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LEWIS AND CLARK BICENTENNIAL
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Since its founding in 1891, the Philadelphia Botanical Club has offered outstanding programs, field trips, and other opportunities for those with an interest in plants to meet and exchange information. Monthly meetings feature speakers from various botanical backgrounds. They are held at 7:30 p.m. on the fourth Thursday of the month in September, October, and January through May and the third Thursday in November and December, at the Marvin Comisky Conference Center, One Logan Square (one block east of the Academy of Natural Sciences of Philadelphia). Each year from April to October, expert field botanists lead numerous field trips in the mid-Atlantic region and occasionally elsewhere in North America or overseas.

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On the Paper Trail in the Lewis and Clark Herbarium

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ABSTRACT. The Lewis and Clark expedition produced a series of journals of more than one million words, and in the two centuries since the expedition in 1803 to 1806 a flood of books and articles has detailed their travels and travails. In this paper we explore a neglected portion of the expedition: the labels and notes associated with the Lewis and Clark Herbarium, a collection of 222 dried, pressed plants housed in the Academy of Natural Sciences of Philadelphia herbarium (PH). We also comment on an additional 10 specimens of Lewis that reside at the Royal Botanic Gardens at Kew. This residue of written records includes notes by Meriwether Lewis (primary plant collector on the expedition), Frederick Pursh (German botanist who first studied the plants), Thomas Meehan (Academy of Natural Sciences botanist who re-discovered the plants in Philadelphia after nearly a century of oblivion in storage), and several other nineteenth, twentieth, and twenty-first century botanists and other researchers who have found occasion to annotate the specimens. The notes reveal insights into the collection, curation, taxonomy, and research uses of the Lewis and Clark Herbarium during the 200 years since Lewis made his gatherings. Much remains to be learned from a closer study of this little-examined part of the paper trail of Lewis and Clark.

INTRODUCTION

"all eaten!"

With this annotation (Fig. 1), botanist Thomas Meehan in 1897 described some of the remaining, ostensibly missing, plant specimens gathered by Meriwether Lewis and William Clark along the Columbia River on 14 April 1806. In fact, his was probably a note of irony. Just years after Lewis and Clark returned from the West, horticulturist Frederick Pursh had copied or paraphrased Lewis's original field label, now lost: "*An umbelliferous plant of which the natives don't eat the root.*" Yet Meehan found just shreds, identifiable only as some kind of *Lomatium*, a wild carrot, which had been a feast to insects. In any other herbarium this would have been a disaster, and the specimens summarily discarded. But in the Lewis and Clark Herbarium they are as informative to a historian as are shards of broken pottery to an archaeologist. The two-century chatter of labels and annotations throughout the herbarium tells stories, too, a cyclorama of travel, botanical discovery, ecological record, and taxonomic opinion about the first-ever scientific exploration of the American Northwest. Not so many of Lewis and Clark's plants were eaten, actually, and 222 herbarium sheets now in the Academy of Natural Sciences of Philadelphia offer a "feast" for the Lewis and

*The order of authors was determined by coin toss. Manuscript submitted 7 November 2003, revised 25 October 2004

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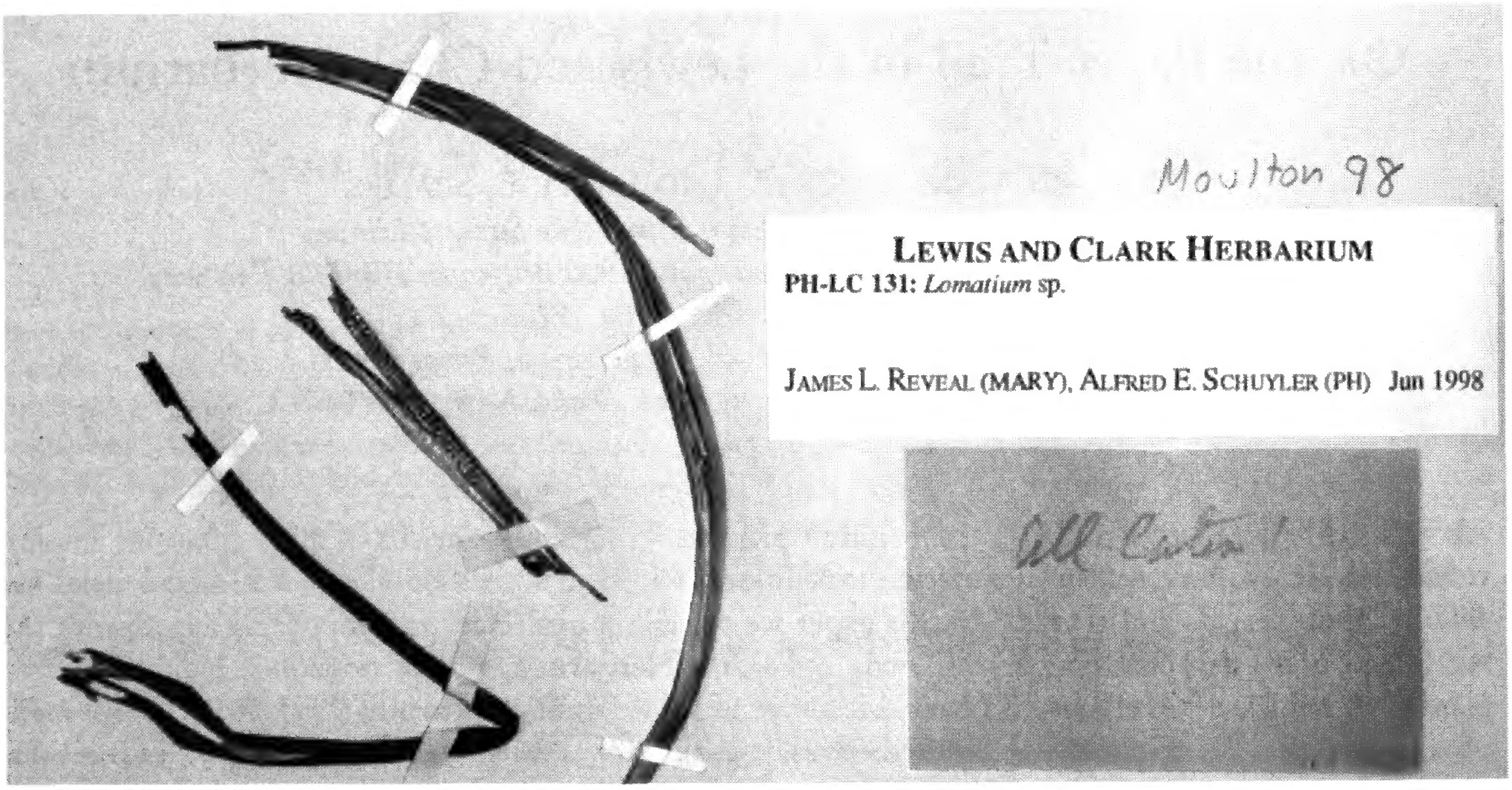

Figure 1. Tag (*all eaten!*) by Thomas Meehan (lower right) and plant fragments. The exclamation point normally indicates confirmation in botanical annotation, although in this case it may also signify dismay and surprise that the insects have had their way with the specimen. (*Lomatium* sp., PH-LC 131.)

Clark aficionado. There also are ten sheets at the Royal Botanic Gardens at Kew, which we mention herein as needed; but our focus will be on the main body of Lewis and Clark's plants in the Academy of Natural Sciences of Philadelphia.

THE LEWIS AND CLARK EXPEDITION

The Lewis and Clark Expedition of 1804 to 1806 is, at least for the moment of its bicentennial, so well rediscovered by the American media that it is superfluous to introduce its historical significance at length. The expedition traveled through a largely unknown territory of the upper Missouri River, the Rocky Mountain divide, and the Columbia River to the Pacific Ocean—and back. The definitive documentaries are two: Gary Moulton's (1986–2001) comprehensive 13-volume edition of the journals of Lewis, Clark, and others of the expedition whose writings survive; and Donald Jackson's (1978) edition of *Letters of the Lewis and Clark Expedition with Related Documents, 1785–1854*, which transcribes all of the important primary manuscripts and correspondences relating to the expedition, its planning, and results. A magisterial bibliographical and literary account of the printed record of the expedition by Beckham et al. (2003) documents the post-expedition history in a handsomely designed and illustrated volume.

In addition to the manuscript residue of the expedition, the explorers shipped back boxes, barrels, and cages full of natural history specimens and ethnological collections to the "civilized world" of what today is the Northeast Corridor of the United States. A few artifacts and relics were kept by the explorers or sent to their relatives; a few more were retained by their first recipient, Thomas Jefferson. He sent the larger prize *en masse* to the American Philosophical Society in Philadelphia, from whence they were promptly dispersed to scholars and learned men in many disciplines. Never again would the entire shipment reside in one place.

Some specimens were displayed in Charles Willson Peale's public museum in Philadelphia. Accident and loss contributed insidious wear on the collections as decades passed. Zoologists, botanists, and geologists studied, corresponded about, and published papers based upon various individual specimens and small subsets of the collections; once these were completed, the material was overlooked. The novelty of these natural curiosities waned as the expanding American frontier filled the blank and imaginative areas of the North American map. In time, more expansive and accessible collections were assembled from geographically broader and ecologically more diverse regions than those of the narrow routes of the explorers. Forgetfulness, too, cast a pall that obscured specimens from the pool of commonly known references (Cutright 1969; Spamer and McCourt 2002b); and the deaths of principal early workers sealed the fate of Lewis and Clark's collections because later researchers went on to work with their own, fresher materials.

Paul Cutright (1969), sixteen decades after the fact, succeeded in publishing the first scholarly treatise on the bounty of the expedition's natural history collections, *Lewis and Clark: Pioneering Naturalists*. It remains the most concise and complete work on the subject. Such a book was intended to have appeared much earlier, edited by botanist and all-around naturalist and ethnologist Benjamin Smith Barton, who served as the "principal investigator" of the expedition's biological, geological, and ethnological collections. The volume was to accompany Nicholas Biddle's (1814) two-volume ghost-written paraphrase of the journals of Lewis and Clark. Barton died in 1815, having never worked on it, and apparently no one else had the wherewithal to bring it into being.

The pressed plants from the expedition have always been the most well-studied portion of the scientific materials brought back from the West. Frederick Pursh's (1813) inclusion of them in his pioneering *Flora Americae Septentrionalis* is the benchmark for all botanical studies of the expedition. His was the first such flora to span the North American continent, one that named dozens of new taxa based on the gatherings of Lewis and Clark. Remarkably, after Pursh, few new taxa were erected based upon the expedition's plants. The historical perspective of these plants has been covered well by Cutright (1969), and the significance of Pursh's work by Joseph Ewan (1979) in his introduction to a facsimile reprinting of Pursh's *Flora*; but more recently this suite of botanical specimens has been reinvestigated with modern eyes. Reveal et al.'s (1999) taxonomic overview of the Lewis and Clark vascular plants was the first since Thomas Meehan's (1898) cursory summary, which in its day followed only the descriptions and notes scattered throughout Pursh's *Flora*. The work by Reveal et al. also brought up to date much of the geographical data associated with the specimens.

Moulton (1999) and Spamer and McCourt (2002a,b) presented historical perspectives about the plants of the Lewis and Clark expedition. Moulton illustrated all of the Lewis and Clark plants for the first time with photographs of entire herbarium sheets. Spamer and McCourt (2002a) showed every specimen, individually, at greater detail in digital format on CD-ROM; this is, in effect, an illustrated edition of Reveal et al.'s (1999) comprehensive taxonomy. The extensive references cited in these recent works open into the deep mine of additional resources, beginning with digital facsimiles of Meehan's (1898) and Coues' (1898) papers, presented in Spamer and McCourt's CD. Spamer and McCourt's (2002b) history is complemented by papers on the conservation of the Lewis and Clark Herbarium (McCourt et al. 2002) and modern biogeochemical investigations of some of the herbarium's preserved specimens (Teece et al. 2002).

With this so noted, we proceed on a new trail—the paper trail in the Lewis and Clark Herbarium in the Academy of Natural Sciences. Many sheets are cluttered with labels and annotations from the nineteenth, twentieth, and now the twenty-first centuries. Paramount among these are the annotations written on blotting papers by Meriwether Lewis in the field, of which now just 34 survive. Frederick Pursh copied, edited, and seemingly threw away many of Lewis's originals—we know because in a few cases we have both Lewis's and Pursh's corresponding labels together—but Pursh left 225 labels now distributed to 210 herbarium sheets, which proxy for those of Lewis's that are now absent. And 170 annotations in 1897 by Thomas Meehan, curator of botany in the Academy, document the recovery of the plants and their reuniting after a century. In a sense, herbarium sheets are akin to web pages for plant species and the labels are links to judgments and knowledge of earlier botanists. Some of those links are followed here; others remain mysteries to be solved by future researchers.

Meriwether Lewis, Botanizer

The journals written by members of the Lewis and Clark expedition (Moulton 1986–2001) contain frequent references to plants, from casual observations to careful descriptions of morphology, ecology, and ethnobotanical uses. Interestingly enough, few references to the plants occur on the very days that label notations indicate were the gathering dates. This discrepancy offers some insight into the ways and means of the expedition as it traveled to the Pacific Ocean and back. Journal entries were made at various times, often on the day of observation or when the group stopped for a time (such as during the winter at Fort Clatsop). By contrast many of the plants were taken as matters of opportunity—when and where the men and Sacagawea, the only woman and Native American in their group, found them. For most of the gatherings, a comparison of the day's events and activities, as registered in the journals, to the day's collection of plants seem to have no consistent correlation. Meriwether Lewis gathered in good weather and bad, on days of ease and labor alike. He very well may have opted to gather better or more mature, or flowering, specimens for those plants that were commonly seen, regardless of when he wrote about them in his journals. He may even have elected to discard previously collected plants in favor of better ones found on later days; but this is speculation.

Meriwether Lewis was the naturalist of the trip, by virtue of his quick, intensive courses of study received in May and June 1803, tutored by the most notable men in their fields in Philadelphia and Lancaster, Pennsylvania. He was not a formal botanist but he was an astute observer, capable of carefully following his instructions and comparing and describing his finds against the published references that he brought with him on the expedition. What he did not already know of plants as a farmer and from his herbalist mother, Lewis learned from Benjamin Smith Barton in Philadelphia. As far as we know, he never made pressed plant collections prior to the expedition nor did he do so in the few remaining years of his life after its return. Lewis may well have improvised some pressing methods as the expedition crossed to the Pacific. Surely, the various climates encountered provided him with numerous problems of pressing and drying. Unfortunately, the journals and correspondences provide not a clue to how all this was done. All we have are the pressed plants and Lewis's annotations. They indicate mostly "where" and "when," adding the occasional ethnobotanical note. And that is precisely what his job was—to observe, record, and communicate back to

Thomas Jefferson. In turn, Jefferson dispatched specimens and scribblings to the American Philosophical Society (he was its president at the time), the premier American "think tank." The "what" would be added by his Philadelphia brain trust.

Lewis did not maintain a separate register of gatherings by place and date, so his field annotations are collectively one of the most important pieces of documentation for the gathered specimens. The fact that he dated most of these annotations are what save the detailed precision of the locality data we have. Because historians have documented precisely where the explorers were on given dates, we are assured that almost all of the plants in the Lewis and Clark Herbarium have precise geographical data. Even though just 34 of Lewis's original annotations are present now in the herbarium, Frederick Pursh's 225 transcriptions document most of the rest. Fortunately, they include the dates that establish the geographical provenance for each.

Labels are the *modus operandi* of museum collections, although they are ancillary to the specimens. As a rule, original labels are never discarded; they corroborate original provenance and taxonomy. Later labels record changing opinions about these data by scientists and other scholars after the fact. Many labels are tags of paper pasted to the herbarium sheet; others are in the form of annotations written directly on the sheet. In the Lewis and Clark Herbarium, there are six general categories of labels and annotations: (1) Meriwether Lewis's annotations, which are about gathering and ethnobotanical uses; (2) Frederick Pursh's transcriptions of Lewis annotations, somewhat edited, with taxonomic information added; (3) Aylmer Lambert's provenance annotations, written after 1812 when a set of herbarium sheets was prepared in London for the specimens separated by Pursh from the original collection in Philadelphia; (4) Thomas Meehan's tags and a few by J. M. Greenman of the Gray Herbarium at Harvard, providing revised taxonomic data upon the restudy of the collection as newly recovered in 1897; (5) American Philosophical Society ownership labels, affixed to the set of herbarium sheets that were probably prepared in 1921 at the Academy of Natural Sciences, 115 years after the expedition returned from the field; and (6) later labels and annotations of the twentieth and twenty-first centuries, contributed by systematists, historians, curators, and collection management personnel. The clamor these six types of labels represent testifies that this is an actively used collection, hardly a quietly sequestered icon of historical reflection. The kinds and numbers of historical labels are summarized in Table 1. Together, all of these annotations and tags provide a chronology and critical history of the thoughts of many professionals as to the identity, source, and scholarly uses of these plants.

What Became of Lewis and Clark's Plants?

Today, 232 herbarium sheets hold plants known to survive from the Lewis and Clark Expedition. Ten sheets are at the Royal Botanic Gardens at Kew (K), near London; 222 sheets are in the Academy of Natural Sciences of Philadelphia (PH), where the collection comprises the Lewis and Clark Herbarium (PH-LC). Several other sheets attributed to Lewis and Clark at PH and K are now considered to be plants grown from seeds brought back by Lewis (and thus from field-collected plants) or gatherings by Thomas Nuttall that were mistakenly attributed to Lewis and Clark (Reveal et al. 1999). Thorough histories of Lewis and Clark's plants and Frederick Pursh's connection with them have been presented by Cutright (1969), Ewan (1979), Moulton (1999), and Spamer and McCourt (2002b). An analytical study of the seed-grown materials has yet to be written.

Table 1. Summary of historical annotations, tags, and labels in the Lewis and Clark Herbarium at the Academy of Natural Sciences of Philadelphia and attributed to Lewis and Clark at the Royal Botanic Gardens at Kew.

Academy of Natural Sciences of Philadelphia	
Total sheets: 222	
A.P.S. deposit	179
Lambert Herbarium	43 (6 circumstantial?)
Lewis annotations cut from blotting papers	34 on 33 sheets
Pursh annotation tags	225 on 210 sheets
Lambert annotations on reverse of sheet	15
Lambert annotations moved to obverse of sheet	29 on 26 sheets
Meehan annotation tags	144 on 139 sheets
Meehan annotations on Lambert sheets	26
Greenman annotation tags	62 on 58 sheets
A.P.S. ownership labels	179
Royal Botanic Gardens at Kew	
*Total sheets: 9–10**	
Sheets with Lambert Herbarium designation	11
Sheets with Pursh annotation tags	10

*Two sheets (*Lupinus pusillus* Pursh and *Eleagnus commutata* Bernh. ex Rydb.) are likely Thomas Nuttall collections (J. L. Reveal, personal communication, 2003), although future research may reveal otherwise. G. E. Moulton (personal communication, 2003) concedes that *L. pusillus* is a Nuttall gathering. Thus, it seems most accurate to say that "there are nine or ten Lewis specimens at Kew from the Lewis and Clark expedition of the eleven that have traditionally been thought to come from that endeavor" (G. E. Moulton, personal communication, 2003). "Traditionally" refers to the listing of Lewis specimens at Kew provided by Ewan (1979) in his introduction to the facsimile reprinting of Pursh's (1813) *Flora Americae Septentrionalis*.

With regard to the paper trail discussed here, it is important to recall that a quarter of the collection had been taken by Pursh to London, where in 1812 or after they were prepared onto herbarium sheets. They went into the herbarium of Aylmer Bourke Lambert, a well-to-do botanist and Fellow of the Linnaean Society. In 1842, following Lambert's death, a small portion of his herbarium was bought at estate auction by an American lichenologist, Edward Tuckerman. Contained therein were 47 sheets from Lewis and Clark. The ten sheets now at Kew were in another auction lot that was acquired by the British Museum. In 1856, Tuckerman gave his share of Lambert's herbarium to the Academy as a gesture of professional reciprocity for the use of the Academy's collection of cryptogams. The remaining two-thirds of the collection had remained in Philadelphia, transferred back to the American Philosophical Society (A.P.S.) after the 1815 death of Benjamin Smith Barton. Thomas Meehan recovered them in 1897 and published the first comprehensive taxonomy of the whole Lewis and Clark herbarium (Meehan 1898). The specimens were transferred on deposit to the Academy in 1897, but herbarium sheets for them were not prepared until 1921, at which time it seems that the surviving original annotations by Meriwether Lewis were salvaged from the blotting papers and affixed to the herbarium sheets. The 179 sheets from A.P.S. remain the property of that institution. Note that 47 Lambert plants, plus 179 from A.P.S., total 226, four more sheets than are now accepted as Lewis material in PH. This discrepancy is accounted for by four sheets previously attributed to Lewis and Clark that are probably gatherings by Thomas Nuttall in 1811 (Reveal et al. 1999). The four

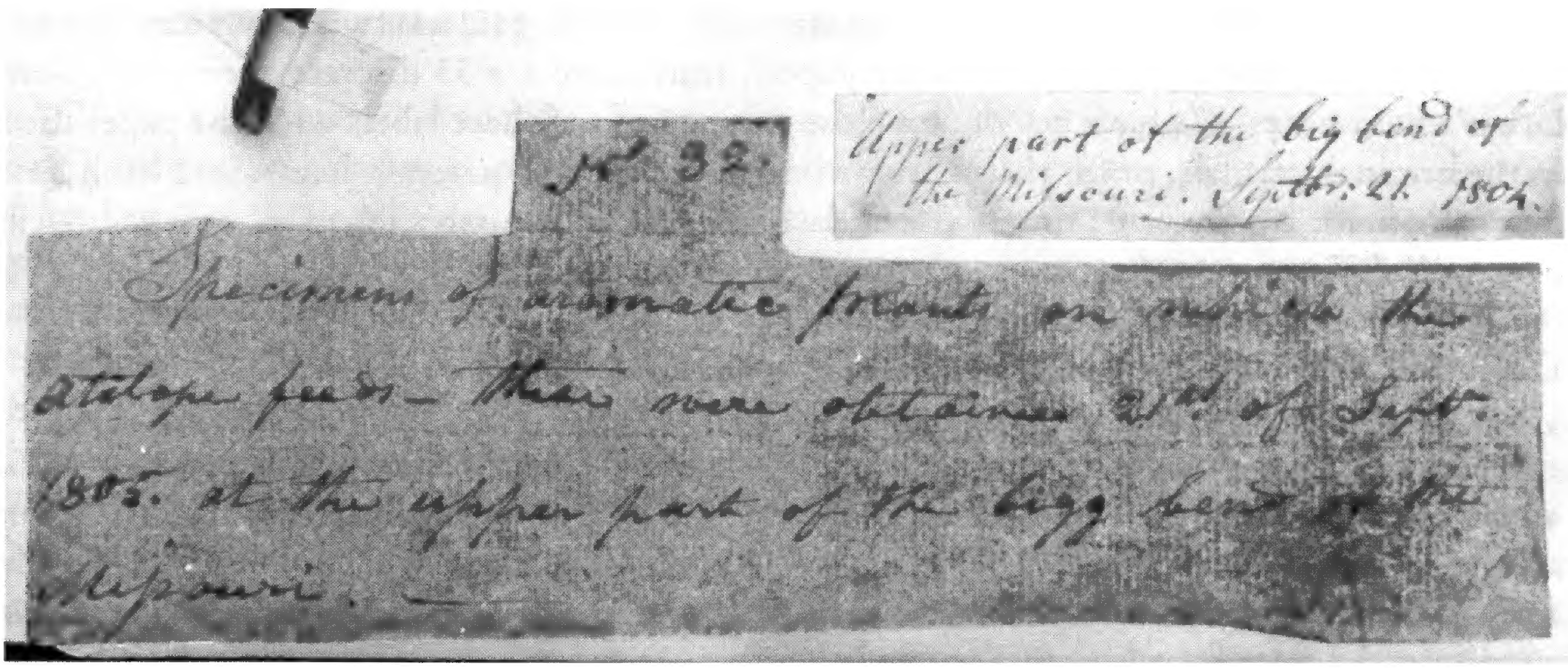

Figure 2. Labels by Meriwether Lewis (dark hued) and Frederick Pursh (light-colored). (*Ericameria nauseosa* (Pall. ex Pursh) G. L. Nesom & Baird var. *graveolens* (Nutt.) Reveal & Schuyler, PH-LC 51.)

are retained in the Lewis and Clark Herbarium at the suggestion of Reveal et al., in the event that new research corroborates the original claim. In 2000, the Academy received a Save America's Treasures grant to conserve the Lewis and Clark Herbarium. Specially constructed containers and cabinets were made for the sheets, which now are stored in a new facility with optimum climatic controls (McCourt et al. 2002).

