NPS Herbaria Go Global (Virtually)

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HERBARIA MANAGERS WORLDWIDE ARE REVOLUTIONIZING HOW THEY PROVIDE ACCESS TO herbarium specimens, and the National Park Service (NPS) is in the forefront of this change. Throughout the USA, regional consortia of herbaria are forming to provide integrated access to specimen images and data. To study the plants of a particular geographic area, users no longer need to visit or borrow specimens from herbaria in multiple, and often distant, locations. Instead they may access the specimens virtually through an integrated Internet search of the participating herbaria. In turn, the regional herbaria are building toward a U.S. Virtual Herbarium, which is likely to lead to a North American virtual herbarium, and so forth, across the globe.

Some park specimens are accessible through regional virtual herbaria, because the specimens are in a non-NPS repository that participates in a regional virtual herbarium. For example, park specimen data from the Pacific West Region are accessible through the Consortium of California Herbaria (see http://ucjeps.berkeley.edu/consortium/),[1] the Consortium of Pacific Northwest Herbaria (see www.pnwherbaria.org/index.php),[2] and the Consortium of Pacific Herbaria (see www.herbarium.hawaii.edu/cph/index.html).[3] Parks may also participate in a regional virtual herbarium by independently listing the park on-site herbarium as a collaborating partner in the consortium. For example, Grand Canyon National Park Herbarium is a participating partner in the Southwest Environmental Information Network (SEINet) (see http://swbiodiversity.org/seinet/index.php). As regional virtual herbaria consortia become operational, parks may join them and provide virtual access to park specimens in both NPS and non-NPS repositories.

Benefits of virtual herbaria

Virtual herbaria offer new tools for resource managers, scientists, and interpreters to access and use herbarium data. For example, they expand access to park herbarium data to inform science and taxonomic studies, phenology and climate change studies, restoration of endangered species, removal of invasive species, and cooperative management of landscapes. They integrate information searches across organizations, giving researchers the ability to look at data using specific criteria, such as a single species over a geographic area, or all species from a specific park, or all specimens from federal lands (a virtual federal herbarium).

In addition, virtual herbaria preserve the original specimens by reducing handling and shipping involved in lending large numbers of specimens to researchers around the world. Re-

searchers may use the virtual herbarium to meet many of their research needs and limit the number of specimens that must be borrowed for on-site study.

Currently, use of herbaria is basically limited to scientists. Virtual herbaria, however, open the herbaria to the general public. For the first time, anyone may access these herbaria from anywhere— their offices, schools, homes, backyards, and even along a park trail (with a smartphone application). The images and data are readily accessible to park staff and partner organizations, such as Landscape Conservation Cooperatives, university staff to enhance teaching and research, other members of the scientific community to facilitate research, school teachers and students, amateur botanists, garden clubs, and other members of the public, both in the USA and internationally. Such universal access helps to build public knowledge of, and support for, conservation.

Virtual herbaria enable users to place park plants in regional and global context, use interactive identification keys and checklists in the field, explore plant distribution and flowering in relation to climate change, identify native plants for use in gardening, learn about plants through educational games, involve youth in conservation activities, and a variety of other activities.

Three challenges to parks going virtual

The first challenge to going virtual is that herbarium specimens must be cataloged in order for the park to participate in a regional consortium. Currently, seventy-six percent of NPS biological specimens are cataloged. Parks should give priority to cataloging the backlog of biological specimens (including herbarium specimens), and seek project funding to accomplish this task.

The second challenge is that virtual herbaria are most useful when specimens are represented by images, in addition to taxonomic, descriptive, locality, collection, and other written information, and most NPS herbarium specimens lack digital images. In addition, parks lack the equipment and skills to create the images. The equipment is expensive (for example, photographic equipment may be in the range of $9,000) and purchase for limited use in a single park's on-site herbarium may not be justified. Servicewide, regional, or repository-based digital imaging projects, such as the demonstration project described below, address this challenge.

A third challenge for parks is that regional virtual herbaria base their listings on the herbarium in which the specimen is physically located. This practice is compatible when the specimens are in NPS facilities—the specimens are listed under the park name when the park is a participating herbarium. Specimens in non-NPS repositories, however, are listed under the non-NPS repository herbarium, and duplicate listings under the participating park herbarium are not currently accommodated. Parks may work with regional virtual herbaria to establish standard search functions that enable users to search by park for all specimens regardless of physical location, as SEINet provides for its participating parks.

Basic steps for NPS herbaria to go virtual

The basic steps for NPS herbaria to go virtual are as follows:

1. Catalog the voucher specimens in the park herbarium.
2. Create digital images of specimens.
3. Collaborate with non-NPS repositories with park specimens.
4. Post data and images on the NPS Web Catalog (at www.museum.nps.gov).
5. Join a consortium that serves data and images on the internet as a regional virtual herbarium.
6. Coordinate with the virtual herbarium to facilitate searches for park specimens regardless of physical location.
7. Create plant checklists and apps using the virtual herbarium.
8. Refer researchers, interpreters, educators, and visitors to the virtual herbarium.

