Department of Botany & the U.S. National Herbarium

The Plant Press

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National Museum of Natural History

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Botany Profile
Cracking the Botanical Barcode

*By W. John Kress and Lee A. Weigt**

I am standing in a Costa Rican rain forest," writes tropical ecologist and conservationist Dan Janzen in his foreword to the new book produced by the Department of Botany, *Plant Conservation – A Natural History Approach* (Krupnick & Kress, 2005; University of Chicago Press). "There are a thousand species of plants within a long stone's throw. Nearly every one of them is a described species with a proper scientific name, a handle that you can plug into Google and come up with something. Nearly all of these species or their near relatives have been studied, sampled, thought about and are in 'the literature.' And I cannot identify a single species. Imagine what it would do to any and all aspects of human interactions with wild plants if you could walk up to any plant anywhere - seedling, sapling, 40 m tree, grass, root, pressed leaf, or fallen log - and know in a few seconds its scientific name. I need not describe how today's technology would then let you use that name to get into the warehouse of collective botanical knowledge. That capacity would transform far more than the science of plant biology, the conservation of plants, and the superficial ways we currently make use of the incredible diversity of form, physiology, genetics and chemistry of plants. It would be to plants what the printing press was to stories, education, science, law, medicine and communication."

Janzen's vision is not fantasy and it is almost here. A rapid and accurate method is now being developed for the quick identification of plant species based on extracting DNA from a tiny tissue sample of a leaf, flower, or fruit. Appropriately called "DNA barcoding," referring to the coded labels one finds on grocery store products, DNA barcodes consist of a short sequence of DNA between 400 and 800 base pairs long that can be easily extracted and characterized for all species on the planet. These genetic barcodes will be accessed through a digital library and used to identify unknown plants in the field, garden, or market.

DNA barcoding can revolutionize our knowledge of plant diversity

Once fully developed, DNA barcoding has the potential to completely revolutionize our knowledge of plant diversity and our relationship to nature. By harnessing technological advances in electronics and genetics, DNA barcoding will help many people quickly and cheaply recognize known species and retrieve information about them, and will speed discovery of the thousands of species yet to be named. Barcoding has the potential to provide a vital new tool for appreciating and managing the Earth's immense and changing biodiversity.

The use of short DNA sequences for biological identifications was first proposed by Paul Herbert and colleagues (2003, *Phil. Trans., Ser. B.* 270; 2004, *Proc. Natl. Acad. Sci. USA* 101) at the University of Guelph with the ultimate goal of quick and reliable species-level identifications across all forms of life including animals, plants, and microorganisms. Although the usefulness and practicality of such DNA-based approaches have long been accepted for identifying microorganisms for which morphological data are limiting, this concept has been applied far most successfully in animals. Until this past year, plants have been notably absent in the early stages of barcoding efforts.

The formation of the Consortium for the Barcode of Life (CBOL; see http://www.barcoding.si.edu/) to create a database of documented and vouchered reference sequences to serve as a universal DNA barcode library has been a great stimulus for barcoding efforts around the world and for all life forms. Under the leadership of Executive Secretary David Schindel, CBOL, which is housed here at the National Museum of Natural History (NMNH) and funded by the Sloan Foundation, has succeeded in building a community of museums, botanic gardens, aquaria, and research institutions that now numbers over 100 institutes from 39 countries across six continents. The Consortium also manages various working groups, e.g., Technology, Plants, Databasing, Data Analysis, and DNA, which will help to lay the foundation for the massive collecting, taxonomy, and sequencing efforts to come.

Despite a delayed start, DNA bar-

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Travel

Pedro Acevedo traveled to Cayenne, French Guiana (1/21 – 2/5) to study Guianese Sapindaceae housed at Herbier de Guyane (CAY).

Robert Faden traveled to London, UK (2/11 – 3/17) to conduct Commelinaceae research at the Royal Botanic Garden Kew and the Natural History Museum, London.

Vicki Funk traveled to Boulder City, Nevada (1/6 – 1/9) to attend as President-elect the council meeting of the International Biogeography Society; to Atlanta, Georgia (1/11 – 1/14) to attend a meeting of the Biodiversity Science Education Initiative Task Force to address questions concerning the gaps in biodiveristy knowledge; and to Gainesville, Florida (3/9 – 3/11) to attend as Treasurer the mid-year council meeting of the Society of Systematic Biology.

Carol Kelloff traveled to Georgetown, Guyana (3/7 – 3/25) to worked on the plant and animal collections at the Centre for the Study of Biological Diversity, University of Guyana.

W. John Kress traveled to Dominica, St. Kitts and St. Vincent (3/6 – 3/17) with graduate student **Vinita Gowda** to conduct *Heliconia* research; and to Logan, Utah (3/30 – 3/31) to give a lecture on DNA barcoding at the USDA research facility.

Mark Littler, **Diane Littler** and **Barrett Brooks** to Carrie Bow Cay, Belize (3/15 – 3/30) to conduct coral reef research.

Dan Nicolson traveled to St. Louis, Missouri (1/6 – 1/19) to attend a meeting of the Editorial Committee of the Botanical Code at the Missouri Botanical Garden and to work on *Taxonomic Literature, Ed. 2, Suppl. F-G*.

Paul Peterson and **Robert Soreng** traveled to Buenos Aires, Argentina (3/1 – 4/12) to collect grasses throughout Argentina.

Rusty Russell traveled to Cambridge, Massachusetts (3/28 – 4/1) to conduct research on the Wilkes Collection in the herbarium library and archives at Harvard University.

Stanwyn Shetler traveled to Richmond, Virginia (3/11) to present the opening talk in the annual workshop of the Virginia Native Plant Society at the University of Richmond.

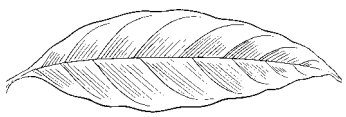
Laurence Skog traveled to Sarasota, Florida (3/5 – 3/12) to work at the Gesneriad Identification Center at Marie Selby Botanical Gardens.

