



eBot: a collaborative learning object repository for Australian flora

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Abstract: *The University of Sydney eBot project was designed as a collaborative, sustainable repository for digital botanical objects. From its inception the repository was viewed as an effective way to bring together the collections of images and resources that we use in research and to support learning and teaching of undergraduate Plant Sciences at The University of Sydney.*

Objects contained within the repository range from the microscopic to entire landscapes. They include digitised herbarium specimens and associated temporal and spatial data. The metadata supporting the system enable effective archiving and retrieval of objects and is informed by international developments in botanical digital standards. The strength of this repository is that part of the metadata maps to the currently accepted taxonomy for the green plants. The eBot schema was derived from a range of descriptive standards, including the Herbarium Information Standards and Protocols for Interchange of Data (HISPID). This will ensure compatibility with digital herbaria in Australia. In addition to describing the scientific content of objects, the project addresses access and sustainability issues by including rights management data and information about the technical attributes of each object. To ensure the integrity of database content, all objects are validated by an expert reviewer prior to the images going 'live'. eBot will be accessible later in 2008. Our view is that the project has potential to be used beyond the Plant Sciences and outside the university environment.

Background

The diversity of botanical interests within The University of Sydney is large, and ranges from traditional botanical subjects like plant ecology, systematics, anatomy and physiology through to the application of these subjects in the agricultural, horticultural, pharmaceutical, medicinal and marine sciences. Teaching and learning in these areas takes place from first year to Honours and into postgraduate degrees, and reflects associated research enterprises established, or developing, within the University. Increasing support for, and interest in, the plant sciences within The University of Sydney has resulted in the (then) Faculty of Science reviewing its plant science curriculum, which was implemented in 2005 and now offers a Plant Science Major.

The impetus in teaching, learning and research activity in a range of plant-related disciplines has also been accelerated. With this increase in activity comes a growing demand for infrastructure support. This demand has been manifested in the generation of a number of *ad hoc* physical and virtual repositories for botanical objects e.g. The Botanical Society of America (<http://www.botany.org/index.php> [accessed July 2008]), The Flora of Europe (<http://www.macmerik.nl/indexflora.html> [accessed July 2008]), CalPhotos at Berkley (<http://calphotos.berkeley.edu/> [accessed June 2008]) and most recently TROPICUS from Missouri Botanical Gardens (<http://www.tropicos.org/> [accessed July 2008]). These collections have been developed to serve specialised plant-related sub-disciplines or to store a particular type of object within the broader realm of the plant sciences and the content reflects northern hemisphere flora, which is only part of our teaching and research focus. Objects range from dried herbarium specimens through to complex digital files such as those produced using cutting-edge technology like tomography. Tomography allows animations of sub-cellular details produced by 'stitching' together sections through specimens using electron transmission microscopy and is one of a raft of new technologies that eBot will be able to accommodate.

The *eBot* project has created a sustainable, centralised repository for digital botanical objects to be used in teaching, learning and research at The University of Sydney, and the wider community. Whilst this repository is generated and based at The University of Sydney and hosted by The University of Sydney Library, due to the collaborative nature of botanical research, professional botanists and students from other institutions will have access and will be able to contribute to the repository. The University of Sydney has taken a leading role in developing and coordinating a centralised repository for botanical objects important to learning and teaching plant sciences in the Australian context.

Here, we note that there is an increased focus in research and education sectors to ensure digital repositories are designed in such a way as to maximize interoperability (or effective cross-talk between disparate repositories and databases).

Organisational context

With the advent of digital delivery modes, our capability to sustain a film-based archive of images was becoming less tenable each year. New objects were being created digitally and sustaining both a film and a digital collection of images was not the solution. The Operational Teaching and Learning Strategic Plan of the Faculty of Science, 2004 (FoS OTLP) and the Teaching and Learning Strategic Plan of the Faculty of Agriculture, Food and Natural Resources 2003 – 2007 (FAFNR TLSP) provided the institutional context with which to align the *eBot* initiative. The consistent themes in these Learning and Teaching plans, and those that *eBot* addresses, were to:

- improve the student learning experience via access to efficient information technology infrastructure and other improvements in the virtual learning environment
- develop programs that foster engagement with the broader university community (e.g. research community, employers, local and international student market). The extent to which *eBot* meets the needs of the broader university community is yet to be determined and to address this we have in place a mechanism to monitor usage patterns from within and beyond the confines of the institution.

eBot – scope of content

The repository currently contains digital objects derived from:

- A. the digitised John Ray Herbarium, which is one of the larger university herbaria containing around 64 000 specimens. The first Professor of Botany at The University of Sydney, Professor A Lawson, started the collection in 1916 and it was intended as a collection to which students and staff could refer, and as a repository for specimens collected during various research enterprises undertaken by staff and students. That students of botany have access to both the history of this Australian botanical collection, as well as to the scientific information contained in these herbarium sheets, enriches their learning. Currently over 500 herbarium sheets have been digitized and reside in the repository.
- B. images used in plant science teaching and learning, including:
 - i) Australian landscapes described in terms of the vegetation type, which plant family dominates, and the location where the photograph was taken (e.g. global positioning system (GPS) data, or longitude and latitude – if known). To date 20 landscapes have been added to the repository.
 - ii) photographs of Australian native plants described in terms of the family to which the plant belongs, the reproductive and vegetative structures that are visible in the image and the location where the photograph was taken. Close to 600 photographs of plants have been added to the repository.
 - iii) micrographs of plant structures described in terms of the family to which the plant belongs, the reproductive and/or vegetative structures that are visible in the image, the tissue and cell types



visible in the image, and a statement indicating scale. Currently over 800 micrographs have been added to the repository and this is close to being the complete complement of the core collection of plant anatomy learning and teaching images within the School of Biological Science at The University of Sydney.

