Oxford Plant Systematics

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

OPS 23 **September 2017**

Engraving of the Oxford Botanic Garden. The Western and Eastern Conservatories, together with wood-and-glass, lean-to-type glasshouses either side of the Danby Gate, showing the 'Professor's House behind the Gate before it was knocked down to widen Magdalen Bridge. Metal engraving based on the *Oxford Almanack* (1766), as engraved by Joseph Skelton and published in 1820.

Foreword

This edition of *Oxford Plant Systematics* is dominated by reports of fieldwork, integrated with laboratory and herbarium research. Botanical fieldwork in exotic places has been a mainstay of travel writing since at least the seventeenth century. Part of the popular appeal of field exploration lies in exotic places, the inherent dangers and surprises of the unknown and the sheer effort that is sometimes necessary to make a field trip successful. As the reports by Tom Carruthers, Caroline Pannell and John Wood illustrate fieldwork can bring immense research rewards.

The products of fieldwork, for example, herbarium specimens, DNA samples, images and field notes, are essential for our understanding of the natural world. Zoe Goodwin's research shows how our understanding of plant diversity is affected by one of these products, the specimens in the world's herbaria. Juan Beltrán has used herbarium specimens and living material collected by botanists working in the Andes to investigate the ecology and evolution of the genus *Puya*. Fieldwork, combined with vast amounts of specimen data, are also used by Cicely Marshall and Gail Stott to identify hotspots of botanical diversity in Africa and Belize.

In the New World, fieldwork by John Wood and Tom Carruthers is revealing the diversity of *Ipomoea* in Bolivia and Paraguay and helping us understand the biology of this important genus, especially when combined with phylogenetic analyses of DNA sequence data. Pablo Muñoz Rodriquez is using genetic resources accumulated by generations of fieldworkers and detailed DNA analysis to produce new insights into one of the world's most important crops, the sweet potato. Alex Sumadijaya is identifying where it will be most productive to concentrate his fieldwork in the investigation of *Stictocardia* and its relatives.

In the UK, the fieldwork of Claudia Havranek and Keith Kirby, which is focused in landscapes where intensive field investigations have produced detailed long-term data sets, shows both the wealth and poverty of current data sets for research.

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News

Awards and Honours

Congratulations to **Robert Scotland** on becoming Professor of Systematic Botany in the Department of Plant Sciences, University of Oxford.

Congratulations also to **John R.I. Wood**, a Research Associate in the Department, who was awarded an honorary doctorate by the University of San Francisco Xavier in Sucre, Bolivia in March 2016. The doctorate was primarily awarded for John's considerable contribution to Bolivian botany, including six years of funding from the Darwin Initiative, and his support of the Language Department at the University in a previous capacity administering language projects.

Dr Terry Pennington, a former student and member of the Department of Forestry, was awarded an MBE in the New Year Honours List 2017. This was awarded for his significant contributions to taxonomy and tropical agroforestry. Terry has worked extensively on tropical American plants and their uses, especially on the genera *Inga* (Fabaceae), *Cedrela* (Meliaceae) and, more recently, *Sloanea* (Elaeocarpaceae).

James Ritchie completes apprenticeship

James has recently completed a three-year apprenticeship for a Level 3 NVQ diploma in cultural heritage. James says "my time as an Apprentice has played an extremely important role in my personal improvement as well as skill development. It has been an exceedingly positive experience for me. As I progress to the next stage in my career, I have been fortunate enough to be able to continue to work with such knowledgeable people in a unique and remarkable environment such as the Herbaria. I hope to continue to learn and evolve my skills and responsibilities." James has now taken on more substantial projects, including reorganisation of the Herbaria's entire holdings of Acanthaceae.

The Florilegium Project - update

The Oxford Botanic Garden and Harcourt Arboretum Florilegium Project is thriving. We have a loyal and enthusiastic group of fourteen providing illustrations for archival purposes, mostly in watercolour, from both sites. Up to five illustrations per person can be submitted annually, which are then judged by a panel in the university, looking for botanical accuracy and a pleasing composition.

In 2016 we mainly concentrated on plants from the very colourful Merton borders in the garden. Designed by Professor James Hitchmough, University of Sheffield, these beds feature plants from the prairies of North America, the Drakensberg grasslands of South Africa and the Eurasian steppes. With hotter, dryer weather conditions forecasted for the future, they have been selected for their sustainability and minimum attention from the botanic garden staff.

As a treat, six of us went to Tuscany for a painting holiday in May. This we so successful that it will possibly become an annual event. The spring flowers were at their best, and, with a new purpose-built art studio at the accommodation, some beautiful paintings resulted.

Rosemary Wise

Publications 2016

Atahuachi, M, Van der Bent, M.L., **Wood, J.R.I.**, Lewis, G.P., Hughes, C,E. (2016). Bolivian *Mimosa* (Leguminosae, Mimosoideae): three new species and a species checklist. *Phytotaxa* **260** (3): 201-222.

Baksh-Comeau,Y.S., Maharaj, S.S.; Adams, C.D., **Harris, S.A.**, **Filer, D.L., Hawthorne, W.D.** (2016). An annotated checklist of the vascular plants of Trinidad and Tobago with analysis of vegetation types and botanical 'hotspots'. *Phytotaxa* **250** (1):1-431.

Draper, D., **Muñoz-Rodríguez, P.**, Marques, I., Moreno Saiz, J.C. (2016). Effects of climate change on threatened Spanish medicinal and aromatic species: predicting future trends and defining conservation guidelines. *Israel Journal of Plant Sciences, special issue* **63**: 309-319.

Harris, S.A., **Marner, S.K.**, Proença, C. (2016). William Dampier's Brazilian botanical observations in 1699. *Journal of the History of Collections* (online 1 July 2016).

Marshall, **C.A.M.,** Wieringa, J.J., **Hawthorne, W.D.** (2016). Bioquality hotspots in the tropical African flora. *Current Biology* **26**: 3214-3219.

Mitchell, T.C., Williams, B.R.M., **Wood, J.R.I.**, Harris, D.J., **Scotland, R.W.**, Carine, M.A. (2016). How the temperate world was colonised by bindweeds: biogeography of the Convolvuleae (Convolvulaceae). *BMC Evolutionary Biology* **16**: 1-16.

Muñoz-Rodríguez, P., Draper, D., Moreno Saiz, J.C. (2016). Global Strategy for Plant Conservation: inadequate *in situ* conservation of threatened flora in Spain. *Israel Journal of Plant Sciences, special issue* **63**(4): 297-308.

Othman, N., Pan, L., Mejin, M., Voong, J.C.L., Chai, H.B., **C.M. Pannell**, Kinghorn, A.D., Yeo, T.C. (2016) Cyclopenta[b]benzofuran and secodammarane derivatives from the stems of *Aglaia stellatopilosa*. *Journal of Natural Products* **79**: 784-791.

Wood, J.R.I., Urbanetz, C., **Scotland, R.W.** (2016). *Ipomoea pantanalensis*, a new species of *Ipomoea* L. (Convolvulaceae) from the Pantanal, Brazil. *Kew Bulletin* **71** (6): 1-3.

Wood, J.R.I., Degen de Arrua, R., Delmas de Rojas, R., **Scotland, .R.W.** (2016). Two overlooked species of *Ipomoea* L. (Convolvulaceae) from Paraguay. *Kew Bulletin* **71** (25): 1-6.

Wood, J.R.I. (2016). A new species of Acanthaceae from the Natma Taung National Park, Myanmar. *Makinoa, New Series* **11**: 67-71.

Expeditions and visits

John R.I. Wood
I spent a week in January in Stockholm funded by the Synthesis programme looking at *Ipomoea* specimens, targeting especially the collections by Erik Ekman from the Caribbean. From February to April I was in South America. I spent six weeks in Bolivia mostly in the field trying to refind and assess the size of different populations of newly described species of *Ipomoea*. The focus was on the Chaco and the inselbergs of the Chiquitano region. The final two weeks were spent in Paraguay and Argentina with Tom Carruthers doing some field work and visiting herbaria in Asunción (Paraguay) and Corrientes (Argentina), in both of which presentations were made about the *Ipomoea* project.

Caroline M. Pannell
Delivered a lecture and an impromptu workshop on *Aglaia* (Meliaceae) identification, at the Tenth Flora Malesiana Symposium, Royal Botanic Garden Edinburgh. Caroline also delivered a lecture at the Australian Systematic Botany Society meeting in Alice Springs. Herbarium visits were made to Trinity College Dublin (TCD), Glasnevin (DBN), Edinburgh (E) to prepare a first draft of *Aglaia* for Flora of Thailand, also to the Darwin Herbarium (DNA) and James Cook University, Cairns (CNS), to identify their holdings of *Aglaia*. Fieldwork visits were made to Queensland and Northern Territory, Australia.

Student reports

Juan David Beltrán (D.Phil., final year) **Ecology and evolution of CAM in the montane genus *Puya* (Bromeliaceae)**

Supervised by Professor Andrew Smith (Oxford) and Dr Stephen Harris (Oxford). Funding: 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 minimising the amount of water lost in transpiration. Therefore, CAM is 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.

Puya is a monotypic genus in the Neotropical family Bromeliaceae comprising 214 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 believed to be CAM plants, and at least 10 species are found at high elevations (>14000 m), which is unusual for CAM plants. The aims of my project are (1) to investigate the occurrence of CAM in *Puya*; (2) to define the climatic niche of CAM and C_3; (3) to investigate the ecophysiology and potential molecular adaptation of CAM species of *Puya* occurring at higher elevations.

During my D.Phil. I have analysed the climatic niche of CAM and C_3 species in *Puya* using georeferenced herbarium records. After quality control, I compiled a set of 433 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. Cloud cover and aridity index are the most important variables to separate CAM and C_3 niches.

To explain the apparent lack of CAM species of *Puya* in the northern Andes, I have explored different hypotheses. The first proposes that this reflects a lack of suitable habitats in the northern Andes. However, according to 10 different climatic niche models, I found suitable regions in the Northern Andes for CAM species of *Puya.* However, the potential areas are relatively smaller and surrounded by very unlikely suitable areas. *Puya* species do not disperse seeds over long distances. Therefore relatively large non-suitable areas might represent a barrier for the dispersion. 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. In 2015-2016 I visited the National Herbario in Colombia (COL) and I sampled exhaustively the *Puya* species occurring in the northern Andes.