THE PAPER TRAIL: 1804–2004 AND ON

To botanists, the specimens of the Lewis and Clark Herbarium are less important for their famous collectors than they are for their taxonomic role; 76 of them are type specimens, 71 of them named by Pursh in his *Flora* in 1813 (Reveal et al. 1999). In the context of this paper, the plants play secondary roles. It is the labels and annotations that reveal data about the travels, not of Lewis and Clark, but of the plants themselves during and since the expedition, a time span of 200 years.

Meriwether Lewis's Annotations (1804–1806)

Thirty-six annotations written by Meriwether Lewis in the field are known to survive, 35 of which accompanied plants (Moulton 1999; Spamer and McCourt 2002a) and the other, a fossil fish jaw (Spamer et al. 2000). Properly speaking, the herbarium annotations are not labels although they have that appearance now (Fig. 2). All but five had been cut out from a larger blotting paper, which presumably had been folded and in which the finished pressed plant was stored for the journey back from the West. The five other annotations were written on more conventional writing paper; why, we do not know. Of the 35 plant annotations by Lewis, 34 are in the Lewis and Clark Herbarium, and one, not associated with any specimens now known from the expedition and obtained from a private collector, is owned now by Gary Moulton (Moulton 1987).

The blotting paper is generally similar to one kind used in two bound volumes of plant specimens assembled by Benjamin Smith Barton in 1795, an exsiccata he called *Herbarium Americanum*. Today these volumes are in the care of the Academy's herbarium, having come from the American Philosophical Society in 1897 (Cutright 1969; Spamer and McCourt

2002b). One herbarium sheet (*Nicotiana quadrivalvis*, PH-LC 146) has two Lewis annotations (one each on blotting paper and writing paper), thus there are 33 discrete sheets that hold Lewis's field notes. We have not done a close comparison of these labels with the paper used in the original journals, or for that matter with paper used in correspondences sent back East from the field. By the circumstantial evidence of Frederick Pursh's labels as well as logical conjecture, many more Lewis annotations once existed.

Dates and Selective Survival of Lewis's Annotations

Dates for Lewis's surviving annotations range from 10 August 1804 to 14 September 1806, which spans nearly the entire duration of the expedition from St. Louis to the Pacific Ocean and back. The distribution of dates is far from uniform, however, with most of the annotations bearing dates in the autumn of 1804, with a few from 1805 and 1806. Because we do not know why all the other Lewis labels were destroyed or lost, the chronological clustering of surviving labels in the autumn of 1804 has no explanation other than the obvious one, that these were part of the first shipment sent back East from Fort Mandan. That shipment was forwarded by Thomas Jefferson to the American Philosophical Society, which redistributed its contents for study. Benjamin Smith Barton received the plants, and it is he who presented them to Frederick Pursh in 1807 when Pursh was hired to write up the taxonomy of the collection. Yet why the Lewis annotations survived preferentially with the Fort Mandan shipment, and not the remainder of the collections received by the A.P.S. in 1806, has not been explained. This is especially bewildering given that Pursh studied the entire collection in Philadelphia and it seems that most if not all of his own annotations, borrowing from Lewis's annotations, were prepared before he left Philadelphia (as we discuss later).

Those Lewis original annotations that did survive apparently benefited from the several decades of oversight and disuse in storage, after which they were cut out and mounted on the herbarium sheets along with the pressed plants. This may have been at the direction of Thomas Meehan, when plans were made for the mounting of loose specimens received from A.P.S. (thus between 1897 and Meehan's death in 1901), or in 1921, when Academy curator Francis W. Pennell supervised John M. Fogg, Jr. in the preparation of the Lewis and Clark herbarium sheets (Fogg 1982; Spamer and McCourt 2002b). In the Academy's herbarium, the intervening time between Meehan's death and Pennell's arrival at the Academy in 1920 seems to have been one of great activity in the curation of collections; for unexplained reasons, however, this work did not address the relatively few Lewis and Clark plants (Spamer and McCourt 2002b).

One Lewis label of blotting paper, no longer associated with plant specimens, is in the private collection of Gary Moulton (Moulton 1987); it may have been associated with one of the 30 plant specimens somehow lost in Philadelphia between 1805 and 1807 (Moulton 1999: 9, *n.* 7), thus also another survivor from the Fort Mandan shipment.

Yet another Lewis label, this one on writing paper, is associated with a fragmentary fossil fish jaw, the type specimen of *Saurocephalus lanciformis* Harlan 1824, which had been collected by expedition sergeant Patrick Gass. It, too, was a part of the Fort Mandan shipment. The specimen is in the Vertebrate Paleontology collection of the Academy (Spamer et al. 1995: 91-92; Spamer et al. 2000: 51, Fig. 4). The label, which had been affixed to the specimen by a small spot of glue on one end, became detached ca. 1990 and was misplaced, as reported by Spamer and McCourt (2002b: 34-35, *n.* 122).

The Mystery of the Blotting Papers and Lewis's Plant Press

Of the 34 Lewis annotations that are affixed to herbarium sheets, 30 are written on the same red-purple blotting papers between which the finished plant pressings seem to have been kept for their journey back East. Four other labels are written on light-colored writing paper. When Thomas Meehan rediscovered many of the plants at A.P.S. in 1897, they were still wrapped "in the original packages as presented many years ago" (Meehan 1898: 14). We have inferred (Spamer and McCourt 2002b) that these bundles were composed entirely of blotting papers, very likely folded in half, in which pressed plants were stored. Although it is common knowledge that Lewis wrote his annotations directly on these blotting papers, there are unanswered questions about where he got them and how he used them in the field. No written records survive from anyone affiliated with the expedition, nor from those who studied the specimens later, that could inform us specifically about the materials and methods used to press these plants in the field. Using the only evidence we have of this portion of Lewis and Clark's paper trail—the trimmed fragments of blotting papers written on by Lewis himself—we here address these questions to see how the collection's artifacts might provide some clues.

As meticulous as Lewis was in itemizing the supplies he purchased in Philadelphia and elsewhere before the expedition embarked in 1803, the crucial blotting papers seem to have been lumped under some larger, all-encompassing category. If Lewis followed his mentor's example, he may even have bought the blotting papers from Barton's supplier.

Lewis's annotations, now serving the purpose of labels pasted to the herbarium sheets, are wide enough for us to infer that they were written across a folded piece of blotting paper sized to fit a plant press. We have it on Meehan's (1898: 15) authority that, in their original state in A.P.S. in 1897, each of Lewis's annotations was "written wholly across the sheet containing the specimens." The fact that he noted, "containing," lends credence to the idea that the loose plant specimens were held within something, like a fold, rather than interleaved between loose, open sheets. This offers a clue toward how the sheets were used in the field, and what constraints Lewis had in pressing his specimens and protecting them for transport back East.

Keep in mind that storage space would have been at a premium during the expedition's laborious travels over thousands of miles in boats and canoes and on foot and horseback; any economy of size would have been beneficial, though not likely a deciding factor between one kind of blotting paper or another. Given the incredible amount of gear that the Lewis and Clark expedition carried even during the laborious overland passages, and given that the mission of exploration included collecting large numbers of bulky and unwieldy specimens and artifacts of all kinds (not to mention living animals!), we rather doubt that "ultralight" contraptions would have been designed and pressed into service solely for the botanical collections.

Close examinations of specimens throughout the herbarium (Spamer and McCourt 2002a) show clear evidence, not surprisingly, that some of them had been folded before being placed in the press. Barton's own *Herbarium Americanum*, the example of pressings that Lewis almost surely had seen when we was tutored by Barton, has reasonably small specimens on page sizes that are smaller (13 × 7¾ inches) than the more standard American herbarium sheets we are used to today (16½ × 11½ inches). Lewis, if he had been restrained to this model, would have had to fold many of his specimens, which he did; and his blotting papers would have been proportioned accordingly, which they were, as we show here.

We do not know the original manufacturing sizes of blotting papers used by Barton and Lewis. Blotting papers were probably manufactured at the same sizes, using the same kinds of frames, as were used for regular printing papers. This is important if we are to understand the economy of paper sizes and how they are cut down for use. Unlike some printing papers, though, blotting papers were probably cut to size by the manufacturer rather than the buyer; the papers would have been sold in bundles for specific purposes like letter-writing. But the needs of specialists like botanists may have impelled them to procure sheets that were larger than those usually stocked for use by writers. Here we hypothesize based on the traditional methods of manufacture and use of printing papers.

One likely unit of measurement for production-sized paper is the conventional unit of measurement, "folio," a size from which many printed works are produced. Regardless of the size of the finished work, most begin with a very large sheet. These single, large, unfolded papers (the so-called double-elephant folio sheet) are about 38 × 28 inches. Folded once, these produce the traditional "folio" pages of large-format books, about 28 × 19 inches; folded twice produces "quarto"-format pages, which for a book are gathered into signatures and their outside edges trimmed off; and so forth to ever greater numbers of pages printed on a single sheet for ever smaller formats.

If we assume that the blotting sheets that Barton used had been cut from a large sheet into four manageable pieces, doubling the dimensions of the blotting sheets in *Herbarium Americanum* yields an original sheet size of about 26 × 15½ inches, or reasonably similar to that of a folio sheet. Paper sizes were not standardized; variations were the result of materials and methods unique to a manufacturer at a given time. Yet for the sake of economy in manufacturing, large pages were all similarly large. Thus, smaller, folded pages would all be proportionately small, closely in agreement with the figures measured and estimated here.

Because we do not know from records the original sizes of blotting paper used either by Barton in Philadelphia or by Lewis in the field, we shall make some observations in the manner of a working hypothesis. We note that a folio-sized sheet as seems to have been used by Barton (about 26 × 15½ inches), folded in half, is about 16 × 13 inches. Thus, this 16 × 13-inch sheet could be cut in half to produce two sheets the size of those in *Herbarium Americanum*—or it could be folded in half to serve as a holder roughly 13 × 8 inches in size for plants pressed in the field (and upon which Lewis could write his annotations across the sheet). This helps to substantiate the supposition that Lewis had seen this unique exsiccata when he was tutored by Barton in 1803. If the folded sheet was the size of Lewis's blotting papers, his plant press was not much larger. A test of this hypothesis is still preserved in a sample of Lewis's own, folded large specimens, too large to have otherwise fit into the press.

Sheet PH-LC 3 is a specimen of the large-leafed maple, *Acer macrophyllum*. The leaf is folded inward from each side, presumably to have fit the dimensions of the plant press and storage container. PH-LC 3 was part of the A.P.S. component of plants that was mounted on modern herbarium sheets at the Academy in 1921, by which time it was too fragile to be unfolded. In this folded form, the leaf's "footprint" on the sheet is about 12 × 8 inches, within the one-fold blotting-paper storage sheet of our hypothetical original in Lewis's press—and the page size of *Herbarium Americanum*.

In comparison, sheet PH-LC 4, also *Acer macrophyllum*, is a specimen that was mounted fully extended. It occupies the width of the herbarium sheet, although the specimen's tips were trimmed off evenly with the sheet edges, perhaps at a later time. This specimen, like its counterpart in PH-LC 3, had been folded; the creases are visible. It was one of those taken to England by Pursh, the herbarium sheets for which were prepared soon after 1812. Just a few years after its gathering, the specimen was apparently still pliable enough to unfold it for mounting. Still, its original folds indicate that spatial economy was important when it was pressed.

Another example is shown by a single large leaf of *Veratrum californicum* (PH-LC 195), which measures 11½ × 5¾ inches. Not folded, this specimen clearly fit in Lewis's press.

A fourth example is expressed with the specimens of wild rice, *Zizania palustris*, on sheet PH-LC 226. Folded, each specimen occupies a "footprint" of about 10 × 6 inches, much smaller than the size of modern herbarium sheets but a comfortable fit within Barton's *Herbarium Americanum* model.

Ironically, historians do not know just how the finished, pressed plants were dried and carried by the expedition. Drying must have taken place in camp, when conditions favored it, probably by a fire. Oiled cloth was purchased in bulk when Lewis was obtaining expedition supplies in Philadelphia, which would have been used to create water-resistant wraps for all kinds of materials collected along the way that needed to be protected from the elements. It is a remarkable testament to Lewis's planning (and luck) that as much made it back East as did, and in fine condition.

William Clark's Copy of a Receipt (1806)

The single example of William Clark's hand in the Lewis and Clark Herbarium (Fig. 3) has nothing to do with plants. It is an unsigned copy of a receipt for wages paid by Lewis to Toussaint Charbonneau, the French fur-trapper who helped the members of the expedition communicate with the Native Americans they met. On the reverse of the receipt is a botanical annotation by Frederick Pursh, occupying a much smaller area than that covered by Clark's writing. This is one of the mysteries of the Lewis and Clark Herbarium. Perhaps Clark had "lost" the receipt amongst Lewis's pressed plants. When Pursh found the large piece of paper, blank on one side, he wrote his annotation on it but cast it aside later. (See more below about Pursh's labels.) The receipt was recovered when the herbarium sheet (now PH-LC 66) was prepared in 1921, and for some reason this document was pasted down—historic, non-botanical side up—to accompany the specimen for which Pursh had originally written his annotation. Perhaps this was because there was also a second tag from Pursh with the specimen, which provides better information.

Even though the Clark receipt is pasted to the herbarium sheet, the ink from Pursh's annotation bled through the paper. Pursh's writing can be read (in reverse) with close examination or more easily by placing the sheet on a light-table—or by reversing and enhancing a digital image of the herbarium sheet. The discarded annotation on the reverse of Clark's receipt reads, "*Specimen from White river Cleome A new species*". The second Pursh tag on the sheet updates the evaluation: "*Cleome Serrulata var rosea Nova Species.*" Pursh (1813) did indeed publish this name as the new species, *Cleome serrulata*.

We can only suppose that the receipt was affixed to the herbarium sheet as a historical relic. Or, we can just as easily opine that the receipt was pasted down in this fashion by mistake. The botanical annotation might have been intended to be cut out and dutifully pasted to the sheet with the other annotation—sacrificing its out-of-scope (non-botanical) "reverse" side!

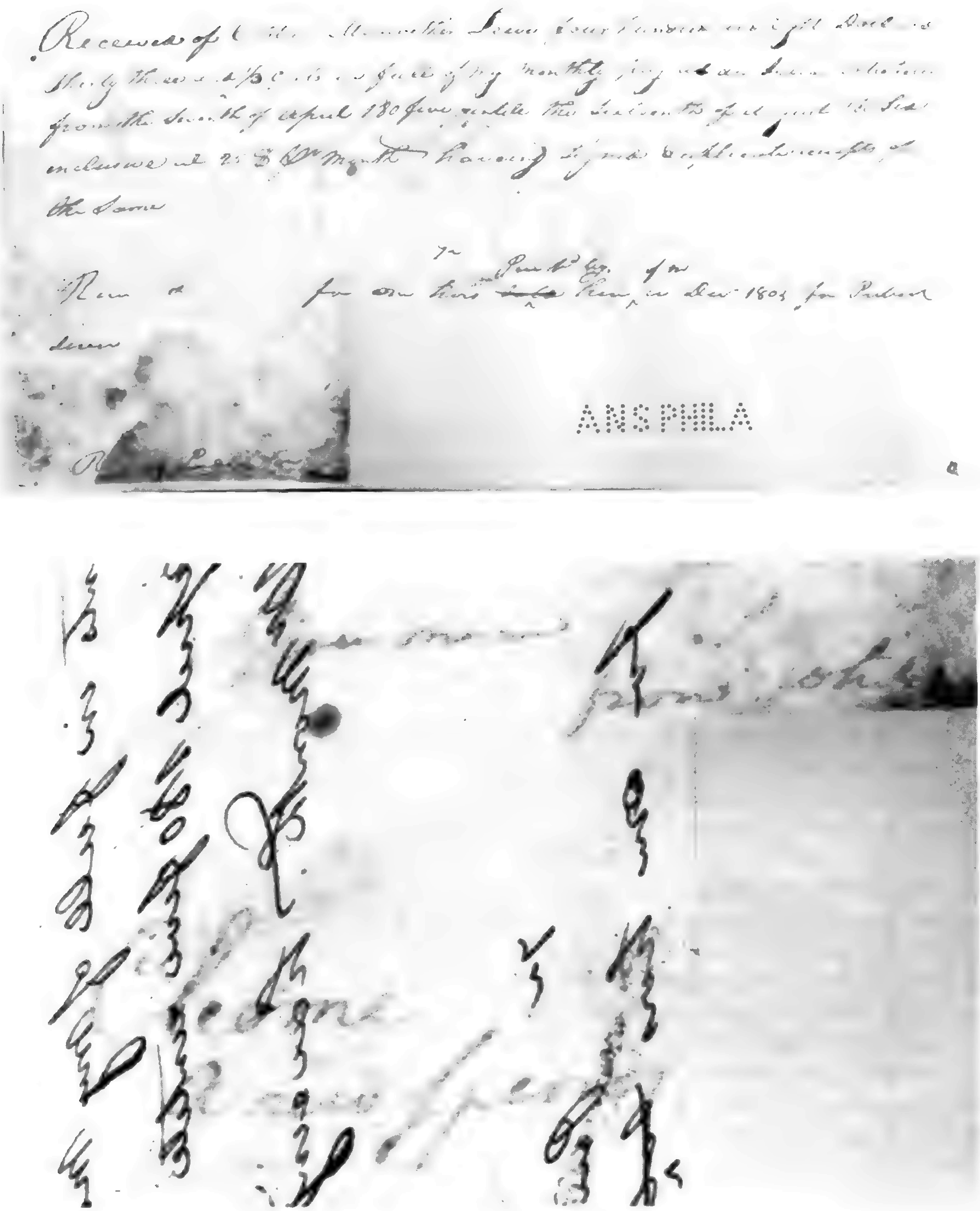

Figure 3. Copy of a receipt written by William Clark for Toussaint Charbonneau (*top*). On the reverse of this receipt, visible more faintly (*below*; image digitally reversed), is an annotation by Frederick Pursh associated with this specimen. (*Cleome serrulata* Pursh, PH-LC 66.)