Alain Touwaide and **Emanuela Appetiti** traveled to Athens, Greece and Naples, Pompeii, and Padua, Italy (1/23 – 2/2) and to Istanbul, Turkey (3/8 – 3/22) to conduct research on the history of botany; to Richmond, Virginia (2/20 – 2/21) to give two presentations at the University of Richmond.

Jun Wen traveled to Bolivia (1/7 – 1/31) to conduct field studies on the neotropical *Prunus* (Rosaceae), Araliaceae and Vitaceae; to New Brunswick, New Jersey (2/17) to give a seminar at Rutgers University; to East Lansing, Michigan (3/13 – 3/14) to give a seminar at Michigan State University; and to Paris, France and London, England (3/19 – 3/28) to study the Asian and New World Araliaceae and Vitaceae at the herbaria of the Paris Museum (P), Kew Gardens (K), and the British Museum (BM).

Kenneth Wurdack traveled to Davis, California (1/22 – 1/29) to work on the unfinished Euphorbiaceae projects of the late Grady Webster at the University of California Davis; and to Gainesville, Florida (2/17 – 2/19) to attend a National Science Foundation, Assembling the Tree of Life (AToL) grant participant meeting at the University of Florida.

Elizabeth Zimmer traveled to New York, New York (1/27 – 1/29) to tour the frozen tissue and laboratory facilities at the American Museum of Natural History and to participate as a judge in a science and robotics competition.



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Web site: http://www.nmnh.si.edu/botany

Visitors

Akiko Soejima, Osaka Prefecture University, Japan; Vitaceae (9/28-3/25).

Ze-Long Nie, Kunming Institute of Botany, Chinese Academy of Sciences; Eastern Himalayan conservation and biodiversity, and molecular biogeography of Northern Hemisphere disjunct plants (10/10-6/9).

Mauricio Diazgranados, Herbario Pontificia Universidad Javeriana, Bogotá, Colombia; Cuatrecasas specimens and archives (10/17-2/15).

Michael Sundue, New York Botanical Garden; Grammitidaceae (1/5).

Kimberley Fisher and **Susan Leopold**, Oak Spring Garden Library, Virginia; Library research and H.A. Allard collections of Bull Run Mountains (1/12).

Tom Gardner, University of Maryland; *Ailanthus altissima* (Simaroubaceae) (1/13).

Joanne Rudolph, **Janet Sandberg** and **Ann Schwendener**, Earthwatch Institute; Medicinal plants of antiquity (1/16-1/20).

Peter Hoch, Missouri Botanical Garden; Onagraceae (1/17-2/4).

Caroline Solazzo, Smithsonian Center for Materials Research and Education (SCMRE); Pinaceae (1/19).

Lynn Clark, Iowa State University; *Chusquea* (Poaceae) (1/24-1/26).

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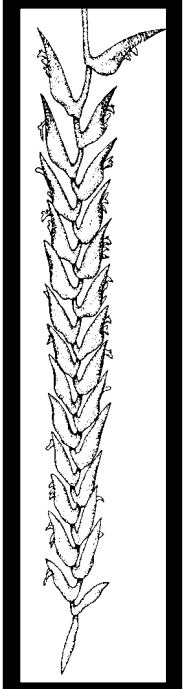
A Preliminary Conservation Assessment of Vascular Plants by 2010: Impossible! Or is it?

Chair With A View — W. John Kress



One of the most ambitious and critical goals of the *Global Strategy for Plant Conservation* is **Target 2: A preliminary assessment of the conservation status of all known plant species, at national, regional and international levels by the year 2010**. Yet with an assessment of the conservation status complete for less than 5% of the world's species of plants how can we even pretend that we will provide an assessment of the remaining 95% in the next four years? Baloney! Impossible! Dream on!

It has to be admitted that sufficient progress has not been made on meeting this target. However, the World Conservation Union (IUCN) has seriously begun to consider how the challenge of meeting Target 2 might be met. At a series of international biodiversity conferences held in late 2005 (IUCN-SSC Plant Conservation sub-Committee in Miami, Florida in September followed by the Convention on Biological Diversity's *Global Partnership for Plant Conservation* meeting in Dublin, Ireland in October) it was emphasized by taxonomists, including scientists from the United States National Herbarium, that the world's herbaria have an opportunity to contribute significantly to meeting Target 2 through an analysis of the vast information contained in preserved plant specimens. Traditional assessment has been carried out through the cumulative knowledge of plant specialists and plant specialist groups and not based on actual plant specimens. Action must now be taken to rapidly assemble the data carried in herbarium specimens.

Plants are universally recognized as an integral part of the world's biological diversity and an essential natural resource for the planet. At present, a complete inventory of the plants of the world has not been assembled, but it is estimated that the total number of vascular plant species is on the order of 300,000 to 400,000. Of particular concern is the fact that many species are threatened by habitat transformation, overexploitation, alien invasive species, pollution, and climate change and therefore in danger of extinction. One of the greatest challenges for today's society is to halt the degradation of plant diversity in order to meet the present and future needs of humankind.

The IUCN strategy to reach the goal of a preliminary assessment aims to gather data on conservation status from a number of sources, including species covered in the *2006 IUCN Red List of Threatened Species*, assessments by the IUCN SSC Plant Specialist Groups, regional and national data sets known to be of high quality (including country Red Lists), and information from leading plant taxonomic specialists. The most comprehensive data available for a scientifically verifiable conservation assessment, i.e., the information contained in the world's plant specimen inventory records located in international, national, and local herbaria, until recently has been underutilized.