The current phylogeny of *Puya* shows a high degree of geographical structure with the central Andean clade and the northern Andean clade containing the majority of species. According to the ancestral character reconstruction, CAM evolved at least twice in *Puya*. The northern Andes clade is entirely C_3. This might be correlated with the lack of CAM species of *Puya* in the northern Andes. It is still not clear whether the C_3 species of *Puya* belonging to the central Andean clade are capable of any nocturnal CO_2 fixation that the carbon isotope values are not able to capture.

High-elevation CAM species of *Puya* are remarkable because these species must fix CO_2 nocturnally at very low temperatures. My current hypothesis is that CAM species of *Puya* from higher elevations have molecular adaptations to fix CO_2 at very low temperatures comparatively speaking with their counterparts at low elevations. I demonstrated that the early divergent low-elevation species of *Puya* exhibit a higher cold tolerance than tropical bromeliads in a common garden experiment. I have been measuring the temperature dependence of phosphoenolpyruvate carboxylase (PEPC) in high- and low-elevation CAM species of *Puya* and other Bromeliaceae. The PEPC activity of *Puya* species is less affected by low temperatures than in other bromeliads. It is likely that cold tolerance evolved before *Puya* colonised the Andes around 10 Ma.

My current hypothesis is that the common ancestor of *Puya* was a cold tolerant plant with an intermediate CAM-C_3 photosynthesis. The cold tolerance allowed the common ancestor of *Puya* to colonise the relatively recent high-elevation environments when the Andes rose from south to north. Constitutive CAM presumably evolved as a consequence of the colonisation of new environments with less cloud cover and more aridity where CAM species could be more advantageous. CAM species did not colonise the northern Andes possibly because their poor dispersion and the scattered suitable areas for CAM species in the northern Andes.

Tom Carruthers (D.Phil., 2nd year) **Evolution of *Ipomoea* in the Neotropics**

Supervised by Professor Robert Scotland (Oxford) Funding: NERC

My interest is in understanding what a robust phylogeny can tell us about the evolution of a group of plants. I am working on this in the context of *Ipomoea* (Convolvulaceae), a large tropical genus of around 800 species. I am particularly interested in how a phylogenetic framework for this genus can provide insights into the timing and tempo of its evolution. A particular focus of this work will be a putative "radiation" of recently evolved species in eastern Paraguay.

In order to provide a basis for this investigation, I have been working on dating the *Ipomoea* phylogeny. Robust age estimates for different clades within *Ipomoea* are necessary for making inferences about the timing and causes of shifts in diversification rates across the genus. This work has been complicated by the recent discovery of a fossil relative of *Ipomoea* which is drastically older than expected. This is important because fossils are required to place a phylogeny in a temporal context.

I also had a fieldtrip in eastern Paraguay before Christmas – a region with particularly high *Ipomoea* diversity. Despite setbacks, I found several interesting species, including the rediscovery of a population of the narrowly endemic *Ipomoea paraguariensis* Peter (see following article).

Zoë Goodwin (D.Phil., 4th year) **Completing the global inventory of plants – species discovery and diversity**

Supervised by Professor Robert Scotland (Oxford) and Dr David Harris (Royal Botanic Garden Edinburgh)
Funding: NERC

Thesis submitted in spring 2017.

Claudia Havranek (D.Phil., 3rd year) **Plants as indicators in the UK countryside**

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

Butterflies and plants are two of the most well studied taxa in the UK. As such, the population sizes and diversity of butterflies and plants has been used to infer the environmental quality of land. In the UK, 71% of land is committed to agriculture, and so agroecosystems present a critical habitat for conservation. The UK government's biodiversity action plan acknowledges the importance of monitoring plants, butterflies, birds and bats to infer the environmental quality of farmland. In the most recent government reports on the UK countryside (presented in 2015) plant diversity is described as not assessed – to be developed, with the most recent plant diversity surveys occurring in 2007.

The lack of use of plant data as an indicator of environmental change in UK countryside could be due to any number of reasons. First-hand experience of collecting both plant and butterfly diversity data in Oxfordshire pointed to one main benefit of collecting butterfly data. When collecting butterfly data using the Pollard Walk method (as used in the UK Butterfly Monitoring Scheme) it is significantly quicker than plant species diversity data collection using quadrats, across the same area (despite the need for repeat visits across a season). Therefore given the time saved, and thus a reduction in manpower required, butterfly surveys may therefore appear a favourable option. Furthermore, with butterflies being a very charismatic taxon, and with fewer butterfly species to learn, butterflies offer potentially greater opportunities to utilise data from amateur surveyors.

Despite the comparative ease with which one can sample butterflies, the ecological information we can gain from butterfly diversity may be limited when compared with plant diversity data. Plants, as the primary producers in any terrestrial ecosystem, are critical in determining the other species present in an environment. Plants provide food and habitat for many other species, therefore ecologically explain to a great extent the environmental state of countryside habitats. Thus despite requiring greater efforts to sample, the payoff from monitoring their diversity may make it worthwhile.

With DEFRA having commissioned no work over the past six months to inform environmental and agricultural policy after BREXIT, it will be interesting to see how the UK's environmental policy changes and develops in coming months, and if the focus will change to develop plant diversity as an indicator of environmental quality in farmland.

Cicely Marshall (D.Phil., 4th year) **Do hotspots of species endemism promote novel lineage diversity?**

Supervised by Dr Stephen Harris (Oxford) and Dr William Hawthorne (Oxford).
Funding: Clarendon Scholarship and Merton College.

This year, part of my thesis was published in *Current Biology* (see Publications 2016). The paper maps bioquality hotspots across mainland tropical Africa, and is derived from a database of 3.1 million species distribution records, and global range assessments for approximately 40,000 species. We reveal broad patterns in global endemism across the continent, highlighting in particular the high concentration of globally rare plants in Somalia. The technique can also be used to reveal very local changes in bioquality, at a scale relevant for management, for example the difference in bioquality between a patch of primary forest and a disturbed, roadside area which abut.

I am using the database now to reassess Frank White's African phytochoria in light of much improved distribution data for the full flora of tropical Africa. I have also built a model to predict local variation in bioquality within sites across Upper Guinea, using variables like disturbance and local landscape position, from survey datasets across the region. To bring my thesis to conclusion, I am building a model to predict bioquality at half degree square grain across Africa, using modern climate data, area and isolation of climate patches, historical locations of climates, soil, altitude, topology and biogeographic frameworks. Taking the local, and half degree square resolution together, I hope to describe how rare plants come to be aggregated into hotspots of biodiversity.

Pablo Muñoz Rodríguez (D.Phil., 2nd year) **Systematics of *Ipomoea batatas* (sweet potato) and its closest relatives**

Supervised by Professor Robert Scotland (Oxford) and Dr Steve Kelly (Oxford)
Funding: Interdisciplinary Bioscience Doctoral Training Partnership Programme, BBSRC.

Sweet potato is among the most important crops in terms of human consumption. It is cultivated in more developing countries than any other root crop, has one of the highest rates of energy produced per hectare and is an important source of carbohydrate, minerals and several vitamins.

Despite its importance for food security, and at a time when crop diversity is under threat, research on sweet potato breeding remains challenging. New breeding strategies include the use of crop wild relatives (CWRs) in breeding programmes. CWRs are the wild species that are most closely related to the crop. These species have not undergone the genetic bottlenecks that characterise domestication, and therefore constitute a source of genetic variability that could be used to augment the properties of the crop. However, in the case of sweet potato, the use of crop wild relatives in breeding programmes is underdeveloped, mainly due to the lack of knowledge about these species and their relationship with the crop.

The aim of this project is to explore the evolutionary relationships between sweet potato and its close relatives, in order to understand the role of these wild species in the origin of the crop. Understanding that relationship would allow the implementation of new strategies in sweet potato breeding, and the addressing of problems associated with the lack of genetic variability. To do this, we are analysing the whole chloroplast genome and over 600 nuclear genes of almost 200 samples belonging to seventy different sweet potato varieties and fifteen wild relatives. The project includes sufficient sampling of taxa and DNA sequence data to answer outstanding questions such as the single or multiple origin of the crop, what is 'wild' sweet potato and which wild relatives are involved in the origin of the crop.

Gail Stott (D.Phil., 3rd year) **Predicting botanical hotspots for tropical forest management**

Supervised by Dr William Hawthorne (Oxford) and Dr David Harris (Royal Botanic Garden Edinburgh)
Funding: NERC Doctoral Training Partnership

I am carrying out my research in Belize (Central America) where I worked in protected area management for four years before coming to Oxford. Management of protected areas is ultimately the responsibility of the Belize Forest Department - sometimes in partnership with local NGOs. Management plans vary considerably in terms of on-the-ground activities (such as ranger patrols and biodiversity monitoring), and some forest reserves permit resource extraction. Increasingly, land managers are trying to strike a balance between meeting the development demands of a growing population and protecting biodiversity. To do this, decisions must be made as to which 'high conservation value' areas should remain intact – their species protected in perpetuity - and which are more suitable as multiple-use zones for activities such as agroforestry, or logging. Limited funding means that it is often necessary to identify conservation priorities *within* protected areas - many of which were designed to cover large expanses of land. It is an unfortunate fact that management decisions (including down-grading the status of a protected area, or de-reserving it completely) are sometimes made with little or no data to hand. Here, as in other developing countries, there is an urgent need for a low-cost, rapid, systematic approach to identifying areas of high conservation value.