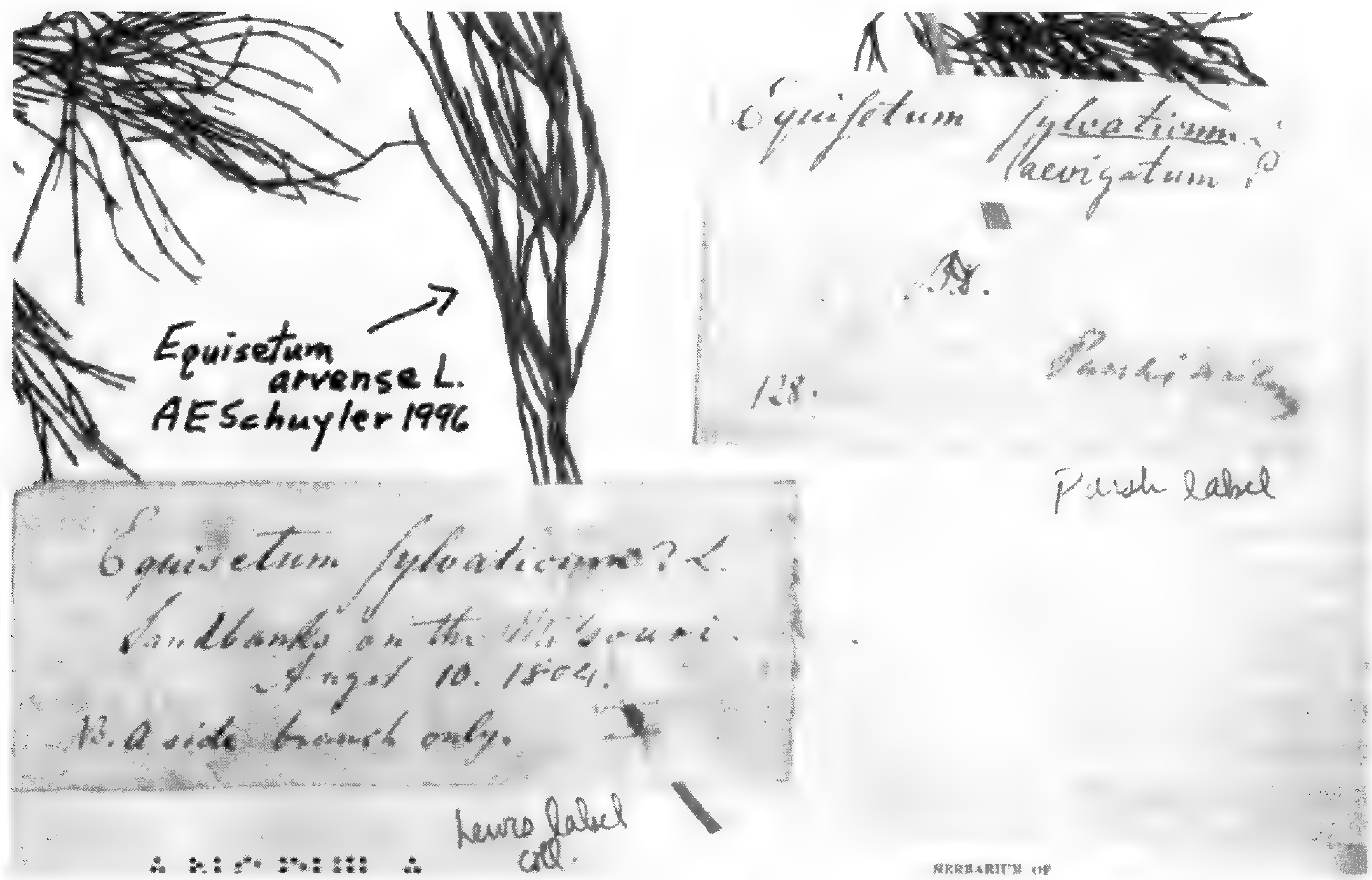

Figure 4. Tags by Frederick Pursh with plant stems passed through parallel slits. These are the only remaining examples in this collection of how Pursh attached tags to specimens. Thomas Meehan has annotated the upper right tag ("Pursh's writing"). His annotation under the lower tag reads "Lewis coll. label." Here Meehan may have erred in attributing the label to Lewis, or he might after all have recognized Pursh's labels as transcriptions of some of Lewis's collecting data. (*Equisetum arvense* L., PH-LC 80.)

Frederick Pursh's Labels (1807 and after)

When Frederick Pursh was assigned the task of identifying the botanical gatherings from the Lewis and Clark expedition, the intention was that these results would be compiled for publication in a volume of the scientific results of the expedition. Of course, that never came to be, and as we now know Pursh left Philadelphia, taking a quarter of the collection with him to London. His tags, however, are found throughout the expedition's gatherings, both in those left in Philadelphia and those he had taken to England. Of the latter group, his tags now are found in the Lambert Herbarium component of the Lewis and Clark Herbarium at the Academy and with the Lambert sheets that are at Kew. Thus it seems very likely that most if not all of the tags were written while he worked on the collection in Philadelphia.

Pursh's tags (Figs. 2, 4) seem to be transcriptions of the information that Lewis had written on the blotting papers in which the loose, pressed plants were returned to the East. This is corroborated by 27 sheets that preserve both Lewis's original annotations and Pursh's labels (seven sheets bear Lewis labels without Pursh counterparts). Pursh was rather faithful to Lewis's original text, as we see in these examples, although he did take some editorial liberties, such as correcting Lewis's inconsistent spelling, or omitting "superfluous," non-scientific observations like some ethnobotanical uses. Fortunately, he was not consistent in such omissions, and some important data survive. In once instance, Pursh even corrected the year of the date of collection, which in context was obvious to him.

Lewis's field notations are written across a broader area than that used by Pursh in his tags; that is most likely because Lewis had a folded sheet of blotting paper upon which to write whereas Pursh was creating tags to be physically affixed to the specimens—tags which, incidentally, would have more legible penmanship than that of Lewis's. In other words, Pursh was curating the collection. His tags would be attached to a stem, usually by cutting two parallel slits in the paper through which the stem would be interleaved to make it more difficult to disassociate the tag from the specimen. The tags were removed prior to mounting in most cases, although two specimens still bear the tag affixed to the stem (Fig. 4). So affixing labels is good curatorial practice for storage, and the procedure can also be seen as preparing them to travel without losing their data.

Of course, the principal reason for having created these tags was to apply taxonomic identifications to the loose specimens, which Lewis, not being formally trained in botany, could not have made. This fact by itself led Thomas Meehan to think at first that these were the original field labels. On 17 August 1897, he wrote in a letter to Gray Herbarium's Benjamin L. Robinson (Gray Herbarium Archives), "The writer in many cases knew something of botany, and the letters were German. I thought they must have had a German botanist with them. Before I got through I was sure the labels were by Pursh! But where did he get the notes!" Meehan meticulously identified every existing label he found ("Lewis" or "Pursh" written in pencil). Somehow, he apparently never did come to the conclusion—so far as we can tell—that each of Pursh's notes was actually a transcription of Lewis's annotation, with the logical inference that Pursh had probably discarded most of Lewis's originals (but see also Fig. 4).

Nearly every sheet in the Lewis and Clark Herbarium contains a Frederick Pursh tag; just 12 sheets do not. Thirteen sheets contain two Pursh tags, and one sheet has three, yielding a total of 225 Pursh labels in the collection. (Of the ten sheets at Kew, all contain tags written by Pursh.) If nothing else, this is adequate testimony that Pursh did carefully study the whole collection.

Aylmer Lambert's Annotations (after 1812)

Provenance data for the plants mounted on herbarium sheets in Aylmer Lambert's collections were written on the reverse side of the sheets (Fig. 5), a custom then used by the British Museum. Lambert indicated on most sheets, "Herb. Lewis & Clark N. America Fred. Pursh," or some similar indication. Many of these verso annotations were later cut off—when and by whom are not known—and pasted onto the fronts of their respective sheets. In some instances, cutting them out would have interfered with another label or the specimen on the front of the sheet, so only part of the annotation was cut out and transferred to the front.

Figure 5. Portion of herbarium sheet bearing Aylmer Lambert's handwriting. Lambert annotated Lewis and Clark specimen sheets on the verso of the top edge. Later, someone cut out some of these annotations and pasted them to the front of the respective sheets. (*Ericameria nauseosa* [Pall. ex Pursh] G. L. Nesom & Baird var. *graveolens* [Nutt.] Reveal & Schuyler, PH-LC 52.)

The purpose was obvious—to place the provenance data on the front of the sheet with the rest of the annotations, although in the process this aesthetically damaged the sheets, sometimes very unsightfully so. Spamer and McCourt (2002a) for the first time illustrated all of the verso annotations.

Academy of Natural Sciences of Philadelphia Ownership Labels (Mid-nineteenth Century)

As might be expected in any large museum collection, many kinds of official labels will reflect design changes and other peculiar needs over time. Among the Lewis and Clark herbarium sheets are those that had been a part of the Lambert Herbarium, which were given to the Academy by Edward Tuckerman in 1856. All of these have Academy herbarium labels of a design from the mid-nineteenth century (Fig. 6). They are not especially remarkable and the handwriting on them has not been attributed, so far as we know.

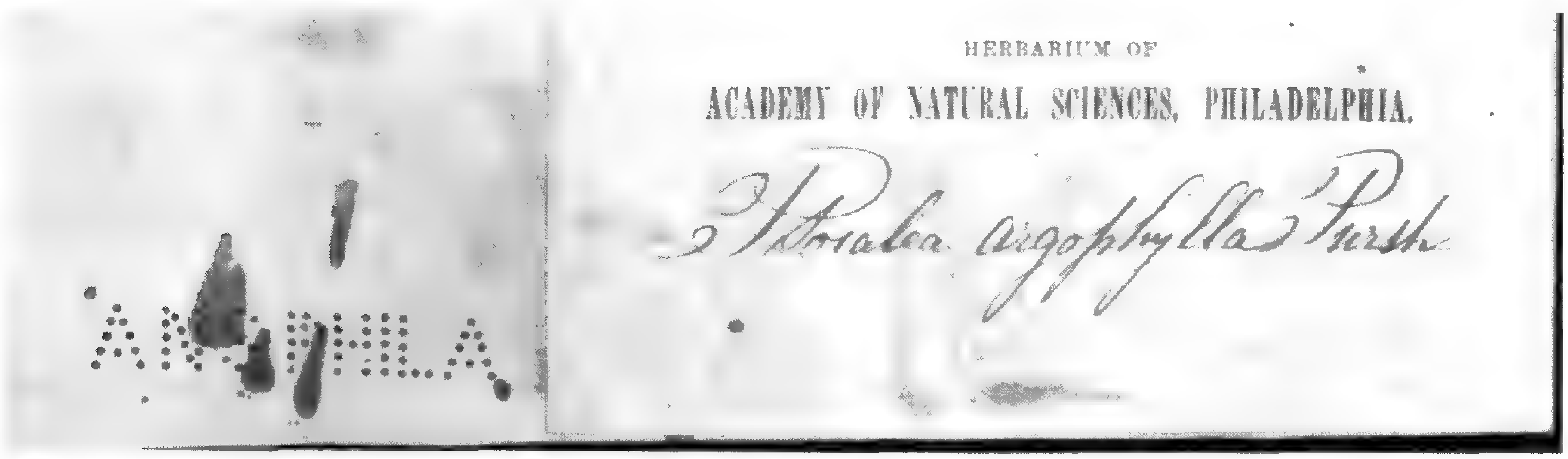

Figure 6. Label of "Herbarium of Academy of Natural Sciences, Philadelphia." These labels were attached to the Lambert specimens that had been bought by Edward Tuckerman. The "ANS PHILA" punch, seen here and in Figs. 3a and 7, is a twentieth century collection identification stamp applied to all of the Academy's herbarium sheets. (*Pediomelum argophyllum* [Pursh] J. W. Grimes, PH-LC 157.)

Thomas Meehan's Labels (1897)

When Thomas Meehan went to see if the American Philosophical Society retained any of Frederick Pursh's study material, first in 1896, he was looking for Lewis and Clark's plants as well as the lode of Pursh's reference specimens. Once he found Lewis and Clark's gatherings among the bundles he saw the opportunity to study the whole collection for the first time in nearly 90 years. They had last been used by Pursh while he was in Philadelphia and the information from them was included in his 1813 *Flora*. Meehan, in correspondence with B. L. Robinson of the Gray Herbarium, mentioned that even as an A.P.S. member he had to be assertive in order to get permission to hunt for Pursh's flora (see Spamer and McCourt 2002b). After Meehan made his find, some tumultuous bureaucratic and procedural entanglements ensued between the administrations of the Academy and A.P.S. Meehan received permission to send the specimens whose identities were not clear to him to Harvard for proper identification; but he decided, seemingly in a fit both of professional despair and bureaucratic defiance, that he was not sure of any of them and sent the whole lot to Massachusetts, where Robinson and Greenman passed their pronouncements on some of the materials, including the historical, insect-eaten fragments.

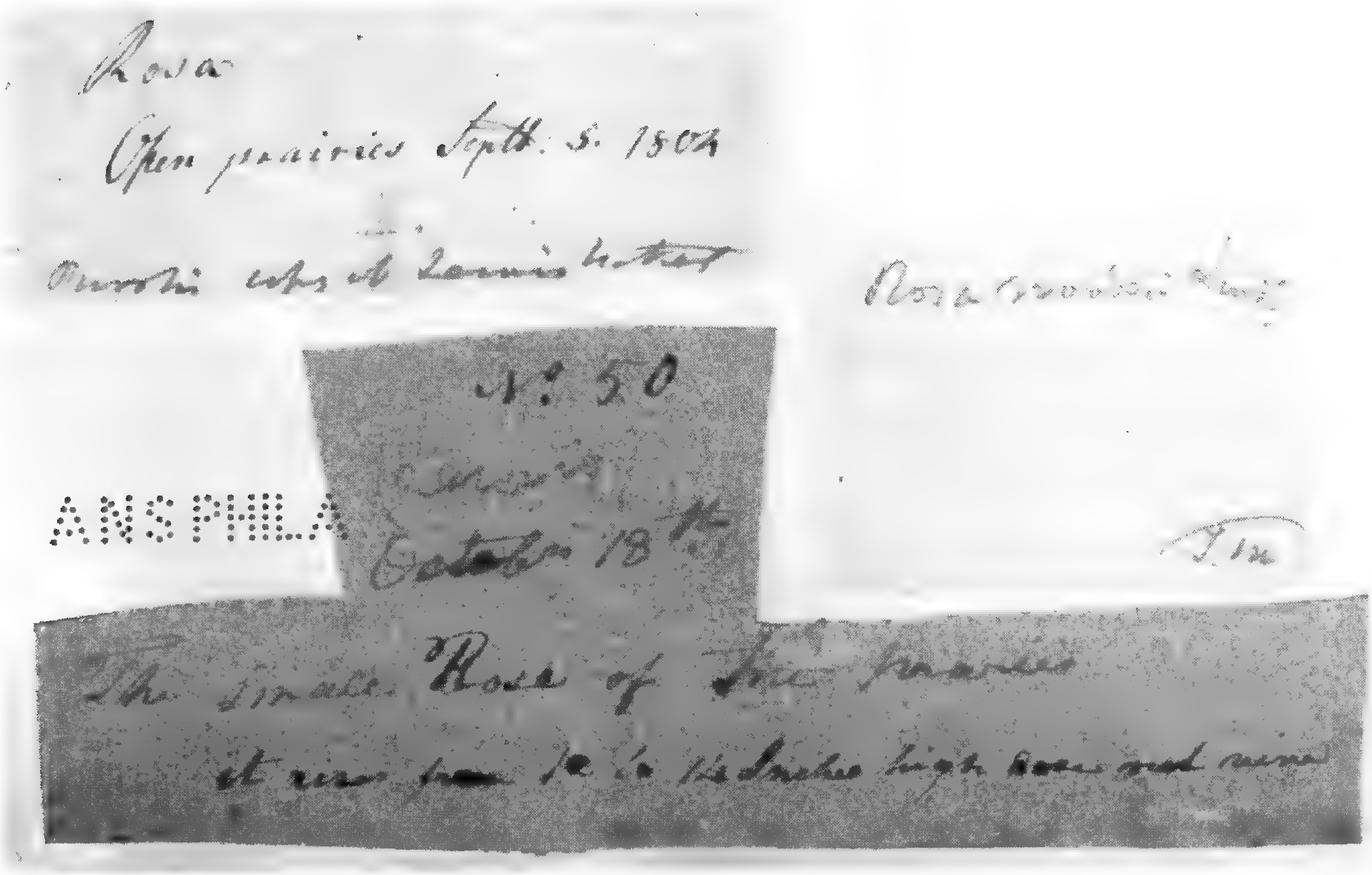

Figure 7. Tag by Thomas Meehan (*right*, initialed "T.M"), confirming species identification. Also visible in this photograph are a Meriwether Lewis label (*lower*, dark), Pursh transcription (*upper left*, light-colored), and perforated initials of the Academy of Natural Sciences Herbarium. (*Rosa arkansana* Porter, PH-LC 195.)

The entire collection was studied and Meehan finished an updated taxonomy for them between August and November 1897—rather short order for such a large and important collection (see Spamer and McCourt 2002b). Meehan's annotations occur as hastily written notes in pencil on small slips of common paper (Fig. 7); there are 144 of them pasted now to 139 herbarium sheets. These are his own identifications as well as those of the Harvard botanists; almost every one of these tags is signed distinctively, "T.M" (with one period). Possibly, Meehan wrote on larger sheets that were laid in with the appropriate specimens and later his annotations were cut out when the herbarium sheets were prepared. This helps corroborate the story that the A.P.S. sheets were prepared in 1921 because Meehan also annotated 26 of the herbarium sheets that had come from the Lambert Herbarium by writing directly on the herbarium sheet. Had sheets already existed for the A.P.S. specimens, surely he would have annotated them directly.

In addition to his tags noting "all eaten" or "all gone," Meehan also wrote notes next to Lewis's annotations on the blotting sheets, most often simply corroborating the identity of the writer, "Lewis." Whoever it was that drew outlines in pen around Lewis's handwriting on the larger blotting papers also was careful to draw around Meehan's adjacent handwriting (Spamer and McCourt 2002a,b; see Fig. 7, where portions of the outline can be seen along the cut edges). Meehan, as part of curatorial projects to mount loose specimens, may have outlined everything himself some time after having annotated the labels in pencil but we believe it is more likely that the Lewis–Meehan annotations were delineated by Academy curator Francis W. Pennell, who supervised John M. Fogg, Jr. in the mounting of A.P.S.'s

Lewis and Clark plants in 1921. Elsewhere we have discussed in more detail the points regarding curation of the collection (Spamer and McCourt 2002b).

J. M. Greenman's Labels (1897)

When Thomas Meehan in his bureaucratic snit sent the entire A.P.S. component of the Lewis and Clark herbarium off to Harvard University in 1897, he was soliciting help in confirming or identifying the taxa represented by what sometimes were mere twigs and leaf fragments. J. M. Greenman replied with a number of identifications—62 of his tags are preserved on 58 of the sheets (Fig. 8). All of them accompany specimens that had been found at A.P.S., another indication that Meehan had not sent away any of the Lambert Herbarium sheets then known to him. In fact, although he mentions the Lambert specimens (expressing ignorance of how they arrived at PH), he does not include them in his table comparing the Pursh material with published comments from Pursh's *Flora* (Meehan 1898). This suggests that Meehan found the Lambert specimens in PH after sending the Pursh find from A.P.S. to the Harvard botanists.

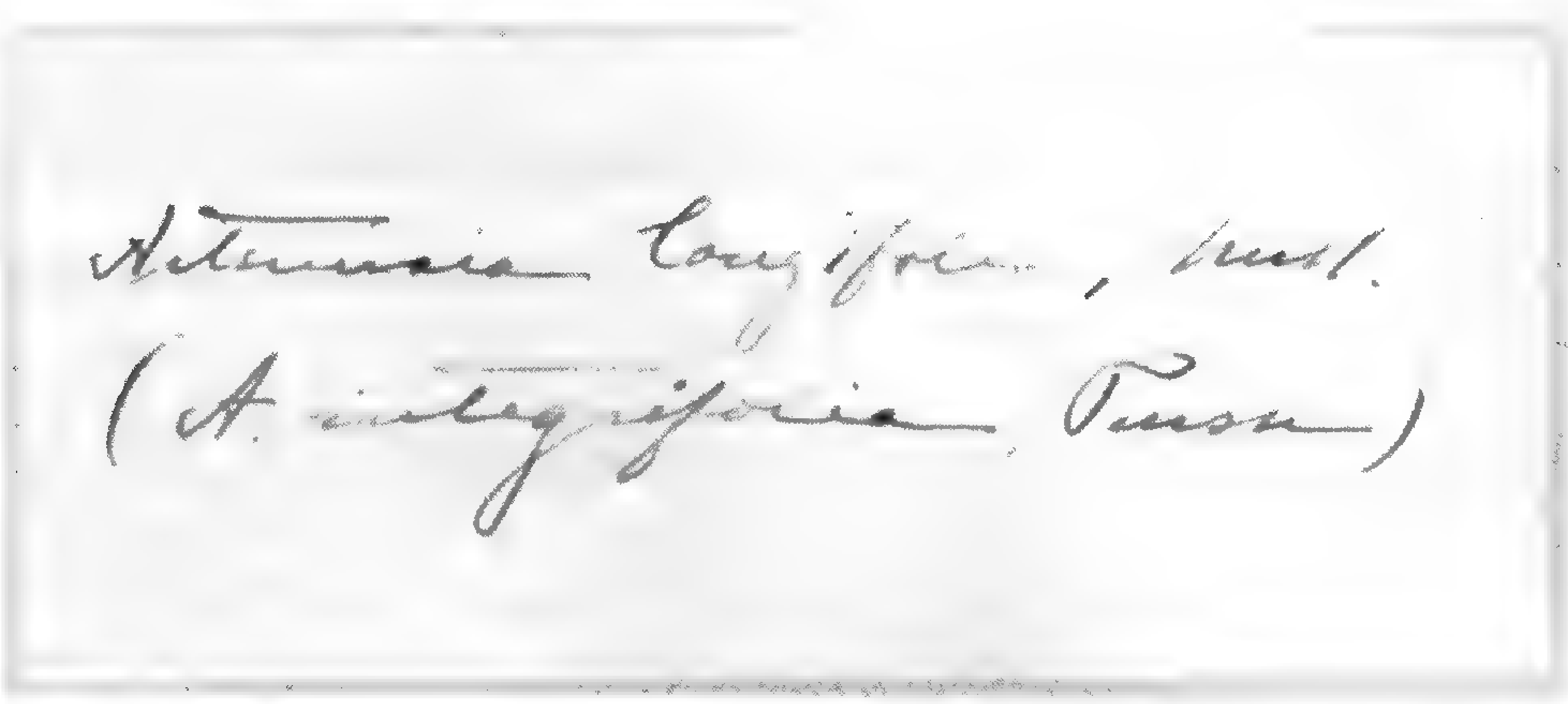

Figure 8. Tag by Jesse M. Greenman with his species identification. (*Artemisia longifolia* Nutt., PH-LC 27.)

American Philosophical Society Ownership Labels (1897?)

All of the herbarium sheets that were prepared from the specimens found in 1897 at A.P.S. hold printed labels with the banner, "American Philosophical Society. Lewis & Clark, Herbarium. From the Atlantic to the Pacific." The ownership labels (Fig. 9) are very unlike other labels in the Academy's collections, even for the thousands of other sheets that at one time had belonged to A.P.S., which have Academy labels with handwritten provenance data crediting A.P.S. So it is reasonable to assume that the "Atlantic to the Pacific" labels were printed at the behest of (or by) A.P.S., specifically as a condition of the deposit, documenting the ownership of these very important plants. Each of these labels has been placed in the lower right corner of the sheets from the A.P.S. component of the Lewis and Clark Herbarium, a style so systematic that it clearly demonstrates that the labels were present when the sheets were prepared; they were not added to preexisting sheets.

