above). This trip was extremely successful. New species of *Ipomoea* were found in the field in both Brazil and Bolivia. Valuable insights were gained from the study of specimens in various herbaria and extremely useful new contacts were made both in Peru and Brazil.

## Caroline Pannell

Research Associate

Caroline Pannell's visit to New York Botanical Garden (commenced September 2013) continued until 21 June 2014. During this time, she contributed to the New York Botanical Garden Science Seminar Series with a seminar entitled 'Alfred Russel Wallace, Wallace's Line and the genus *Aglaia* (Meliaceae)'. She exhibited a poster at the Smithsonian Botanical Symposium, Location, location, location... New Advances in the Science of Biogeography in April 2014. Her visit to the Smithsonian continued until 29 April, with measurements of leaves on all relevant *Luehea* specimens in US herbarium for morphometric analysis of vegetative differences between four Brazilian cerrado species, an exercise she also carried out at NY. Analysis of the figures from measurements in both herbaria is in progress. She helped complete the determination of specimens collected by Doug Daly, John Mitchell, Susan Pell and colleagues in Indo-China and New Guinea, and determined the entire holdings of *Aglaia* in NY.

Caroline attended a field meeting at Crum Bryological Workshop at Blackwater Falls State Park, West Virginia, USA, June 1 - 6, 2014.

In August 2014, Caroline Pannell commenced a ten-month visit to the Wissenschaftskolleg zu Berlin and the Berlin Botanisches Museum (B), continuing her work on *Aglaia*, and on the dispersal biology and biogeography of tropical trees. She visited the Nationaal Herbarium Nederland in Leiden in December, to examine and determine newly acquired *Aglaia* collections from Maluku and other herbarium material accessed since publication of her monograph of *Aglaia* in 1992.

## Cicely Marshall

D.Phil. student

Oxford University Expedition to SW Ghana 2015: Cicely Marshall led a botanical expedition to south west Ghana in January – March 2015. She was accompanied by her supervisor William Hawthorne, Department of Plant Sciences, and two botanists from Ghana's Forestry Research Institute (FORIG), Jonathan Dabo and Markfred Mensah.

We spent eight weeks conducting botanic research in the forests of south west Ghana. The aim of the expedition was to survey Boi Tano Forest Reserve. Boi Tano was completely unexplored botanically until the early 1990s due to its remoteness, and remained largely unexplored until our survey. It lies to the north of the Ankasa conservation area, a known 'hotspot' of plant diversity. Our objective was to collect up-to-date baseline data about which plant species live where within Boi Tano in order to dramatically improve our delimitation of the SW Ghana hotspot: How far north does the hotspot extend? Is it confined to particular vegetation types? We also sought to investigate how well the reserve has fared in the c. 20 years since it was legally established, in terms of the distributions of globally rare plants, by comparing our new distribution data with the (albeit limited) earlier data.

We collected using the Rapid Botanic Survey method, a sampling method designed to facilitate the botanic inventory of floristically diverse and poorly known places. For every sample enumerated, we aimed to record every vascular plant species present in the understorey, as well as the identity of canopy trees. Specimens were collected of all plants for which identification was not absolutely certain. We carried out 31 samples, resulting in 5300 specimens, which I am happy to say arrived safely in the Daubeny Herbarium. The next challenge is to identify them all, before repatriation of duplicates.

We also spent some weeks in Ankasa, where we worked in three one-hectare plots currently managed by Yadvinder Malhi's group at the Environmental Change Institute (University of Oxford). We identified the tagged trees (and some lianes) as well as conducting a species inventory of the understorey.

The expedition was a great success, lots of fun, and everyone returned home safe and healthy.

# Publications 2014


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**Wood, J.R.I.**, Adhikari, B. (2014). *Strobilanthes nutans*. *Curtis's Botanical Magazine* **31**: 168-179.

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Poster:
**Pannell, C.M.**, Grudinski, M., Muellner-Riehl, A.N. (2014). Wallace's Line and the biogeography of *Aglaia* (Meliaceae). Poster displayed at the Smithsonian Botanical Symposium on 'Location, location, location … New Advances in the Science of Biogeography' held 24-25 April 2014.


# Student reports

## **Juan David Beltrán** (D.Phil., 2nd year) **Ecological and evolutionary significance of CAM in the montane genus *Puya* (Bromeliaceae)**


Supervised by Professor Andrew Smith (Oxford) and Dr Stephen Harris (Oxford). Funded by awards from the Louis Dreyfus-Weidenfeld Scholarships and Leadership Programme and from Colciencias.


Crassulacean acid metabolism (CAM) is a photosynthetic pathway used by nearly 6% of vascular plants. CAM plants fix $CO_2$ at night and maintain their stomata closed for most of the daytime, thereby minimizing the amount of water lost in transpiration. Therefore, CAM is considered to be a water-saving mechanism representing an adaptation to dry and warm environments. As yet, however, there is no formal definition of the climatic niche of CAM plants and the environmental variables that distinguish it from the niche of $C_3$ plants.

CAM is also regarded as a complex physiological trait that has evolved multiple times independently from $C_3$ ancestors. While the understanding of CAM evolution is relatively good at higher taxonomic levels, such as orders and families, there has been less work at the species and population levels to determine whether this trait is evolutionarily labile.

*Puya* is a genus in the Neotropical family Bromeliaceae comprising about 230 species found from central Chile to Venezuela and Costa Rica. The genus is predominantly Andean, but extends from sea level to 5000 m. According to the latest survey of carbon-isotope values, approximately 20% of *Puya* species are CAM plants, but several of these are found at very high elevations (>4000 m), which is highly unusual for CAM plants. The aim of my project is thus to investigate the occurrence of CAM in *Puya*, to define the climatic niche in which this mode of photosynthesis is favoured and thereby to formulate a hypothesis about the ecological and evolutionary significance of CAM in this genus.

During my first year I analysed georeferenced herbarium records in order to investigate the climatic niche of CAM and $C_3$ species of *Puya*. After quality control, I compiled a set of 446 herbarium records representing 149 species. I have found that CAM species of *Puya* are largely restricted to the central Andes and the lowland regions of northern Chile. Another result of climatic niche modelling was that mean annual temperature does not appear to play a major role in determining the distribution of CAM species of *Puya*; the best predictors were precipitation seasonality and annual mean precipitation.

To explain the apparent lack of CAM species of *Puya* in the northern Andes, I am exploring different hypotheses. The first proposes that this reflects a lack of suitable habitats in the northern Andes. However, according to my climatic niche models, I found suitable regions in the northern Andes for CAM species of *Puya*, but with a region of zero probability for CAM species separating suitable habitats in the central and northern Andes. This suggests the possibility that a biogeographic barrier prevented migration of CAM species of *Puya* between the two regions but allowed migration of their $C_3$ counterparts. A second hypothesis I am currently considering is that the apparent lack of CAM species in the northern Andes may be a result of sampling bias, so an exhaustive survey of *Puya* species is being undertaken by carbon-isotope analysis to complete the survey of CAM and $C_3$ taxa in this genus.

Currently I am conducting some ecophysiological studies on selected species of *Puya*, measuring their day–night $CO_2$ exchange patterns, titratable acidity and enzymatic activity to underpin the results of the carbon-isotope analyses. Of particular interest are the two subspecies of *Puya alpestris* from Chile, which according to their carbon-isotope values may represent the first instance of a single species complex that comprises both CAM and $C_3$ populations. If substantiated, this could provide a new model for understanding the evolutionary origins of CAM photosynthesis at the genomic level.

