IRREPLACEABLE ARCHIVES: The Scientific Legacy of Herbaria

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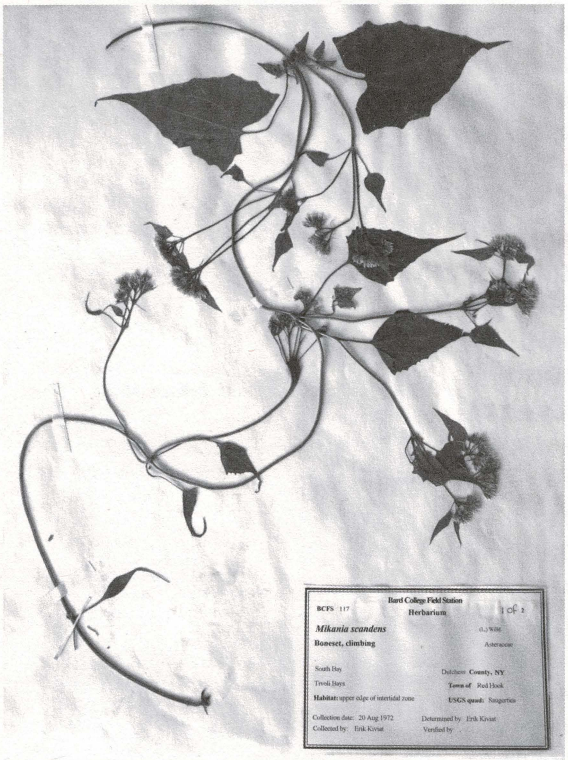

Herbarium specimen of climbing hempweed (*Mikania scandens*), a herbaceous vine of moist thickets. Photo © Erik Kiviat 2014

They have been used to solve crimes; describe the chemistry of soil, water and air in bygone times; assess the effects of climate change; discover the origins of diseases, insect pests, and invasive plants; locate extant populations of rare species; identify fossils; identify prehistoric plant parts found at archaeological sites; learn about distribution and habitats of extinct species; determine native ranges of plant species; and elucidate fungus and insect relationships with plants.[1,2,5]

They are used by historians, artists, agronomists, forensic investigators, and medical scientists, as well as conservation biologists, ecologists, and taxonomists. Herbaria—collections of preserved plant specimens—have rich stories to tell about plants and the world they inhabit.

Herbaria range in size from the small personal herbarium that might contain 100 specimens, to a massive collection such as that of the New York Botanical Garden which contains 7 million vascular plant specimens. The Bard College Field Station herbarium, curated by Hudsonia with assistance from students and volunteers, is a regional collection of over 6000 catalogued vascular plant specimens in addition to several thousand more in process, as well as smaller numbers of mosses, liverworts, lichens, and fungi.

Vascular (higher) plant specimens in a herbarium are typically pressed, dried, and mounted on pH-neutral sheets of stiff paper, and labeled with information on where, when, and by whom the plant was collected, and often some details about the habitat or microhabitat where the plant was found. Mosses, liverworts, lichens, and fungi (the latter two groups are not actually plants) are simply dried, labeled, and stored in small pH-neutral paper envelopes. Specimen data are commonly entered in a computerized database, sometimes accompanied by digital images of the specimen itself.

Why go to all the trouble of preserving things that just grow outdoors?

A herbarium is part of the basic library of botany that allows scientists and naturalists to classify and identify plants, and study many aspects of plant anatomy, chemistry, genetics, and geographic distribution. Although biologists collect plant specimens for a variety of purposes related to immediate scientific research, the value of a preserved specimen with the accompanying data has a much greater reach. Herbarium specimens that are kept in dry, vermin-free environments can last hundreds and perhaps thousands of years, and can thus be available to taxonomic, ecological, anthropological, and genetic research long after they are collected.

A plant specimen provides a permanent record of the species' occurrence at a particular location, in a particular habitat or microhabitat, and on a particular date. Depending on the plant's status and condition at the time of collection, the specimen can provide a record of when the species flowers, develops fruit, or senesces, all of which can influence the interactions of the plant with pollinators, grazers, foraging animals, and detritivores. The timing of these stages can help us understand some of the complex dynamics of ecological communities. Some plant specimens retain physical or chemical markers of climate, air quality, soil characteristics, and water chemistry that can help researchers understand environmental conditions in the span of the plant's life.

Plant specimens can document the ranges of occurrence of particular species—e.g., ranges in habitat types, elevations, geography—and changes in those ranges over time. Specimens can document regional differences in the species' morphology (form and structure) and phenology (timing of, e.g., leafing out, flowering, fruiting). Changes in these characteristics can help us understand and predict some of the consequences of climate change.