Although the A.P.S. ownership labels contain printed lines for "Locality," "No.", and "Date," almost none of the 179 labels have these data filled out. Most labels contain only the

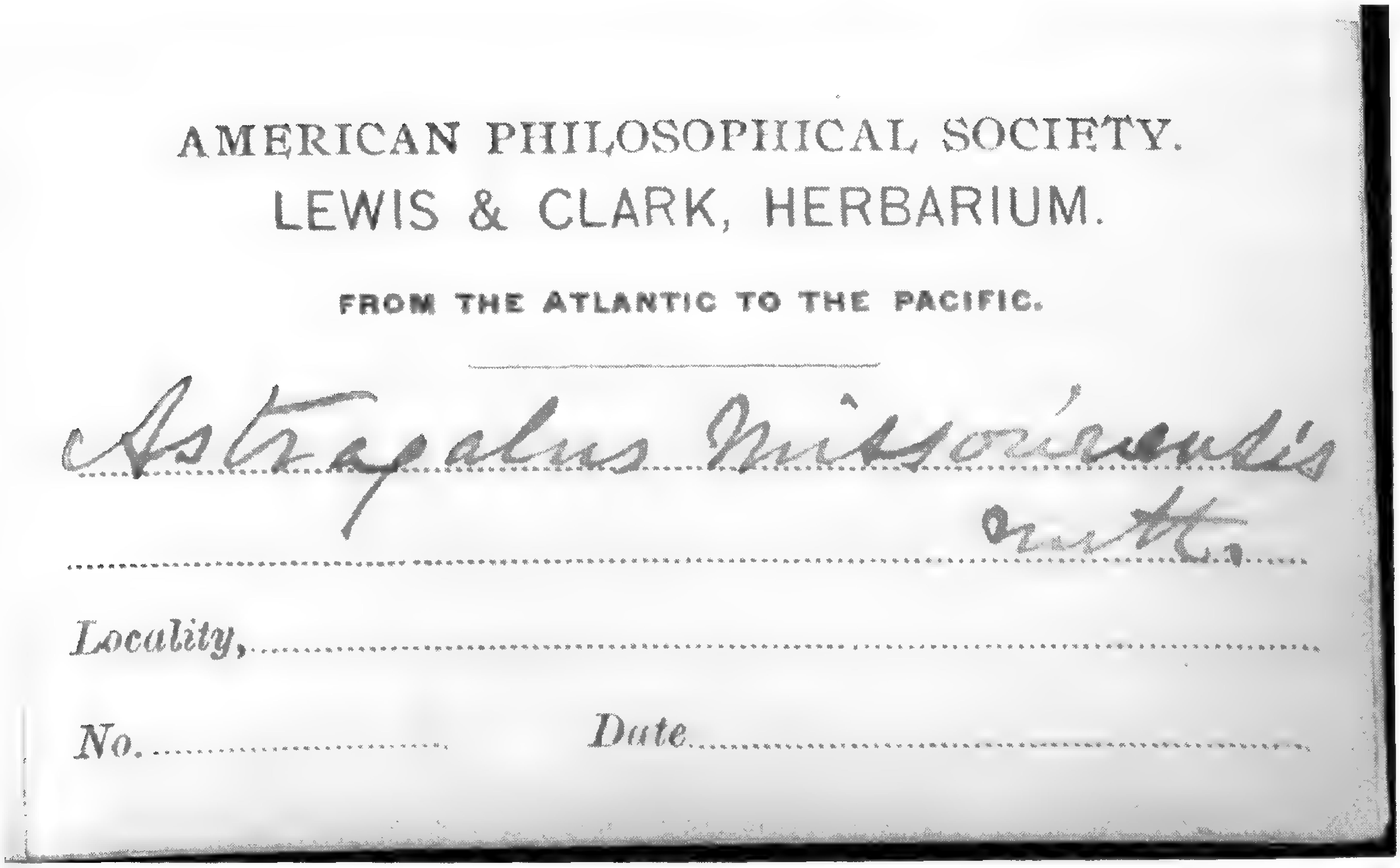

Figure 9. Label identifying specimen belonging to American Philosophical Society, with species name written by Thomas Meehan. (*Astragalus missouriensis* Nutt., PH-LC 33.)

taxonomic identifications, and on the few labels where the geographic data have been added the handwriting is different from that of the person who wrote the taxonomic identifications. Until now, no one seems to have mentioned whose hand this is for the taxonomic data. We have compared the handwriting to Thomas Meehan's and believe it is his handwriting. This effectively dates when the labels were printed to between 1897 and 1901. Notably, this was when a great number of unprocessed botanical collections were being curated in the Academy's botany department (see Spamer and McCourt 2002b). However, many jobs were interrupted by Meehan's death in 1901, including, it seems, the mounting of A.P.S.'s Lewis and Clark plants. We do not know who added the few annotations of geographic data or when this was done.

As for the labels indicating "From the Atlantic to the Pacific," this is a generalization of the historical origins of the expedition on the eastern seaboard, perhaps also to specifically acknowledge A.P.S.'s role in establishing the collection. The easternmost specimens in the herbarium were collected in Missouri. Inasmuch as the Delaware and Schuylkill Rivers in Philadelphia are tidewaters of the Atlantic Ocean, the notation of "Atlantic" may be defended as literary, if not geographical, license.

Twentieth- and Twenty-first-century Labels and Annotations

As with any working collection of botanical specimens, a herbarium sheet continues to accrue labels and annotations. They reflect taxonomic revision, changes of information associated with the specimens on the sheet, or comments about work performed with the specimens or the herbarium sheet itself. In every respect they indicate (in the parlance of the explorers' journals) how science and history have "proceeded on" in the study and use of the

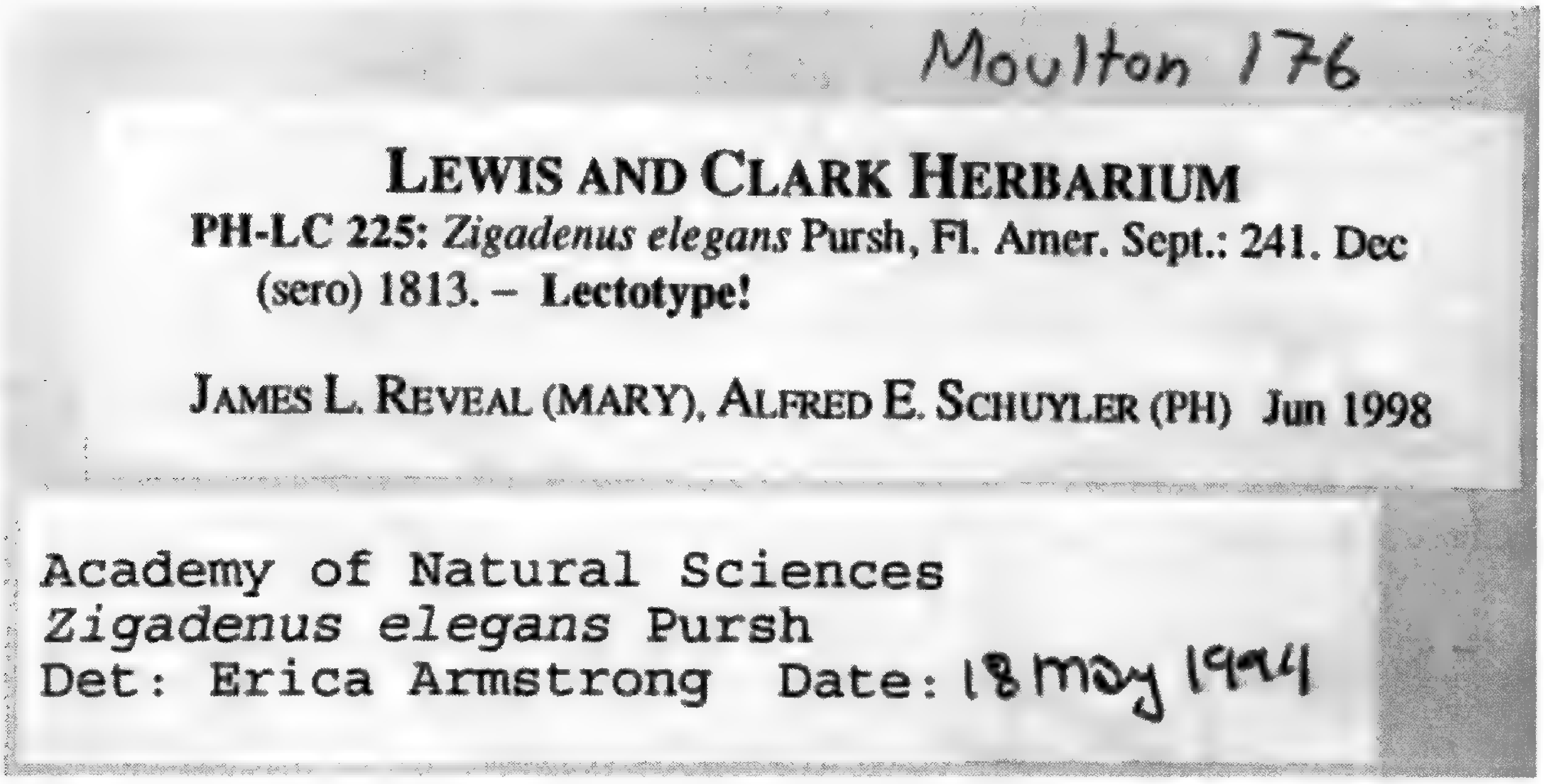

Figure 10. Annotations of three late-twentieth-century researchers. (*Lower*) label of Academy of Natural Sciences of Philadelphia intern Erica Armstrong; (*middle*) label of Reveal et al. (1999); (*upper*) annotation of Earle E. Spamer indicating photographic plate number in Moulton (1999). (*Zigadenus elegans* Pursh, PH-LC 225.)

collections. Numerous sheets contain the usual taxonomic chatter of botanists who confirm or contradict previous identifications or who make comments on typification or the reliability of putative geographic data that accompany the specimens. These all are typical kinds of annotations found in herbaria everywhere. Every label and annotation on the Lewis and Clark Herbarium sheets has been transcribed, and their writers identified, by Moulton (1999: 13-55).

Unfortunately, some annotations were made with archivally unsuitable materials, such as ballpoint pen, which over time will bear watching in a historically important collection such as this. One peculiar mark requires an explanation. On every sheet, there is a small green dot; they seem to have been drawn with a felt- or other soft-tipped pen. These were marked during a project around 1980 that photographed the Academy's entire Type Collection and other special collections of flowering plants and ferns. The green dots were the photographer's key to assure that all herbarium sheets were photographed. These photographs were reproduced on microfiche, with a large, folio volume that served as an introduction and index (Mears 1984). The set of hundreds of 60-frame fiche of negative images was available commercially. The Academy's Archives holds a set of these fiche; and interestingly, the image subset for the Lewis and Clark Herbarium is a "sample copy" of positive images.

Unique to the Lewis and Clark Herbarium are labels and annotations that relate to specialized work done with these sheets, either by Academy curatorial staff or by conservationists and visiting researchers. Rather noticeable throughout the herbarium are laser-printed labels in a Courier font by Erica Armstrong (Fig. 10); they appear on 174 sheets. Armstrong was an intern in the Academy's Department of Botany who in 1993 and 1994 worked on a project to update the taxonomy of the Lewis and Clark plants. Only those sheets that had not been recently studied by a taxonomic botanist were updated; thus her annotations do not appear on every sheet.

In 1997, Mark A. Teece, then of the Carnegie Institution of Washington's Geophysical Laboratory, inquired to the Botany Department about the utility and likelihood of the Lewis

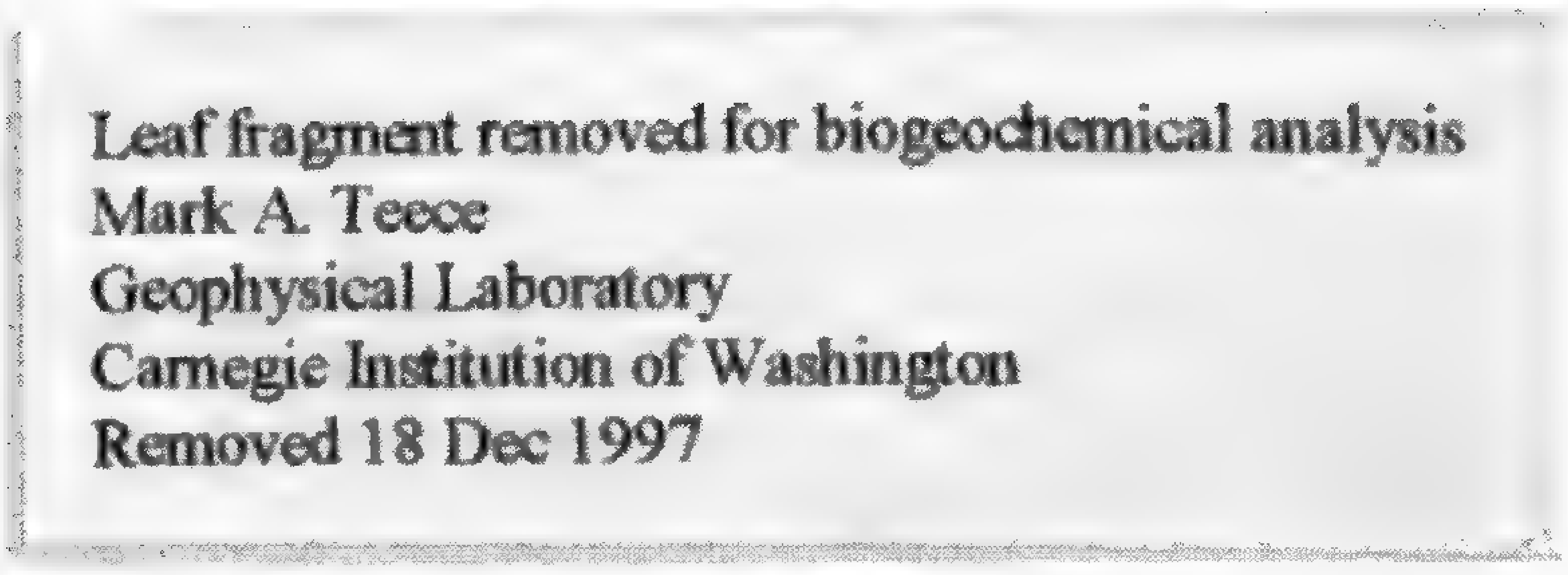
Leaf fragment removed for biogeochemical analysis
Mark A. Teece
Geophysical Laboratory
Carnegie Institution of Washington
Removed 18 Dec 1997

Figure 11. Label of Mark A. Teece indicating samples taken for biogeochemical analysis. (*Zizania palustris* L., PH-LC 226.)

and Clark plants being available for biogeochemical analysis (Teece et al. 2002). His research relates to carbon-based fatty acid and stable-isotope compositions of leaf tissues. Specimens in older collections that are accompanied by well-documented date and locality information can be used toward interpreting regional atmospheric chemistry, which can be applied to studies on larger geographic scales. Since many old collections lack the precision of date and locality among their specimens, they are not suitable for these analyses. The Lewis and Clark Herbarium, however, is unusual in this regard. Historians have very well documented the daily locations of the Lewis and Clark expedition from 1803 to 1806. The fact that Lewis dated almost all of his botanical gatherings thus allows us to locate with geographic and temporal precision the provenance of each specimen, which is precisely the kind of resolution required in Teece's work. Because the Lewis and Clark Herbarium predates the Industrial Revolution, which instigated dramatic changes in the chemistry of the world atmosphere, this herbarium has the potential to provide information on the atmospheric chemistry of the American Northwest from a time before the introduction of gases of factory effluents and internal combustion engines.

Teece did obtain the permission necessary to sample some specimens in the Lewis and Clark Herbarium. Some of the results of the analyses were published by Teece et al. (2002). At the time when the samples were taken from the sheets, on 18 December 1997, labels documenting the act were affixed to each sheet so sampled (Fig. 11). Eleven sheets were sampled. The size of each sample was not large, approximately a centimeter square, and care was taken that the sampling did not take proportionally too much of the specimen nor that it aesthetically damaged the specimen. Normally, aesthetics is not a concern in sampling a herbarium sheet but given that this collection is a public treasure of immense historical importance, it is accorded this special criterion. The selection and sampling process was documented by Teece et al. (2002).

In 1999, Reveal et al. published the first comprehensive taxonomic review of the Lewis and Clark Herbarium in a century. Their review assigned a "PH-LC" number, an acronym indicating the Lewis and Clark Herbarium in the Academy of Natural Sciences Herbarium, which is housed in the Types and Special Collections room of PH. As a result of that publication, every sheet bears the authors' printed labels indicating the PH-LC number; most up-to-date name for each specimen sheet; author, publication, and date for the name; type status (lectotype, duplicate, etc.); and the names of the determiners, J. L. Reveal and A. E. Schuyler (see in Fig. 10). These labels were printed on 100% rag bond, acid-free paper using a laser printer. A Reveal and Schuyler label appears on every sheet in the Lewis and Clark Herbarium, including the seaweed, moss, and liverwort sheets not included in their review (Reveal et al. 1999) but included in Spamer and McCourt's (2002a) CD-ROM (see below).

In 1999, the Academy of Natural Sciences was awarded a grant from the Save America's Treasures program administered by the Institute for Museum and Library Services and the

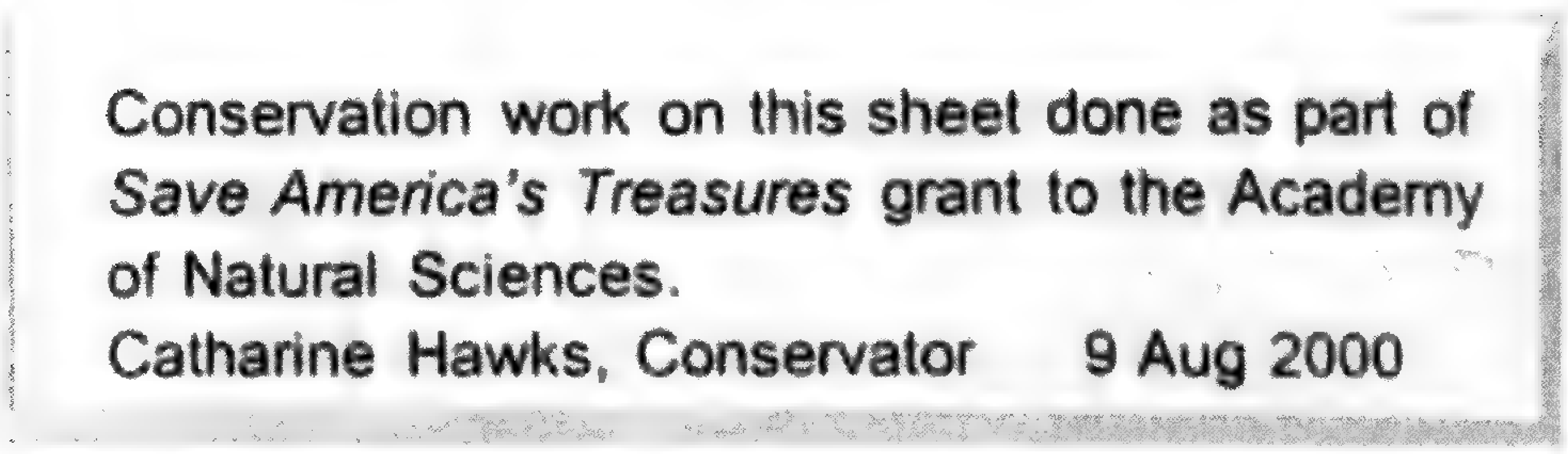
Conservation work on this sheet done as part of
Save America's Treasures grant to the Academy
of Natural Sciences.
Catharine Hawks, Conservator 9 Aug 2000

Figure 12. Label of Catharine Hawks indicating conservation work performed under the auspices of the Save America's Treasures program. (*Atriplex nuttallii* S. Watson, PH-LC 34.)

U.S. Department of the Interior, National Park Service. Matching funds from private-sector sources were received from the Lattner Foundation and The Bay Foundation, Inc. The purpose of the grant was to re-house the entire Lewis and Clark Herbarium in new, archivally long-lasting housings, stored in new cabinetry in a climate-controlled room designed specifically for it. Sheets and specimens requiring special conservation measures were evaluated and the work performed by conservator Catharine A. Hawks. For the 31 sheets so affected, dated labels were affixed to document the acts (Fig. 12). In addition, the special containers, modified from an original design first funded by the National Geographic Society in 1998, were constructed to hold each sheet within a separate stiff, closable holder. These holders also are used to display the specimens when needed, thus greatly reducing the amount of handling of the specimens while leaving them easily available for botanical and historical researchers. For a description and documentation of the conservation program, see McCourt et al. (2002).

When one of us (Spamer) was Collection Manager in the Academy's botany department, he made digital images of the entire Lewis and Clark Herbarium between 1999 and 2001. This was for the purpose of conservational documentation of the plant specimens. Rather than imaging whole sheets, each specimen on every sheet and sometimes specimen groups were digitized with an accompanying scale for size comparison. The images were recorded in grayscale format rather than color, and usually at a resolution of 300 dpi, to conserve the disk space necessary to store the more than 500 images (e.g., Fig. 13). Only a couple of specimens that retain relict coloration were imaged in color. This collection of digital images was later used to produce a CD-ROM study set for the Lewis and Clark Herbarium (Spamer and McCourt 2002a), which is in part an illustrated edition of the taxonomic revision of the herbarium made by Reveal et al. (1999). In the process of creating the digital images, Spamer also annotated the reverse of the herbarium sheets as a means to keep track of the images in an unobtrusive manner. These annotations (Fig. 14) have no significance to the history or taxonomy of the specimens; they were a matter of temporary record-keeping only. Spamer annotated the front of every sheet, as close as possible to the PH-LC label, to reference the sheet's corresponding plate number as published by Moulton (1999; Fig. 10).

Finally, in 2000, whole-sheet, high-density, color digital images of the entire Lewis and Clark Herbarium were made by intern Sarah Rice. The TIFF-format images, prepared under controlled lighting, presently occupy 27 CD-ROM disks (about 15 GB total). A copy of this set is in the Archives of the Academy of Natural Sciences. Migration to newer media will significantly reduce the physical storage space required, and eventually the entire image collection should be made available on a single disk or other storage medium. Copies on DVD were also stored in the Department of Botany. In 2003, McCourt prepared medium-resolution JPEG-format images of the full sheets, which can be used in more widely focused

Figure 13. Black and white digital scan of specimen from CD-ROM on the Lewis and Clark Herbarium, with ruler for scale (Spamer and McCourt 2002a). Visible are portions of tags by Meehan (*left*) and Pursh (*below*). (*Fritillaria pudica* (Pursh) Spreng., PH-LC 95.)