My research is conducted within the Rapid Botanic Survey (RBS) framework, which has previously been used to guide national-scale conservation priorities in Ghana and Trinidad and Tobago, and to inform 'within landscape' conservation priorities in season-ally dry tropical forests in Oaxaca (Mexico) and southern Honduras. RBS incorporates a suite of desk and field-based activities that relate to the assessment of vegetation 'bioquality' - a measure of biodiversity that

places emphasis on high concentrations of globally rare species ('bioquality hotspots'). For practical land management – primarily to guide the direction of in-situ surveys – it would be useful if we could reliably predict the location of bioquality hotspots. A major component of my DPhil is to test two different Species Distribution Modelling (SDM) methods. The first uses a 'predict first, assemble later' approach, whereby outputs from individual SDMs are 'stacked' to predict community composition. Predictions are constrained, and GHI scores are derived from the resulting species list. This will be compared against the 'assemble first, predict later' approach, where known GHI scores (from RBS sample plots) are treated as the response variable. Predictions will be tested in the field later this year.

Data for SDM largely comes from voucher specimens held in herbaria. I inherited an existing BRAHMS database of vascular plant records for Belize from a previous project and have further curated this for my research. The database currently contains c. 55,000 records, resulting in a 'working checklist' of c. 3,800 accepted names and c. 1,600 synonyms. Simply by mapping these records, it was possible to determine areas that have received little or no botanical collecting. In the south of the country, the 150,000-acre Columbia River Forest Reserve is not only under-collected compared to neighbouring protected areas, but currently receives very little by way of on-the-ground management. While carrying out RBS sampling in 2016, we found evidence of hunting and logging, as well as subsistence agriculture encroaching on the southern perimeter. At present, the level of illegal activity here is low compared to other parts of Belize, but with the combined pressures of a rapidly growing population, cross-border incursions from Guatemala, and increasing demand for tropical hardwoods, it is unlikely to stay that way. I hope that my research will make a valuable contribution to the development of a much-needed management plan for the reserve.

I spent five months in Belize in early 2016, collecting additional botanical data in the south of the country. In-country capacity for botanical research is very limited, so the first few weeks were occupied with recruiting and training a team of four field assistants. Most sample sites were located in and around the foothills of the Maya Mountains, with access to many sites requiring hiking and overnight camping. Despite rough terrain, the late arrival of the dry season, our truck falling apart on the highway, ticks a-plenty, and three very persistent botfly larvae, we completed 30 RBS plots and still managed to stay relatively sane. Over 1,200 voucher specimens were collected, pressed, dried and sorted (identified at least to family level) before being posted back to the UK. I spent two weeks working on the identification of specimens at the Forest Department herbarium in Belmopan, with a further three months at the Royal Botanic Garden Edinburgh and the Natural History Museum in London. Preliminary analysis of new and existing data indicates that the foothills of the Maya Mountains in the southwest have high apparent species richness, and high GHI scores. One hypothesis is that this may be due (in part) to the complex topography of the area – where Cretaceous limestone forms a rugged karstic landscape of sinkholes, valleys, and ridges. As my research progresses, I hope to achieve an improved understanding of how geological heterogeneity, and topographic complexity influence local - landscape distribution patterns of bioquality hotspots across Belize.

Alex Sumadijaya (D.Phil., 1st year) **Investigating a clade of Old World *Ipomoea***

Supervised by Professor Robert Scotland (Oxford)
Funding: LPDP (Indonesia Endowment Fund for Education)

Ipomoea is a pantropical, species-rich, morphologically diverse genus in Convolvulaceae. Published phylogenetic studies based on multiple genomic regions show that *Ipomoea* is not monophyletic; multiple segregate genera are nested within it. The focus of this research project is on a specific clade of Old World *Ipomoea* that includes *Stictocardia*, and some species of *Turbina*, *Lepistemon* and *Ipomoea*. Most species in this clade have the following combination of characters: black glands on the leaves, accrescent sepals and indehiscent fruits. As this clade has not been previously recognised it remains unclear which species belong in it. The aims of this research are to identify the limits of the clade, test the consistency of species delimitation, circumscribe the group and assemble a botanical monograph. This research involves gathering and integrating data from morphology, DNA, and biogeography to better understand the taxonomy of the group and develop biogeographic hypotheses to explain its distribution.

Fieldwork in Paraguay

Over the past year, I have been on two field trips to South America. The first, in March/April 2016 to Bolivia, Argentina and Paraguay with John Wood, and the second just to Paraguay in November/December 2016. The purpose of the trips was to record and collect the species of *Ipomoea*, several of which have not been recorded for decades, focussing particularly on a group endemic to eastern Paraguay and neighbouring parts of Bolivia, Argentina and Brazil.

The trip in April/May 2016 was my first visit to South America. We started in Bolivia, travelling east from Santa Cruz to Santiago de Chiquitos, a small town in the highlands of southeast Bolivia. On the journey across, we found several species growing on road verges – classic *Ipomoea* habitat. Over three days, we collected several species and I learnt some of the basics of *Ipomoea* identification, before returning to Santa Cruz to catch a flight to Asunción (Paraguay).

Once we had arrived in Paraguay and had a good night's sleep at the Hotel del Sur (nestled in a jungle of ring roads, petrol stations and half-built shopping centres) we went to the herbarium and reviewed the *Ipomoea* specimens. The following week we made several trips out from Asunción, accompanied by the official driver from the herbarium, Hernan, and the head, Professor Rosa Degan. Both were very keen to learn about *Ipomoea* from John. During the week we collected several interesting species including *Ipomoea morongii* Britton and *Ipomoea malvaeoides* Meisn., two species which prior to this trip had an uncertain taxonomic status.

The following weekend we travelled by coach south from Asunción to Posados in northern Argentina. Here, we were guided by Hector who works at the nearby herbarium in Corrientes. During one day in the field (which was refreshingly cool and wet) we collected over ten species of rare *Ipomoea*. A very successful short visit.

The purpose of my second trip in November/December 2016 was to try to reach some of the more remote places in eastern Paraguay and to sample species which flower at this time of year (thus making identification possible). The most productive period was spent in Curuguaty in the far east of the country with Arnaldo Alfonso, a ranger from a nearby reserve.

Ipomoea paraguariensis near Curuguaty
Photo ©Tom Carruthers

During the four days spent riding round dirt roads on a motorbike, we collected several interesting species including *Ipomoea paraguariensis* Peter. This species was previously thought to be extremely rare, restricted perhaps to a single plant in a completely different part of the country.

After returning from Curuguaty, I made a further trip to Alto Paraná. Situated on the eastern border with Brazil, this region features a large reserve sponsored by a hydro-electric company following the construction of a dam. During the final week I was closer to Asunción with the final few days somewhat disrupted by a combination of huge storms, and the festival of the Virgin of Caacup (involving 300,000 pilgrims travelling to a nearby town).

Tom Carruthers
D.Phil. student

Below: Serrania de Santiago de Chiquitos in Bolivia. These mountains are characterised by a mixture of dry forest and savannah habitats and are inhabited by several rare and endemic species of *Ipomoea*. Photo © Tom Carruthers

An evaluation of taxonomists studying *Ipomoea*

During our monographic work on *Ipomoea* L. we have revised the types of almost all taxa described in *Ipomoea* or transferred into *Ipomoea* from other genera like *Pharbitis* Choisy or *Calonyction* Choisy. Over the course of these studies it has become clear that species described by some authors are more likely to be accepted by later generations than species described by others. In order to see whether this impression was really correct, I decided to list every *Ipomoea* species described by a particular author and record whether it was currently accepted or not. A percentage score could then be given for each author.

Seven taxonomists who published at least 15 new species of American *Ipomoea* after the publication of Choisy's monograph in De Candolle's *Prodromus* (1845) were included in the survey. Gray, Hallier, Hassler, Brandegee, B.L. Robinson and Kuntze were all excluded, as they described a smaller number of American species. Also excluded were all authors working in the last fifty years as it is too soon to evaluate their output. All species described as new from the New World by the selected authors and now treated as belonging to *Ipomoea* were included, whether or not they were originally described in *Ipomoea*. Upgrades from a previous infraspecific taxa were included in the totals but otherwise infraspecific taxa were ignored. New combinations and new names for previously described species were excluded.

The number of accepted species after a lapse of at least 50 years seems a relatively good proxy for taxonomic competence at the species level. In particular, it picks up the author's skills at species delimitation as well as their awareness of previous publications

The exclusion of earlier authors is justified on several grounds. Apart from Choisy and Desrousseaux no earlier author described as many as 15 species of *Ipomoea* from the Americas but we have excluded these two authors because they described species from all parts of the world. Most of the collections they were working on clearly represented new taxa as they were working on the first collections to emerge in the post-Linnean era. All the featured authors in Table 1 were working on material from countries whose floras were partially but incompletely known.

Table 1: The dates given below are the first and last dates of publications related to *Ipomoea* by the authors.

Name of taxonomist	Species described	Species accepted today	Proportion accepted
Martens & Galeotti (1845)	25	7	28 %
Grisebach (1862–1879)	15	8	53.3 %
Meisner (1869)	59	24	40.6 %
House (1904–1922)	62	24	38.7 %
Urban (1902–1930)	30	7	23.3 %
Standley (1924–1952)	23	6	26.1 %
O'Donell (1941–1960)	56	45	80.4 %

Two preliminary comments on the results should be made. Martens and Galeotti score less well because their important paper was published just months after Choisy's account in the *Prodromus*, which they could not have seen in advance. In contrast, Meisner scores better than he deserves. Many of his species concepts are obscured by the excessive recognition of infraspecific taxa, some describing trivial variation but others representing totally distinct, sometimes unrelated new species.

Several conclusions can be drawn:

- Not all taxonomists are equal, some are more competent than others.
- Apart from the figures for O'Donell there is no evidence that taxonomic competence is improving over time, despite improved communications.
- Only Galeotti collected all (or nearly all) the species he described. O'Donell and Standley collected some but not the majority of the species they described. These figures do not support the view that field knowledge is a major factor in taxonomic competence.
- O'Donell's achievement is outstanding, particularly given his isolation from major international herbaria and libraries. He lived and worked in Argentina and received loans from some herbaria but he had none of the advantages of a modern taxonomist, nor those of the other botanists cited. He died at the early age of 42; age is not necessarily an indication of taxonomic competence!

References

Choisy, J.D. (1845). Convolvulaceae. In: Candolle. A. P de (ed.) *Prodromus Systematis Naturalis* 9: 323-462 Fortin, Masson & Co, Paris.