## **Zoë Goodwin** (D.Phil. 3rd year) **Completing the global inventory of plants – Species discovery and diversity**

Supervised by Dr Robert Scotland (Oxford) and Dr David Harris (Royal Botanic Garden Edinburgh). NERC funded.

The Global Strategy for Plant Conservation (GSPC) is the part of the Convention of Biological Diversity developed to deal with the threats to plants and to slow the rate of plant extinction. The first target of the GSPC and one that underpins all the others is that of creating an online Flora of all plants. A first step towards this, a preliminary checklist (The Plant List), is available online and currently includes over 1 million published species names, however nearly two thirds of these species names have not been assessed with high confidence. The second target of the GSPC is to complete conservation assessments for all plant species. IUCN Red List conservation assessments require a comprehensive level of knowledge of the distribution, ecology, population genetics, and threats against each species, however it is thought that very little is known about most plant species beyond the initial description.

The main part of my project focuses on *Aframomum* (Zingiberaceae) from Africa. The first species of *Aframomum* was first described as early as 1753 in the genus *Amomum*, before being split into a new genus *Aframomum* in 1904, the genus has been recently revised by David Harris and Alexandra Wortley at the Royal Botanic Garden Edinburgh. Initial analyses of specimens and species names indicate that *Aframomum* appears to demonstrate very pronounced patterns in specimen collection, specimen identification and species discovery. I hope that the completion of my analysis of the history of *Aframomum* will allow us insights into the process of taxonomic revision, how we can refine this process to allow us to rapidly revise the two thirds of all names that are uncertain and identify the remaining undiscovered species.

If a global checklist of plants, Target 1, is to be completed before 2020 then efforts need to focus on neglected groups in need of revision, how do we work out which are the priority taxa? What are the common characteristics? Thus I will also examine large, 'difficult' groups that have recently been monographed resulting in the discovery of many new species. I will use this to compare and contrast different methods for working out which are the remaining neglected groups which are in need of a recent revision.

IUCN Red List assessments of vascular plants, required for Target 2 of the GSPC, rely on accurate species distribution data. A long time lag in understanding a full species distribution post species description could mean that it would be impossible to perform conservation assessments for the majority of plant species in the immediate future. For the last year of my D.Phil. I will investigate the extent of our knowledge over the history of a species since its first collection particularly in reference to species distribution.

## **Claudia Havranek** (D.Phil., 1st year) **Agriculture and conservation in Oxfordshire: finding the perfect solution to the perfect storm**

Supervised by Dr Stephen Harris (Oxford). Funded by an Oxford-HDH Wills 1965 Charitable Trust Graduate Scholarship.

We are currently faced with what has been described as 'the perfect storm': population growth and increased food, water and energy demand. This increase in demand is likely require doubling food production by 2050, due to both an increase in the global population and to changes in food demand per capita.

These pressures on the global agricultural system come alongside a global extinction crisis. The rate of extinctions we are currently observing is in line with that of the five previous mass extinctions: if we continue at this rate, we should expect to see significant changes in our ecosystems.

To tackle the food crisis in the short term, food production may be increased by intensification (e.g. increased application of pesticides). However, intensification can lead to environmental degradation, and is thus responsible for species extinctions. Not only does this exacerbate the extinction crisis; these ecosystem services provided by species are critical for agriculture. This can create a downward spiral operating on intensification and ecosystem degradation, until land finally becomes uncultivable. It is therefore crucial to maintain species in the long term to feed a growing global population sustainably.

Managing land for agriculture and managing land for conservation are often falsely considered to be conflicting interests requiring different strategies. My research tackles the question of how to promote biodiversity on agricultural land. I am addressing the problem through fieldwork at a local level, at Ditchley Park, a 1,600 hectare mixed farm 20 miles north of Oxford.

Plants provide habitat and food to many species. Through surveying the plant diversity in hedgerows, I hope to identify correlations between biodiversity, crop yield and land-management strategies. I will focus on the scale over which agri-environmental policy should be implemented and the importance of heterogeneity in a landscape for yield and conservation.

This will then feed into a model that I am developing using GIS data from other sites, as well as Ditchley Park, to predict areas of high diversity on farmland. I hope that this model may then be applied to sites beyond Oxfordshire.

This work may be used to identify practical land-management strategies, in order to maximise both species diversity and crop yield. It may be implemented to improve agri-environmental schemes and government policy. My research addresses a global crisis which may be tackled at a national and local level, through improved understanding of the repercussions of land-management techniques.

## **Cicely Marshall** (D.Phil., 2nd year) **Do hotspots of species endemism promote novel lineage diversity?**

Supervised by Dr Stephen Harris (Oxford) and Dr William Hawthorne (Oxford).
Clarendon Scholorship funding (University of Oxford).

My interest is the Upper Guinean angiosperm flora, in particular its endemic elements. My aim is to draw on biogeographic, phylogenetic, ecological and taxonomic methods to illuminate the origins, diversification and botanic relationships of the Upper Guinean forest flora.

I have spent the last year assembling a large database of African plant distributions, with thanks to collaborators at the Conservatoire et Jardin Botaniques de la Ville de Geneve, University of Bonn and the National Hebarium of the Netherlands. These herbarium data have met our plot data collected in West Africa over the years, and have been supplemented by our recent expedition to the south west Ghana hotspot. With these data I will ask how Upper Guinea can best be defined and where the hotspots of endemism are within Upper Guinea. I also spent my time organising our Ghana trip (see article in the expeditions and visits section on page ) and carrying it out. We sampled in the south west Ghana hotspot, and I will use the data to delimit this hotspot by discovering how far it extends, and to what these globally rare species' distributions are related.

Species distribution data are the mainstay of botany. Aspects of species ranges have been used to define regions, hotspots, species themselves, and conservation priorities; they have inspired evolutionary and ecological theories and have even been called upon to reconstruct historical climate changes. While species distribution data have contributed much to our understanding of macroecological and evolutionary patterns, combining them with taxonomic and phylogenetic data has the potential to reveal much more about the origins and diversification of species at different geographic scales. By combining these data with my community phylogeny of Upper Guinean species, I aim to illuminate the origins, diversification and botanic relationships of the Upper Guinean forest flora. But for now, I am busy identifying our specimens in the herbarium!

## **Pablo Muñoz Rodríguez** (DPhil, 1st year) **Systematics of the sweet potato and wild relative species**

Supervised by Dr. Robert Scotland.
Interdisciplinary Bioscience Doctoral Training Partnership Programme, BBSRC.

*Ipomoea batatas* (L.) Lam. (Convolvulaceae), the sweet potato, is a globally important food crop, and it is a main source of vitamin A in developing African countries. Despite its importance and being the focus of research interest during almost 200 years, most aspects of its evolution remain unclear. One key element for understanding the evolution of sweet potato are the species that are its closest relatives. These species are of interest for future breeding programmes, but they are presently underutilised compared with other crops as they are poorly known and taxonomically problematic.