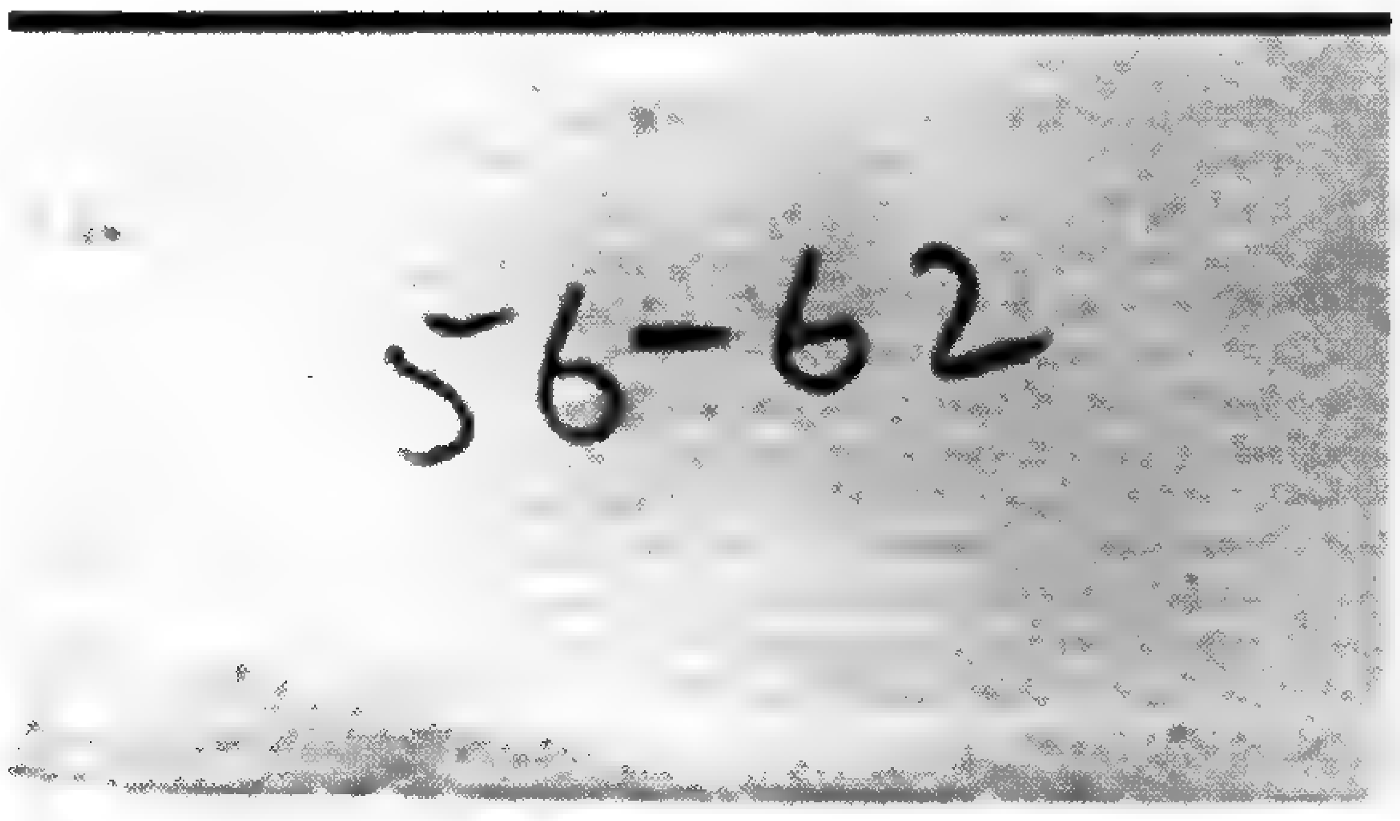

Figure 14. Code number on reverse of herbarium sheet added by Spamer during digital imaging of the Lewis and Clark Herbarium (Spamer and McCourt 2002a). (*Berberis nervosa* Pursh, PH-LC 39.)

public venues such as web sites and future technologies when they become available. These digital images were made possible by the Academy's Albert M. Greenfield Center for Digital Imaging of Collections and a grant from the Save America's Treasures program of the National Park Service.

Proceeding On Along the Paper Trail

The history to be gleaned from the paper trail of Lewis and Clark is not complete. The labels offer data for testing historical hypotheses such as those proposed above. Each label and annotation attached at a particular date become traits of the specimen and contain unique information—some of which its author intended and some he or she did not. For example, the 34 Lewis labels are found only on specimens that remained in Philadelphia at the American Philosophical Society; none is found on the specimens Pursh took to London. This falsifies the hypothesis that surviving Lewis labels are remnants of a random process. But the finding begs further questions. Why did only 34 Lewis labels survive with the plants? Why this particular set of 34? And what of the 35th plant label, now owned by Gary Moulton, which may have been associated with the so-called "missing 30 plants" that were lost between 1805 and 1807? The labels are the desiderata of the plant collections in which to search for patterns that can lead to new insights into the botany of Lewis and Clark. Clearly, much remains to be learned from the paper trail of the Lewis and Clark Herbarium.

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Effect of Herbivore Exclosure Caging on the Invasive Plant *Aliaria petiolata* in Three Southeastern New York Forests

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ABSTRACT. We examined effects of herbivore exclosures on non-native *Alliaria petiolata* (Bieb.) Cavara and Grande, and on the native herb layer, to determine if selective herbivory by mammals (particularly white-tailed deer) may facilitate *A. petiolata* invasion. The study was done from 1996 to 2000, in one urban forest without deer (New York Botanical Garden Forest), and two suburban forests (Kitchawan Preserve and Mt. Holly Sanctuary), both in a region with > 50 deer km^{-2}. Each forest had four pairs of 4-m^2 plots, with one of each pair caged to exclude deer. No significant differences developed in percent cover of native plants between uncaged and caged plots. At Mt. Holly, *A. petiolata* cover in caged plots averaged nearly twice its cover in uncaged plots, with a similar trend at Kitchawan but not at NYBG. Individual *A. petiolata* size in caged plots at Mt. Holly averaged more than three times that in uncaged plots. Herbivory on *A. petiolata* was 30 to 40 times more frequent in uncaged plots in both forests with deer, but only one plant showed herbivory at NYBG. We attribute *A. petiolata* cover and size differences between caged and uncaged plots to deer herbivory, noting that Mt. Holly appeared most heavily browsed. We suggest that interactions between deer and invasive species could change as densities of both increase, and that these interactions should be considered in forest management.

INTRODUCTION

Alliaria petiolata (Bieb.) Cavara and Grande (Brassicaceae), commonly known as garlic mustard, is one of the most important non-native herbaceous plants threatening native woodland plants in eastern deciduous forests of North America (McCarthy 1997; Nuzzo 1993a; Schwartz and Heim 1996; Yost et al. 1991). In southeastern New York, where this study was done, *A. petiolata* is a biennial, with germination and growth of a basal rosette of leaves in the first spring and summer, persistent foliage and some new growth throughout the winter, followed by further growth, flowering, and fruiting the subsequent spring and summer. It grows under closed forest canopy and along forest edges, and exhibits wide ecological amplitude for light levels and soil moisture, which may be due to high phenotypic plasticity (Byers and Quinn 1998; J. A. Morrison, unpublished data). *Alliaria petiolata* has been a component of the North American flora at least since it was first recorded on Long Island in 1868, and it has spread exponentially since then. It is now found throughout 30 northeastern states and southeastern Canada (Cavers et al. 1979; Nuzzo 1993b). It can spread

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rapidly once introduced to a site, with apparent displacement of native herbaceous species within ten years (Anderson et al. 1996, Nuzzo 1994).

Researchers focus mostly on attributes of the plant itself to understand why *A. petiolata* is invasive. Its high reproductive capacity, autogamy, and competitive ability, for example, have been addressed by various studies (Anderson et al. 1996; Baskin and Baskin 1992; Byers and Quinn 1998; Cavers et al. 1979; Cruden et al. 1996; McCarthy 1997; McCarthy and Hanson 1998; Nuzzo 1991, 1993a; Nuzzo et al. 1991; Yost et al. 1991). Underlying ecological changes that may promote its spread have received little attention, however, even though there is growing recognition of the need for broader ecosystem understanding for management of plant invasions (Hobbs and Humphries 1995).

One ecological factor that may be important in *A. petiolata* invasion, but has not been investigated experimentally in the field, is herbivory by mammals, particularly white-tailed deer (*Odocoileus virginianus* Zimmerman). White-tailed deer have increased dramatically since the early twentieth century in the successional, fragmented forests of the northeastern United States (Anderson 1997; McShea et al. 1997; Porter and Underwood 1999). For example, Knox (1997) estimates pre-colonial density of fewer than 4 deer km^{-2} in the eastern United States, in contrast with densities of 6 to 12 deer km^{-2} in much of Virginia by 1988. Alverson et al. (1988) suggest pre-colonial estimates of 4 deer km^{-2} in northern Wisconsin, compared with up to 9 deer km^{-2} in 1988. Deer density can be much greater in some areas. In northern Westchester County, New York, where we conducted part of our study, density is estimated at more than 50 deer km^{-2} (Glenn Cole, Regional Wildlife Manager, New York State Department of Environmental Conservation, Region 3, personal communication).

White-tailed deer at their current densities have become a keystone species, significantly altering the composition of forest ecosystems and leading to alternate stable states in many forests of eastern North America (Alverson and Waller 1997; DeCalesta 1997; Healy 1997; Schmitz and Sinclair 1997; Stromayer and Warren 1997; Waller and Alverson 1997). Deer herbivory can affect plant growth, fitness, and competitive ability of food plants, especially where deer densities are high due to a lack of natural predators, where active management increases deer populations, or where hunting is limited because of proximity to towns (McShea et al. 1997; Philips and Maun 1996). Selective herbivory by dense deer herds damages trees of certain species, potentially leading to long-term changes in forest composition (Horsley and Marquis 1983; Stewart and Burrows 1989; Strole and Anderson 1992; Tilghman 1989). In addition, deer eat more-palatable herbaceous flora (Williams et al. 2000), allowing less-palatable herb species to increase (Alverson et al. 1988; Waller and Alverson 1997).

Whether or not a plant species is eaten or avoided by selective herbivores like deer can be very important for its success, and can be considered a potential influence on the invasiveness of a species. Several studies suggest that deer avoid *A. petiolata* in favor of more palatable species, and it is tempting to attribute the invasiveness of *A. petiolata*, in part, to this selective herbivory (Anderson et al. 1996; Williams 1996). A lack of herbivory is often suggested as an explanation for why certain non-native species become invasive. This "enemy release hypothesis" (Keane and Crawley 2002) primarily concerns herbivory by insects and pathogens that specialize on a host plant in its native range and help to regulate its population size. When a host plant is introduced to a new region it is possible for these specialists to be left behind, resulting in plant population release, and invasiveness. The hypothesis also predicts that generalist herbivores will have greater effects on native rather than non-native plants, but there is no obvious reason why even selective generalists like deer should avoid non-native species per se. Because food plant choice by deer is partly frequency-dependent (Brown and Doucet 1991), it is even plausible that deer may switch to an invasive species if it becomes very abundant while native species become scarce. Field experiments are needed to explore whether non-native species are avoided by generalist herbivores, and whether preference for native food plants is frequency-dependent.

We investigated how *A. petiolata* responded to protection from herbivory by comparing caged and uncaged plots of vegetation dominated by *A. petiolata* in three southeastern New York forests (two with deer, one without). We compared changes in percent cover of *A. petiolata* and other vegetation over four years in caged and uncaged plots, and also measured differences in *A. petiolata* size and herbivory rate. We hypothesized that, within a forest, there would be no difference between caged and uncaged plots for *A. petiolata* cover, size, or herbivory rate if deer did not eat *A. petiolata*. Alternatively, if deer did eat *A. petiolata*, then cover would be less, plants would be smaller, and herbivory greater in uncaged plots relative to caged plots, but only in the forests with deer.

Our hypotheses address direct effects of herbivores on *A. petiolata*. It is also possible for herbivores to have indirect effects on plant cover and size (Damhoureyeh and Hartnett 1997). For example, smaller size and lower cover of *A. petiolata* in caged plots could be caused by increased competition from native plants released from herbivory. In addition, herbivory is only one of the complex ways that deer can affect plant cover and size and lead to differences in caged and uncaged plots (Waller and Alverson 1997). Trampling can damage plants, but may also create disturbed microsites for recruitment. Nutrient addition from deer scat may favor certain plant species, particularly invaders (Stohlgren et al. 1999). Our experiment does not directly assess all deer affects, but our results can be interpreted in reference to them.

Study Areas

We conducted the caging experiment in three forests. The 16-ha New York Botanical Garden (NYBG) Forest, located in the Bronx, New York City, is an old-growth, never clearcut forest remnant, completely surrounded by a highly urbanized landscape. The latest published vegetation survey, from 1985, showed that canopy dominants were, in order of importance, *Tsuga canadensis* (L.) Carriere, *Quercus rubra* L., *Acer rubrum* L., *Betula lenta* L., *Fagus grandifolia* Ehrh., *Liquidambar styraciflua* L., *Prunus serotina* Ehrh., *Liriodendron tulipifera* L., and *Fraxinus americana* L. (Rudnicky and McDonnell 1989). There has been high mortality of *T. canadensis* since that survey due to the hemlock woolly adelgid (J. A. Morrison, unpublished data). Deer are not present in the NYBG Forest.

The other two forests are Westchester County's 84-ha Kitchawan Preserve, in Kitchawan, New York, and The Nature Conservancy's 86-ha Mt. Holly Sanctuary, near Cross River, New York. Both preserves consist of second-growth deciduous forest with closed canopy, located in northern Westchester County. Kitchawan is 42 km north of NYBG and Mt. Holly is 15 km northeast of Kitchawan. Both forests are contiguous with tracts of privately held forest fragments embedded in a suburban matrix of mixed land use, including houses, lawns, and forest. No formal canopy study has been done at either Westchester site, but common canopy trees at Kitchawan are *A. saccharum*, *B. lenta*, *Fraxinus pennsylvanica* Marshall, *P. serotina*, and *Quercus* spp. Common trees at Mt. Holly are *A. rubrum*, *B. lenta*, *P. serotina*, and *Quercus* spp. (J. A. Morrison, personal observation). Common herb layer species in the three forests are shown in Table 1. White-tailed deer are not present in the

NYBG Forest, but Kitchawan and Mt. Holly fall within the northern Westchester region, with estimated density of more than 50 deer km^{-2}. Mt. Holly in particular has the appearance of a forest strongly impacted by deer, with a clearly defined browse line and a nearly barren herb layer in many places (J. A. Morrison, personal observation).

METHODS

At NYBG and Kitchawan, in July 1996, we established four pairs of 4-m^2 plots, with each plot surrounded by an additional 0.5-m walkway. We originally established four pairs at Mt. Holly also, but two pairs had to be eliminated due to a new property line demarcation. We established two new pairs at Mt. Holly in May 1997; initial data collected from the two older pairs were dropped from the study. We chose locations for plots by searching each forest for four areas where *A. petiolata* occurred in stands large enough to accommodate the plots. A plot pair was situated within each stand so that each plot had similar *A. petiolata* densities. One plot plus walkway, per pair, was randomly assigned to a caging treatment (described below). Distances between the outer edge of the walkways of caged and uncaged plots, within a pair, ranged from 0.5 to 2 m. Distances between the four stands within a forest ranged from 10 to 500 m.

We censused the herb layer vegetation in all plots, prior to cage installation, between July 10 and 25, 1996, except in the two new plots at Mt. Holly, which we initially censused between May 28 and June 10, 1997. We divided each 4-m^2 plot into sixteen 0.25-m^2 subplots with a quadrat frame, and by careful visual estimates assigned a percent cover interval score for each species in each subplot, as follows: < 5%, 5-10%, 11-20%, 21-30%, 31-40%, 41-50%, 51-60%, 61-70%, 71-80%, 81-95%, > 95%. This method allowed us to census all plots within a short enough time interval to avoid large phenological differences from one plot to another. Dividing plots into 16 smaller subplots allowed us to be more accurate in our visual rankings. We were able to stand in the walkway on all sides of the 4-m^2 plot and lean over each subplot to make estimates, thus avoiding trampling the estimated vegetation. To obtain total percent cover per species per 4-m^2 plot, we converted interval scores to interval midpoints, summed across all 16 subplots, and divided by 16. Total percent cover for all native species combined was calculated by adding the values for all native species. In a few cases this resulted in more than 100% cover in a plot due to overlapping layers of foliage. Species names and native status were assigned according to Gleason and Cronquist (1991). Specimens of species not readily identified in the field were brought to the lab for identification and are stored at The College of New Jersey. Specimens of some uncommon species lacked sufficient characters for identification; they were assumed to be native.

We installed the cages after the initial censuses in July 1996 or June 1997 (for the two plot pairs added at Mt. Holly). Cages were square, with an open top, made with flexible plastic fencing stapled to 2-m cedar posts at each corner. The fencing at Kitchawan and Mt. Holly was strong black polypropylene netting, with filaments 1 to 2 mm wide and a 36-cm^2 opening between filaments (manufactured by Deerbusters, Inc., Frederick, Maryland). The fencing was staked along the cage bottom; small animals such as voles, birds, or chipmunks could move in and out of the plots through the open top or through the fencing at the forest floor. The netting used at NYBG was a finer plastic of 0.5 to 1-mm width, with a 4-cm^2 opening. It was loosely staked at the bottom so that small animals could enter the plot under the netting as well as through the open top. Stronger netting was required in the

Westchester County sites where deer are abundant but its extra expense was not justified at NYBG.

The cages excluded larger animals, such as white-tailed deer or eastern cottontail rabbits (*Sylvilagus floridanus* [Allen]). In another study, rabbits were able to chew gates through similar fencing material (J. Courteau, personal communication), but we observed no such gates in any of our cages. Our study focused on deer exclusion because of the overabundance of deer in suburban forests but we have observed rabbits on the NYBG grounds near the forest and presumably they are present in the other two forests also (but were not observed by us). Differences between caged and uncaged plots in the NYBG Forest could be attributed to exclusion of rabbits, while differences in the two suburban forests could be attributed to deer or rabbit exclusion.

The very thin filaments of the caging material allowed free movement of air and no appreciable shading and neither type of fencing was considered likely to alter microsite conditions inside cages compared to uncaged plots. We documented light and temperature in the plots. Using an AccuPAR 2000 (Decagon Devices, Inc., Pullman, Washington), we measured photosynthetically active radiation (PAR) in caged and uncaged plots. Measurements were taken in all pairs of plots at Mt. Holly and Kitchawan on September 17, 2000. At NYBG, two pairs of plots were measured on September 20, 2000 (the two other pairs of plots had been eliminated by treefall and flooding during the previous year). The AccuPAR was configured to first read full-sun PAR from a nearby light gap or forest edge, and then, at the plot in the forest, collect and average measurements from 10 points along a 1-m probe over 30 seconds. The probe was held over a plot at waist height at four regularly spaced positions, ensuring that no shade was cast by the operator. We used the averages of the four probe positions to obtain percent of full-sun PAR transmitted to the plot and found no significant difference between caged and uncaged plots (mean percent [*SE*]: caged, 5.01 [0.023]; uncaged, 2.97 [0.009]; one-tailed *t*-test for paired comparisons, $t = 1.21$, $P = 0.13$, $N = 10$). We measured one-time temperature in caged and uncaged plots at Mt. Holly and Kitchawan at the same time PAR data were collected and found no difference (mean degrees C [*SE*]: caged, 17.87 [0.895]; uncaged, 17.81 [0.886]; one-tailed *t*-test for paired comparisons, $t = 1.00$, $P = 0.18$, $N = 8$).

We censused the plots twice more, from May 28 to June 3, 1998, and May 21 to May 29, 2000, following the same procedure described above. *Alliaria petiolata* is a biennial, so plants were either in rosette form or flowering form during the censuses; we combined both forms when estimating cover. We did not quantify rosette and adult forms separately, but field notes indicate that most of the *A. petiolata* in 1996, 1998, and 2000 was in flowering form in all plots except for one uncaged plot at NYBG that was dominated by rosettes. Censusing the same plots every two years allowed us to see *A. petiolata* stands at the same life history stage during each census, with the exception of the two new plot pairs at Mt. Holly established in 1997. The May/June census dates in 1998 and 2000 were earlier in the growing season than the July 1996 census but *A. petiolata* rosettes have largely finished their spring growth by the end of May and do not change size appreciably though July. Flowering adults have cauline leaves, but these leaves are present and fully expanded by late May and are retained through July (Anderson et al. 1996) at our sites (J. A. Morrison, personal observation). Therefore we were confident that plots in different treatments were not affected differently by the census dates.

We analyzed percent cover of *A. petiolata* and total percent cover of all native plant species with repeated measures analysis of variance (von Ende 1993) using PROC GLM of

SAS v. 6 (SAS Institute 1990). There were a few other non-native species present, but they contributed little to total percent cover in these plots, and so were not included in the present study (the exception was *Polygonum cuspidatum* Sieb. and Zucc., but it occurred in only one set of plots at NYBG). Between-plot effects were caging and stand, and within-plot effects were time, time × caging, and time × stand.

The percent cover measures were analyzed separately for each forest because of differences in the duration and timing of data collection, However, because the experiments tested the same hypotheses we determined the significance of F statistics with the Simes-Hochberg method (Simes 1986; Hochberg 1988), a sequential Bonferroni correction. At Kitchawan, four pairs of plots were in the experiment from 1996 through 2000. At Mt. Holly, two pairs of plots were added one year later than the others. At NYBG, repeated measures analysis of all four pairs could be done only through 1998 because one pair of plots was destroyed by flooding and another by a fallen tree in 1999.

We assigned all pre-caging measurements a 1996 date in the Mt. Holly analysis, even though two plot pairs were initially measured in 1997. Combining the 1996/1997 initial census dates is reasonable ecologically because the data from both years describe the vegetation before the caging treatment was begun. Our focus is the comparison of percent cover change between caged and uncaged plots, and the 1997 plots were equally divided between caged and uncaged treatments.

We also measured size of adult, flowering *A. petiolata* individuals inside and outside of cages during the June 1998 census. Ideally, we wanted a size measurement that would capture individual biomass, since our observations of uncaged plants suggested that they were smaller overall, with both shorter stems and smaller leaves. We could not measure destructively, however, so we opted to measure stem length of adult plants. We measured the degree to which stem length reflects plant biomass by destructively sampling additional *A. petiolata* plants along transects in each forest (81 plants total) and correlating stem length with aboveground dry mass, obtained after harvesting and drying plants to constant weight at 60° C (Pearson's $r = 0.79$, $P < 0.01$).