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Herbaria in the Botanic Garden

In 1853, when Charles Daubeny (1795-1867), Professor of Botany and Head of Oxford Botanic Garden, formally accepted the herbarium of Henry Fielding on behalf of the university he argued that collections of living and of dried plants were complementary teaching and research tools. The living collections raised people's interests in plants, and provided access to large quantities of seasonal material, from a limited array of species, for teaching. In contrast, a limited amount of material from a great diversity of plants was available all year round in a 'dried garden'.

The Oxford Botanic Garden, established in 1621, was, for over three centuries, the focus for botanical research and teaching in the university. By the end of the nineteenth century, it was obvious that facilities in the Garden would be inadequate for botany in the next century. Consequently, in 1951, the Department moved from the Garden to its present site, taking with it the university's herbarium. By the year 2000, the herbarium from the Garden had been joined by that of the Department of Forestry (established in 1924) and the vast personal collection of George Claridge Druce (1850-1932) to create Oxford University Herbaria, a collection of approximately one million specimens.

Complementarity of botanical collections was recognised by Jacob Bobart (c.1599-1680), and his son, also called Jacob (1641-1719), the first Keepers of the Garden. In addition to building up the Garden's living collection they also built three collections of dried specimens (Harris, 2017): Bobart the Younger's *Hortus Siccus*; Bobart the Elder's Herbarium; and the Morisonian Herbarium. The *Hortus Siccus* was evidently well-known in Oxford. In his hagiographic poem *Vertumnus* (1713), Abel Evans mentioned it*:* *'*Thy *Hortus Siccus* still receives: / In Tomes twice Ten, that Work immense! / By Thee compil'd at vast Expence; / With utmost Diligence amass'd, / And shall as many Ages last'. Bobart the Elder's herbarium is a single, leather-bound, elephant-folio book herbarium whose existence was unknown until it was re-acquired by the university in the early 1950s; it appears to have gone missing in the early eighteenth century. Despite its name, the Morisonian Herbarium was not put together by Robert Morison (1620-1683), the first Professor of Botany in the university; it was assembled by Jacob Bobart the Younger to support Morison's *Plantarum Historiae Universalis Oxoniensis* (1680, 1699).

The single largest addition to the early herbarium came in the 1720s when William Sherard (1659-1728) presented his personal herbarium to the university. Sherard, whose botanical enthusiasm had been ignited as a law student by Bobart the Younger, became

Fig. 1. Book herbarium of Jacob Bobart the Elder (mid-seventeenth century) © Oxford University Herbaria

a prominent and wealthy diplomat. Sherard studied botany in Paris and Leiden, established an extensive network of personal and professional relationships across Europe and funded plant collection expeditions. When he died, James Edward Smith, founder the Linnean Society of London, described Sherard's herbarium as 'the most ample, authentic, and valuable botanical record in the world'.

During the eighteenth century, the Bobart and Sherard herbaria were augmented with the collections of subsequent Sherardian Professors, including Johann Dillenius (1647-1747) and John Sibthorp (1758-1796), plus large donations such as the herbarium of Charles Dubois (1656-1740), cashier-general of the East India Company. In 1850, Daubeny, the man who in collaboration with William Baxter (1787-1871) resurrected the fortunes of the Garden, reported there were 43,812 specimens in the university's herbarium. These numbers appear to be underestimates, as there are approximately 80,000 pre-Linnean collections in the Herbaria today. For example, there are more than 21,000 specimens in Sherard's herbarium; Daubeny reported 14,792.

In 1852, Daubeny convinced the university to accept the herbarium (c. 80,000 specimens) of Henry Fielding. Fielding had spent much of his inherited fortune accumulating one of largest personal herbaria in the Victorian world. With optimistic bravura that the task of cataloguing the diversity of the world's plants was near its end, Daubeny praised the completeness of Fielding's collection: 'So large a portion indeed of its [the world's] surface has been ransacked to supply the contents of these cabinets, that it would seem to be a much shorter task for me to enumerate the deficiencies, than to recount the contents of the Collection' (Daubeny, 1853: 5). Over the next 70 years at least 25,000 specimens were added to the herbaria though donation and purchase of collections. The most comprehensive summary of the contents of the herbarium in the Garden is Clokie (1964).

Initially the Garden's herbarium and library were the Bobarts' personal property. This changed in the 1720s when Bobart the Younger and Sherard bequeathed their collections to the university. However, until the end of the eighteenth century, the university's herbarium was likely to have been located in the Professor of Botany's private accommodation. First, 'The House for Evergreenes', built in 1670, outside the Garden's north wall was converted to professorial accommodation. In the 1780s this was demolished in a road-widening scheme, and Professor Humphrey Sibthorp (c.1713-1797) had Cowley House (now part of St. Hilda's College) built. The death of John Sibthorp in 1796, and the inadequacy of the two conservatories, built in 1734, for plant propagation, probably precipitated conversion of the Eastern Conservatory to accommodation for the gradually-growing herbarium.

When Charles Daubeny took over as Professor, space in the Eastern Conservatory was needed for other purposes and the herbarium was evicted. Daubeny chose to create a 'Room for Seeds & Herbarium', which backed onto a garden shed, erected on the banks of the Cherwell. With the arrival of Fielding's herbarium, the university's botanical collections got a new home in the converted Western Conservatory. Here they were divided between two floors, accessible only by 'a ladder so shaky that an eminent botanist, the Reverend William Newbould, once said that, but for the strain it inflicted upon his nerves, Oxford would have been his place of residence' (Gunther. 1912: 149).

By 1885, the herbarium had been moved again, into six rooms of the house Daubeny had built as the 'Professor's Residence'. Here the collection remained until it was moved to its current location.

For the vast majority of its existence at the Garden the herbarium was the responsibility of the Professor of Botany. There appears to have been no individual who was responsible for looking after it, although an aging William Baxter started to catalogue Sherard's herbarium in the mid-nineteenth century. The first Fielding Curator, twenty-year-old Maxwell Masters was appointed in 1853 but resigned after about three years. In 1886, Selmar Schönland arrived for a three-year stint as Fielding Curator. The post was then vacant until George Druce became honorary Curator in 1895; he remained in post until he died.

Druce took his role as Curator seriously and made major changes to the organisation of the collections (Harris, 2007). However, he was critical of the herbarium's physical housing and state of preservation in the Garden: 'in what was little more than a loft

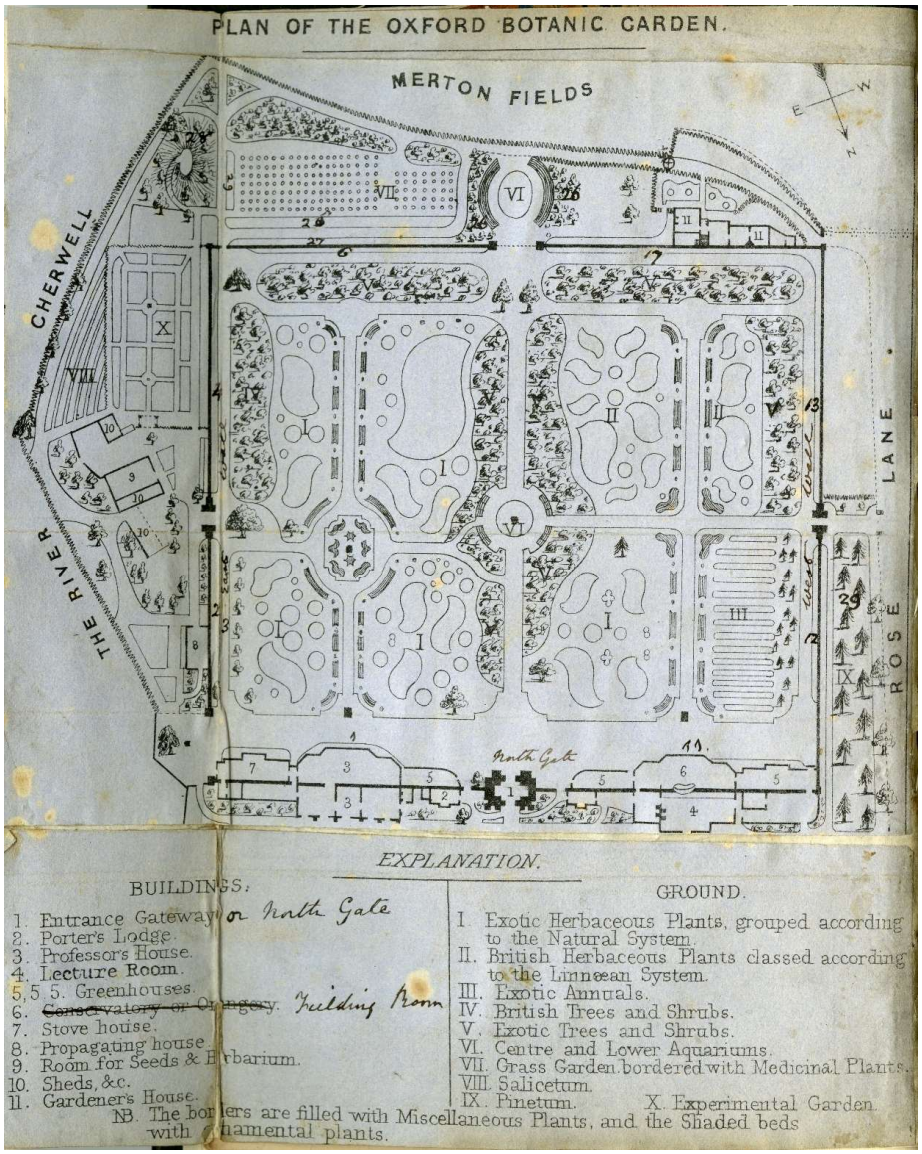

Fig. 2. Layout of Daubeny's Garden in 1850, with annotations by Charles Daubeny. '9' shows the location of the herbarium © Sherardian Library

above the lecture room at the Botanic Garden. There were no facilities for warming, and the place was damp. … The immense mass of the Morisonian (Bobartian), Dillenian, and Sherardian collections were in loose unarranged sheets, often unmounted. Even the Fielding Herbarium was mostly unnamed and roughly sorted into the different families'. Clokie has cast doubt on Druce's representation of the state of the herbarium when he became Curator. However, there is abundant evidence of extensive water damage to specimens in some of the pre-Linnean collections and Druce records he discarded many specimens because of insect damage.