The schema

The schema (or the way we have structured and described the content within the repository) has involved the objects being meta-tagged for effective archiving and object retrieval. Each image has information generated when the image was captured (i.e. when the image was created, information about its size, format, etc.). Three elements for the schema discussed in this paper are: i) the taxonomic architecture of the *eBot* schema; ii) how we have dealt with rights management; and iii) object validation.

Taxonomic underpinning

The digital objects derived from the John Ray Herbarium informed, to a large degree, how the meta-tagging schema (to provide the metadata) was designed and developed. For interoperability we based part of the schema on the Herbarium Information Standards and Protocols for Interchange of Data (HISPID) with the schema being structured around the taxonomy of plants, which is similar to the approach taken by Ramirez, Coddington, Maddison et al. (2007). When and if the taxonomy is changed, the schema will easily accommodate these change(s) and so the metadata can be readily kept up to date.

Rights management

Currently, the copyright holder of all objects contained within the repository is The University of Sydney and the creator of the image is also acknowledged in the record and within the watermark on the image file. Provision has been made for individuals and other institutions to contribute to *eBot* in which case the individual or the other institution will retain copyright.

Object validation

All images put into *eBot* are subject to validation prior to being made accessible. The validation process allows the scientific information, particularly the taxonomic data, associated with each object of the repository to be checked by an expert so that the integrity of the repository is maintained. So far, the images are being used to populate the pages of another digital taxonomically based initiative, *eFlora* (focused on the flora of the Sydney region (Carolin and Tindale 1994)), making the scientific underpinning (i.e. classificatory information) of the image repository essential.

Teaching and learning

This repository brings together important collections of images that proved indispensable in the learning and teaching plant science in the Australian context.

In teaching plant science we rely heavily on using photographs and micrographs. Images depict patterns in the ways plants are distributed, vegetation types are described by the scientific community, the diversity of floral forms and the variation in cell distribution in plant organs require students to go beyond what they are seeing and to understand the underpinning biology that constrains these patterns. Being able to recognise the patterns is a critical step in being able to integrate 'pattern' and 'process' and is fundamental to understanding biology.

To assist students with improving their pattern recognition skills we incorporated images into student learning tasks, and since the advent of the digital age we have created: i) a CD-ROM to support

student learning in plant anatomy and physiology practical classes; ii) online learning modules for revising plant anatomy and physiology (e.g. <http://bugs.bio.usyd.edu.au/2003A%2BPmodules/home.html> [accessed July 2008]). We know that about 75% of students use our online resources and that they are primarily using them to consolidate their knowledge (Quinnell, May and Lloyd 2004), which aligns to the module design objectives and justifies our continued investment in this strategy. Like all online modules, the modules we have created need to be reinvigorated and updated; having access to the repository will allow this update to proceed more efficiently. In the design of the repository, therefore, we have been mindful of the interoperability of middleware systems to access images for re-purposing in our current online modules and for our future developments. It should be stated that at this stage, our focus has been to establish the repository in such a way that dependence of other initiatives on this one is viable.

Key concepts in learning plant science in an Australian context

The Australian landscape has a unique diversity of vegetation that shows adaptations to our continent. Plant families represented include the Proteaceae, Myrtaceae, Fabaceae and Ericaceae. Many of the plant species within these families have adapted to the dry and hot conditions and many have xeromorphic features such as hard, sclerophyllous leaves with reduced surface area to reduce water loss and the effects thereof. One of the challenges for students is to see how geography relates to the biology of the Australian flora. The results of a search for one species of plant, *Hakea teretifolia* is presented in Figure 1. The results of this search are:

- several herbarium sheets (Panel A), which will allow students to see the conventions that dictate how plant specimens are archived and the information that must be kept with the specimen;
- an image showing the features of the leaves and the flowers including their arrangement and colour (Panel B), this information is important in plant identification;
- a landscape showing the habit and likely habitat of *Hakea* spp. (Panel C);
- the woody fruit of this species (Panel D); and
- a micrograph of a transverse section of the leaf showing the sclerophyllous adaptations of this plant (Panel E).



Figure 1. Botanical information can be conveyed powerfully by being able to view a collection of related images. In this example, a search for images of *Hakea teretifolia* has yielded herbarium sheets (one of which is shown Panel A), information relating to the arrangement of the leaves and flowers (Panel B), the habit and likely habitat of *Hakea* spp. (Panel C), the woody fruit (Panel D), and the xeromorphic adaptations of the leaves (Panel E).



We have given an example of only one plant species to show the linkages we would like to see our students make. The scope of the repository goes well beyond this and as stated we will be monitoring the usage patterns of the objects within eBot to determine how others use this resource.

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