We measured size of all adult *A. petiolata* individuals within each plot, or up to 32 plants per plot, sampling in a systematic manner by dividing the plot into an 8 × 4 grid and measuring the plant closest to each grid intersection point. We collected size data from all four pairs of plots at Mt. Holly and from three pairs at Kitchawan (one was inadvertently not sampled) and at NYBG (one had only rosettes at the 1998 census). We tested for difference in plant size between caged and uncaged plots in each forest with t-tests for paired comparisons, using the mean plant size per plot as the tested variable to avoid pseudoreplication (sample sizes in Table 2).

In September 2000, we scored *A. petiolata* plants for presence or absence of herbivory inside and outside of cages. We observed all plants in the plots and in the 0.5-m walkway surrounding the plots, noting whether rosettes had any bitten petioles with missing leaves, or no bitten petioles and all leaves present. We used G-tests for independence (Sokal and Rohlf 1981) for each forest data set to determine if the frequency of bitten plants inside cages differed from the frequency outside of cages.

Table 1. Mean percent cover estimates of 10 most abundant herb layer plant species in *Alliaria*-dominated 4-m^2 plots (N = 8) at start of experiment before caging. Plots were censused in July 1996, except for four at Mt. Holly that were added and censused in June 1997. *SE* = standard error.

	mean % cover	*SE*
Mt. Holly		
Alliaria petiolata (Bieb.) Cavara & Grande	29.92	3.82
Eupatorium rugosum Houttuyn.	3.21	2.21
Carex sp.	1.68	0.86
Oxalis sp.	1.53	0.81
Berberis thunbergii DC	0.59	0.47
Fraxinus americana L.	0.43	0.20
Arisaema triphyllum (L.) Schott	0.40	0.30
Polygonum sp.	0.40	0.18
Acer rubrum L.	0.27	0.10
Celastrus orbiculatus Thunb.	0.19	0.10
Kitchawan		
Alliaria petiolata (Bieb.) Cavara & Grande	15.86	1.84
Acer saccharum Marshall	4.73	1.26
Fraxinus americana L.	4.65	1.84
Galium sp.	2.15	1.52
Parthenocissus quinquefolia (L.) Planchon	1.91	0.92
Polystichum acrostichoides (Michx.) Schott	1.52	0.91
Carex spp.	1.50	0.87
Lindera benzoin (L.) Blume	1.29	0.39
Arisaema triphyllum (L.) Schott	0.94	0.49
fern	0.94	0.94
NYBG		
Alliaria petiolata (Bieb.) Cavara & Grande	44.31	6.46
Polygonum cuspidatum Sieb. & Zucc.	14.15	8.36
Circea lutetiana L.	2.62	1.97
Impatiens capensis Meerb.	1.88	1.34
Phellondendron amurense Maxim.	1.67	1.05
Acer negundo L.	1.57	1.57
Solanum sp.	1.13	1.13
Fraxinus americana L.	1.06	0.93
Commelina communis L.	0.90	0.81
Viola sp.	0.90	0.56

Results

Percent Cover

Over the course of the experiment at Mt. Holly, percent cover of *A. petiolata* decreased significantly in uncaged plots relative to caged plots (Fig. 1). This is shown by the significant

Table 2. Number of plant size measurements of *Alliaria petiolata* used to calulate average plant size per plot in caged and uncaged plots.

Forest	plot treatment	number of plots measured	number of plant size measurements in each plot
Mt. Holly	caged	4	32, 32, 21, 31
	uncaged	4	16, 14, 17, 23
Kitchawan	caged	3	32, 28, 32
	uncaged	3	31, 31, 32
NYBG	caged	3	32, 32, 32
	uncaged	3	32, 32, 12

caging effect, and in the marginally significant time × caging interaction in the repeated measures analysis (Table 3A). Before caging, those plots assigned to the caging treatment had, by chance, somewhat lower average *A. petiolata* percent cover compared to plots assigned to the uncaged treatment, but over four years the caged plots ended up with significantly higher percent cover (Fig. 1). In Kitchawan Preserve (Table 3B) and in the NYBG Forest (Table 3C), percent cover of *A. petiolata* was not significantly different in caged and uncaged plots, although at Kitchawan the trend was toward lower cover in uncaged plots (Fig. 2), and at NYBG there was no consistent trend across the four years (Fig. 3).

Native plant percent cover showed no significant differences between caged and uncaged plots at Mt. Holly (Table 3A, Fig. 1), Kitchawan (Table 3B, Fig. 2), or NYBG (Table 3C, Fig. 3). No consistent trend of differences in native plant cover between caged and uncaged plots was evident.

Alliaria petiolata Size

Individual *A. petiolata* plants were significantly larger in caged plots than in uncaged plots at Mt. Holly (Fig. 4; *t*-test for paired comparisons: Mt. Holly, $t = 3.19$, $df = 3$, $P = 0.05$). At Kitchawan, sizes were similar in caged and uncaged plots (Fig. 4; $t = 0.68$, $df = 2$, $P = 0.57$). At NYBG, they were more variable and not significantly different (Fig. 4; $t = 1.18$, $df = 2$, $P = 0.36$).

Herbivory

Herbivory on *A. petiolata* plants occurred with significantly greater frequency in uncaged plots, compared to caged plots, at both Mt. Holly (Fig. 5; $G_{adj} = 132.13$, $df = 1$, $P < 0.001$) and Kitchawan (Fig. 5, $G_{adj} = 46.87$, $df = 1$, $P < 0.001$). At Mt. Holly, 27% of the 255 uncaged plants and 0.82% of the 488 caged plants observed had bitten petioles. At Kitchawan, bitten petioles were present in 8% of the 562 uncaged plants and 0.21% of the 460 caged plants. The NYBG plants did not experience herbivory either inside or outside of cages, except for one out of 332 uncaged plants observed (the *G*-test of independence for NYBG data was not needed, or possible, because the frequency of observations for one level of the herbivory factor was so low across both levels of the caging factor).

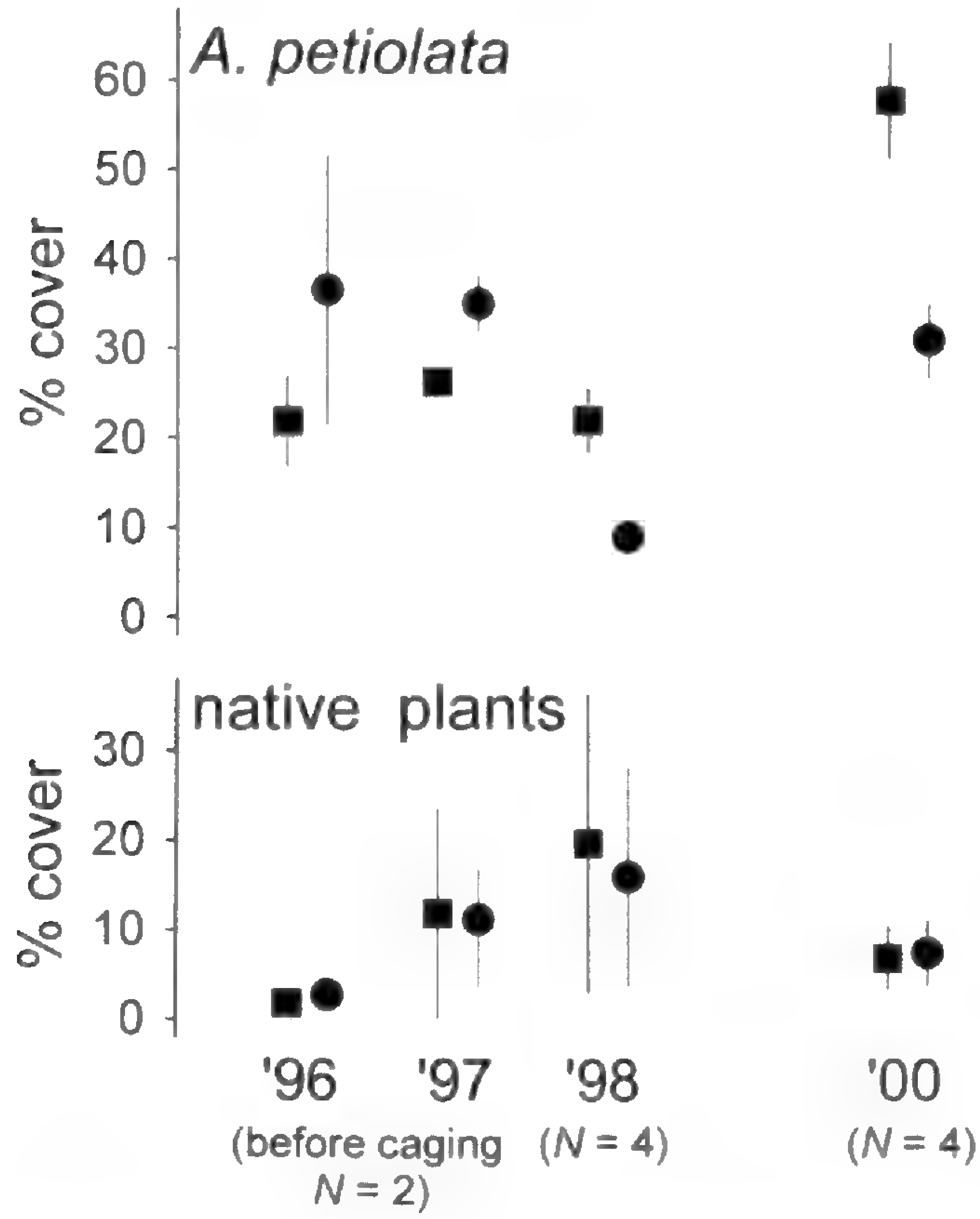

Figure 1. Mt. Holly Sanctuary: estimated percent cover (mean ± *SE*; small error bars are hidden by the symbol) in 4-m² plots that were caged to prevent herbivory (squares) or uncaged (circles).

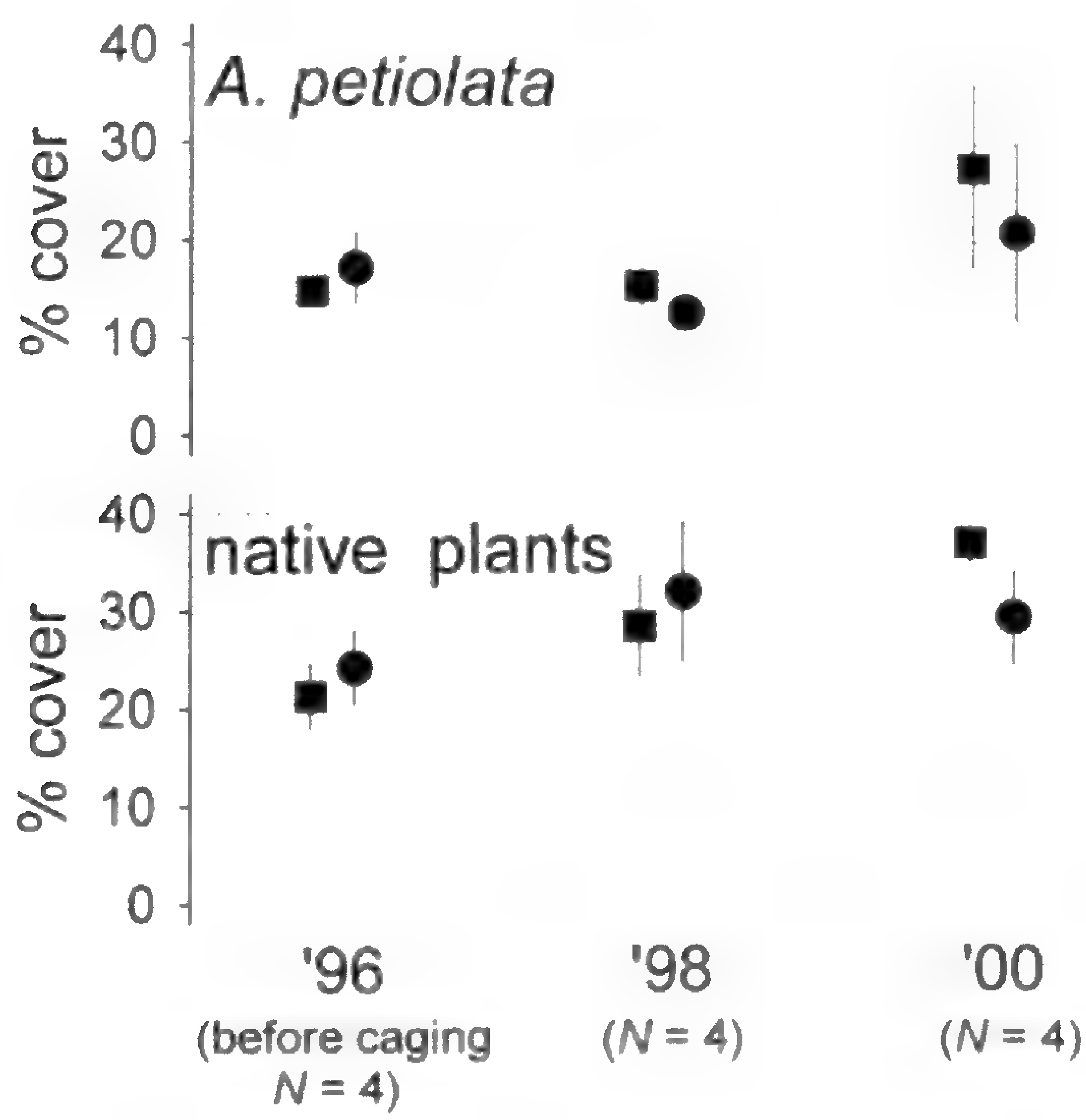

Figure 2. Kitchawan Preserve (see Fig. 1 caption).

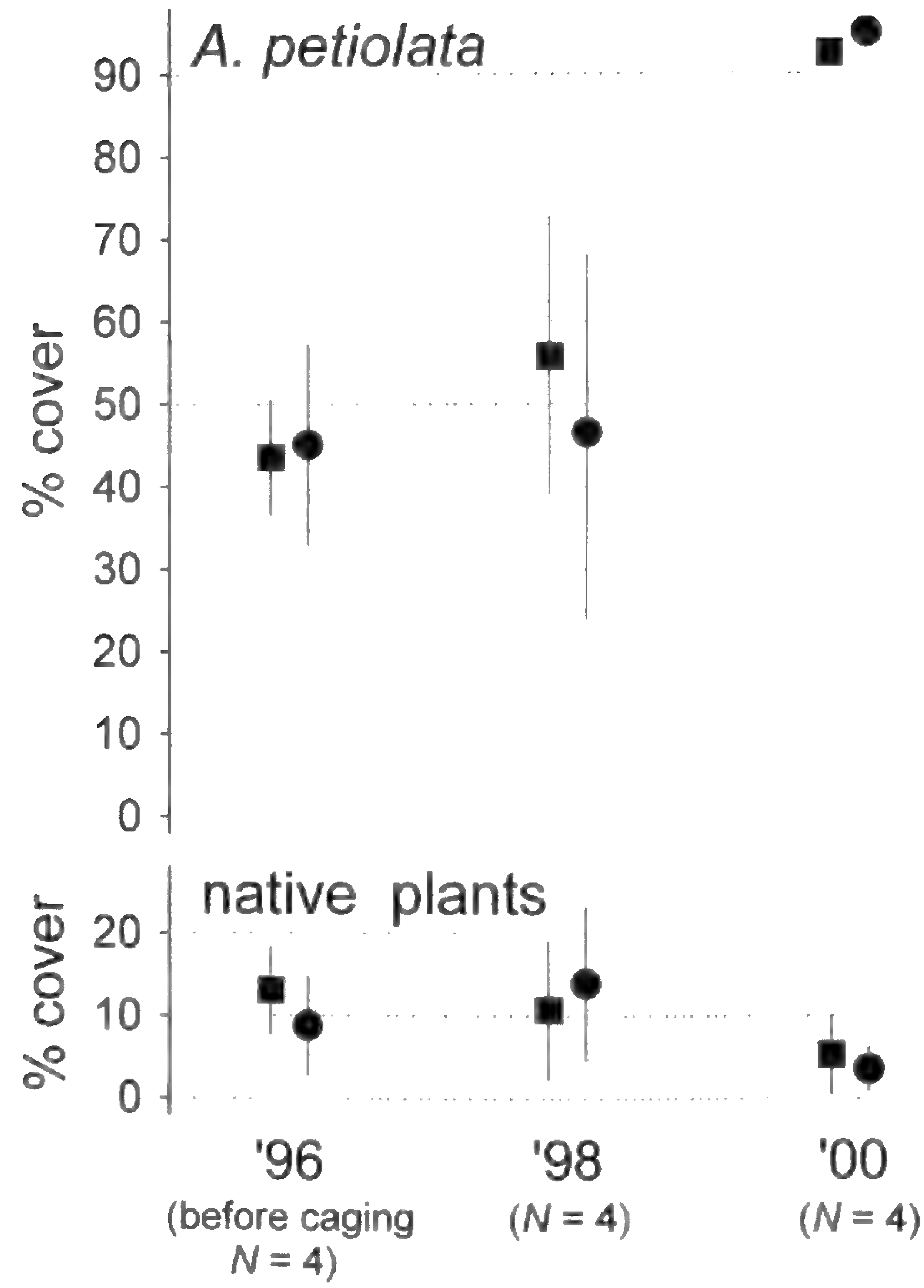

Figure 3. NYBG Forest (see Fig. 1 caption).

Figure 4. Mean (± *SE*) across plots of average *A. petiolata* size in plots that were uncaged (circles) or caged (squares) for two years (one year for two plots at Mt. Holly) to prevent hebivory (N = 4; small error bars are hidden by the symbol). Size is the sum of stem lengths measured on adult flowering plants.

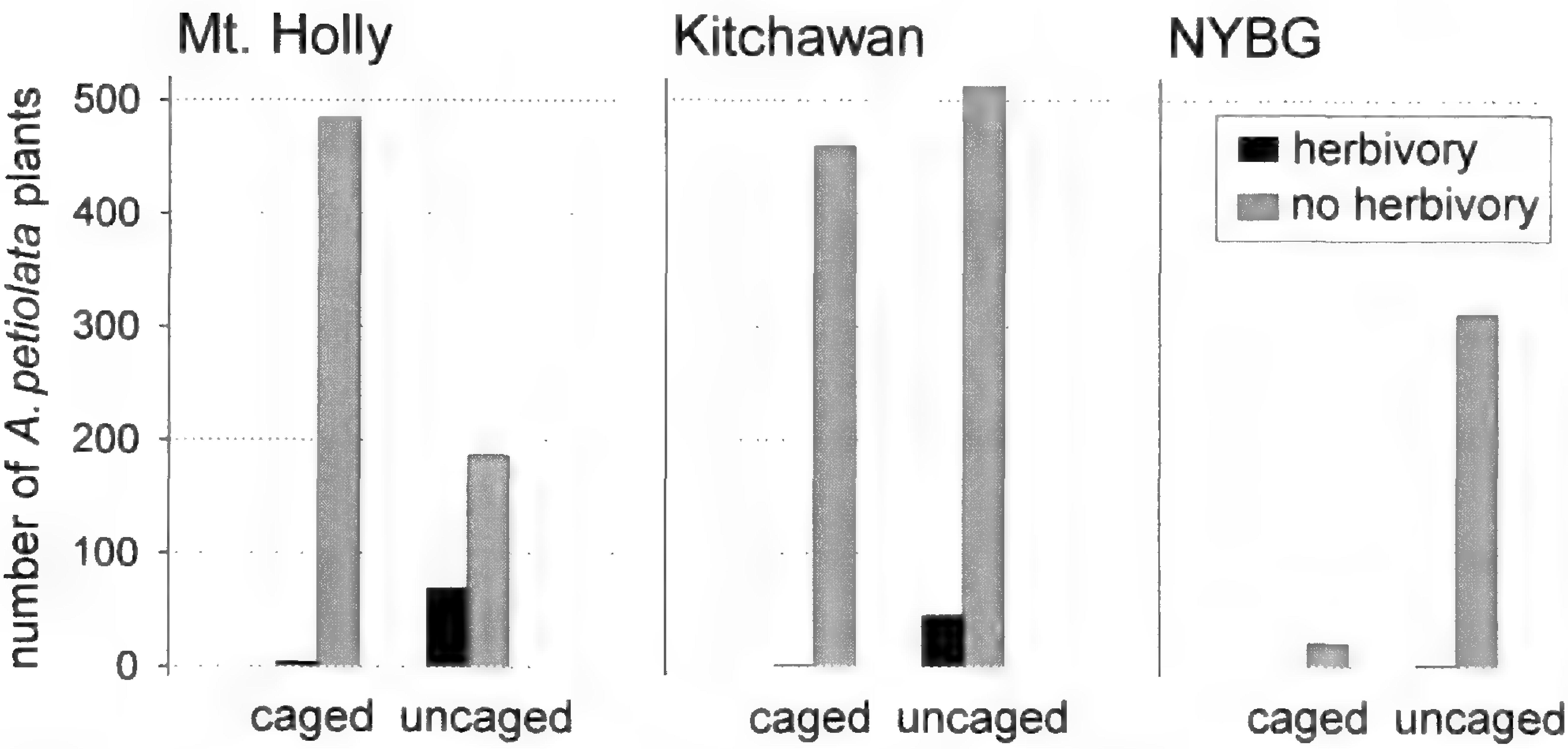

Figure 5. Frequency of *A. petiolata* plants with herbivory (bitten pitioles and missing leaves), inside and outside of cages. Plants were censused in September 2000.

Discussion

We expected that protection from herbivory would have little effect on *A. petiolata* but would have a dramatic effect on the native herb layer in the forests with deer. We had three major grounds for our expectation: the prevalent idea that non-native species gain an advantage, in part, because they lack a suite of herbivores that utilize them as food (Baker 1974; Mack 1985; Keane and Crawley 2002), comments in the literature that deer do not eat *A. petiolata* (Nuzzo 2000; Tilghman 1989), and our observations of thriving *A. petiolata* in forests with deer herds. However, our results were not consistent with this expectation.

We found that native vegetation did not respond to protection from herbivores after four years, but *A. petiolata* did respond under certain circumstances. The following evidence supports this conclusion: (1) there was no difference in percent cover of native vegetation inside and outside of cages over the four years of the experiment; (2) *A. petiolata* cover was higher inside of cages, but only in the two forests with deer, and significantly higher only at Mt Holly, where the native vegetation is especially denuded, potentially providing little food for mammalian herbivores, particularly in the winter; (3) individual *A. petiolata* plants were larger inside cages only in one of the forests with deer, Mt. Holly; and (4) there were much greater herbivory rates on uncaged *A. petiolata* in the forests with deer, especially at Mt. Holly, and hardly any herbivory at NYBG, the forest without deer.