NPS virtual herbarium demonstration project

Arizona parks are participating in a demonstration project that virtually integrates park herbaria with collaborating federal, tribal, state, county, university, and non-governmental herbaria with collections from the American Southwest and Mexico. The NPS project, known as the Herbarium Imaging Project (HIP), is coordinated by the senior advisor for scientific collections in the office of the associate director, Natural Resource Stewardship and Science, Washington, DC. Beyond imaging 17,000 park herbarium specimens and making them electronically accessible, one goal of HIP is to develop examples of procedures and templates that parks may use to generate images of park specimens, and cooperate in their own regional virtual herbaria.

The Arizona project involves collaboration with non-NPS repositories to generate images of park specimens in both NPS and non-NPS repositories, and post the data on SEINet. NPS coordinates imaging tasks with non-NPS repository partners through the Cooperative Ecosystem Studies Units (CESU) cooperative agreement, and the Colorado Plateau CESU (CPCESU). The Natural Resource Preservation Program (NRPP) and the CPCESU are the primary funding sources.

SEINet is a specimen-based virtual herbarium of the American Southwest and northern Mexican (Sonoran) flora. It covers 1.7 million specimens housed in 20 herbaria in the region including 10 in Arizona, five in New Mexico, four in adjacent western states, and one in Sonora, Mexico. Specimens are also house in three consortia, and the New York Botanical Garden. SEINet features species checklists, an interactive identification key, interactive Google maps, an image library, and educational games and quizzes. Users may search one or many herbaria in a single search. Pre-set custom searches are available for federal agency specimens and projects.

Arizona State University (ASU) manages SEINet collaboratively with consortium partners. The non-NPS repositories that participate (or are committed to participate) in SEINet, and are HIP partners, are Museum of Northern Arizona (MNA), Northern Arizona University (NAU), and University of Arizona (UA). Twenty NPS units in Arizona are participating.[4]

The HIP images are created in three formats—one as a RAW (minimally processed) image file, one as a TIFF (tagged image file format) file at native resolution (at least 300 dpi) for research and publication, and one as a JPEG (compressed) file at 72 dpi for posting on the web. The park posts the images on the NPS Web Catalog, and collaborates with the cooperating partner to post the images on SEINet.

Each of the three partners has park specimens in its herbarium. NAU and the UA Herbarium are creating specimen images on site. The Western Archeological and Conservation Center manages park specimens that have been moved temporarily to the nearby University of Arizona Herbarium for imaging. In addition, the UA Herbarium has developed a mobile imaging unit that can travel to other partner locations and parks.

Key herbarium imaging project tasks

The Arizona demonstration project involves the following tasks and specifications.

Task 1. Parks develop a photographic shoot tracking list as an Excel spreadsheet. The list includes textual catalog record data that will be provided to SEINet, as well as metadata that will be attached to the image, including NPS catalog number and non-NPS repository accession or catalog number, scientific name, ownership, and copyright information (generally NPS photos are in the public domain), photography credits, and contact information. In addition, it provides instructions to the photographer regarding sensitive locality information on the herbarium label that must be blurred before the image is posted on SEINet. The shoot tracking list travels with the specimen from the storage location to the imaging station and back. It provides space for staff comments and instructions.

Task 2. The herbarium staff retrieve the specimens to be imaged, and work with the photographer to pace the retrieval and refiling of specimens.

Task 3. The photographer images the specimens using a digital single lens reflex camera body, normal macro 60 mm f/2.8 autofocus lens, right angle viewfinder, copy stand, and other related equipment.

The photographer first completes a batch of 15 test images in RAW format, followed by two batches, each with 50 percent of the images. The specifications include instructions on layout, use, and placement of color and metric scales. After taking all the required RAW images, the photographer then saves the images in TIFF and JPEG formats, layers the blurring of sensitive locality data and insertion of a catalog number on a placard, and attaches the metadata provided on the shoot tracking list.

Task 4. In consultation with the park, a quality control specialist checks all test images, as well as a random sample of the large batches.

Task 5. The photographer provides the TIFF and JPEG image files to the park, and sends the RAW images to the Park Museum Management Program, in the Washington office, for archiving.

Task 6. The park posts the images and other catalog data on the NPS Web Catalog.

Task 7. The park or partner herbarium that houses the specimens posts the catalog data on SEINet and provides SEINet access to the images. Both the NPS catalog number and the partner's identifying number appear in the SEINet record.

Task 8. On an ongoing basis, the park and partner repositories coordinate with SEINet to update the records. As described in the SEINet discussion below, SEINet can update records through user feedback and annotations to the herbarium.