The time has come for herbarium specimens to play a central role in determining preliminary conservation assessments. With over two centuries of collecting efforts in habitats around the world the resulting specimens maintained in large, medium, and small herbaria constitute the best data we currently have for making conservation assessments. The information contained in these specimens, unlike the recommendations of experts, can be verified, rechecked and reanalysed, and therefore increase the scientific importance of the assessment. For example, specimen information tells us about the rarity and distribution of a species: if only a few collections (e.g., one to two) are known to exist or if all collections of a species were collected over 50 years ago from a limited geographic area, then we can legitimately infer that today this taxon is rare, threatened, or possibly even extinct. Numbers of collections, dates of collection, and geographic distribution of collections for each species together can give us a solid conservation assessment. This preliminary list of threatened plant species can then serve as the base-line for a more in-depth analysis of conservation status by botanical institutions and conservation specialists around the world.

At the U.S. National Herbarium we have completed a careful analysis of the value of herbarium records to assess conservation status and are developing an algorithm to use plant specimen records to provide a verifiable assessment of the conservation status of the world's known species of vascular plants. The immensity of the task of assessing over 350,000 species is intimidating, especially to complete in four years. Therefore, our strategy is to greatly reduce the task by eliminating species from consideration that can be quickly assessed as non-threatened. Our 4.7 million specimens can rapidly tell us which species are common and not in danger, which is clearly the majority of species, and thereby let us concentrate our assessment efforts, and those of our colleagues in herbaria around the world, on the remaining taxa. We estimate that we can identify at least two-thirds of known species as non-threatened and therefore only need to provide a more critical conservation assessment of the remaining 100,000 species. The task still remains large, but becomes manageable.

The U.S. National Herbarium at the Smithsonian Institution is well-suited to assist in achieving Target 2 of the *Global Strategy for Plant Conservation*. As

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Staff Research & Activities

On 20 January, **Diane** and **Mark Littler** were featured speakers at the Chapman School for Seamanship in Stuart, Florida, known worldwide for its advanced training in multiple mariner professions. On 23 January they lectured to the Sebastian and Vero Beach Power Squadrons, Sebastian, Florida, on their current research in the vast Indian River Lagoon System. The Littlers also did book presentations at the 21st Annual Everglades Coalition Conference and the Jensen Beach Barnes & Noble, on 28 January.

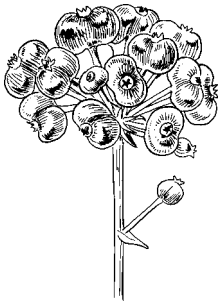
On 6 -11 January, **Dan Nicolson** traveled to St. Louis as a member of the Editorial Committee of the Botanical Code, now being edited to incorporate changes made during the week-long discussions preceding the Vienna Congress this last summer. Nicolson has been a member of Editorial Committee since Sydney (1979). He stayed on another week, working on *Taxonomic Literature, Edition 2, Supplement F-G.*

On January 24, **Stanwyn Shetler** opened the Loudoun County Master Gardeners' Class of 2006 in Leesburg, Virginia, with a forenoon-long lecture on botany.

Alain Touwaide gave two presentations at the University of Richmond. On 20 February, he presented "Poisons, Venoms, and Medicines in Antiquity. A Strange Mixture" to the Department of Biology; and on 21 February, he presented "Schemes, Individuals and Concepts: Representing Plants in Renaissance Herbals" to the Departments of Classics and English.

On 28 February, Touwaide delivered a talk, "Ancient Medicine in the Renaissance," at the College of Physicians of Philadelphia, for the annual meeting of the Samuel Lewis Circle devoted to medical bibliophily. The talk was accompanied by a display of 30 books from the collections of the college, ranging from 1485 to 1568, and illustrating the process of reception, analysis and assimilation of ancient (particularly Greek) medicine into contemporary science during the Renaissance.

Touwaide and **Emanuela Appetiti** traveled to Istanbul, Turkey, 8-22 March to conduct research on the history of botany. At the library Suleymaniye Kütüphanesi they analyzed manuscripts containing the Arabic translation of Dioscorides' *De materia medica*; at the Archeological Museum they examined medical instruments and other related objects; and at the herbarium of the Department of Pharmaceutical Botany at the Istanbul Universitesi, they photographed specimens of plants mentioned in *De materia medica*. Touwaide and Appetiti made some 1,200 slides corresponding to some 300 species. During their trip, they also visited the Department of History and Deontology of Medicine at Istanbul Universitesi's Medical Faculty of Cerrahpasa, including a visit to the atelier of painting of miniatures reproducing ancient medical manuscripts, particularly ancient plant representations. Other visits included the Garden of Medicinal Plants at the Marmara Universitesi, and the History of Medicine Museum of the Istanbul University. Touwaide delivered three talks during his visit: "Dioscorides' *Kital al-Hasa'ish* in Istanbul Libraries" at the Department of History and Deontology, Istanbul Universitesi, Medical Faculty of Cerrahpasa on 17 March; "Malaria and Its Treatment in Antiquity" at the Turkish Society for the History of Medicine on 17 March; and "Dioscorides of Aynzarba and Medicinal Plants in the Eastern Mediterranean" at the Department of Pharmacy, Istanbul Universitesi on 20 March.



Awards & Grants

Deborah Bell's Collections Care Proposal for the "Acquisition of Herbarium Cases for Decompression in a Critical Research Area" has been funded in the amount of $8,880 from the National Museum of Natural History's Central Collection Care fund. The storage capacity in the herbarium is so overtaxed that in many places it is impossible to insert new specimens. These funds, to purchase nine cabinets, will allow a little breathing room in a section comprising the specialties of three staff curators.

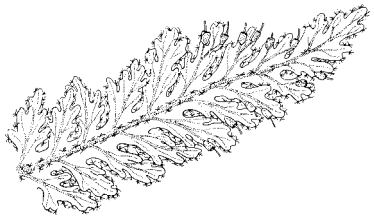
The Global Checklist for Compositae project, co-investigated by **Vicki Funk**, has received $200,000 in funding from Electronic Catalogue of Names of Known Organisms (ECAT), a program of the Global Biodiversity Information Facility (GBIF). The funds will cover initiation and start-up of the project over the first 18 months.