The lack of response to caging by native vegetation at NYBG can be explained by the absence of deer in the forest and appears to indicate that there is also little herbivore pressure from rabbits. In the forests with deer, however, reasons for the lack of native plant response are less clear. It is possible that some single-species percent cover responses occurred, but if so they were not great enough to affect the overall cover of the native community (a future paper will explore responses of individual species). There was some indication of native cover increase in the 2000 data at Kitchawan (Fig. 2) indicating that a longer time of protection from herbivory may allow natives to recover, but that trend was not observed at Mt. Holly. We did not directly measure herbivory on native species as we did for *A. petiolata*, but it is unlikely that native vegetation would be avoided by mammalian herbivores; the browse line and barren appearance of the herb layer strongly suggest otherwise, especially at Mt. Holly. We hypothesize that the lack of response by the native community compared to *A. petiolata* may be explained by the fact that the native community was so severely reduced to begin with, while the *A. petiolata* population was comparatively vigorous, with many successfully reproducing individuals. The native species were sparse and small, and perhaps had little resources to draw on for growth after release from herbivory. In addition, many species may have a depleted seed bank due to a history of chronic overbrowsing, in which case recruitment could remain very low even when pro-

Table 3. Repeated measures analyses of variance for percent cover of *Alliaria petiolata* and native species in caged and uncaged 4-m^2 plots situated in four *A. petiolata* stands in each of four sites. Asterisks denote significance based on the Simes-Hochberg sequential Bonferroni procedure, which provides critical values of α' for three tests across the three sites (^{a} = $\leq$0.10; * = $\leq$0.05; ** = $\leq$0.01). The "adjusted *P*" values given for within-plot effects are conservative tests that account for departures from sphericity in the variance-covariance matrix in repeated measures data. (A) Mt. Holly: measurements were made shortly before cages were installed in 1996 or 1997 (treated as one date) and also in 1998 and 2000. (B) Kitchawan: measurements were made shortly before cages were installed in 1996 and also in 1998 and 2000. (C) NYBG: measurements were made shortly before cages were installed in 1996 and again in 1998 (adjusting *P* values is unnecessary when there are only two repeated measures).

Source of variation	*df*	*MS*	*F*	*P* (Bonferroni-adjusted significance level)	Greenhouse-Geisser adjusted *P*	Huynh-Feldt adjusted *P*
(A) Mt. Holly Sanctuary						
Alliaria petiolata						
Between-plot effects						
Caging	1	5.272	23.85	0.016*		
Stand	3	0.956	4.33	0.130		
Error (= caging × stand)	3	0.221				
Within-plot effects					(ϵ=0.55)	(ϵ=1.81)
Time	2	16.807	14.74	0.005*	0.025*	0.005*
Time × caging	2	7.616	6.68	0.030^a	0.073	0.030^a
Time × stand	6	0.705	0.62	0.713	0.657	0.713
Error	6	1.140				
Native Species						
Between-plot effects						
Caging	1	0.062	0.18	0.702		
Stand	3	13.704	39.47	0.007*		
Error (= caging × stand)	3	0.275				
Within-plot effects					(ϵ=0.575)	(ϵ=1.944)
Time	2	3.066	25.70	0.001**	0.010*	0.001**
Time × caging	2	0.113	0.94	0.440	0.411	0.440
Time × stand	6	2.822	23.65	0.001**	0.009*	0.001**
Error	6	0.051				

(continued)

Table 3 (*cont'd*)

Source of variation	*df*	*MS*	*F*	*P* (Bonferroni-adjusted significance level)	Greenhouse-Geisser adjusted *P*	Huynh-Feldt adjusted *P*
(B) Kitchawan Preserve						
Alliaria petiolata						
Between-plot effects						
Caging	1	0.328	0.31	0.618		
Stand	3	1.970	1.84	0.314		
Error (= caging × stand)	3	1.069				
Within-plot effects					(ϵ = 0.65)	(ϵ = 2.50)
Time	2	2.479	9.49	0.014*	0.035*	0.014*
Time × caging	2	0.405	1.55	0.287	0.298	0.287
Time × stand	6	2.351	8.99	0.009*	0.029	0.009*
Error	6					
Native Species						
Between-plot effects						
Caging	1	0.009	0.01	0.935		
Stand	3	3.064	2.70	0.219		
Error (= caging × stand)	3	1.136				
Within-plot effects					(ϵ = 0.694)	(ϵ = 2.821)
Time	2	2.390	14.82	0.005*	0.015*	0.005*
Time × caging	2	0.777	4.82	0.057	0.087	0.057
Time × stand	6	0.299	1.85	0.236	0.278	0.236
Error	6	0.161				
(C) NYBG Forest						
Alliaria petiolata						
Between-plot effects						
Caging	1	0.603	1.10	0.372		
Stand	3	17.469	31.73	0.009*		
Error (= caging × stand)	3	0.550				
Within-plot effects						
Time	1	1.899	0.87	0.420		
Time × caging	1	1.186	0.54	0.515		
Time × stand	3	19.59	8.95	0.052		
Error	3	2.188				
Native Species						
Between-plot effects						
Caging	1	0.129	0.47	0.543		
Stand	3	4.849	17.60	0.021*		
Error (= caging × stand)	3	0.275				
Within-plot effects						
Time	1	0.268	5.20	0.107		
Time × caging	1	0.241	4.65	0.120		
Time × stand	3	2.986	57.77	0.004**		
Error	3	0.051				

tected from herbivory. It is possible, however, that the native community did respond to caging with increased recruitment, but our percent cover measure did not detect it. Percent cover is very useful for making accurate yet rapid estimates of biomass per species, which is important in a study like ours in order to avoid large phenological differences between sampling sites. It does not measure numbers of plants, however, so if new individuals recruited but contributed little new biomass, the percent cover of the species may not show any change.

We attribute the differences in *A. petiolata* cover and size between caging treatments to protection from a direct effect of herbivory rather than any indirect herbivory effect or some other cage effect. Indirect effects of herbivory could be lower cover and size in caged plots because of increased competition from plants released from herbivory, or higher cover and size in uncaged plots due to decreased competition from plants subject to herbivory. However, *A. petiolata* cover and size showed the opposite pattern — higher in caged plots relative to uncaged plots — indicating direct herbivory. Disturbance of the herb layer by trampling could be a second direct effect of mammals in our study, but the strikingly lower herbivory rate inside cages suggests that herbivory differences were of primary importance. If there was another cage effect not attributable to mammal exclusion, we would expect to detect it in all three forests. However, differences inside and outside of cages were seen only in the two forests with deer and were more pronounced at Mt. Holly, where deer density was probably highest. We chose the thin filament mesh for use as caging material to minimize any effect on the plant community and, as expected, microsite measurements of light and temperature were no different inside and outside of cages.

We did not detect the animal species responsible for the observed herbivory on *A. petiolata*. It makes sense to attribute the herbivory to deer, because it best explains our results and because of the high density of deer in northern Westchester County (>50 km^{-2}), but it is possible that leaves could also have been taken by rabbits (*S. floridanus*) or voles (for example, *Microtus pinetorum* [Le Conte]). However, if the herbivory we observed was due only to small mammals such as voles, then we should have consistently seen little difference inside and outside of cages because small animals could easily access the caged plots through or under the mesh. There was some herbivory inside cages at Mt. Holly and Kitchawan indicating the presence of small herbivores, but there was significantly more herbivory outside of cages. If the difference was due to rabbits, that would not explain why herbivory on *A. petiolata* was nearly nonexistent at NYBG but common at Kitchawan and Mt. Holly, because we know that rabbits were present at NYBG.

We do have reason to think that deer were browsing more heavily at Mt. Holly. There was a noticeable deer browse line at Mt. Holly and at every visit over four years we observed deer in the forest. Native plant cover measured before the experiment was lower at Mt. Holly than at Kitchawan (Figs. 1 and 2), which is consistent with the almost barren herb layer throughout much of the Mt. Holly forest. Kitchawan did not have a distinct browse line and the herb layer appeared more abundant (J. A. Morrison, personal observation). We did sight deer at Kitchawan but less frequently than at Mt. Holly, even though these forests are not far from each other and are in similar landscapes. We hypothesize that deer may be less prevalent at Kitchawan because many area residents take dogs there, usually allowing them to run unleashed. We saw deer at every visit to Mt. Holly but we saw dogs at nearly every visit to Kitchawan. Our evidence that deer are the animals responsible for herbivory on *A. petiolata* is indirect but compelling. It would be useful to investigate this problem more closely with hand-lens examination of bitten petioles at regular intervals throughout the year, in order to distinguish the shredded bites of deer from the clipped and nibbled bites of rabbits and voles (Strole and Anderson 1992). Experimental feeding trials would also be helpful.

A key reason for successful invasion by a non-native plant species is commonly thought to be a relative lack of herbivory because of escape from herbivore species found in its native range (Baker 1974; Mack 1985; Keane and Crawley 2002). In fact, the enemy release hypothesis is the premise upon which the scientific discipline of biological control is based (Debach and Rosen 1991; Guretzky and Louda 1997) and a biological control program is being developed for *A. petiolata* (Blossey et al. 2001). The idea applies especially to feeding by highly specialist insect herbivores but it may not apply to herbivores with a broader diet. White-tailed deer have diet preferences leading to avoidance of relatively unpalatable plant species as long as preferred species are available (Alverson et al. 1988; Longhurst et al. 1968; McCullough 1985; Nudds 1980; Short 1975; Strole and Anderson 1992; Vangilder et al. 1982); however, they do not rely on any tightly co-evolved genetic relationship with their host plants. The fact that *A. petiolata* is non-native is probably of little importance in whether it is eaten by deer compared to the fact that it is a member of the mustard family (Brassicaceae) and so contains a suite of secondary chemicals (Chew 1988; Cole 1975; Larsen et al. 1983; Van Etten and Tookey 1979). These bitter compounds can make mustards less palatable to vertebrate herbivores, although cows in Ontario are reputed to eat *A. petiolata* leaves in autumn and spring (Cavers et al. 1979). Anecdotally, *A. petiolata* is considered unappealing to deer (Tilghman 1989).

A. petiolata's life history, on the other hand, could encourage herbivory, especially during the winter, by animals that otherwise would avoid such a chemically defended plant. It germinates in early spring and spends the following winter as a basal rosette of green leaves, even growing new leaf tissue in the winter months (Anderson et al. 1996). In addition, it begins spring growth before nearly all other understory plants and shrubs (J. A. Morrison, personal observation). Fresh *A. petiolata* leaf tissue is thus available to herbivores throughout the winter, when most other foliage is unavailable. If deer make frequency-dependent food choices, a plant species that occurs at very low frequency may be relatively ignored, but may become a primary food as its proportional representation in the flora increases (Brown and Doucet 1991). In addition, deer are predicted to shift to a more generalist diet during winter (Nudds 1980). Whether or not *A. petiolata* has become a primary food for deer at Mt. Holly we cannot say, but our results are consistent with deer including *A. petiolata* in their diet because of a lack of other forage plants below the browse line. If deer do feed on *A. petiolata* at some sites, it is possible that biological control in those sites will have little additional effect because deer already may be suppressing the *A. petiolata* population to a substantial degree.

It appeared that deer ate *A. petiolata* at lower rates at Kitchawan and had less effect on its size and cover than at Mt. Holly. The 8% of uncaged plants with herbivory at Kitchawan was lower than the 27% at Mt. Holly, and this was just a one-time look at herbivory in the fall while there were still other species available as food. It would be of interest to measure and compare herbivory on native species and *A. petiolata* over the course of the year, especially in the winter when most other species have senesced or are perennating underground, unavailable to herbivores. There is so little plant food available to deer at Mt. Holly in the winter that the green foliage of *A. petiolata* rosettes may be their only choice, while at Kitchawan, where the woody vegetation is not as denuded, other foods are available. Another possible explanation for different herbivory rates among sites is population variation in defensive chemistry. Recent evidence indicates that different populations of *A. petiolata* express different levels of chemical defenses (Haribal and Renwick 2001), which can be due to differences in site environmental quality (Cipollini 2002).

Our results for *A. petiolata* in metropolitan forests near New York City are likely to be relevant to other similar areas where deer herds cause overbrowsing and there are populations of invasive plant species. Forest fragments adjacent to human use and habitation are increasing. These forests have a high edge-to-interior ratio and can have a high rate of immigration of invasive plant species (Brothers and Spingarn 1992; Hill 1985). They often support large deer herds that have virtually no natural predators and are subject to very limited or no hunting. Lands that face this dual challenge of an overabundance of deer and invasion by non-native plants may also be the repositories for much of an entire metropolitan region's biological diversity. We need to understand the relationship between deer abundance and the spread of non-native plants in the urbanizing landscape if our goal is to maintain native plant biodiversity in these areas.

Ecosystem management should become the tool of choice for limiting plant invasions (DeCalesta 1997; Hobbs and Humphries 1995), but we urge caution in assuming that management of deer in an ecosystem will necessarily be effective in reducing the abundance of invasive plants and favoring recovery of the native plant community (Alverson et al. 1988). In a forest such as Mt. Holly, with high deer density, very denuded vegetation, and herbivory on the *A. petiolata* population, deer herd reduction could potentially cause further population growth of *A. petiolata* before there is time for the native community to recover. We did not measure reproductive effort of *A. petiolata* directly, but it is likely that the observed larger size of plants protected from herbivory would result in more seeds because there is a correlation between seed number and plant size in this species (Byers and Quinn 1998). Such forests may be particularly appropriate for deer management combined with a program of invasive species biological control, perhaps augmented with native species restoration efforts. When planning management of metropolitan forests to preserve and increase biodiversity, attention should be paid to if and how deer affect invasive plant population growth, and how the effect may alter as densities of both change over time.

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The Genus *Ophioglossum* in Pennsylvania

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ABSTRACT. Three species of *Ophioglossum* are known from Pennsylvania. The distribution of *Ophioglossum vulgatum* Linnaeus and *Ophioglossum pusillum* Rafinesque is related to the glacial boundary in Pennsylvania. *Ophioglossum engelmannii* Prantl is known from only one county. Until this report, *O. vulgatum* was considered extirpated in the state. The status of *O. pusillum* should be reassessed, and *O. engelmannii* is endangered. A key to the species is provided.

INTRODUCTION

Efforts to identify specimens of *Ophioglossum* collected at three different sites discovered in Greene County in 1993 and 1996 led to the need to understand the differences among the species occurring in Pennsylvania. The Greene County specimens were determined to be *O. vulgatum*, which, at that time, was a species listed as extirpated in the state by the Pennsylvania Natural Heritage Program. In this paper, we provide a key to the species of *Ophioglossum* in Pennsylvania, a discussion of the results of our investigation, and a review of the legal status of each species.

METHODS

Nomenclature follows the Flora of North America (Wagner and Wagner 1993). Other names have been used in recent floras. The Southern adder's-tongue, *O. vulgatum*, has also been known as *O. pycnostichum* (Fernald) A. Löve & D. Löve and *O. vulgatum* L. var. *pycnostichum* Fernald. Northern adder's-tongue, *O. pusillum* has been referred to as *O. vulgatum* L. var. *pseudopodum* (S.F. Blake) Farwell. No synonymy for *O. engelmannii*, the Limestone adder's-tongue, was found.

We investigated the occurrences of *Ophioglossum* species to find and map historic localities in Pennsylvania. Based on characteristics published by Wagner and Wagner (1993) we found that several of the specimens at the Carnegie Museum of Natural History (CM) herbarium were misidentified. After determining these specimens, *Ophioglossum vulgatum* was discovered to be more widespread than previously believed. In addition to the CM specimens, loans of Pennsylvania specimens of *Ophioglossum* were requested from the Cleveland Museum of Natural History (CLM), Ohio State University (OS), Penn State University (PAC), Academy of Natural Sciences of Philadelphia (PH), Shippensburg University, and West Virginia University (WVA). Specimens were also examined at the Missouri Botanical Garden (MO) and Youngstown State University (YUO). Herbarium specimens were also requested from the northern panhandle of West Virginia and Ohio counties adjacent to Pennsylvania for examination. The following key uses the characters that the authors found to be reliable for identification.

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Key to *Ophioglossum* in Pennsylvania

A Blade with apiculate apex, veins forming larger heavier areoles enclosing smaller areoles. Plants from thinly vegetated limestone habitats
. . . . **Ophioglossum engelmanii** Prantl

A Blade rounded at apex, veins forming areoles that enclose free included veinlets, not forming small areoles enclosed by larger areoles. Plants from non-calcareous sites . **B**

B Frond widest near base and tapering abruptly to the stipe; dark colored leathery persistent sheath present at base of stipe; sporangia oblong and closely crowded. Plants from humus-rich woodland areas . . . . . **Ophioglossum vulgatum** Linnaeus

B Frond widest near middle, gradually tapering to the base; sheath at base of stipe if present, membranous and papery; sporangia globular and more widely spaced. Plants from moist midly acid open areas and meadows
. . . . **Ophioglossum pusillum** Rafinesque

Results

A total of 173 herbarium sheets were examined (Appendix 1). Several sheets had more than one mounted specimen. Of the Pennsylvania specimens, 74 proved to be *O. pusillum*; the oldest was collected in 1863 from Chester County, the most recent in 1965 from Erie County. Eighty-four were determined to be *O. vulgatum,* the oldest of which was collected in Chester County circa 1840 and the most recent in Greene County in 2003. Localities were found from 20 Pennsylvania counties for *O. pusillum* and 26 counties for *O. vulgatum. Ophioglossum engelmannii* was found in Franklin County in 1990 and collected there again in 2001. All but two of the *Ophioglossum* collections north of the glacial boundary are of *O. pusillum* and the glaciated region accounts for more than half of this species' recorded occurrences in the state (Fig. 1).

Specimens were requested from the four Ohio counties adjacent to Pennsylvania and the northern panhandle of West Virginia. Seven specimens from two Ohio counties were examined. *O. pusillum* was found from both Ashtabula and Mahoning Counties. *Ophioglossum vulgatum* was found from Ashtabula County only. No specimens were seen from the northern panhandle of West Virginia. Two sheets appeared to be mixed specimens and two sheets were too poor to determine to species level. (Appendix 1)

Discussion

Keys tend to rely on the presence or absence of a basal sheath to differentiate *O. vulgatum* and *O. pusillum*. Many specimens examined did not have roots and in most of these cases the basal sheath was lacking. McAlpin (1971) assessed the taxonomic usefulness of the developmental and morphological nature of the sheaths in separating these species, which he considered varieties of *Ophioglossum vulgatum*. "Regardless of the mechanism, the value of the sheath as a character to separate var. *pycnostichum* from var. *pseudopodum* lies in the persistence of the sheath and not in whether the sheath is present or absent." Wagner (1971)

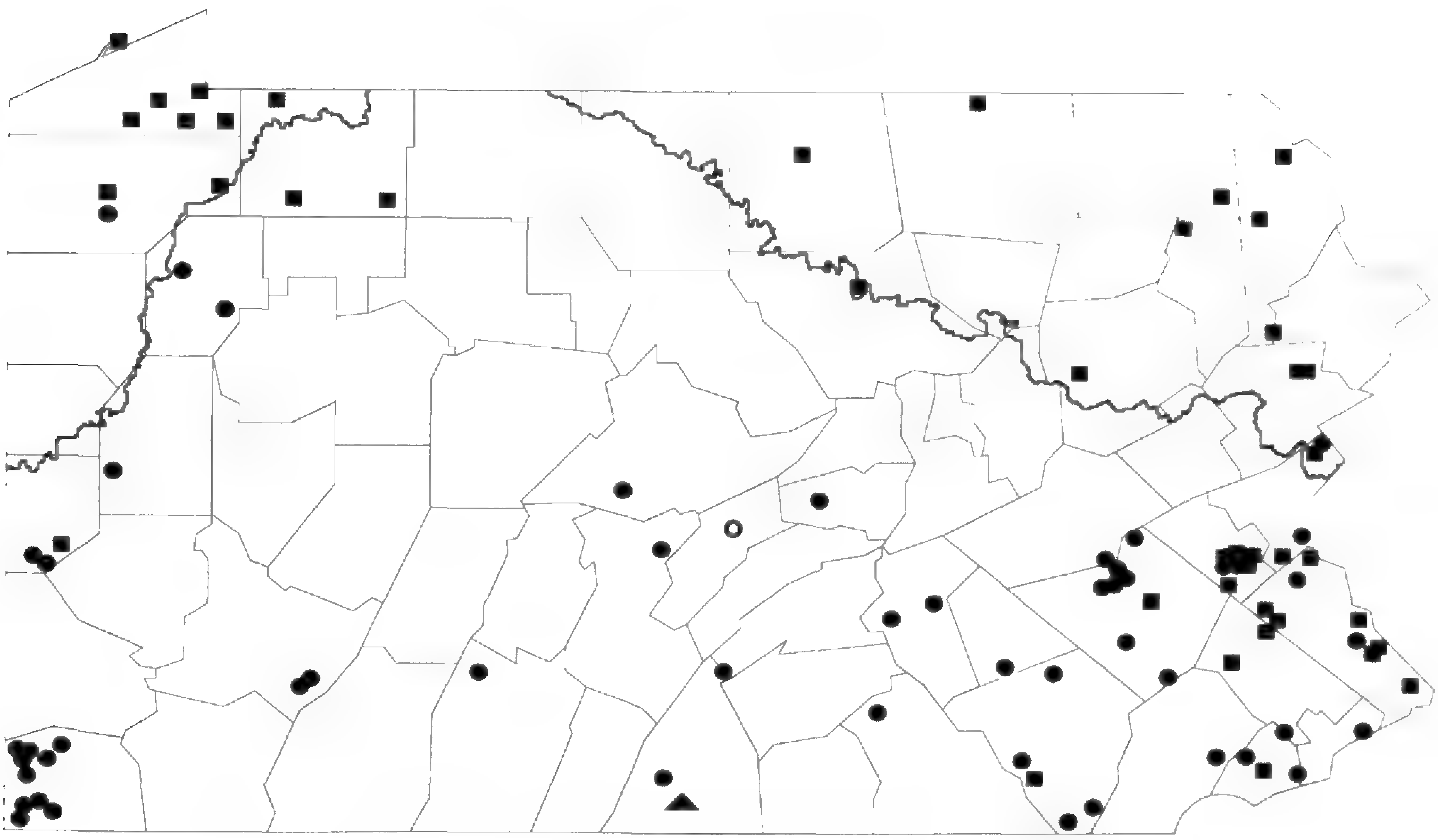

Figure 1. Localities of *Ophioglossum* specimens examined from Pennsylvania.
▲ = *O. engelmanii* ■ = *O. pusillum* ◆ = *O. vulgatum* ◇ = *O. vulgatum* without precise locality information. The thick line is the maximum southern advance of the most recent (Wisconsinan) glaciation.

pointed out that the "differences are not confined to sheath development alone." Thus, other characters were searched for to help determine the specimens to species. In combination with other characters, frond shape proved to be the most readily available, useful character found on herbarium sheets. The blade of the frond when pressed occasionally folds backs upon itself and makes it difficult to determine the widest point of the frond. Mature fronds are more readily distinguishable. The frond shape by itself, however, is not always diagnostic. Blake (1913) noted "the plants, which grew in two adjacent bits of sphagnous meadowland, usually in the open but occasionally on the edges of thickets, show great variation in size, shape, and position of leaf, size of spike, and number of fronds, sufficient to constitute half a dozen 'species' if brought back by collectors from as many regions."