What is known is that sweet potato forms a monophyletic group with 13 other species. In the last taxonomic revision of this group, twelve species and three hybrids were included in the Section *Batatas*, and several other species have been added since. Most species of this group are difficult to identify and discriminate from each other as the taxonomic boundaries between species remain unclear. The group is distributed in America, from southern United States to northern Argentina including the Caribbean, with one species in the Asian Pacific coast. The highest number of species are found from central Mexico to the northern Andean Region.

The research will generate morphological and molecular sequence data to aid the assembly of a new taxonomic revision of *Ipomoea batatas* and wild relatives. The research will tackle a number of questions concerning the sweet potato and its wild relatives, including, what is the entity referred to as 'wild' sweet potato?

# A lost plant re-discovered

Wytham Woods, owned by Oxford University since 1943, are one of the most studied patches of woodland in the world. One of the early pioneers in, and champions of, Oxford ecological studies was Charles Elton, Director of the Bureau of Animal Population which was affiliated to the Department of Zoology. His book, the *Pattern of Animal Communities*, published in 1966 contains many references to observations and insights made in the Woods, based largely on the notes he made of over 400 visits between 1943 and 1965. These notes, held in diaries in the Oxford Museum of Natural History, have recently been put into digital form to make them more accessible through the efforts of Professor Caroline Pond, herself a graduate of the Zoology Department.



The diaries of Charles Elton

One entry triggered a botanical 'treasure hunt' last summer. H.N. (Mick) Southern, well known for his work on the relationship between tawny owl populations and the small mammals on which they feed, collected a specimen of the yellow birdsnest (*Monotropa hypopitys*) from Brogden's Belt. On 25th July 1953, Elton notes a particularly fine display of flowering spikes there.

*'Went up through Lower Seeds and Brogden's Belt to the "Bowling Alley", it being a cool cloudy afternoon turn into heavy showers later..... In the beech wood south of the path (above the swimming bath, where Cephalanthera damasonium site is) was a great outburst of the birdsnest (**Monotropa hypopithys**) growing in scores under the beeches, on the barish-ground or litter, parasitizing the roots. Never seen such a sight before, though we have a specimen previously from this Belt (H.N.S.). The plants were fruiting stage.'*

A few years later Elton records the plant again from the same area. On 6th October 1958 he notes: *'On the south (beech) end of Brogden's Belt has a few white toadstools. **Cephalanthera damasonium** is rather abundant this year (now in seed); one Epipactis, either latifolia = helleborine or purpurata, probably (from its broad oval*

*leaves) the former – this was in seed; seeding brown shrivelled-leaved stems of* ***Monotropa*** *species. =* ***M. hypophagea*** *Wallr. E.F. Warburg det. 1959 All these were on beech humus.'* Both Southern's original specimen and one collected by Elton in 1958 are in the Druce Herbarium (see below).







No-one then seems to have recorded the species from Wytham for 40 years. Charlie Gibson's compilation of plant records for the Estate notes it as having been recorded also by Druce, but not seen since the 1950s. So was it still there?

As saprophytic species it only appears above ground when it flowers, so in June I set off to look for it. Brogden's Belt is not very big and the description of where it was found was very clear. Forty-five minutes of searching however left me thinking it was no longer present. Ah well, just write it off and go for a walk round the rest of the Woods. Just as I was leaving the belt I spotted a solitary spike no more than a metre from the main track!

So the species still occurs in Brogden's Belt, even if, in 2014, it was not displaying in the same abundance as 1953 – which was obviously a good year for it.

Does it also occur elsewhere in the Woods? There are other blocks of beech near the Chalet and along the Singing Way that were established at a similar time as Brogden's Belt. In October 2014 I noticed a dead flower spike in one that looked very like the remnants of the plant in Brogden's. I checked that spot again this summer and there were some more spikes.


A view of Wytham Woods

Elton's notes are most useful for the general descriptions that he gives of Wytham Woods in the 1950s and 1960s – a period for which there is relatively little other good material. However amongst the more detailed species records there are probably more gems like this one to be discovered.

The notes for Wytham and various other documents are now on line in the Oxford Research Archive.

***Keith Kirby***
*Woodland Ecologist*


Flower of *Luehea* seen in Brazil
© S.A. Harris

## *Luehea* morphometrics

One of the features of the Rapid Botanic Survey (RBS) technique is that many of the plants are infertile at the time of the survey. Much effort has already gone into developing tools for accurate identification from vegetative material, including matching with herbarium material and keys designed for identification using vegetative characters (Hawthorne & Jongkind, 2006). Occasionally, however, several species grow in the same location without obvious distinguishing vegetative features. This is the case for three species of *Luehea* in the cerrado of Brazil and it prompted an attempt to look for parameters for distinguishing between the species using morphometrics.

*Luehea* belongs to the Malvaceae subfamily Grewioideae (formerly Tiliaceae and still filed under that family in most herbaria). It is a neotropical genus of about 17 species, first described by Willdenow in 1801. The most recent revision is an unpublished Ph.D. dissertation by Howard L. Setser at the University of Kentucky, U.S.A. The account for *Flora Neotropica* is being prepared by L. Dorr of the Smithsonian Institution, Washington D.C. Fertile material is usually easily assigned to a species. However, in RBS of Brazilian cerrado, three of the four species encountered were difficult to determine with certainty in the absence of flowers. We have therefore attempted to find a combination of vegetative measurements of leaves that reliably separate these three species: *Luehea candicans, L. divaricata* and *L. paniculata.* The vegetative appearance of the fourth species, *L. grandifolia* is distinctive in the field, but collection of morphometric data for this species was also included in this study. Caroline Pannell measured 18 parameters (see diagram) on nearly 150 leaves of *Luehea* on herbarium specimens from Goias, Minas Gerais and Distrito Federal, at NY and US. The measurements have been subjected to statistical analysis and the final results and conclusions are being prepared. We are hoping that it will result in a key based on statistically supported quantitative characters.