Linda Hollenberg and **Robert Sims** received an $11,199 Collections Care grant from the National Museum of Natural History's Central Collection Care fund. The aims of the project "Diatom Collection: Type Imaging and Storage Improvements" are (1) to purchase one archival storage case for the Environmental Protection Agency (EPA) diatom collection of ca. 15,000 slides, at risk because of storage in substandard cases, and (2) to digitally image the US diatom types (326 specimens on slides) for inclusion in the online Botany Type Register <http://ravenel.si.edu/botany/types>. The taxonomy of diatoms is based largely on the shape and structure of the siliceous valves, and species-level identification is typically accomplished by examination of "cleaned" and prepared slides. Therefore, a high quality image will, in most instances, be as useful as having the actual specimen.

The first Smithsonian Collections Care and Preservation Award Competition, organized by the Undersecretary for Science and the National Collections Program, has awarded the Department and principal investigator **Rusty Russell** a $54,400 grant to continue the work of conserving the plant collections of the U.S. Exploring Expedition (1838-1842). The botanical specimens acquired by the first U.S. Government naval scientific expedition, a collection that laid the foundation for the National Collections and the U.S. National Herbarium, are at risk due to historic treatments using mercuric chloride and fragile mounts. This project will proactively conserve

more than 10,000 deteriorating specimens. The data supporting each specimen will be collected from specimen labels, field notebooks, and published and unpublished reports of the four year journey that touched six continents. For each specimen, a high resolution digital image will be generated. By making these data electronically available, global access to high quality data and images will be provided to researchers around the world, while simultaneously preserving these fragile specimens.

Earthwatch has renewed **Alain Touwaide** research project on Renaissance herbals for an additional three years. In 2006, he will receive $90,000 to conduct research at the National Library in Rome, the Botanic Garden of Padua, and the U.S. National Herbarium. The grant will be applied to the development of the Web site "Renaissance Herbals."



New Faces

This year the herbarium began a new program of accepting college students for an intensive one-week internship during what would have been their spring vacation. Each student was vetted through their respective universities, and their museum experience was a product of their interests and our needs.

Tonia Schneider, University of Michigan (28 February – 4 March): As a graduate student in Archives Conservation, and practical experience working in archives in Barcelona, Schneider arrived ready to go. She worked closely with Jamie Whitacre on the Mexican Ethnobotany project, constructing chronologies and building reference lists from library and online resources. She also researched the International Boundary Commission (1911). The thousands of plant collections made by Edgar Mearns, the botanist attached to this government funded survey, form an important element of the herbarium's collections from Mexico and the southwestern U.S. Finally, she spent one day consulting with Jim Harle on the conservation problems associated with older, deteriorating maps.

Rebecca Conner, Arizona State University (13-17 March): Conner is an accomplished braillist working with the Mesa County Schools who has returned to school to execute a career change to Museum Studies. Her specific interest is in material handling and conservation. Conner worked in the imaging lab, the mounting room, and the herbarium, providing significant hands-on experience. She also consulted with conservation specialists in the Departments of Paleobiology and Anthropology. Conner receives her M.S. this spring and plans to enroll in a Museum Studies Program next year.

Daniel Fitzpatrick, University of Maryland (20-24 March): History and Civil War archaeology are Fitzpatrick's academic interests, but geography is his passion, making him a perfect fit to work with Jim Harle on cataloging and digitizing the map collection. The easy parts are collecting and entering explicit data from maps, and digitizing the image. The more challenging part came when Fitzpatrick had to interpret content from maps and determine unclear boundaries. Fitzpatrick will be continuing his work with Harle through May.

The Department is grateful to all three students for spending their spring breaks in the U.S. National Herbarium. The success of this year's program portends an even more productive Spring 2007.

Visitors

Continued from page 2

Doreen Bolnick, Independent researcher; Library studies (1/25).

Robert Leucking, Field Museum; Mason Hale Costa Rican collections (1/30-4/2).

Lynn Gillespie, Canadian Museum of Nature; *Poa*, Poaceae, and Euphorbiaceae (2/3-2/16).

Mary Lee Archer, **Allison Idestrup** and **Tatiana Riabokin**, Earthwatch Institute; Medicinal plants of antiquity (2/6-2/10).

Walter Lewis, University of Missouri; North American *Rosa* (Rosaceae) (2/7-2/9).

Christopher Hardy, Millersville University; *Geogenanthus* (Commelinaceae) (2/10).

Chelsea Specht, University of California; Costaceae (2/20-2/21).

Tonia Schneider, University of Michigan; Internship (2/27-3/3).

Ying Meng, Kunming Institute of Botany, Chinese Academy of Sciences; *Smilacina* (Liliaceae) (2/28-6/6).

Danny Fitzpatrick, University of Maryland; Internship (3/2-3/24).

Eva Gonzalez, Rutgers University; *Trillium reliquum* (Liliaceae) (3/7).

Danica Harbaugh, University of California, Berkeley; *Santalum* (Santalaceae) (3/13).

Terry Pennington, Royal Botanic Gardens Kew; Meliaceae (3/13-3/15).

Rebecca Conner, Arizona State University; Internship (3/13-3/17).

Shiliang Zhou, Institute of Botany, China; Calycanthaceae (3/14-8/14).

Anna-Elena Berz, Independent researcher; Volunteer interview (3/20).

Hannah Baker, University of Maryland; Internship (3/20-3/24).

Ron Lance, Independent researcher; *Crataegus* (Rosaceae) (3/23-3/24).

Elizabeth Zacharias, University of California, Berkeley; *Atriplex* (Chenopodiaceae) (3/23-3/24).

Tracey Parker, Independent researcher; Central American plants (3/23-3/31).

Carol Dover, Georgetown University; "Historia Plantarum" collection (3/31).

Michael Dillon, Field Museum; Peruvian Asteraceae (3/31-4/7).