Since a herbarium is a teaching and research tool it is reasonable to ask who used the collection and for what purposes in the Garden. Until the mid-eighteenth century the herbarium appears to have been used extensively by those who created it given the extent of marking and annotation on individual sheets. In the latter half of the eighteenth century, use of the herbarium declined. For example, during Humphrey Sibthorp's 37-year tenure of the Sherardian chair, there is only direct evidence he annotated spcimens in 1749; two years after he was appointed. Although Frederick Pursh praised the quality of the North American collections fter he visited during the preparation of his *Flora Americae septentrionalis* (1813). Despite Daubeny's optimism, there is little evidence acquisition of the Fielding's herbarium stimulated an increase in herbarium-based research and teaching during the latter half of the nineteenth century. Visitors came who were curious about the herbaria but the use of the herbarium imagined by Daubeny had to await its effective amalgamation with the herbarium of the Department of Forestry when both collections moved to South Parks Road.

Over the past two decades, the specimens for the Garden's original herbarium have been given new relevance in research and teaching as innovative approaches are applied to them to answer modern questions. The challenge now is to ensure that Oxford University Herbaria remains sustainable as a scientific collection into the future.

References

Clokie H.N. (1964). *An account of the herbaria of the Department of Botany in the University of Oxford.* Oxford: Oxford University Press.

Daubeny, C. (1853a.) *Address to the members of the university. Delivered on May 20, 1853.* Oxford: Botanic Garden.

Gunther, R.T. (1912). *Oxford gardens based upon Daubeny's popular guide of the Physick Garden of Oxford: with notes on the gardens of the colleges and on the University Park.* Oxford: Parker & Son.

Harris, S.A. (2007). Druce and the Oxford University Herbaria. *Oxford Plant Systematics* 14: 12-13.

Harris, S.A. (2017). *Oxford Botanic Garden & Arboretum. A brief history.* Oxford: Bodleian Library.

Stephen A. Harris
Curator of Oxford University Herbaria

The Amazonian waterlily (*Victoria amazonica* (Poepp.) J.C.Sowerby) grown by Joseph Paxton at Chatsworth in 1849. The desire to grow this species was responsible for Daubeny's decision to build glasshouses where he had originally located the herbarium.
Photo © Oxford University Herbaria

A tale of two species

In 1973, my supervisor suggested I study the growth of bramble *Rubus fruticosus* L. agg. in Wytham Woods, just outside Oxford, because it formed such a major part of the ground flora. There were thickets up to two metres, or more, high in places. So, I spent an, at times, painful year, cutting and collecting bramble from 1 m^2 plots, separating it into its various components to see how much of the biomass was in the leaves, stems, flowers, etc. At the same time, Colyear Dawkins, David Field and colleagues were laboriously hacking lines through the thickets to establish a 100 m grid of posts across the woods with 10 m x 10 m vegetation plots recorded at every other post position (Dawkins and Field, 1978).

Revisiting the Woods in the 1980s it was obvious that the bramble had much declined and that grasses were becoming more prevalent. This was confirmed by full re-recordings of the Dawkins plots in 1991 and again in 1999 (Kirby and Thomas, 2000, Kirby, 2004) using two measures: the number of plots in which a species was recorded (Table 1); and the mean score (out of 14) for the number of 0.01 m^2 subplots in which it occurred in each 10 m x 10 m plot (Figure 1).

Brachypodium sylvaticum (Huds.) P. Beauv. increased on both measures; while bramble remained fairly frequent at the main plot level but had declined in its abundance within plots. Changes in the degree of canopy closure may have played a part, but a key driver for the bramble decline and increase in graminoids at Wytham Woods, and elsewhere in lowland England, has been the increase in deer populations (Ward, 2005).

In recent years deer numbers at Wytham have been much reduced. Casual observation and the most recent records (2012) from the Dawkins plots show that bramble has been recovering (Figure 2). The bramble leaf canopy has the potential to overshadow most woodland plants and dense thickets can reduce local species richness (Kirby and Woodell, 1998). Therefore I looked at whether there was any indication that the bramble recovery at Wytham had affected the cover and diversity of the rest of the ground flora.

The 164 plot records from 1999 and 2012 were compared in terms of the number of ground flora species per plot and their combined cover in relation to the cover of bramble in 2012 and its change since 1999. The cover of all ground flora species was derived by converting the Domin scores (Rodwell, 1991) allocated to each species in the field to percentage cover values by taking the mid-point of the score range. The relationship between the occurrence of *Brachypodium sylvaticum* and bramble cover was then considered separately.

34 of the 164 plots showed an increase of more than 10% in bramble cover between 1999 and 2012; only three plots showed a decrease of more than 10% cover. The combined cover of all other species in the ground flora declined by about 30% in the plots where bramble increased, whereas there was no change where bramble cover showed little change or a decline. However, the plots where bramble increased were not any less rich in species.

Between 1999 and 2012 *Brachypodium sylvaticum* cover increased in 23 plots by more than 10% cover, but declined by this amount in 41 plots; plots where *Brachypodium* declined were significantly more likely to be those where bramble had increased by more than 10% cover. There were no instances where both *Brachypodium* and bramble increased in the same plot.

Thus, this preliminary analysis suggests that the grass-dominance (Figure 3) encouraged by increased deer grazing may be reversible. However other low-growing species may also be reduced through increasing competition from the bramble, and local changes in species-richness in future cannot be ruled out.

Table 1. The number of 10 m x 10 m plots from which species were recorded.

Year	**1974**	**1991**	**1999**	**2012**
Rubus fruticosus	143	128	127	141
Brachypodium sylvaticum	64	137	142	146

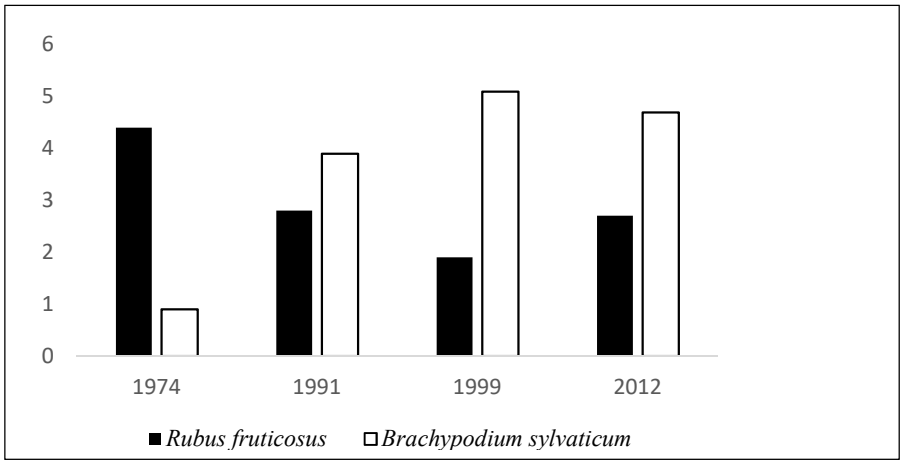

Figure 1. Mean frequency score within plots (out of 14), based on 0.01 m^2 sub-plots across the plot diagonals.

Figure 2. Recovery of the bramble in 2012 presents a recording challenge for visiting researcher Professor Dawn Bazely. Photo © Keith Kirby

Figure 3. *Brachypodium sylvaticum* dominance in a plot in 2012. Bramble is only just starting to spread in this area. Photo © Keith Kirby

References

Dawkins, H.C.D., Field, D.R.B. (1978). A long-term surveillance system for British woodland vegetation. *Commonwealth Forestry Institute Occasional Paper* 1 Oxford: Commonwealth Forestry Institute.

Kirby, K.J. (2004). Changes in ground flora in Wytham Woods, southern England, 1974-2002, in stands of different origins and past treatment. *In:* Honnay, O., Verheyen, K., Bossuyt, B., Hermy, M. (eds.) *Forest biodiversity: lessons from history for conservation.* Wallingford: CABI.

Kirby, K.J., Thomas, R.C. (2000). Changes in the ground flora in Wytham Woods, southern England from 1974 to 1991 – implications for nature conservation. *Journal of Vegetation Science* 11: 871-880.

Kirby, K.J., Woodell, S.R.J. (1998). The distribution and growth of bramble (*Rubus fruticosus*) in British semi-natural woodland and and the implications for nature conservation. *Journal of Practical Ecology and Conservation* 2: 31-41.

Rodwell, J.S. (1991). *British plant communities: 1 woodlands and scrub,* Cambridge, Cambridge University Press.

Ward, A.I. (2005). Expanding ranges of wild and feral deer in Great Britain. *Mammal Review* 35: 165-173.

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Tropical rainforest dispersal biology in Far Northern Queensland

In South East Asia, placental mammals are important dispersers of the seeds of fleshy fruits. Primates, especially the apes, disperse large numbers of viable seeds and thereby contribute significantly to the cycle of forest regeneration. Other placental mammals, including bats, elephants, bears, deer, cats and civets are also seed-dispersers. In Australasia, the placental mammals are limited to bats, rodents, humans that arrived 50,000 years ago and the domestic animals that have been introduced during the last few hundred years, mainly by colonists from Europe. Some of these domestic animals have become feral. Marsupials rarely eat much fruit. The one exception in Australia is the Musky Rat-kangaroo (*Hypsiprymnodon moschatus* Ramsey, 1876) which feeds predominantly on fallen fruits and seeds, but destroys most of the seeds. It caches some seeds, a proportion of which are not retrieved and are therefore dispersed in a viable condition.

Fruit bats and fruit-eating birds are the predominant seed-dispersers in Australasia, including cassowaries, fruit-eating pigeons, birds of paradise, bowerbirds, honey-eaters and members of other bird families.