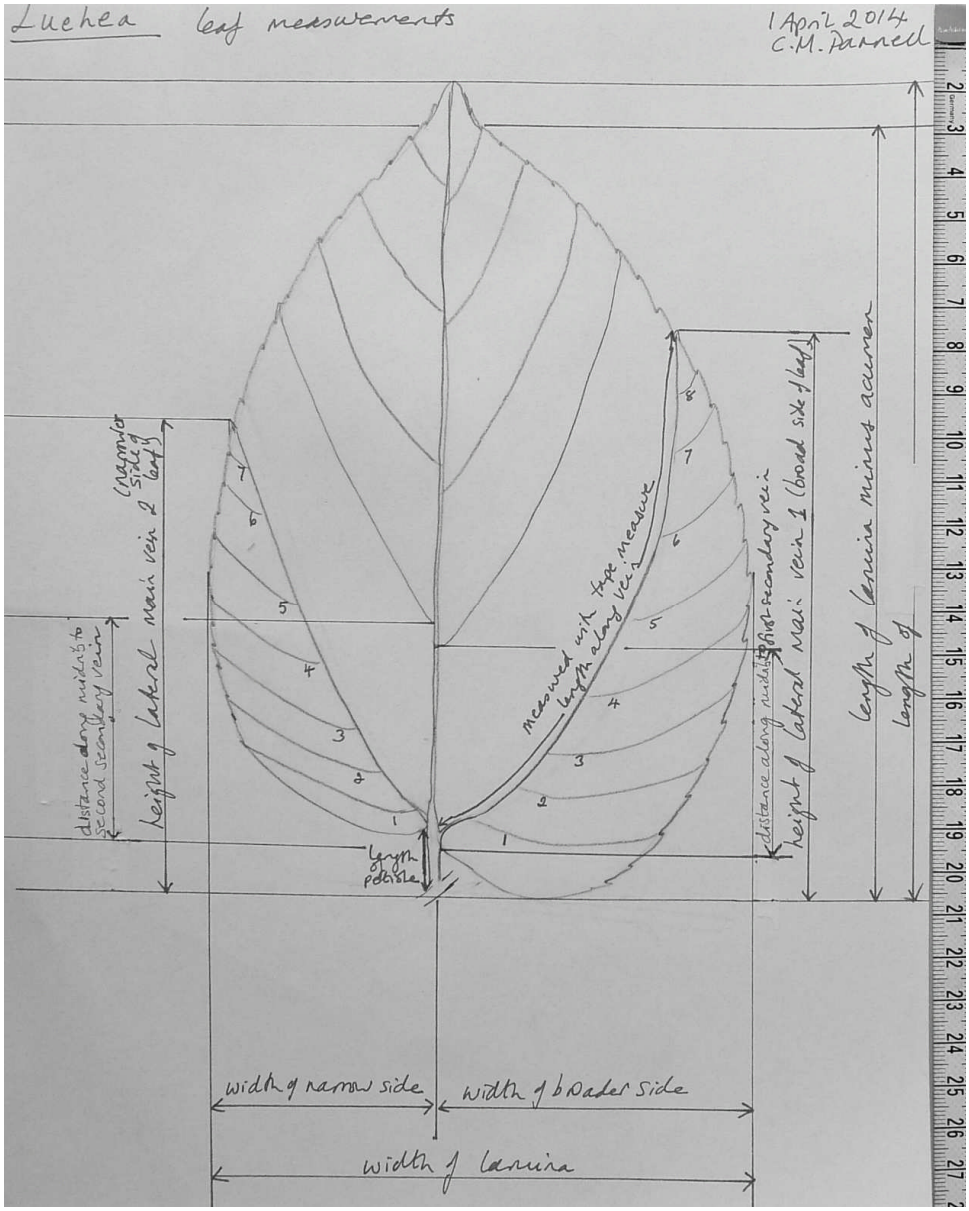
**Reference**

Hawthorne, W.D., Jongkind, C.C.H. (2006). *Woody plants of Western African forests. A guide to the forest trees, shrubs and lianes from Senegal to Ghana*. 1023 pp.

**Acknowledgements**

We are grateful to D. Cavaliere and A. Henderson of New York Botanical Garden, L. Dorr of the Smithsonian Institution and I. Ramsay McFadden, Kraft Lab, University of Maryland, for being generous with their time and expertise.

***Caroline Pannell***
*Research Associate*




Leaf parameters measured in the *Luehea* morphometrics investigation

# News from the Herbaria

## Fielding-Druce (OXF) and Daubeny (FHO)

One of the main events for the herbarium during 2014 was that we were able to appoint a Herbarium Apprentice to join our (small) team. James Ritchie joined us, firstly as a summer vacation student in July, and then as an apprentice from September (see James's report on page 3). It is proving most useful to have another pair of hands to help with the day-to-day curation of the collections and a delight to teach someone young and enthusiastic. We were also delighted to have another vacation student, Libby McGowan, working in the Herbarium again last summer. Libby did a splendid job of mounting specimens from a number of new accessions which included collections from Liberia, Gabon, Ecuador, Malaysia and South Carolina, USA. Over 600 specimens were mounted during the summer. To continue the process, Pauline White, one of the technical staff in the Department of Plant Sciences, is working in the herbarium two afternoons per week mounting specimens, which is being carried out with great care and attention.

## Visitors

During 2014, seven group visits were made to be given tours of various parts of the collections, plus further visits by Oxford University students attending the Graduate Training Programme. 163 visitors came to the Herbaria, excluding the students.

In May eight members from the Eden Project Florilegium Society visited and were given an introduction to the historic collections. A selection of plants collected over the last four centuries, with complementary illustrations from library material, was shown. Methods used to conserve herbarium specimens were also discussed. In August eight members of the Anglo-German Society (based in Abingdon) visited the Herbarium for a talk on the contribution German-born naturalists and explorers have made to the botanical collections in Oxford; in particular the roles played by Jacob Bobart the Elder (1599-1680) and Johann Jacob Dillenius (1684-1747) in the early development of the Botanic Garden and herbarium. Specimens collected by Georg Marcgrave [Markgraf] (1610-1644), Englebert Kaempfer (1651-1716), Ferdinand Deppe (1794-1861), Johann Franz Drège (1794-1881), Sir Robert Hermann Schomburgk (1804-1865), August Fendler (1813-1883) and Sir Ferdinand Jakob Heinrich von Müller (1825-1896) were exhibited.

Three group visits came to see materials associated with the publication of John Sibthorp and James Edward Smith's *Flora Graeca* (1806-1840). In August twelve professional and amateur artists, who were part of a week-long international summer school focused on botanical drawing, came to see Ferdinand Bauer's drawings, watercolours and specimens from the Sibthorp Herbarium. The students were introduced by their tutor Dr Sarah Simblet, from the Ruskin School of Fine Art. In December eleven members from the London Metropolitan University also visited to see the *Flora Graeca* material. The Florilegium Group from the Oxford Botanic Garden came to see the *Flora Graeca* watercolours, the numbered pencil sketches prepared by Bauer in the field, together with herbarium specimens collected on the trip in 1786-7, so they could study Bauer's techniques.

In October the Bobart Group, from Oxford Botanic Garden, was shown a selection of materials from the herbaria and Sherardian Library on the theme of plant collecting and plant collectors. Examples of the types of equipment collectors take into the field to record data, along with field notebooks were shown. The importance of the link between published material and specimens was introduced using the 1699 collections and publications of the privateer William Dampier. Linnaeus's journey to Lapland was illustrated using the *Flora Lapponica* and associated specimens, whilst the importance of collecting for the horticultural trade was illustrated using the work of North American collections of Mark Catesby (1722-1726) and the Chinese collections of Robert Fortune (1812-1880). Fortune's expedition returned to Britain with familiar garden plants (e.g., *Forsythia*) and the knowledge of how to cultivate, and process, tea. The display was brought up to date by showing how plant collecting continues and

how herbaria are used in ways that the original collectors and authors could never have conceived.

Many individuals came to look at a range of different specimens including three visits from the BBC researching and filming for a documentary. Paul Harmes and Jessica Turner continued their search for plant specimens collected in Sussex for data for a new county flora.

Natalie Henriksson, a student studying plant ecology and systematics at Lund University Sweden, came to Oxford University Herbaria in March 2015 as part of her Erasmus internship at Oxford Botanic Garden and Harcourt Arboretum. Natalie mounted specimens which had been collected in Japan by staff at the Botanic Garden and Harcourt Arboretum. These specimens will be held in the OXF collections.