Survey of Saba Bank Finds Botanical Riches

Diane and **Mark Littler** and **Barrett Brooks** participated in a multidisciplinary survey of Saba Bank, the largest atoll in the Atlantic Ocean Basin (about 140 square miles in area). Saba Bank is a classic atoll consisting of a submerged mountain crowned at the summit with a ring of actively growing coral reefs. The program is a joint initiative of the Department of Environment and Nature of the Netherlands Antilles and Conservation International.

The National Museum of Natural History had two separate teams (algae and fish) working on the biodiversity survey. The fish team, led by Jeff Williams (Division of Fishes) and including Jim Van Tassell (a Smithsonian Tropical Research Institute research associate) collected specimens and photographed many of approximately 200 species of fishes during the survey (40 fish species had previously been recorded from Saba Bank). Several probable new species of fishes and possibly a new genus and species of goby were collected for the NMNH fish collection.

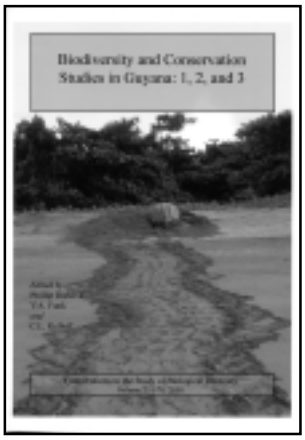
The algal team, joined by nine other scientists and park managers, spent two weeks on Saba, conducting detailed biological assessment and sampling programs surveying fishes, mollusks, crustaceans, macroalgae and sponges. The algal team collected over 360 specimens (20 putative new species), discovered four new seaweed community types and took over 1,000 photographs in truly exceptional habitats. One dive to 30 m revealed all the common species of algae found in shallower seagrass beds minus the seagrasses (seagrasses generally do not grow below 20 m). The expedition only scratched the surface of this unique seamount.

Plans are underway for a permanent web site to present photographic results of the biological survey. Once specimens are catalogued and digitized, the Web site will be converted into a virtual Saba Museum of Natural History that will allow anyone to visually experience Saba Bank and its biological wonders.

Barrett Brooks (left) and Mark Littler encounter a giant barrel sponge (*Xestospongia muta*). (Photo by Diane Littler)

Encouraging Research in Developing Countries

The goals of the Smithsonian are the increase and diffusion of knowledge. There are many ways of accomplishing these goals. On the diffusion side we scientists can publish papers, give talks at meetings and for the public, and train students and staff. The Biological Diversity of the Guiana Shield program (**Vicki A. Funk**, Director and **Carol L. Kelloff**, Assistant Director) has taken the additional step of helping Guyana publish a new scientific journal. The *Contributions to the Study of Biological Diversity*, a new publication series aimed at contribution to our knowledge about the Guyana region, is published out of the Centre for the Study of Biological Diversity, University of Guyana (UG) in Georgetown, Guyana. It is edited by Philip DaSilva, Dean, Faculty of Natural Sciences (UG) and Funk and Kelloff (SI). The first volume was published in 2003 and contained a paper by Kelloff. The second volume has just been published (December 2005) and it contains three papers by graduating seniors at UG. These papers represent a milestone for UG in training its students to be productive members of the conservation and biodiversity communities in Guyana.



Correction

In "Significant Collections of 2005" (Vol. 9, No. 2; January 2006), the third paragraph should read: "In November, 2001, a momentous work on lichens, *Lichens of North America*, was published by Irwin Brodo, and Steve and Sylvia Sharnoff. In support of their work, over 5,000 lichen samples were collected across the continent over many years. The entire first set is housed at the Canadian Museum of Nature. The first set of duplicates was donated to the U.S. National Herbarium. These collections form the foundation of their research on every lichen species reported in their publication. As such, these specimens are critical links that allow one to revisit the time, and place, and possible mindset of the authors years from now. Providing historic reference services to researchers is an important function of the U.S. National Herbarium."

Launch of the Global Checklist for Compositae

The Department is pleased to announce that work on a "Global Checklist for Compositae" was initiated in March 2006. This project was started at the International Botanical Congress in Vienna, 2005, when The International Compositae Alliance (TICA) undertook this effort. The scope of the project is the creation, consolidation and initial editing of names of Compositae taxa integrated from existing electronic checklists and Floras that are complete, or nearly complete, and which are available in structured databases or digital form. This will be followed by processing additional digital and hard-copy publications.

The principle objectives of the project are: the collation and integration of prioritized existing checklists into a Global Checklist of the Compositae; where possible resolve and complete nomenclatural content (including homotypic synonyms); capture, examine, report and resolve (as much as possible) differences in taxon concepts; provide data contributors with regular reports of editorial changes; and make the developing checklist accessible via the Internet, hosted by TICA, and eventually linked to the Global Biodiversity Information Facility (GBIF). Plans include providing a framework for facilitating information flow and content revision among data contributors and the broader TICA community, providing a substantial information basis (including a gap analysis) and operating framework for the completion and long-term maintenance of the global checklist. An overview of the project will be presented at the TICA workshop in Barcelona on 7 July 2006 as part of the symposium "Systematics and Evolution of the Compositae."

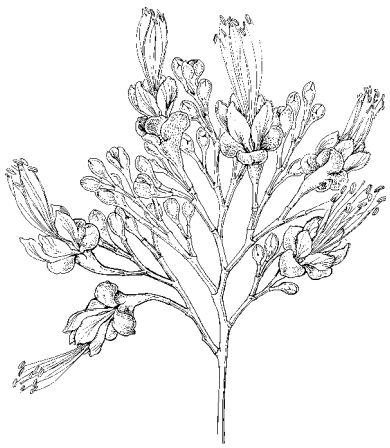
TICA operates as an international email group (organized by **Vicki Funk**) and has members from over 45 countires. The project is led by Ilse Breitwieser, Plant Systematics, Landcare Research, New Zealand. Christina Flann, Wageningen, is the postdoctoral coordinator for the checklist. Funding for the initial 18-month phase of the project has been provided from GBIF's Electronic Catalogue of Names of Known Organisms (ECAT) program. The partner organizations in the project are (alphabetical by city): Botanic Garden and Botanical Museum, Berlin; Instituto de Botánica Darwinion, Buenos Aires; Australian National Herbarium, CSIRO, Canberra, New South Wales; Royal Botanic Gardens, Kew; Plant Systematics, Landcare Research, Christchurch, New Zealand; South African National Biodiversity Institute, Pretoria; Missouri Botanical Garden, St. Louis, Missouri; University of Tokyo; U.S. National Herbarium, Smithsonian Institution, Washington, D.C.; and, TICA.