I spent three months with Wendy Cooper in the tropical rainforests of far northern Queensland at the end of 2016 in an attempt to gain a better understanding of seed-dispersal by vertebrates in this part of Australasia. We gathered data on fruiting and fruit eaters by a combination of direct observation of fruiting trees and fallen fruits, identifying regurgitated and defaecated seeds and setting up camera-traps which recorded still photographs and videos. The latter worked best for activity on the ground, night and day, or in small trees where the camera could be positioned close to the fruits under observation.

The family of large (up to 1.8 m tall) flightless birds, the Casuaridae, is confined to Maluku, New Guinea and Australia. In New Guinea, there are three species of cassowary. One species, *Casuarius casuarius* (L., 1758) Brisson, 1760 occurs in Australian tropical rainforests. Its diet is made up almost entirely of fallen fruits, supplemented with small amounts of fungi and animal matter. It defaecates all seeds intact and viable. In contrast to South East Asian forests, where most fallen fleshy fruits rot quickly, some fruits remain in a fresh state after falling to the ground in Australian tropical rainforests. Such fallen fruits might be fed on daily by the cassowaries and all or most of the fruits removed from the ground. Cassowaries are strictly diurnal, feeding between dawn and dusk. Fruiting was lean during my visit, with only three species favoured by cassowaries producing reasonable crops. These were *Acronychia vestita* F.Muell. (Rutaceae), *Elaeocarpus grandis* Bl. (Elaeocarpaceae) and *Prunus turneriana* (F.M.Bailey) Kalkman (Rosaceae). However, once an abundance of fruit falling from one tree of *P. turneriana* was discovered by feral pigs, they visited the ground beneath the tree every night and consumed the fallen fruits, leaving few or none for the cassowaries during the day. The pigs grind up their food, so that no seeds or fruit fragments are visible to the naked eye in their faeces. Most of the seeds they consume are therefore destroyed, although it is possible that intact seeds occasionally survive passage through the pig's gut and are dispersed. Cassowaries are able to store large amounts of fat to meet their energy requirements during lean times. In the Dwarf Cassowary (*Casuarius bennetti* Gould, 1857), fat deposits can be up to 5 cm deep on its back (D.D. Wright, 1998; 2005) and the birds are able to endure long periods of starvation, such as the 51 days the male spends on the nest. The male neither eats nor drinks while incubating a clutch of eggs (Bentrupperbäumer, 1997). A male cassowary, with one newly-hatched chick, frequented the forest for the latter half of my stay. Being immediately after the period of starvation during incubation, he may have had difficulty surviving on the lean fruit crop, especially given the competition from feral pigs for meagre resources. On last sighting, however, father and chick appeared to be active and healthy. They were apparently finding enough food in their home-range to sustain them during this lean period.

Flying fruit-eaters are responsible for much of the fruit eaten in the canopies of Australian

Southern Cassowary,*Casuarius casuarius,* with the yellow fruits of *Acronychia vestita* (Rutaceae) on the ground, captured with a cameratrap. Photo © Caroline Pannell

tropical rainforest trees. During my fieldwork, I observed three or four Spectacled Flying Foxes (*Pteropus conspicillatus* Gould, 1850) feeding on ripe figs of *Ficus crassipes* F.M.Bailey (Moraceae) at night. They discarded wadges of dry flesh and seeds and these littered the ground beneath the tree. A Pied Currawong (*Strepera graculina* Shaw, 1790) fed during the day. It held a fig between its foot and a branch of the tree and tore off pieces of flesh with its beak. These pieces were swallowed. It discarded only the hard peduncle with some shredded flesh attached. It swallowed most of the flesh containing the achenes. Whole or partially eaten ripe fruits were dislodged and fell beneath the tree, mainly when the bats were feeding. When the figs first ripened and some fell to the ground in this way, camera traps recorded visits by an adolescent cassowary, but a group of pigs began to visit the site at night and consume much of what was on the ground. The camera trap did not record cassowary visits after the pigs began to clear the more palatable fruits and fragments. Both flying foxes and Pied Currawongs might carry seeds some distance before defaecating and therefore effect dispersal. Metallic Starlings (*Aplonis metallica* Temminck, 1824) foraged in flocks and consumed quantities of the small black fruits of *Polyscias elegans* (C.Moore & F.Muell.) Harms (Araliaceae).

Pigeons of several species, of which the Wompoo Fruit-dove (*Ptilinopus magnificus* Temminck, 1821) was the most conspicuous, made frequent visits to trees of *Polyscias elegans* and *Archontophoenix alexandrae* (F.Muell.) H.Wendl. & Drude (Araceae), when they bore abundant ripe fruits. The pigeons plucked and swallowed the whole berries and drupes. No regurgitation or discarding of fruit material by these birds was observed and their faeces were not identified in the forest. Pigeons are strong fliers and often travel some distance to roost or on migration. They are, therefore, candidates for dispersal beyond the local vicinity of the fruiting trees in which they feed.

Evidence of what Victoria's Riflebird (*Ptiloris victoriae* Gould, 1850) was feeding on during my visit initially came from their regurgitations and droppings. Occasionally faeces were found containing only seeds of the rubiaceous shrub/epiphyte *Timonius singularis* (F.Muell.) L.S.Sm., known as false fig, presumably because of the superficial resemblance of its fruits to figs. All the seeds in the faeces germinated and produced tiny vigorous seedlings. For a week or two, we found regurgitated seeds of the nutmeg *Myristica globosa* Warb. (Myristicaceae) on paths and beneath riflebird display perches. Most of these were completely stripped of flesh, but occasionally a seed had a few strands of the red aril adhering. No fruiting tree was located in the immediate vicinity, so these seeds must have been carried at least a short distance from the feeding tree to where they were regurgitated, potentially effecting dispersal of viable seeds, were they to have fallen on soil. Two trees of *Sarcotoechia protracta* Radlk. (Sapindaceae) came into fruit on the edge of the forest, with their crowns visible and affording excellent views of the methodical foraging of male, female and juvenile individuals. They extracted arillate seeds from the dehisced fruits and were seen regurgitating them, sometimes within minutes of beginning to feed in the tree. On one occasion, a seed was regurgitated with the aril still attached and was swallowed again. The riflebirds left and returned to the trees frequently enough that regurgitation was also likely to be taking place away from the trees. Seeds, with and without the aril attached, germinated within a day of placing them on a damp kitchen towel.

Observations were also made of the Silvereye (*Zosterops lateralis* Latham, 1801 ssp. *vegetus* E.J.O.Hartet, 1899) feeding on ripe fruits of *T. singularis*, by pecking at the fruit, removing fragments and swallowing them. Since these berries each contain several seeds, it is likely that the birds sometimes swallow seeds with the pieces of flesh.

Tooth-billed Bowerbirds (*Scenopoeetes dentirostris* Ramsey, 1876) often defaecated from a calling perch at their court. In such sites, we found numerous seeds of a rubiaceous vine, *Gynochthodes oresbia* Halford & A.J.Ford. and endocarps (actually anatomically mesocarps) of *Elaeocarpus* sp.

The small tree, *Casearia costulata* Jessup (Salicaceae), bore fruits that dehisced one by one to expose a mass of seeds surrounded by red flesh. No bird had been recorded removing or eating the seed mass. Sometimes it was two days before the seeds were taken. The camera trap captured stills and videos of a Lewin's Honeyeater (*Meliphaga lewinii* Swainson, 1837) removing a seed mass and manipulating it in its beak. It is probably safe to assume that it swallowed the seeds and flesh and deposited the seeds elsewhere.

Finally, confined to east of Wallace's Line, the cockatoos (Family Psittacoidea) have a great impact on fruiting trees, because of their efficient manipulation of fruits, using their claws, beak and tongue, resulting in destruction of most of the seeds they consume. Members of this spectacularly conspicuous and charismatic family are rarely likely to effect dispersal of viable seeds away from the parent tree, although large numbers of intact seeds are sometimes dropped beneath the tree, when the parrots are feeding.

In conclusion, although the percentage of Australian tropical rainforest trees that bear fleshy fruits is over 90%, there is a narrower cohort of mammal dispersers of the seeds of fleshy fruits in these forests than there is in South East Asia. With the exception of the Musky Rat-kangaroo, non-flying mammals contribute little, but the terrestrial flightless cassowaries consume enormous quantities of fallen fruits and disperse their seeds intact. Arboreal dispersers are almost entirely birds and fruit-bats. Some birds involved are from families endemic to Australasia, such as the birds of paradise and bowerbirds, others belong to families with much wider distributions. In spite of belonging to a globally distributed family, there are numerous fruit pigeons endemic to the region. These are clearly important seed dispersers and they may even be responsible for some long-distance dispersal.

Acknowledgements
I was most fortunate to be the guest of Wendy Cooper, author of *Fruits of the Australian Tropical Rainforests* for my entire stay in FNQ. She treated me to the most generous hospitality, shared her immense knowledge of fruits and their dispersers, took me to many sites and was my tireless companion in the forest. Wendy Cooper, Brian Venables, Steve and Rachel Murphy, Rigel Jensen, Andrew Ford of CSIRO, were extraordinarily generous with their knowledge, hospitality and loan of equipment which made this field trip a great success. I am grateful to Queen's University Belfast for giving me Visiting Researcher status and facilities at Queen's Marine Laboratory for the duration of this project.

References

Bentrupperbäumer, J.M. (1997). *Reciprocal ecosystem impact and behavioural interactions between cassowaries, Casuarius casuarius, and Homo sapiens: exploring the natural-human environment interface and its implications for endangered species recovery in north Queensland, Australia*. Unpublished Ph.D. dissertation, James Cook University of North Queensland, Australia.

Cooper, W.E., Cooper, W.T. (2004). *Fruits of the Australian tropical rainforest.* Nokomis Editions.

Wright, D.D. (1998). *Fruit choice by dwarf cassowary, Casuarius bennetti, over a three-year period in Papua New Guinea.* Unpublished Ph.D. thesis, University of Miami.

Wright, D.D. (2005). Diet, keystone resources and altitudinal movement of dwarf cassowaries in relation to fruiting phenology in a Papua New Guinean rainforest. In Dew, J.L., Boubli, J.P. (eds), *Tropical fruits and frugivores: the search for strong interactors*: 204 – 235.