Herbarium Apprentice James Ritchie with his pine cone exhibit in the Oxford University Museum of Natural History © OUMHM

## Loans for exhibitions

Four specimens collected in China in the nineteenth century were borrowed by the Ashmolean Museum for display in an exhibition entitled 'A View of Chinese Gardens'. This exhibition ran from 5 August to 30 November 2014. The specimens accompanied paintings of Chinese gardens and scenes and the purpose was to demonstrate the actual form of some of the traditional garden plants grown in China. Three of the specimens chosen (an orchid, *Chrysanthemum* species and a *Prunus* species) had been collected by Robert Fortune in the mid nineteenth century.

Towards the end of 2014 we were asked by the University Museum of Natural History to put a temporary exhibit in their 'presenting' case on a theme related or appropriate to Christmas. We chose to exhibit a range of pine cones and this was curated by James Ritchie. The display was entitled 'Presenting …. Pine cones, great and small'. The cones of a dozen pine species were selected from a large collection in the Daubeny Herbarium, plus two trunk sections of 'pine' wood from the xylarium and one accompanying herbarium specimen (http://www.oum.ox.ac.uk/visiting/presenting11.htm) (see image above right).

## Loan material

The processing of loan material continued. Any new loans being sent out are automatically databased in BRAHMS before being despatched, and any specimens returned from loan have their new determinations or confirmations documented in the database before being returned to the main collections. Loans sent out from FHO included specimens of *Cedrela* (Meliaceae) mainly from Colombia and Costa Rica, *Friesodielsia* (Annonaceae) from tropical Africa and *Drypetes* (Putranjivaceae) from West Africa. These loans highlighting the wealth of material FHO holds from tropical Africa and also that the family Meliaceae is very well represented in the Herbarium. A number of 'internet loans' of specimen images were also sent in response to requests for very specific material. This included a number of sheets from the Morisonian Herbarium plus several specimens of Cyperaceae collected by Nathanial Wallich (1786-1854) in India. Among material being returned to OXF were three specimens of Algae collected by William Dampier from an ancient loan which had been re-discovered by a keen eye at the Natural History Museum. Included in a loan returned to FHO from K was the holotype specimen of *Protea poggei* Engl. ssp. *mwinilingensis* Chisumpa collected in Zambia by W.D. Holmes. Twenty loans were received for study in FHO and these consisted mainly of specimens of *Ipomoea* (Convolvulaceae) for the work of John Wood and some for Rosemary Wise to draw, plus some material of the related genus *Stictocardia* for study by Bethany Williams. During 2014 a small number of sheets of *Convolvulus*, *Strobilanthes* and *Salvia* were returned from loan.

## New accessions

New accessions to OXF, for the Fielding Herbarium, included 126 specimens collected in South Carolina by Dr Dixie Damrel, sent as exchange material from Clemson University Herbarium. These collections are of particular interest in the light of South Carolina being one of the areas of the USA explored by Mark Catesby in the eighteenth century, and this compliments the Mark Catesby collections in the historic herbaria of Sherard and Du Bois (see front cover). 89 specimens of Convolvulaceae collected in South America, mainly from Brazil and Bolivia, were also received for the Fielding Herbarium. 68 sheets of miscellaneous species collected in the UK by John Killick were incorporated in to the Druce (British) Herbarium. This accession included many interesting records of plants collected in Oxfordshire and Berkshire, on a very local level.

We were also presented with an unusual but beautiful item by one of the Friends of the Oxford Botanic Garden and Harcourt Arboretum, Mrs Harriet Bretherton. The item entitled "York Manuscript" is a small book bound in vellum of plant, insect and snail illustrations. The watercolours in the book are in the Dutch painting style of the late seventeenth century with some later Victorian/early Edwardian additions.

Over 300 specimens were received into the Daubeny Herbarium (FHO) which included 143 specimens sent from Dr C. Jongkind (WAG) of plants collected in Liberia. Missouri Botanical Garden Herbarium (MO) sent 89 specimens of Acanthaceae collected in Bolivia plus 20 specimens of *Lupinus* (Fabeaceae) collected in Ecuador. 33 miscellaneous collections from KEP, Kepong Herbarium, collected in Peninsular Malaysia by Caroline Pannell and others were also received. Additional accessions to FHO included a few specimens of South American Tiliaceae sent from the Smithsonian Institution and *Ipomoea* from RB, Jardim Botânico do Rio de Janeiro.

***Serena Marner***
*Herbarium Manager*



Cone of the 'Big cone pine', *Pinus coulteri*

Oxford University Herbaria database and back issues of OPS can be viewed at: http://herbaria.plants.ox.ac.uk/bol/oxford

# Identifying Ferdinand Bauer's materials and methods

In Richard and Samuel Redgrave's 1866 publication, *A Century of British Painting* (the first definitive history of British painting) the authors declared that 'perfect knowledge and perfect mastery' in the medium of watercolour had finally been achieved in the paintings of J.W.M. Turner. The popularity of Turner's watercolours in the nineteenth century, and his virtuosity with the technique certainly changed the status of watercolour painting, which was at the time still considered inferior to oil painting. However it also cast a shadow over both later artists and over the appreciation of earlier artists who worked in the medium. And while mastery of technique in watercolour was demonstrated extensively in Turner and in the paintings of the English eighteenth and nineteenth century landscape school, it is certain that in the paintings of the much lesser known natural history painters, mastery and knowledge of the medium was present in abundance.

Oxford's collection of Ferdinand Bauer's watercolour paintings for the *Flora Graeca* (1806-40) is one of the great treasures of the University, and is the subject of a new three-year research project. *Painting by Numbers: Decoding Ferdinand Bauer's Flora Graeca Colour Code* is being carried out at the Bodleian Libraries' Conservation Research Department, funded by a Leverhulme Trust Research Project Grant. The multi-disciplinary project, which builds on the extensive body of research on Bauer carried out by H. Walter Lack, David J. Mabberley and Stephen Harris at Oxford, aims to identify the painting materials Bauer used to create his magnificent watercolours for the *Flora Graeca*, unravel the complex methods he used, and recreate (as much as possible) his lost colour chart.

Ferdinand Bauer (1760-1826), considered to be amongst the greatest of botanical artists, is of course notable for the means by which he approached his paintings. As travelling artist on John Sibthorp's 1786 expedition to Greece and the Levant, he was required to move quickly from place to place, collecting and sketching specimens as he went, often under difficult circumstances. Bauer took only brief pencil sketches of each specimen in the field, and in order to record the vital colour information necessary to recreate the specimens accurately in watercolour, he annotated them with a complex colour code, which could be used when he returned to Oxford by referring to a painted colour chart of his own design.

The extent of visual information contained in Bauer's drawings is extremely sparse. His drawings are little more than outline sketches. There is a complete lack of shading, no indication of texture, gloss or other tactile qualities and more notably, no further written annotations regarding tone, shade, hue or intensity of colour. The code seems to be all that Bauer required to achieve extraordinary accurate colour fidelity in the replication of living specimens on the page, some of which that he had observed some five years prior to painting them.



Ferdinand Bauer, sketch showing *Iris germanica* and numerical colour codes, graphite pencil on paper, 1786–87 (MS Sherard 247/107). © Bodleian Library, University of Oxford, 2015.