***Didelta spinosa* Ait. (Photo by Vicki Funk)**

Exploring Our Roots

The Department has teamed up with the U.S. Botanic Garden (USBG), the museum's "Botanical Partner on the Mall," to present the exhibit "The U.S. Exploring Expedition, 1838-1842: Ports of Call" at the USBG Conservatory, 8 April through 4 June. Every spring the Smithsonian and USBG celebrate the U.S. Exploring Expedition and the legacy of Charles Wilkes by exploring our roots: both institutions' original collections began with the living plant specimens and the thousands of other artifacts that were collected during the worldwide expedition.

This year's exhibit focuses on some of the ports of call visited by the expedition – from Rio de Janeiro, to the Antarctic coast (an area later named "Wilkes Land"), to many South Pacific islands, Australia, and South Africa. Visitors can pick up a "passport" at the "Hampton Roads dock" in the Garden Court and sally forth with the Expedition along a Ports of Call trail throughout the Conservatory. At each "port" they stamp their passports and learn about the adventures of a merciless sea captain and his unruly crew. These exotic ports provided provisions, plants, and some of the highly detailed observations that established our young nation as a scientific power. Just as did the U.S. Exploring Expedition, this Ports of Call journey ends near New York harbor in the Conservatory's West Gallery, where the exhibit display includes Expedition artifacts on loan from the U.S. Naval Academy Museum and a rare dried plant specimen actually collected when the Expedition visited the Oregon Territory in 1841, on loan from the U.S. National Herbarium.



New DVD-set of the Plant Type Collection Produced

In March, **Cristián Samper**, Director of the National Museum of Natural History, and other Smithsonian staff attended the eighth meeting of the Conference of the Parties to the Convention on Biological Diversity in Curitiba, Brazil. They carried with them a secret weapon: a 2-DVD set containing 78,736 images of plant type specimens. These disk sets were distributed to representatives of more than 180 countries and contained a basic message: "to conserve and manage your sovereign biological resources, you need to understand the species in your care...and, to better understand species, you need type specimens." All attendees found a copy waiting at their seats at the convention dinner and, in his address, Samper emphasized the powerful message contained within. The disks were enthusiastically received, according to Len Hirsch, Smithsonian's CBD representative.

The task of organizing the existing data and images on two disks and designing a user friendly interface that permitted searches by country (or geographical unit) fell to **Ellen Farr** and her staff. **Alice Tangerini** provided the artwork and graphics that gave the product a polished, professional look, and **Rusty Russell** supervised the overall production of the disks. In the end, it was an actual team effort for a virtual plant species collection.

Ellen Farr (left), Rusty Russell, and Alice Tangerini display the new DVD set of plant type specimens. (Photo by Deborah Bell)

Botanical Partners Lecture Series

Roger Hangarter, Associate Professor of Plant Physiology at Indiana University, continued the Botanical Partners Lecture Series by presenting "Environmental Sensory-Response Systems and Plant Development" on 19 January at the United States Botanic Garden (USBG) Conservatory. On 6 April, Michael Balick, Vice President and Chair of Botanical Science Research and Training, and Director and Philecology Curator at the Institute of Economic Botany at the New York Botanical Garden, presented "Ancient Wisdom and Modern Medicine: Plants, People, and Cultures in the Tropical Rainforest." The Botanical Partners Lecture Series is a collaboration between the Department and USBG, designed to bring together the Washington scientific community interested in botanical studies. Invited speakers have been chosen to attract participants from a broad spectrum of the local community who are interested in the botanical sciences. Informal receptions after the talks were hosted to promote discussion and exchange of ideas. If you have suggestions for future speakers, please contact Gary Krupnick at krupnickg@si .edu.

Chair with a View

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a department in one of the oldest and largest natural history museums, the plant collections at the National Museum of Natural History are among the most extensive in the world. Our herbarium is a global collection with special geographic (e.g., North America, the neotropics, the Pacific Region, and the Indian subcontinent) and taxonomic (ferns, monocots, and many dicot families) strengths, and it is extremely rich in historical specimens providing a critical temporal element to its information content. The US National Herbarium also maintains the largest inventoried and fully verified type specimen collection with high resolution digital images of all vascular plant specimens accessible via the Internet (see http://ravenel.si.edu/botany/types/).

To address Target 2 we now need to complete the inventory of the remaining 3.9 million vascular plant specimens in the herbarium at the Smithsonian. The challenge is great and the problems of stockpiling and managing the specimen data are formidable. Staff from our Information Management Team, lead by Ellen Farr, are developing methods, including voice recognition protocols, that will allow us to speed up data entry to finish the inventory in as fast a way possible. However, no matter how fast the technology, it is clear that we will need massive people power and funding (about $3M!) to complete the job. By initially mobilizing the data currently available in the U.S. National Herbarium, we can provide critical baseline data for use by other large botanical institutions as well as local and regional herbaria throughout the world to complete the Target 2 assessment. Time is of the essence. We must begin now. We should have started yesterday.

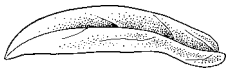
For more information on addressing Target 2 with specimen data, see Plant Talk *(January 2006; 43: 46-47).*

Historia Plantarum Collection Opens

The Department is pleased to announce that the "*Historia Plantarum Collection*," brought to the National Museum of Natural History (NMNH) by **Alain Touwaide** and **Emanuela Appetiti**, is now open and accessible to Smithsonian staff and external scientists.