The shoot tracking list template, associated instructions, and a generic task agreement and scope of work are available from the senior advisor for scientific collections. The project is scheduled to run through 2013, when images and data for all 17,000 specimens will be available on the NPS Web Catalog and SEINet.

How a virtual herbarium works

SEINet serves as a good model to understand the technical workings of a virtual herbarium. Search parameters include taxonomic and locality criteria, geographic references, and collector and collection information. The list of specimens in the search results offers links to detailed information on specific specimens, including images of the herbarium specimen and the species in the wild, as well as general information about the species. Images of the living specimen in situ are especially useful for field identifications. The system allows searches on both scientific and common names.

An interactive identification key allows the user to select characteristics (such as "leaves opposite," "hairy stem") to narrow a list of many possible choices. For example, a list of all Asteraceae in a park may be narrowed to only a few options that can then be checked against the image library to identify the specific specimen.

ASU developed SEINet's open-source search engine, Symbiota, under a grant from the National Science Foundation, which has a program to support the development of virtual herbaria. SEINet and Symbiota use an international metadata standard, Darwin Core, and the DiGIR (Distributed Generic Information Retrieval) and TAPIR (Taxonomic Databases Working Group Access Protocol for Information Retrieval) client/server protocols to import, integrate, and display data. Such data standards and protocols are the first step toward interoperability. (See more on biodiversity information standards at www.tdwg.org.)

Symbiota (http://symbiota.org) can schedule automatic updates, providing that the source

data are web-based. SEINet currently uses this function to update UA and ASU display data daily. The goal over the next year is to extend these interoperability features to all the collections currently integrated in SEINet.

Similarly, any researcher annotations or public comments received through SEINet can be forwarded by Symbiota to the data source node. The service-oriented architecture (SOA) not only passes data between nodes, but also can involve two or more services coordinating some activity, such as dynamically updating regional or state-level species checklists when new data are added from any one of the SEINet partners. It could send messages to update scientific names when changes occur, but is not currently performing this function.

Spreading the word on virtual herbaria
NPS units in Arizona have welcomed the opportunity to participate in the Herbarium Imaging Project, contributing staff time and funding to the joint effort. The Sonoran Desert Network is complementing the imaging work by creating park checklists, and posting them on SEINet with direct links to the specimen vouchers and images (see Coronado National Memorial example at http://swbiodiversity.org/seinet/checklists/checklist.php?cl=2541&proj=5&showvouchers=1).

The Bureau of Land Management, the U.S. Forest Service, and Valles Caldera National Preserve have joined the NPS to create a virtual federal herbarium prototype on SEINet, facilitating simultaneous searches of data from these federal lands. In 2009, the Biodiversity and Ecosystem Informatics Work Group (BioEco), under the National Science and Technology Council Committee on Environment, Natural Resources, and Sustainability (Subcommittee on Ecological Systems), selected the virtual federal herbarium prototype as a demonstration project, highlighting integration and interoperability of federal data.

At the 2010 National Mall Earth Day celebration in Washington DC, the public responded enthusiastically to a demonstration of the virtual federal herbarium prototype. Teachers spoke of how they could incorporate the virtual herbarium into school curricula. Gardeners asked whether they could use the virtual herbarium to identify native species to plant in their yards. Outdoor enthusiasts were excited by the prospect of a smartphone app that would allow them to identify plants along the trail. NPS resource managers and interpreters have endorsed the virtual herbarium as a useful new tool for stewardship and communication.

Going global
As regional virtual herbaria consortia become operational across the USA, all national park sites are encouraged to collaborate with their non-NPS repository partners to make park herbarium specimens, in NPS and non-NPS repositories, virtually and globally accessible.

Endnotes
1. Search for Cabrillo National Monument, Channel Islands National Park, Death Valley National Park, Joshua Tree National Park, Lassen Volcanic National Park, Mojave National Preserve, Redwood National and State Parks, Sequoia and Kings Canyon National Parks, Yosemite National Park.
2. Search for Crater Lake National Park, Mount Rainier National Park, Olympic National Park.
3. Search for Hawai'i Volcanoes National Park, Kalaupapa National Historical Park, War in the Pacific National Historical Park.
4. Canyon de Chelly National Monument, Casa Grande Ruins National Monument, Chiricahua National Monument, Coronado National Memorial, Fort Bowie National Historic Site, Glen Canyon National Recreational Area, Grand Canyon National Park, Montezuma Castle National Monument, Navajo National Monument, Organ Pipe Cactus National Monument, Pipe Spring National Monument, Petrified Forest National Park, Saguaro National Park,

Sunset Crater Volcano National Monument, Tonto National Monument, Tumacacori National Historical Park, Tuzigoot National Monument, Walnut Canyon National Monument, Western Archeological and Conservation Center, Wupatki National Monument.