Caroline Pannell
Research Associate

News from the Herbaria

Fielding-Druce (OXF) and Daubeny (FHO)

The Herbaria received more visitors during the twelve months of 2016 than any year before, even higher than last years' record! Our visitor numbers seem to have almost doubled since 2013 with many more groups with specialist interests visiting. We are introducing the collections to those working in a range of other disciplines and presenting possibilities for the material to be used for research in many different ways. Another trend is that specimen images sent as 'internet' loans are replacing sending loans of physical specimens. However we will continue to send post-1796 specimens upon request, if essential for research or for special exhibitions.

Visitors 2016

At least 294 people visited the herbaria and this included individual visits plus 16 group visits, many of which are detailed below indicating the variety of material presented.

Starting in January, five researchers from the Clarence Bicknell Association visited. Clarence Bicknell (1842-1918) was a botanist, archaeologist, illustrator and author. Over a hundred of his botanical collections and an illustrated Flora are held in OXF. The group, which included the great grand-nephew of Clarence, was interested to find that Bicknell's correspondents who were researchers/collectors in the second half of the nineteenth century around Europe (as seen from the labels on his herbarium specimens) played a major role in the rise in interest in natural history and science at that time. One of the group, who is based in Boston, is writing a biography of Clarence Bicknell which will be published in 2018 to coincide with the centenary of his death.

During March there were three group visits. 30 members of the Friends of the Oxford Botanic Garden came. The theme of their visit was the "Early history of the Garden and the role of plant collectors". A small group from the Royal College of Physicians also visited. They were interested in the medicinal plants in the Herbaria, and how these had been used in the past. 18 Oxford Sconal Library trainees visited the Sherardian Library and the Herbaria. Items from the archives of manuscripts, rare books and historic herbarium collections were shown to emphasize the links between them. The purpose was also to show the trainees why these collections are consulted by visitors and that the links are important for working out the identification of plants, their distributions, classification and evolution, and many more interesting aspects.

In April a group of 12 botanical artists from the Denver Botanic Gardens, Colorado School of Botanical Art & Illustration, visited to see the original field sketches and watercolours made by Ferdinand Bauer, which were eventually published in Smith and Sibthorp's *Flora Graeca* (1806-1840). Given the quality of the botanical collections held in Oxford, the opportunity was taken to place this work within a wider context of the history of botanical illustration and exploration, and to show a wide range of methods used to record botanical information over the past 350 years.

In May a visit was made by 10 members of the extended family of Charlotte and Anne Trower to see the sisters' botanical notes, illustrations, specimens and letters (between them and George Claridge Druce). Charlotte Trower (1855-1928) is an overlooked English botanical artist whose work was bequeathed to Druce and eventually the university (see *Journal of the History of Collections* 22, 2010: 115-128). The sisters produced over 1,800 fine botanical watercolours. Charlotte specialized in painting sedges and brambles, two very difficult plant groups.

In June nine students studying for a Royal Horticultural Society Level 3 Practical Horticultural Course and their tutor visited the Herbarium for an introduction to the collections. They were shown a range of items starting with specimens that had been growing in the Oxford Physic Garden (now Oxford Botanic Garden) in the seventeenth century. Comments from the visitors included 'the visit provided wonderful background for us'. Also in June, 15 members of the University's Spanish Society visited particularly to see collections made by Spanish contributors to the herbarium such as Hipólito Ruiz López and José Antonio Pavón, who collected plants in Peru and Chile between 1777-1788. OXF also holds many specimens collected by the Spaniard Martin Sessé, who was joined by the Mexican botanist José Mariano Mociño when exploring Mexico in 1790.

In August we again welcomed Dr Sarah Simblet from the Ruskin School of Fine Art with 19 students from her Oxford summer-school course on botanical drawing. It was a truly international group including participants from Australia, Belgium, Hong Kong, Italy, Spain, USA, as well as those from the UK. The focus of their visit was to see Ferdinand Bauer's drawings, water-colours and herbarium materials associated with the publication of the *Flora Graeca*. A general introduction to the modern use of historic herbarium collections was given to 25 people from the Oxford University Alumnus Group in September.

The autumn saw another clutch of group visits. In October 11 students and their tutor from the Institute of Historical Research, University of London, visited as part of their course on the 'History of Botanic Gardens'. As the Herbaria and Sherardian Library are rich in material dating back to the early history of the Oxford Botanic Garden, many items from centuries past were shown including documents, maps and preserved specimens relating to the Garden. One comment from the group was 'a treasure, both for plant lovers and students of history'. A joint group of 16 from the Society of American Foresters and Canadian Forestry Institute, visited the Herbaria while on a Forestry field tour of the UK. They were shown a selection of woody plant material from the collections of OXF and FHO, including new species collected by members of the Systematics Research group. In November 10 members from the Oxford University Society of Bibliophiles were shown collections on the theme of the links among seventeenth-century book herbaria and rare botanical books starting with the printed catalogues to the Oxford Physic

Garden 1648, 1658 and the '*Hortus Siccus*' of Jacob Bobart. In December 7 members of a Forestry research group were given an introduction to the Herbaria. Their interest was particularly in North American woody plants and in conifers. As part of the University's DTP programme through the Doctoral Training Centre, 30 first-year students were introduced to the botanical collections as part of a two-week course on 'Data Management, Analysis and Statistics for Bioscience'.

A few people made visits of more than one day to work specifically on material in the Druce (British) Herbarium and Dr Jacques Florence from Paris made a two-day visit to work on specimens of *Khaya* (Meliaceae) in the Daubeny Herbarium. Three student artists from the Ruskin School of Art, plus one of the Florilegium group members, made visits to draw from herbarium material.

Loan material

A steady stream of image requests were received throughout the year, many for specific and/or possible type specimens in the collections. This resulted in 25 image loans being sent, the largest of which was an individual loan of 91 sheets of *Xylopia* (Annonaceae). There is a mechanism on the BRAHMS website for returning determinations of specimen images sent in specific 'loans' to individual researchers, which appears on the same screen as the specimen details appear. We appreciate receiving this information so that names can be updated in the database and cupboards, keeping identifications as current as possible.

During 2016 material that was returned to OXF and FHO comprised 16 loans including 14 microscope slides and one historic specimen from the Sherardian Herbarium which had been lent to the Ashmolean Museum for an exhibition. During the same period 185 specimens as part of nine loans were received for study and identification by John Wood. Six of these loans consisted of specifically requested specimens of *Ipomoea* (Convolvulaceae) for work on the *Ipomoea* monograph project and three loans of miscellaneous Acanthaceae were received for identification.

New accessions

198 miscellaneous specimens of Acanthaceae collected in Myanmar, sent to FHO for identification by John Wood, were received from the Makino Botanical Garden in Kochi, Japan. Another 60 specimens of Acanthaceae gifted to FHO included specimens collected in Vietnam and Papua New Guinea and type material of two species of *Strobilanthes* collected in China. Another gift to FHO was an isotype specimen of *Sloanea Eugenifloresiae* (Elaeocarpaceae) collected in Costa Rica. A few miscellaneous tropical African specimens were sent from Kew as a continuation of exchange.

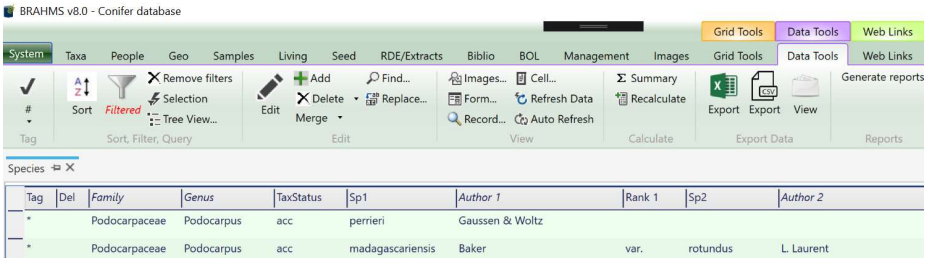
149 specimens were accessed to the Fielding Herbarium during the year. This included 89 specimens collected in Japan by Tom Price and Ben Jones from the Oxford Botanic Garden and Harcourt Arboretum. 52 specimens collected on an Oxford University expedition to Iceland in 1973 by a former post-graduate student in the Department were also incorporated. 42 miscellaneous British specimens were added to the Druce Herbarium, consisting of plants collected in Oxfordshire with interesting distributions.

Towards the latter part of 2015 the Herbaria received a large collection of lichens, mosses and liverworts collected by H.J.M. Bowen, these being transferred from Oxfordshire County Council's Museum's Resource Centre. For a few weeks a volunteer, Francis St-Amour, worked on accessing, mounting and incorporating the lichen material collected by H.J.M. Bowen. In total 376 lichen specimens were added and 7% were new species added to the existing collections in OXF. All the material had been collected in Oxfordshire in the 1970s.