It is interesting to note that Bauer seems to have been the only botanical artist to have used such a system so extensively. Other artists certainly used shorthand to convey colour information to be used at a later stage, but none of them seem to have used a method similar to Bauer's. Sydney Parkinson for example, used a combination of handwritten notes and the addition of small patches of colour to areas of significance on his pencil drawings, and other botanical artists used similar methods. In 1999, Lack and Mabberley discovered that the eighteenth century naturalist Thaddäus Haenke created an extensive colour chart, based around an earlier chart by Bauer himself that was in Haenke's possession, and now in the archives of the Reál Jardin Botánico in Madrid. However, although he seems to have experimented with the system, Haenke was not a trained artist, and as Mabberley has recently pointed out, his system appears to have been little more than an academic exercise.

Colour charts and systems of ordering colour in themselves were nothing new. Isaac Newton had identified the prismatic spectrum of daylight in 1672, and soon after this naturalists began finding ways to systematise and order colour. In the seventeenth century, and particularly in the eighteenth century, numerous colour systems were proposed as a means to assist art and industry in a practical way by offering a standard for accurately describing colour in nature and reproducing it in pigment. While these systems were presented at scientific societies and sometimes published, there is scant evidence that they were ever used by artists, craftsmen or naturalists in any practical sense. Ferdinand Bauer (and to a lesser extent his brother Franz) appear to be the only significant artists to have used such a colour chart extensively in the field.

**Recreating Bauer's Colour Chart**

Bauer's *Flora Graeca* colour chart is lost. However, by means of identifying the pigments that he used in the original watercolours for the publication, and cross referencing these results with the numerical codes in his field sketches, our intention with the Bodleian research project is to recreate, albeit partially, the colour chart that Bauer used. We approach this in a number of ways.

Looking at eighteenth century artists' manuals can gives us a good idea of the pigments that were available, and those that were recommended for watercolour painting in the 1780s and 1790s. Similarly, looking at early examples of historic watercolour



Ferdinand Bauer, *Morina persica*, watercolour on paper (MS. Sherard 243/19).
© Bodleian Library, University of Oxford, 2015.

cakes as sold by Artists' Colourmen also provides a good sense of what artists used around this time.

The solid watercolour cake, or pan as we know it today, was invented by the London Colourman George Reeves around 1766, and boxes of solid, moist watercolours were certainly available from around 1770. These portable painting boxes eliminated the need for frequent, laborious and time-consuming grinding of dry pigments with gum and water, and were invaluable to travelling artists in the eighteenth and nineteenth centuries, whether on natural history expeditions or on the Grand Tour. Working in the 1790s in Oxford, Bauer certainly would have had access to manufactured watercolours, but it is perhaps more likely, given the fact that he seems to have learnt the art of traditional botanical illustration in watercolour near Lichtenstein in the 1770s, that he still purchased his pigments dry and prepared his paints himself, allowing more control over their quality and working properties.

Using this kind of information as a means by which to know what pigments we might be looking for, we can begin to look for specific pigments on Bauer's watercolours using instrumental analysis. Analysing pigments on oil paintings and other works of art typically requires the removal of a tiny sample of paint from the object itself. With watercolour painting where the paint layer is extremely thin, this is simply not possible and so in situ methods of analysis, where the painted surface itself is never touched, are required. At the Bodleian, we currently use two techniques that have the potential to identify pigments with a very high degree of accuracy: Raman Spectroscopy and Hyper Spectral Imaging (HSI). Raman spectroscopy in particular has a long historyof yielding very accurate results in watercolour pigment analysis.

Bauer's watercolours are painted on sizeable sheets of handmade paper, and are bound together in very large volumes and so accessing minute areas of colour can be challenging. Physically Raman instruments are not generally set up for use with works of art - analysis is typically carried out on samples on a small microscope stage. However, a portable Raman system that can be set up for use with cultural heritage objects of almost any size has recently been developed at Durham University, and we are very fortunate, thanks to a collaboration with Prof. Andrew Beeby, Professor of Chemistry at Durham, to be able to access this equipment for use on the *Flora Graeca* watercolours.

Bodleian's Conservation Research Department has also recently purchased an HSI spectrometer, a method which is finding increasing use in the heritage science field. HSI captures a single digital image of a work of art that contains many hundreds of layers of information over the visible and infrared spectrum, each layer representing a very narrow wavelength band of the spectrum. Because every pigment (or combination of pigments) can appear differently at specific wavelength bands, the method can often be used to differentiate between pigments that look visually identical in the painting itself. Additionally, because the image has an extremely high spectral resolution, each pixel of the digital image can be individually analysed to produce a unique spectrum of the area of interest. These can then be compared to the standard spectra of known historical watercolour pigment samples and used for identification.

Examining Ferdinand Bauer's paintings closely, it is clear that his visual memory for colour and ability to reproduce it with great accuracy is remarkable. We may never understand completely how he was able to perfect this method of painting. However this project, in taking a closer look at Bauer's materials and decoding his colour system, will go some way in understanding more about how he was able to create works of astonishing beauty, while at the same time achieving such an impressive degree of colour fidelity and accuracy.

***Richard Mulholland***
*Bodleian Library Research Associate*

# William Sherard: his herbarium and his *Pinax*

James Edward Smith (1816), purchaser of Carolus Linnaeus's herbarium and founder of the Linnean Society of London, praised William Sherard's herbarium as 'perhaps, except that of Linnaeus, the most ample, authentic, and valuable botanical record in the world'. At about the same time, the German-American authority on the North American flora, Friedrich Pursh (1814), was praising the herbarium as 'the most complete collection of North American plants'. Unlike the herbarium of Sherard's contemporary Hans Sloane, Sherard's herbarium continued to expand over the eighteenth century after it had been acquired by the University of Oxford in 1728 (Clokie, 1964). Furthermore, since its acquisition, Sherard's herbarium has been reorganised on multiple occasions and significant parts hived off into other herbaria in the University, such as those of Johann Jacob Dillenius and Robert Morison (Clokie, 1964, Harris, 2015a). Today, Sherard's herbarium comprises approximately 21,000 sheets, and appears never to have been bound in book form unlike other herbaria of the period.

Specimens in Sherard's herbarium are typically poorly labelled with limited information on collector and collection date and locality. This is apparently a consequence of relabeling by Sherard, and later contributors, who were primarily focused on registering names rather than collection data. Sherard's herbarium appears to have been a tool for helping him complete a list of the world's plants and their synonyms – his *Pinax*. By understanding the structure and content of Sherard's *Pinax* it may allow us to determine the size of his original herbarium, fill gaps in our knowledge of individual specimens and understand how the specimens were originally ordered.

William Sherard, eldest son of a Leicestershire landowner, read law in Oxford at St. John's College and graduated in 1683. Sherard's interest in plants appears have matured as an undergraduate, probably through his friendship with Jacob Bobart the Younger, son of the first keeper of the University's Physic Garden; a friendship maintained until Bobart's death.

During the 1680s, Sherard completed his botanical education at the Jardin du Roi (Paris), under the tutelage of Joseph Pitton de Tournefort and at Leiden (Netherlands), under Paul Hermann. On returning to England, Sherard became travelling companion or tutor to wealthy individuals such as Wriothesley Russell, Arthur Rawdon, Lord Townshend and the grandson of Mary Somerset, dowager Duchess of Beaufort.