The collection is devoted to the history of botany and medicine, with a particular focus on the Old World and medicinal plants. Among the fields covered are botany in Antiquity, the Middle Ages and the Renaissance, botanical illustration in manuscript and printed books, the history of medicine and pharmacy, and the history of natural sciences. The collection includes many of the primary sources in the original language, the necessary reference works for the study of such sources, the secondary literature, and many scientific journals. Books, off-prints and journals are complemented by slides, microfilms, and "non-book" material.

Future requests for access to the *Historia Plantarum Collection* should be addressed to Alain Touwaide and Emanuela Appetiti (Tel: 202-633-0967; e-mail: touwaidea@si.edu), or in case of their absence Dan Nicolson (Tel: 202-633-0910). Books are housed in W500-C and W511 in the west wing of NMNH, where they are to be consulted and used. A computerized catalogue is currently being prepared and will soon be accessible online.



DNA Barcoding

Continued from page 1

codes have now been successfully applied to flowering plants. In a 2005 paper entitled "Use of DNA barcodes to identify flowering plants" published in the *Proceedings of the National Academy of Sciences*, members of the Department of Botany and the Laboratories of Analytical Biology at NMNH (Kress et al., 2005) identified two DNA barcodes that have the potential to be a practical and standardized tool for plant species identification in biodiversity assessments, life history and ecological studies, and forensic analyses. As described in their paper, a successful DNA barcode must be 1) short enough to be quickly sequenced (e.g., approximately 400-800 base pairs in length), 2) easily located and amplified in all plant species, and 3) variable enough to provide a unique sequence for each species. The short sequence in the cytochrome c oxidase (CO1) gene, which has been found to be widely applicable in animal barcoding, is not appropriate in the case of plants because of a much slower rate of COI gene evolution in higher plants than in animals.

The two regions identified so far for plants are the nuclear internal transcribed spacer (ITS) and the plastid *trnH-psbA* intergenic spacer. ITS is the most commonly sequenced locus used in plant phylogenetic investigations at the species level and shows high levels of interspecific divergence. The *trnH-psbA* spacer, though short in length (~450 base pairs), is the most variable plastid region in angiosperms and is easily amplified across a broad range of land plants. Together, these two DNA regions may unlock the key to DNA barcoding in plants.

Herbarium collections, such as the millions of specimens maintained in herbaria at natural history museums and botanic gardens, provide a documented source for building the plant barcode library. In the Kress et al. (2005) study, dried herbarium specimens over 100 years old were tested and shown to be usable for DNA barcodes. Despite the overall success of ITS and *trnH-psbA* as plant barcodes, it is recognized that each of these DNA regions also poses some problems, such as the inability to amplify ITS in a number of groups of vascular plants (such as ferns) and the variable length of the plastid spacer that makes it difficult to align among species. More extensive trials of these and other possible plant DNA barcodes are now underway in laboratories around the world, including those at NMNH, the Royal Botanic Gardens at Kew and Edinburgh, New York Botanical Gardens, and the Natural History Museum in London.

Already a number of significant projects have been initiated to utilize the best plant barcode when it is available. In the Department of Botany, our early work on developing a workable plant barcode centered on the 200 plus species now found on Plummers Island, Maryland, a National Park Service habitat reserve in the Potomac River that has been studied and inventoried by biologists in the Washington, D.C., area for over 100 years, making it an appropriate test site

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Emanuela Appetiti and Alain Touwaide explore the new *Historia Plantarum Collection*. (Photo by Elaine Haug)

DNA Barcoding

Continued from page 9

for barcoding trials. We have so far surveyed a broad range of angiosperms in 50 plant families, 72 genera, and 83 species that occur on the island. We will shortly complete the remaining 120 species so that each taxon can be uniquely identified by their ITS and *trnH-psbA* signature.

In discussions with scientists at the Smithsonian Tropical Research Institute in Panama, we will soon begin a project to produce a DNA barcode library for all the plant species on Barro Colorado Island (BCI), one of the primary research stations for tropical biologists in the world. The experience gained from barcoding the 200 species on Plummers Island will be applied to the over 1,400 species now recorded from BCI. Once completed, the DNA barcode library of plant species will be an invaluable tool for ecologists and evolutionary biologists conducting investigations on BCI. In addition, plans are in place to begin a massive project to barcode the plants of Costa Rica in collaboration with the Asociación Instituto Nacional de Biodiversidad (INBio) and the Área de Conservación Guanacaste (ACG) in Costa Rica as well as the Missouri Botanical Garden.

One of the most exciting barcode projects has recently been launched in collaboration with the United States Botanic Garden here on the Mall in Washington, DC. We are building a DNA barcode library for all plant species that are used by people as medicines. According to *World Economic Pants: A Standard Reference* (Wiersema & León, 1999; CRC Press), over 1,000 species are currently classified as medicines, which are defined as plants "that serve as sources of specific pharmaceutical agents and those that are widely used, mostly in the crude sense as folklore remedies." This estimate of the number of medicinal plants is conservative as it does not include numerous species used locally by indigenous peoples. We expect to develop barcodes for nearly 2,000 species that have medicinal value. A universal and simple means of identifying these medicinal species through DNA barcodes will facilitate the use of these species and the easy identification of species in the many forms by which they are applied. David

Department staff and volunteers explore and collect plants on Plummers Island, Maryland, for a DNA barcoding project. (Photo by Rusty Russell)

Erickson has joined our team as post-doctoral fellow to spearhead the project.