Specimens can help to establish when certain plants first arrived in a

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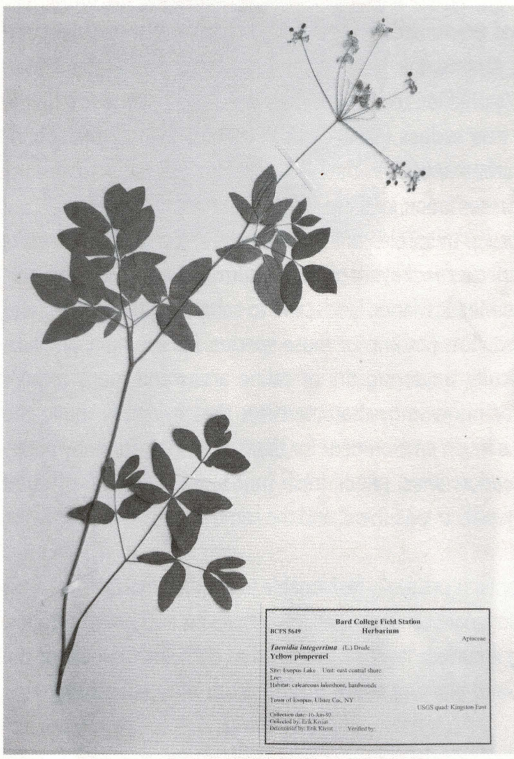
region or at a particular location, which can help ecologists understand aspects of the introduction, ecology, and spread of non-native plant species, for example, and can inform our efforts to control the spread of non-native pests. A reference plant collection can assist with identification of new plant specimens, and help to correct past identification errors.

Some herbaria contain historically important plant collections. For example, specimens collected by the Lewis and Clark expedition in the early 1800s, and now housed in the herbarium of the Academy of Natural Sciences of Drexel University, were used by botanists to describe, classify, and name the plants soon after Lewis and Clark returned to the East, and are still considered an essential reference for botanical studies of the western US.[5]

British researchers, comparing contemporary plant specimens with those collected over the previous century, found that the density of stomatal pores in leaves of native trees in southeastern England had decreased in inverse proportion to levels of atmospheric carbon dioxide.[7] That finding has since been corroborated by other laboratory and field studies, and has been used by climate scientists and paleoecologists to track historic and prehistoric CO^2 levels in other parts of the world.[6]

Herbarium specimens may also provide information about the behavior and distribution of other living creatures. In Puerto Rico, researchers discovered a species of moth whose cocoons mimicked spore dots of certain ferns, thus camouflaging the developing larvae from predation. By examining herbarium specimens of ferns collected in tropical regions throughout the western hemisphere, more evidence was found of the cocoons, but only from herbarium specimens collected in the Caribbean.[3]



Herbarium specimen of yellow pimpernel (*Taenidia integerrima*), a forb of calcareous habitats. Photo © Erik Kiviat 2014

Herbaria are the basis for worldwide systems of plant nomenclature, and are fundamental to plant identification and studies of plant diversity. But despite the foundational importance of herbaria to science, many of the world's herbaria are falling on difficult times. It takes funding and climate-controlled, pest-protected space to create and maintain a herbarium. Although there are virtual herbaria of sorts (websites such as the US Department of Agriculture *Plants Database*, the JSTOR *Global Plants* website, and the New England Wild Flower Society's *Go Botany*), they do not provide all the opportunities for science and natural history that are offered by physical herbaria and the important incidental information that physical specimens contain. Unfortunately, many universities and botanical gardens are either curtailing or outright eliminating their plant science programs or shuttering their herbaria.

But even though there are many examples of herbarium closures, scale-backs, and consolidations, there are some positive developments. Some governments and institutions have made investments in herbaria a priority. The Royal Botanic Gardens, Kew (England) has for many years sponsored a Herbarium Techniques course that travels to developing countries to teach endemic botanists and technicians the proper methods for establishing, building, and maintaining herbaria. Many of these countries are biodiversity hotspots, so establishing herbaria is imperative.

Another bright spot is the Herbarium at the Natural History Museum in Paris, currently undergoing a renovation with funding from the French government. Temperature and humidity controls are being installed and, amazingly, the whole collection of over 8 million specimens is being digitized. Having this all-important collection conserved properly and made available online will be a boon to plant science. The New York Botanical Garden, the Botanical Research Institute of Texas and Harvard University have recently invested in modernizing their facilities as well.

With the acceleration of climate change, invasive species incursions, hydrological changes, land conversions, human population growth and habitat destruction, we anticipate that herbaria will become an increasingly important resource for understanding the natural world and the responses of biological communities to the changing environment. ■

REFERENCES CITED

1. American Society of Plant Taxonomists. 2004. American Society of Plant Taxonomists position statement. Society of Herbarium Curators. betelgeuse.sunsite.utk.edu/shc/?q=node/14 (viewed March 2014)
2. Anonymous. No date. The Lewis and Clark Herbarium today. The Academy of Natural Sciences of Drexel University. (darwin.ansp.org/home/~mccourt/lc_today.html, viewed March 2014)
3. Barker, M.S., W.W. Shane, R.J. Hickey, J.E. Rawlins, and J.W. Fetzner Jr. 2005. Lepidopteran soral crypsis on Caribbean ferns. Biotropica 37(2):314-316.
4. Cox, C.B. and P.D. Moore. 2005). Biogeography: An ecological and evolutionary approach. Seventh edition. Blackwell, Malden, MA. 433 p.
5. Funk, V. 2004. One hundred uses for a herbarium. U.S. National Herbarium, Smithsonian Institution, Washington, D.C. (www.virtualherbarium.org/vh/100UsesASPT.html; viewed March 2014))
6. Royer, D.L. 2001. Stomatal density and stomatal index as indicators of paleoatmospheric CO^2 concentration. Review of Palaeobotany and Palynology 114:1-28.
7. Woodward, F.I. 1987. Stomatal numbers are sensitive to increases in CO^2 from pre-industrial levels. Nature 327:617-18. (Original not seen; cited in Cox and Moore [2005].)