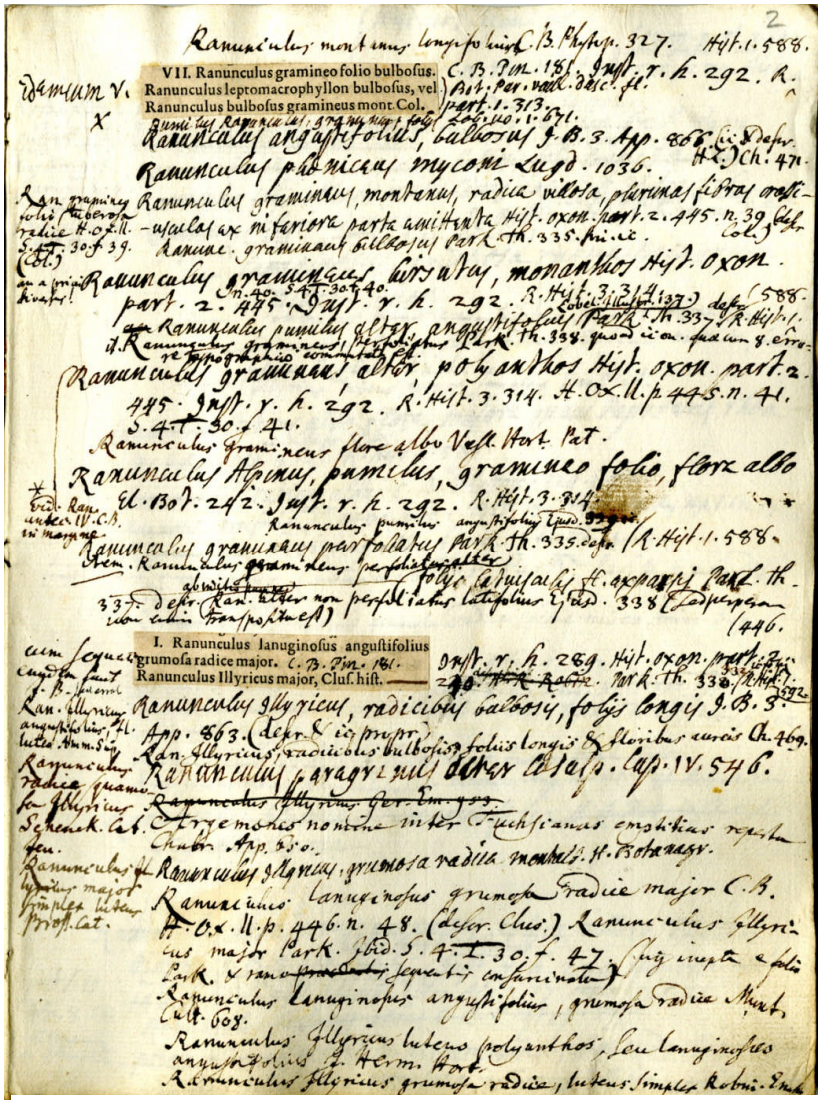



Fig. 1. Typical page of Sherard's *Pinax* (MS Sherard 091 f.2r).

In 1703, Sherard was appointed Consul at Smyrna (Turkey) where he maintained his botanical interests, and returned to England, in 1717, a wealthy man. A year later he was elected a Fellow of the Royal Society. During the final years of his life, Sherard was based in London. However, he continued to travel to the continent, visiting botanists, maintaining and renewing friendships and acquiring new contacts. In particular, he employed the young German botanist Dillenius as his assistant. Through his amiability, intellect and diligence Sherard emerged as a key figure in early eighteenth-century European botany.

Sherard died in 1728 and was buried at Eltham, the home of his brother James. William bequeathed his herbarium, library and manuscripts to the University of Oxford. In addition, he offered the University £3,000 to establish a Chair of Botany. Years of dispute followed until Dillenius finally became the first Sherardian Professor in 1735 (Clokie, 1964; Riley, 2011).

By the end of the sixteenth century, natural philosophers had published tens of thousands of disconnected names for the plants they studied. Confusion and contradiction reigned as the Swiss botanist Caspar Bauhin began the laborious, four-decade-long task of distilling these names to approximately 6,000 species and their synonyms; a pre-Linnaean version of the current global *Plant List*. Bauhin's *Pinax theatri botanici* which was eventually published in 1623 (reprinted 1671) was divided into twelve books, each with six sections. Under each section there is a hierarchy of groups which ends with species polynomials and their synonyms. Historians of science have marked this publication as pivotal in our ability to communicate accurately and scientifically about plants. It provided a common basis to start answering the question of how many plant species occurred on earth.

As exploration of the natural world increased during the seventeenth century it became obvious that Bauhin's *Pinax* was inadequate; a revision was needed. Tournefort thought Sherard had the intellectual and personal qualities that would be important in bringing such a revision to fruition. This project occupied the last decades of Sherard's life. In the case of the two Sherardian Professors, Dillenius and his successor Humphrey Sibthorp, it is unclear

whether their involvement was through obligation or conviction (Linnaeus, 1751). The project died with Sibthorp in 1797 and has remained incomplete and unpublished; the 16 volumes of the Sherardian *Pinax* (‘register’) is a testament to the Sisyphean task Sherard started.

Sherard’s *Pinax* is split into 130 separate manuscripts (MS Sherard 44-173; Sherardian Library of Plant Taxonomy, Bodleian Library). Except for the Appendix (MS Sherard 172 & 173), each manuscript comprises between 24 and 131 pages bound inside a sheet of fawn-coloured blotting paper; 24 pages are usually sewn to the cover, the remaining pages are loose. The covers are made from old drying papers used in the preparation of herbarium specimens; 29 manuscript covers have deep specimen impressions in their surfaces. Some impressions match specimens in Sherard’s herbarium, for example, the covers of MS Sherard 56, MS Sherard 68 and MS Sherard 100 match specimens of *Theobroma cacoa* (Sher-1580), *Cinnamomum* sp. (Sher-0260-3) and *Coix lacryma-jobi* (Sher-1679-10) respectively.

Sherard’s *Pinax* is formed around Bauhin’s *Pinax* (1671), copies of which were cut up and pasted into the blank manuscript books; usually two species and their synonyms per page. These entries were annotated with new synonyms, references added and new species names intercalated where necessary. In addition, notes were added regarding sources of unpublished names, or plants collected from or seen in gardens across Europe. Many of these names are likely to be associated with specimens in Sherard’s herbarium. As the work continued 3,110 bound pages grew to 6,215 pages with the insertion of additional sheets. The front of each manuscript cover is annotated with a reference to the book, section and page number in Bauhin's *Pinax* that forms the start of the manuscript, although the manuscript contents frequently do not match the title.

Finding polynomial names in Sherard's *Pinax* is complicated by intricacies of understanding Sherard's interpretation of Bauhin's nomenclatural arrangement. Thousands of additional names were added to Bauhin's arrangement as Sherard and his collaborators combed published and unpublished sources until the 1750s. Furthermore, thousands of unsorted polynomials appear in the Appendix of Sherard's *Pinax*. Many handwritings, including those of William and James Sherard, Johann Dillenius, Jacob Bobart the Younger and Humphrey Sibthorp, are represented in the *Pinax*. Together these features create a confused palimpsest, especially as to what constitutes species and their synonyms.

In the absence of an index to Sherard’s *Pinax* it is necessary to use Sherard’s interleaved and annotated copy of Bauhin’s *Pinax* (MS Sherard 176 & 177) to locate names. If the first word of a polynomial is




Impression of *Theobroma cacao* in the back inside cover of of Sherard *Pinax* MS Sherard 56.