In addition to the plant barcoding marker work, NMNH has had an active role in numerous barcoding projects from the start with well publicized articles on butterflies and birds. When the idea of DNA barcoding in its present form started circulating, Paul Hebert and Lee Weigt, current head of the Laboratories of Analytical Biology (LAB), met at a genomics conference and upon return Weigt and Noreen Tuross, then Director of LAB, wrote a Smithsonian new initiative proposal to incorporate DNA barcoding into the museum's methodologies. This idea morphed into a DNA barcoding proposal and included other elements for "enhanced taxonomy" at NMNH. As a result NMNH received an annual increase of $700,000 in the base budget starting in September 2005 that was split between barcoding and basic collections needs. The funding has a three-year ramp up of infrastructure requirements, including two new staff and over a half million dollars of equipment, much of which in now functional at LAB instrumentation rooms at Smithsonian's Museum Support Center (MSC) in Suitland, Maryland, including new high-throughput automated DNA extractors for both plant and animals tissues. One can extract 96 individuals in less than 30 minutes and the other does high-quality CTAB (plant) or organic (animal) tissue extractions for less than $1 each. Currently, samples can be processed at LAB from tissue through sequencing (both strands of DNA) for $2 per sample, including an archival DNA extract.

As of 2006, all biological departments at NMNH have active DNA barcoding projects. Two global efforts underway in which NMNH is very active are: Fish – Barcode of Life (FISH-BOL) and All Birds Barcoding Initiative (ABBI). Both of these projects aim to be taxonomically comprehensive. FISH-BOL hopes to barcode 22,000 marine and 8,000 freshwater fish species by 2010. ABBI has the same target date for the approximately 10,000 species of birds on the planet. The Feather Identification Lab, directed by Carla Dove in the Bird Division at NMNH, and LAB have teamed up to create a database to utilize DNA to identify remains of birds involved in strikes on aircraft. The desire for this bird strike identification database led to the DNA barcoding of almost all the birds of the United States and Canada, and NMNH is now actively participating in the global effort.

Similar to the Department of Botany's collaboration with STRI to barcode the plants of BCI, LAB is taking the barcoding project and lab resources to taxonomists in the field in Panama and will participate in two taxonomy workshops at the Bocas Marine Station at STRI. They will focus on sponges in July and tunicates in August of this year and will extract DNA from freshly collected,

expertly identified and vouchered specimens, and then bring those extractions back to LAB for subsequent processing and databasing.

Taxonomists, geneticists, biotechnicians, and statisticians are working hard to implement a universal system for DNA barcoding in both plants and animals. Scientists at NMNH are clearly taking a leadership role in international efforts to make barcoding a routine technique for the specialist and layperson as well. By harnessing advances in instrumentation and genetics, barcoding will help many people quickly and inexpensively recognize known species and retrieve information about them, and will speed discovery of the millions of species yet to be named. Barcoding will provide a vital new tool for appreciating and managing the Earth's immense and changing biodiversity. Within a few years, Janzen's vision of quick and accurate identification of all plant species in a Costa Rican forest may become a reality. And in the long run, respect for nature and its conservation will proportionally increase as well.

*** Lee A. Weigt is the Manager of the Laboratories of Analytical Biology, Smithsonian Institution.**

A shortened version of this article appeared in Plant Talk *(October 2005; Issue 42).*

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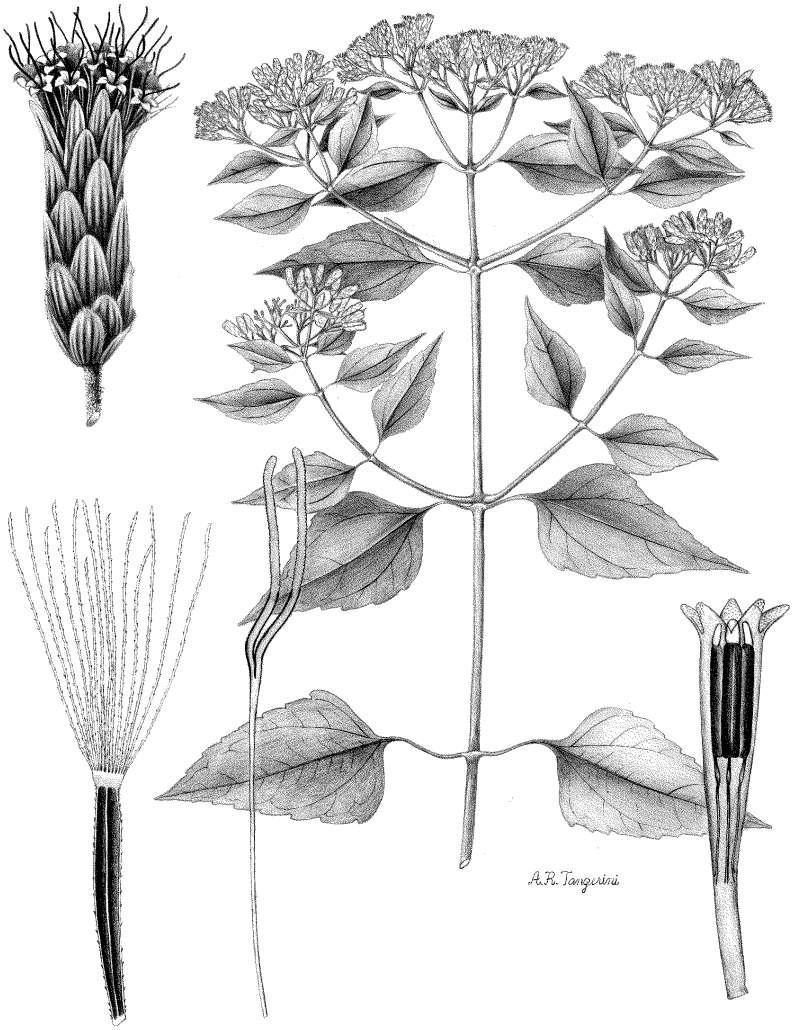
Art by Alice Tangerini

Chromolaena odorata (L.) King & H. Robinson

Chromolaena odorata is one of the many species from Barro Colorado Island (BCI), Panama, that will be added to the DNA barcode library (see cover story). BCI was declared a biological reserve in 1923, and is currently supervised by the Smithsonian Tropical Research Institute (STRI). The island, an international center for tropical research, is one of the most important and well-studied biological reserves, and remains as one of the few areas of tropical forest in the world where the entire flora has been identified.



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