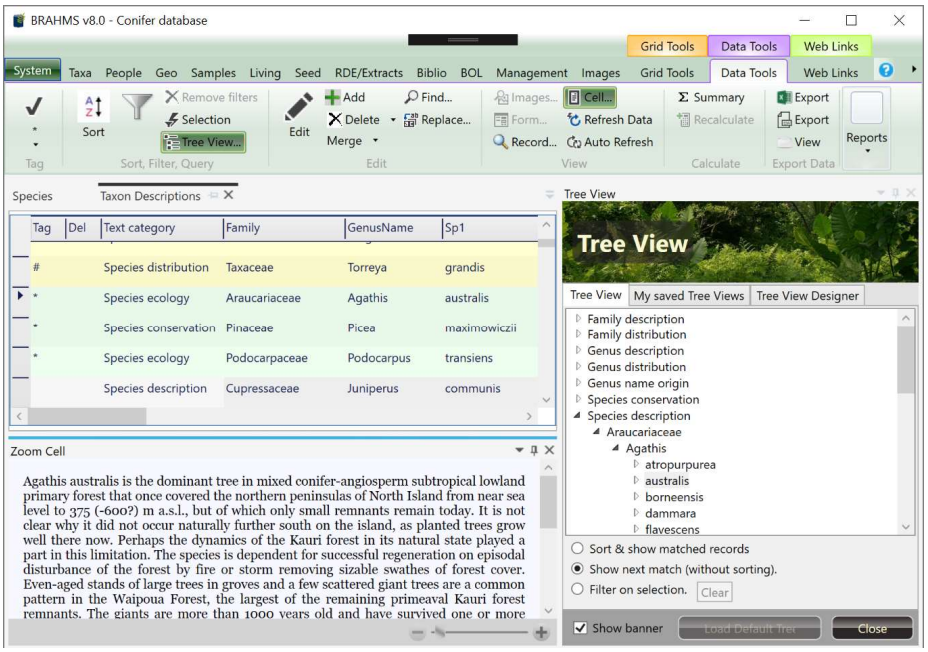
Serena Marner
Herbarium Manager

BRAHMS and BRAHMS online

A new version of BRAHMS is under development and due for release around the end of 2017. Although broadly based on the current system, this is a complete re-development from the ground up, capable of storing data for all natural history collections and at any scale. The new version 8 system embraces the latest technologies for all aspects of its operations, extending connectivity with other software platforms and applications. Version 8 is equally accessible to the individual researcher with minimal technical support as it is to large institutions wanting to integrate their enterprise-scale data as widely as possible using stores such as PostgreSQL or MS SQL Server. The software itself can be shared and the entire source code will be provided to appropriately licensed users so that distributed development becomes possible.



BRAHMS v8 has context sensitive menus and toolbars – similar to MS Office applications.



An example v8 screen showing a user defined tree view docked right. The tree has been built using text category followed by family, genus and species. The Cell zoom window has been docked below the main data grid.

All of the key functionality found in the current system has been implemented in the new version but with improvements. For example, Rapid Data Entry (RDE) and query files are maintained but now have identical file structures and, with GUIDs assigned to every record, data from these files are easily edited and used to update the main database. Another feature, well known to current users, is the ability to add custom or 'link file' fields. In the new system, custom fields can be more fully integrated with your database allowing you to extend the structure of your data store.

Other examples of improvements and system additions: links to external web sites such as Plants of the World Online and JSTOR dynamically update as you browse through your data; ArcGIS mapping is fully integrated as a system component; Tree Views to view data hierarchically can be used in all tables and you can design and save your own trees; filter and query commands are now one and the same and can be used with all fields of all types and are saved for future combination and use; BRAHMS v8 stores data in any language and the system is fully translatable. A final novelty to mention is the ability to open multiple tables simultaneously, for example, your species, specimen and botanic garden accession tables, with the ability to dock or display each in a separate window or monitor.

BRAHMS Online search form designer

An interactive designer for online search forms has been added to BRAHMS online. Once logged in to your website, you can set up one or more search forms for any of your data categories, choosing the data fields to include. You can search for text in fields such as species descriptions and specimen locality notes. The form designer generates the code you need, ready to copy and paste into a search page on your website. Here, if necessary, you can edit the code to alter the form appearance. An example here: http://herbaria.plants.ox.ac.uk/bol/hanoi/formsearch

Search results can be displayed as they are now using lists, grids and maps. But you can also choose to display the results in text pages. The display format can also be edited – rather like a visual report, with click to zoom images.

You can set up several forms, each with different search fields and with a different audience in mind. Both the form and the results operate well on smart phone size screens.

Further information:
http://herbaria.plants.ox.ac.uk/bol/brahms/software/v8
http://herbaria.plants.ox.ac.uk/bol/brahms/Publishonline/bolfeatures

Denis Filer
Independent Research Fellow

A visit to Bolivia to refind and reassess some recently described species

During February and March 2016 I enjoyed some six weeks field work in Bolivia in the company of Bolivian and British botanists. The expedition had various aims focused principally on *Ipomoea*, the subject of monographic work here at Oxford. Although we published a major paper on Bolivian *Ipomoea* in 2015 (Wood et al. 2015), there is still much to discover about the different species in Bolivia and indeed about the whole flora of this biodiverse country.

Most journals require conservation assessments of new species described in their pages. Inevitably, it is impossible to make any realistic assessment of population size in most cases, as new species are usually known from one or two collections accompanied by minimal field notes. In nearly every case, the collectors were unaware of the significance of their collection and made not even a cursory assessment of the frequency of the plant. Thus, one of the aims of last year's field work was to rediscover some of the rarer species described recently and to obtain some idea of their frequency and of any obvious threat to their continued existence.

Our first attempts were focused on granite inselbergs in eastern Bolivia, from where two new species of *Ipomoea* were described in our 2015 paper (Wood et al. 2015). These take the form of domes or platforms that emerge out of the surrounding Chiquitano Dry Forest. Although easily visible from the air, these inselbergs are surprisingly difficult to see, let alone reach, as you cut your way through the surrounding undergrowth. We targeted three possible locations in the search for *Ipomoea graniticola* J.R.I.Wood & Scotland. The first inselberg we visited was the type locality where we found far more extensive populations than we had expected and the second revealed a good population in a location some 40 km distant. At the third location we spent a sweaty hour in dense bamboo scrub to end up in front of an unscaleable granite rock wall with not a sign of an *Ipomoea.* The second species we were looking for was *Ipomoea chiquitensis* J.R.I.Wood & Scotland but we reached the type locality in pouring rain and a sodden search revealed not a single plant – it was perhaps too early in the year for an annual species. However, we did score a dramatic success with *Pectis harryi* D.J.N.Hind & Frisby (Asteraceae), a species described by Nicholas Hind, who was with me in the field at this point. The type locality (and only known location) was on another nearby rock platform which was known to have been partially destroyed by agricultural "improvements" and the species was thought to be possibly extinct (Hind & Frisby 2014). Search in the rain found a couple of depauperate survivors, but when we stopped 15 minutes later near an area of grassy slopes interspersed with exposed rock surfaces, we found hundreds of the *Pectis* plants growing in golden swathes at the edge of the rock. A sharp reminder that a species may be more abundant than at first apparent.

Our next attempts were focused on the Andean foothills where the mountains meet the Chaco. In 2014 we had found a single plant of a new *Ipomoea* with curious tumour-like swellings on its sepals, which we named *Ipomoea appendiculata* J.R.I.Wood & Scotland. I remembered the type locality well so we headed straight there and found the original plant. Now the search began: the area consists of steep stony hillsides covered in dense impenetrable spiny scrub forest stretching away as far as the eye can see. Cautious scrambling revealed three other plants so we moved on along the road, stopping every kilometre or so and finding further plants at the next couple of stops but then nothing. We could conclude that there were scattered populations along a two to three kilometre stretch of road going in an east-west direction, but what about the endless scrub forest extending north and south of the road? The habitat all seemed much the same so there could be extensive colonies of the plant extending over a considerable distance. I doubt we will ever know for certain.

Our final attempt was aimed at an area of cloud forest in the border zone of the Amboró National Park, where I had found *Ipomoea odontophylla* J.R.I.Wood & Scotland and *Salvia raymondii* J.R.I.Wood ssp. *mairanae* J.R.I.Wood in 2005. Both species are endemic to this location. The *Ipomoea* is remarkable for its distinctly toothed leaves and the *Salvia* is a handsome erect plant at least a metre high with purple flowers and attractive purple undersides to the leaves. It has considerable potential as a garden plant. I remembered a single population of the *Ipomoea* on a slope by a track and a few plants of the salvia along the same pathway. Our return visit was very reassuring. After a few false starts along the maze of access roads through potato fields interspersed with forest relics we got to the end of the road and then walked into the forest. With greater knowledge than in 2005 I was able to spot the distinctive leaves of the *Ipomoea* growing everywhere along the path and scrambling high over trees – it was much more of a liana than I had realized. It was abundant and soon enough we found plants in flower at regular intervals. As for the *Salvia*, it was common along the path and in clearings with much greater numbers than I ever remembered. We left the forest certain that populations of both species were extensive and healthy and the only threat was forest clearance. Since the area enjoys some legal protection – it lies above the park guards' checkpoint – and both species would tolerate a degree of interference, these two species seem safe for the next few years at least. Our only concern

is that neither species can be found at other nearby entry points to the Amboró Park.

This field trip served to underline the fact that we rarely know the true frequency of newly discovered species and that any assessment is unlikely to be the whole story. A realistic conservation assessment requires time and focused study. Happily our field trip had positive results, and 2016 also brought other good news. *Ipomoea graniticola* was found on Cerro León in northern Paraguay and also on a granite outcrop in north east Brazil, so a rare Bolivian endemic is now known from isolated locations in three countries. And the role of the inselbergs as a stepping stone for plant distribution is reinforced by yet another surprising discovery, this time of the *Ipomoea* we failed to find, *I. chiquitensis*, growing on an inselberg in Ceará in Brazil some 3,000 km distant. There is still hope for rare plants.

Thanks are due to Nicholas Hind and Lynsey and John Pink for photographs, and to Maria Teresa Buril for information about species in Brazil.

References

Hind, D.J.N., Frisby, S. (2014). *Pectis harryi* (Compositae: Heliantheae: Pectidinae), a new species from a rock platform in the Departamento de Santa Cruz, Eastern Bolivia. *Kew Bulletin* 69: 9520. doi:10.1007/s12225-014-9520-2

Wood, J.R.I., Carine, M.A., Harris, D.J., Wilkin, P., Williams, B.R.M., Scotland, R.W. (2015). *Ipomoea* (Convolvulaceae) in Bolivia. *Kew Bulletin* 70 (31): 1-124.

John R.I. Wood
Research Associate

Pectis harryi, nearly extinct in the type locality, was found growing in abundance some five km distant © Nicholas Hind.

Ipomoea odontophylla with its distinct toothed leaves was refound in abundance © John Pink.

The rich purple flowers and striking purple undersides of the leaves of *Salvia raymondii* subsp. *mairanae* have great horticultural potential © John Pink.

The very rare *Ipomoea appendiculata* was found in additional populations © John Wood.

Ipomoea graniticola growing in a new locality on an isolated inselberg © John Wood.