Specimen of *Theobroma cacao* (Sher-1580) from the Sherard Herbarium pressed using the cover of Sherard's *Pinax* MS Sherard 56.



William Sherard (1659 – 1728)

presented in Bauhin's *Pinax* this can be looked up to find a page reference and its corresponding place in Sherard's *Pinax*. It is then a case of searching the bound and interleaved pages around the name to locate the required polynomial. In the case of polynomials which start with a word not found in Bauhin's *Pinax* these can only be located by searching for similar names or for other words in polynomials. If unknown names are of North American, Chinese or Japanese plants then it is worth searching the lists in Volume 16 of Sherard's *Pinax* (MS Sherard 173); this volume also contains an extensive list of unsorted polynomials (ff.13-143).

Independent of the system Bauhin adopted in his *Pinax*, Sherard's project was almost bound to fail in the absence of detailed descriptions, illustrations or specimens that could be positively ascribed to Bauhin's names. Furthermore, the climate of botanical research was changing as the herbal tradition gave way to a new botanical approach spearheaded by the Swedish naturalist Carolus Linnaeus.

Bauhin's system was apparently in widespread use across Europe as Linnaeus briefly visited Oxford in 1736 but it is unclear whether he saw Sherard's herbarium, and even if he did, whether he had the opportunity to study it. The broad acceptance of Bauhin's system meant that Linnaeus had to try and align his names with those of Bauhin. Linnaeus's task was made easier by access to the herbarium of Bauhin's correspondent Joachim Burser, which was named and arranged according to Bauhin's *Pinax* (Jarvis, 2007). Burser's herbarium and Linnaeus's annotated copy of Bauhin's *Pinax* provides the link between the nomenclature of the pre-Linnaean and post-Linnaean botanists. Controversially, Bauhin's *Pinax* has been lauded as anticipating Linnaean nomenclature and Linnaeus's ideas of genera and species (Morton, 1981; Cain, 1994).

With hindsight, the half-century devotion of Oxford-based botanists to Sherard's *Pinax* appears to be a distraction from botanical developments that were happening in other parts of Europe. However, it does not appear to have distracted Sherard from his role as a botanical patron or interfered with Dillenius's interests in 'lower plants' (Harris, 2015b, Nelson and Elliott, 2015). Today, Sherard's *Pinax* may allow us to understand more about the specimens in Sherard's Herbarium and give us the opportunity to investigate how an important early modern herbarium was constructed through networks of personal correspondents, sponsorship of individual botanical explorers and personal collecting habits.

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***Stephen A. Harris,*** *Druce Curator of Oxford University Herbaria*


# Tropical important plant areas – deep, dry isolated valleys

As part of their science strategy the Royal Botanic Gardens, Kew (2015) have recently begun an initiative to identify Tropical Important Plant Areas (TIPA) with a view to highlighting their importance for conservation. I was pleased to note that one of the countries chosen for this programme was Bolivia as this will obviously build on information from the recently published *Catálogo de las Plantas Vasculares de Bolivia* (Jorgensen et al. 2015) as well as the extensive data stored in TROPICOS and that collected by two Darwin projects, headed by Oxford University Plant Sciences, which is stored using BRAHMS.

I am not aware of what criteria are used to define a TIPA but assume that absolute numbers would be of less importance than bioquality and in particular the presence of a significant number of locally endemic species. It may well be that Hawthorne's Star System will prove useful in quantifying the conservation value of these areas, a black star species being a species from the top, that is the rarest category (Hawthorne 2012). However, I do see problems in defining TIPAs geographically in Bolivia, particularly in the Andean region, as to some degree almost the whole region could be considered a large single TIPA. With very few exceptions the whole Andean region is rich in endemic species; even the arid SW altiplano with its soda lakes boasts large numbers of endemic grasses and unusual representatives of other families. The endemic species tend to be dispersed over a relatively wide area and apparently localised species are often found to be more widely distributed once informed searches have been carried out in suitable habitats. Details of the distribution of most species found in Bolivia are still very inadequately known, which makes defining individual TIPAs difficult.

It may be the case that isolated ridges and peaks function as inselbergs which harbour significant numbers of rare and endemic species but here I want to draw attention to the opposite phenomenon, the deep, dry valleys that are like oceanic trenches lying between the folds of the Andes. They may not be species-rich but they harbour isolated populations of rare and endemic species. In Colombia there is the Chicamorcha Valley, in Peru the Apurimac and the Marañon Valleys and in Bolivia the valley of the Rio Grande and its principal tributaries, the Rio Caine, the Rio Chico and the Rio Mizque. This river basin below 1500 m, and above the point where the Rio Grande breaks through the Andes into the Chaco plain, merits consideration as a potential TIPA.

The significance of this valley has only been appreciated recently. Superficially it



John Wood and Daniel Villarroel climbing on black shale in the Rio Grande Valley. Photo © Beth Williams



The new species of *Ipomoea* flowering when leafless. Photo © Nelly de La Barra

has little to attract a botanist. It is arid and rocky with outcrops of black shale and the heat trapped in the valley in summer is almost unbearable; the slopes are precipitous and the vegetation consists of spiny thorn scrub. Areas fit for cultivation are limited to the occasional narrow strips of flat land beside the river. Perhaps the first local endemic to be found in this area was in 1967 when Donald Ugent found *Salvia graciliramulosa* which is abundant on sandstone outcrops in one part of the Rio Chico side valley. Since then there has been a steady increment of new species from a range of different plant families, none found elsewhere. When this is combined with the presence of several more widely distributed Bolivian endemics and very rare chaco species, the importance of this area for conservation becomes apparent.

Quite recently my attention has been drawn to a spectacular new species of *Ipomoea* from this region. I was shown photographs of an unknown leafless *Ipomoea* found independently on different sides of the valley by two Bolivian botanists. At first I was baffled by the plant but after being shown a portion of an inflorescence and being told it had abundant white latex I strongly suspected it was a representative of the tree or "Arborescens" group of *Ipomoea*, hitherto unknown in Bolivia. Recently Julia Gutierrez from Sucre was able to send photographs and a leaf sample. This confirmed not only the placement of this species in the "Arborescens" group but showed that it was a new species, sister to other species in the group. The Rio Grande Valley, therefore, is a host to the most southerly and most isolated species of this neotropical group which extends northwards into Mexico.

What else lies within this potential TIPA? We know of about a dozen endemics to the area, all described in the last fifty years. Amongst these perhaps the most spectacular is the very distinctive cactus *Espostoa guentheri* with its bearded branches. This is easy to find but some of the endemics are surprisingly local such as *Senegalia riograndensis* which grows in one side valley but fails to cross the river. At least one, *Gaya woodii*, is only known from the type collection whereas others such *as Bonamia riograndensis* are quite widely distributed on black shales in the depths of the valley. I am also aware of putative new species in *Jacquemontia*, *Euphorbia*, *Croton* and *Heliotropium* but what else is to be found? The area is largely unexplored and can only be profitably visited after significant rain at the height of summer. I have every confidence that it will prove a true Tropical Important Plant Area.



The new species of *Ipomoea* flowerless when with leaves. Photo © Norha Paucar



*Espostoa guentheri* Photo © Darwin Initiative



*Salvia graciliramulosa* © Darwin Initiative

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***John R.I. Wood***
*Research Associate*