We found, as did Wagner (1971), that the separation of these two species is, "...strongly warranted on the basis of a number of average differences." Wagner also found that, "...a correlation can be demonstrated between the two taxa and the southern boundary of Wisconsin[an] glaciation...", although this correlation seems to break down near the coastal plain. Unique ecological habitats or hybridization (as suggested by Wagner and Wagner 1966) may explain this phenomenon.

The shape of the sporangia is useful before they mature, split, and release spores. Once the sporangia split, the shape is difficult to distinguish. *Ophioglossum pusillum* (Fig. 2) has very globular sporangia, which are not as closely arranged as the transversely oblong sporangia of *O. vulgatum* (Fig. 3). The color of the frond can also be helpful. *Ophioglossum pusillum* fronds are duller and paler green than those of *O. vulgatum*. This character can be very difficult to interpret on dried herbarium specimens because of variation in drying

Figure 2. *Ophioglossum pusillum* (scale bar = 1 cm).

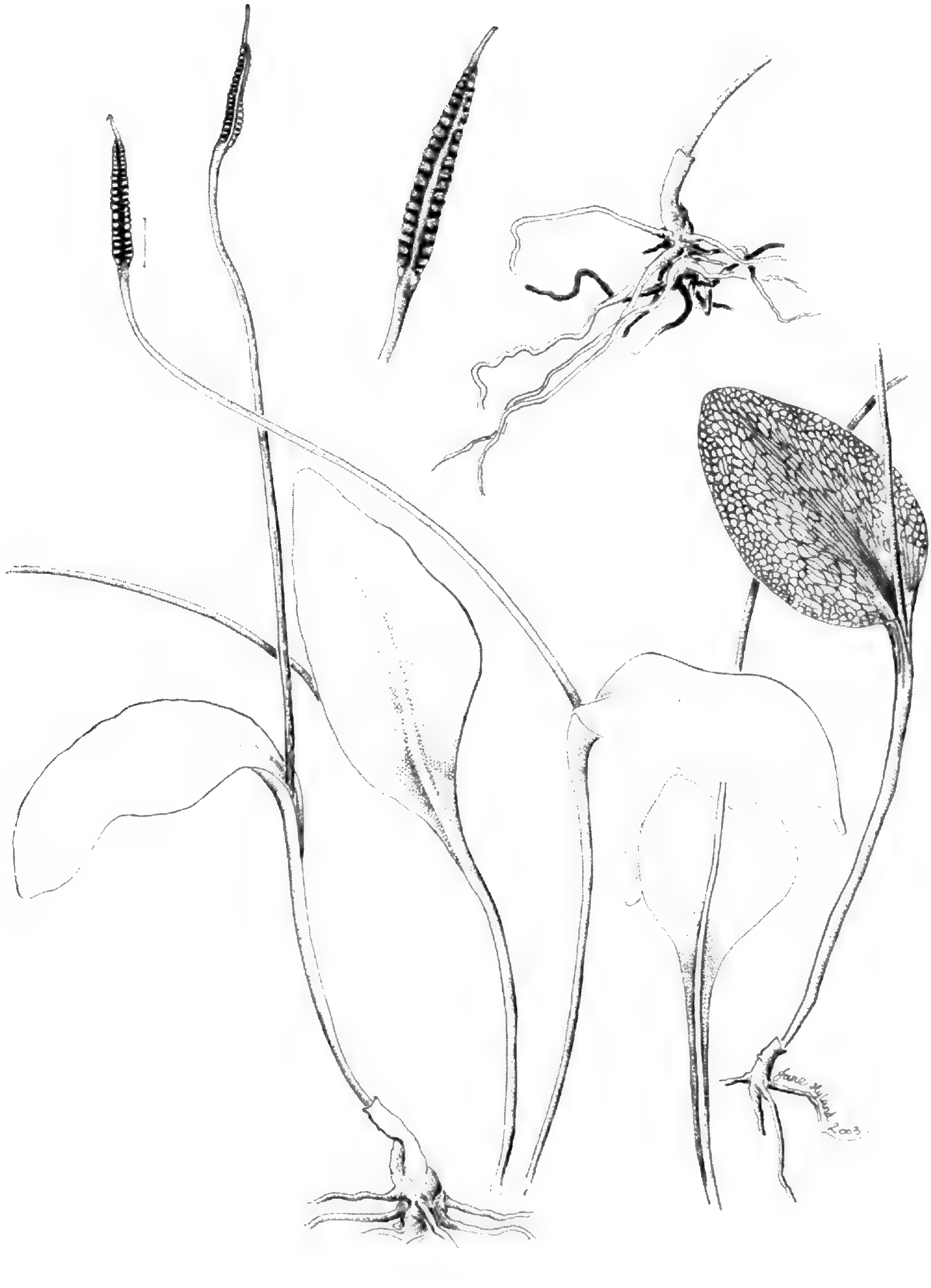

Figure 3. *Ophioglossum vulgatum* (scale bar = 1 cm).

techniques. Rapid drying of specimens aids in color retention. Wagner (1971) also noted a difference in spore size.

Ophioglossum pusillum tends to prefer open mesic sites. McMaster (1994) suggested that *O. pusillum* "...is an early-successional species that frequently occurs in small, isolated habitat patches subject to rapid succession." *Ophioglossum vulgatum* on the other hand, is most often found in rich mesic wooded areas. *Ophioglossum vulgatum* also generally tends to emerge and senesce earlier in the year than *O. pusillum*. Cranfill (1980) conveniently summarized these differences discussed by Fernald (1939, pp. 494-499) Wagner (1971) and Wherry (1961).

The status of *O. vulgatum* in Pennsylvania was listed as tentatively undetermined (TU) in 1986. "It was listed as TU based on the lack of field investigation concerning verification of historical records" (Rare Plant Forum, 1986, unpublished notes). This species then had its status changed from TU to extirpated in Pennsylvania (PX), following a proposal at the 1991 Pennsylvania Rare Plant Forum (Rare Plant Forum, 1991,unpublished notes). At that time, *O. pusillum* was assumed to be a more widely distributed taxon, not in need of protection. Parks and Montgomery (2000) noted that *O. pusillum* is "...uncommon in wet meadows and moist woods; throughout." *O. pusillum* has never had any special protective status in Pennsylvania. However, because this species has not been collected in Pennsylvania since 1965, its conservation status should be reassessed. The authors are unaware of any fieldwork for this species, and several other authors have noted the ease at which *Ophioglossum* is overlooked. Clute (1901) wrote, "It is safe to say that the adder's-tongue ... is much better known to the collector from pictures and herbarium specimens than it is from experience in the field. ... All who have once found it testify to the ease with which they subsequently find other stations for it, and incline to the belief that its single leaf is often passed under the impression that it is the leaf of some flowering plant. ... It seems a plant that one must first discover by accident before he can find it by intention." Cranfill (1980) stated, "because of their manifestly unfern-like appearance, together with their proclivity for unfern-like habitats ... they are inconspicuous and often passed over." Wagner and Wagner (1966) noted, "The plants are probably more common than our few records ... indicate, but they are notoriously easy to overlook (and indeed, many field botanists have never seen the species alive and consider it a great rarity)."

Ophioglossum engelmannii was first listed as endangered in Pennsylvania (PE) in 1991. This species is at the northern edge of its range and has a limited, specialized habitat. It is unlikely that many more sites for this species will be found in the state. Thus it is likely to retain its endangered status in Pennsylvania.

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APPENDIX 1: SPECIMENS EXAMINED

Standard herbarium acronyms follow Holmgren et al. (1981).

Ophioglossum engelmannii Prantl

PENNSYLVANIA: **Franklin Co.**: 0.5 mi. S of Williamson, between Conococheague Creek & Rt. 955, under power line, successional red-cedar woods on limestone, 13 June 1990, *J. Walck & L. Klotz 446* (PH, Shippensburg); near Williamson, near abandoned dirt road, limestone prairie, 22 June 2001, *D. Laughlin 943* (PAC).

Ophioglossum pusillum Rafinesque

OHIO: **Ashtabula Co.**: East Conneaut, 17 May 1933, *L. E. Hicks s.n.*, (OS); East Conneaut, 17 June 1933, *L. E. Hicks s.n.*, (OS); Farnham, 17 June 1933, *L. E. Hicks & F. B. Chapman s.n.*, (PH). **Mahoning Co.**: North Jackson, 9 June 1909, *E. W. Vickers s.n.* (OS).

PENNSYLVANIA: **Beaver Co.**: bluff above Potato Garden Run and Raccoon Creek, 23 July 1944, *L. K. Henry s.n.* (CM). **Berks Co.**: 1 mi. N of Moselem Springs, 18 August 1915, *W. H. Leibelsperger 340* (PH). **Bradford Co.**: Sayre, swampy ground, August 1905, *W. C. Barbour s.n.* (PH). **Bucks Co.**: Monroe, July 1885, *J. A. Ruth & H. F. Ruth s.n.* (PH); near Monroe, July 1885, *J. A. Ruth & H. F. Ruth s.n.* (PH); near Monroe, July 1889, *R. Brothers s.n.* (PH); The Hedge, Lower Solebury Twp., low damp woods, 4 July 1896, *A. B. Williams s.n.* (PH); near Langhorne, 30 May 1904, *L. Sowden s.n.* (PH); below Woodburne, 30 May 1904, *A. Jahn, s.n.* (PH); Finland, 5 July 1913, *J. R. Mumbauer 5* (PH); SE tributary to Ridge Valley Creek, Finland, boggy swale on streamlet, 29 June 1921, *B. Long 24751*, (PH); ca. 0.75 mi. W of Monroe, boggy swale, 17 June 1933, *B. Long 40559* (PH); 0.5 mi. N of Geryville, marshy spring-run, 5 June 1938, *E. T. Wherry s.n.* (PH). **Chester Co.**: [no further locality] 1863, *W. M. Canby s.n.*(PH). **Crawford Co.**: Shelmadine Springs, old orchard, 11 September 1939, *J. Murdock s.n.* (CM); 4 mi. ENE of Meadville, wet depression at woods margin, 7 June 1942, *E. T. Wherry s.n.* (PH); 4 mi. ENE of Meadville, wet pasture and thickets, 7 June 1942, *W. H. Wagner 848* (PH). **Delaware Co.**: 1 mi. NW of Lima, Upper Middletown Twp., 17 June 1906, *F. Pennell s.n.* (PH); near Lima, swamp, 6 July 1907, *W. A. Poyser s.n.* (CM); Pratts Swamp, N of Lima, among tall grass, 6 July 1907, *W. A. Poyser s.n.* (PH); Pratts Swamp, Lima, 6 July 1907, *W. A. Poyser 11153* (PH); Pratts Swamp, Lima, between hummocks, 6 July 1907, *W. A. Poyser s.n.*

(PH); Pratts Swamp near Lima, 6 July 1907, *W. A. Poyser s.n.* (PH); Lima, among tall grass, 6 July 1907, *W. A. Poyser s.n.* (MO). **Erie Co.**: Presque Isle, 8-9 June 1906, *O. E. Jennings s.n.* (CM, PH); near E end of Presque Isle, July 1926, *O. E. Jennings s.n.* (CM); Presque Isle, 16 July 1927, *J. Bright, s.n.* (CM); 4 mi. SE of Wattsburg, bog, 1 July 1950, *W. E. Buker s.n.* (CM); 3 mi. N of Edinboro, off Route 99, Edinboro Bog, among *Sphagnum*, 17 July 1962, *L. K. Henry s.n.* (CM); 1 mi. W of Corry, calcareous bog, 14 August 1962, *C. Hand s.n.* (CM); 1 mi. NE of Union City, behind Union City Fish Hatchery, bog, 2 July 1963, *C. Hand & J. Stull s.n.* (CM); 1 mi. E of Union City on Rt. 6, *Sphagnum* bog, 26 June 1965, *W. E. Buker s.n.* (CM); 1 mi. E of Waterford, 26 June 1965, *J. Stull & D. Stull s.n.* (CM). **Lackawanna Co.**: E of Baylors Lake, Fleetville, damp bramble thicket, in clearing, 18 July 1946, *S. L. Glowenke 7736* (PAC, PH). **Lancaster Co.**: Mountville, June 1864, *A. P. Garber s.n.* (PH); West Hempfield Twp., A. Garbers swamp, 5 June 1865, *A. P. Garber s.n.* (PH). **Lehigh Co.**: opposite Duck Farm Hotel, ~SW of Allentown, knoll in meadow, 16 June 1911, *H. W. Pretz, 3507* (PH); along Cedar Creek, Griesemersville, marshy meadow, 27 July 1912, *H. W. Pretz 4853a* (PH); S of trolley tracks just SW of Trexlertown, meadows, 27 July 1913, *H. W. Pretz 5927* (PH); about 1.5 mi. S by SW of Lanark P.O., vicinity of springy slope (just E of road) on gneissic hillside, 12 September 1915, *H. W. Pretz, 7911* (PH); about 1.5 mi. S by SW of Lanark P.O., open springy marshy slope, just E of road, 4 July 1917, *H. W. Pretz 8863* (PH); Saucon Creek, ca. 5/8 mi. S by slightly SE of Friedensville Crossroads, in low open meadows beside (S side-W of road), 8 June 1919, *H. W. Pretz 9690* (PH); just E of Sigmund (Hampton Furnace), in open marshy meadow along streamlet, 15 June 1919, *H. W. Pretz 9738* (PH); along Little Lehigh River, on S side of stream about 3.25 mi. SW by S of Centre Square, Allentown, open (calcareous) marshy meadow, 15 August 1920, *H. W. Pretz 10352* (PH); along S side of Cedar Creek about 2.12 to 2.25 mi. W by SW of Centre Square, Allentown, open meadows, 30 May 1924, *H. W. Pretz 12083* (PH); 0.25 mi. S of Allentown, along Cedar Creek, in meadow, 14 September 1930, *C. E. Mohr s.n.* (PH); along Little Lehigh River, on S side of stream about 3.25 mi. SW by S of Centre Square, Allentown, open marshy place, 23 May 1948, *H. W. Pretz 13971* (PH). **Luzerne Co.**: Lily Lake, 29 July 1889, *A. A. Heller s.n.* (PH); Lily Lake, 15-16 August 1889, *J. K. Small s.n.* (PH). **Lycoming Co.**: Williamsport, 25 May 1920, *J. P. Young s.n.* (CM). **Monroe Co.**: Tannersville, 4 July 1896, *J. Albrecht s.n.* (CM); Tannersville, 4 July 1896, *S. Brown s.n.* (PH); Pocono, 4 July 1896, *C. D. Fretz s.n.* (PH); near Tannersville, peat bog, 4 July 1896, *T. C. Porter s.n.* (PH); Henryville, 18 August 1906, *B. Long s.n.* (PH). **Montgomery Co.**: SE tributary to Ridge Valley Creek, Finland, boggy swale on streamlet, 16 June 1920, *B. Long 23301* (PH); Zieglersville, wet meadows, 5 August 1943, *J. R. Mumbauer s.n.* (PH). **Northampton Co.**: Mount Bethel W + 0.5 mi. S of RR, 1 July 1908, *C. C. Bachman s.n.* (PH); Mount Bethel, +0.5 mi. W, S of RR, 2 August 1908, *S. S. Van Pelt & C.C. Bachman 11122* (PH); 1 mi. W of Wassergass, meadow, 15 August 1946, *R. L. Schaeffer, Jr. 24381* (PH). **Susquehanna Co.**: Mud Pond, Ararat region, moist muddy pastured margin, 26 June 1936, *E. T. Wherry s.n.* (PH). **Tioga Co.**: Wellsboro, 7 July 1869, *A. P. Garber s.n.* (PH). **Warren Co.**: near Donaldson, open grassy patch on wooded hillside, 29 May 1933, *A. N. Leeds 543* (PH); 3 mi. W of Tidioute, sphagnous area at edge of maple-hemlock woods, 8 June 1942, *W. H. Wagner 879* (PH); 3 mi. N of Tidioute, in sphagnous areas at edge of maple-beech hemlock woods, 8 June 1942, *C.E. Wood 2267* (PH); near Bear Lake, 22 August 1962, *C. Hand s.n.* (CM). **Wayne Co.**: South Sterling, 17 June 1906, *B. Long s.n.* (PH); vicinity of White Oak Pond, 24 August 1920, *O. E. Jennings, G. K. Jennings & E. M. Gress s.n.* (CM); E of Weigh Lake, Preston Twp., swamp, 24 August 1921, *H. B. Meredith s.n.* (PH).

Ophioglossum vulgatum Linnaeus

OHIO: **Ashtabula Co.**: Jefferson, maple grove, July 1917, *R. J. Sim s.n.* (OS); Farnham, 17 June 1933, *L. E. Hicks s.n.* (OS).

PENNSYLVANIA: **Beaver Co.**: southern Independence Township, Witherow, 10 June 1947, *E. Mason s.n.* (CM); 1 mi. from Rt. 30 crossing of Raccoon Creek, 14 July 1951, *M. Henrici s.n.* (CM); 100 yards E of Hwy 30, 0.5 mi. N of E end, Raccoon Creek State Park, meadow, 20 July 1964, *J. T.*

Laitsch s.n. (PH). **Bedford Co.**: 2.5 mi. SE of Alum Bank, moist woods, 1120 ft., 5 July 1952, *D. Berkheimer 13866* (CM, PH). **Berks Co.**: Hamburg, 17 May 1891, *J. Crawford, s.n.* (PH); Hamburg, 11 July 1892, *S. Brown s.n.* (PH); Blue Ridge, Hamburg, no date, *W. Stone 34* (CM); foot hills, Blue Mountains, above Hawley [probably Hamburg], 11 June 1892, *J. Crawford s.n.* (PH); Hamburg, 15 July 1891 & 11 June 1892, *J. Crawford s.n.* (PH); Hamburg, 11 June 1892, *B. Heritage s.n.* (PH); 1.4 mi. NW of Shartlesville, rich moist woods, 31 July 1938, *W. C. Brumbach 3076* (PH); 1.25 mi. NNW of Shartlesville, rich woods, 800 ft., 20 July 1941, *D. Berkheimer 2836* (PH); 1.5 mi. NE of Bernharts, moist flat in woods on E side of stream (above abandoned buildings), 23 July 1947, *E. T. Wherry s.n.* (PH); 2.25 mi. NE of Bernharts, damp woods, 23 July 1947, *E. T. Wherry s.n.* (PH); 1.37 mi. WSW of Hopewell, moist woods, 540 ft., 24 July 1948, *D. Berkheimer 10041* (PH); 1.5 mi. WSW of Hopewell Furnace, damp soil in low woods, 19 July 1950, *W. C. Brumbach 4318* (PH); 1 mi. NW of Eckville, swamp, 22 July 1953, *R. L. Schaeffer, Jr. 44239* (PH). **Bucks Co.**: Riegelsville, 1882, *J. F. Ruth s.n.* (PH); Buckwampum Mtn. near Springtown, 6 August 1903, *W. D. Witte s.n.* (PH); near Gerharts Mill, 4 July 1918, *F. Ball s.n.* (PH); along Fork of Jericho Creek, 1 mi. ENE of Pineville, rich woods, 21 May 1953, *B. Long 76504* (PH). **Butler Co.**: NW side of Connoquenessing Creek, NW of Zelienople, 4 August 1985, *F. Lochner s.n.* (CM). **Centre Co.**: 2 mi. N of Port Matilda, Worth Township, 19 June 1976, *W. Harpster s.n.* (CM). **Chester Co.**: West Chester, ca. 1840, *J. Wolle herbarium s.n.* (CM). **Crawford Co.**: 3 mi. SE of Meadville, soggy humus, 7 July 1970, *R. C. Leberman s.n.* (CM). **Dauphin Co.**: 0.5 mi. S of Manada Gap, 9 mi. N of Hummelstown, in swamp, 14 June 1936, *E. T. Wherry s.n.* (PH); 2 mi. NNE of Dauphin, moist woods, 420 ft., 20 May 1952, *D. Berkheimer 12563* (PH). **Delaware Co.**: near Darby, no date, *Leidy s.n.* (PH); Darby Creek, above Bonsalls Mill, June, *G. Miller s.n.* (PH); Middletown, 4 July 1906, *W. A. Poyser s.n.* (PH). **Franklin Co.**: 4 mi. NE of Ft. Loudon, wet woods along stream, 22 May 1963, *D. L. Emory s.n.* (PH). **Greene Co.**: ca. 2.5 mi. WNW of Hunters Cave on T-581, Morris Township, mixed hardwood forested hillside, 17 June 1993, *J. A. Isaac 4363* (CM); ca. 1.5 mi. WNW of Triumph, State Game Lands 179, Jackson Township, mixed deciduous woods, dry hillside, 19 June 1993, *J. A. Isaac 4504* (CM); ca. 3 mi. SW of Deep Valley, along Knob Run, mature deciduous forest, 39°43'N, 80°30'W, 26 May 1996, *B. L. Isaac & J. A. Isaac 8912* (CM); 0.3 km WNW of Crabapple, dry young forest, 39°55'13"N, 80°28'42"W, 5 June 2002, *J. A. Isaac &, M. Takacs 14409* (CM); 1.8 km NW of Durbin, wooded hillside, 39°55'49"N, 80°29'54"W, 7 June 2002, *J. A. Isaac &, M. Takacs 14421* (CM); just E of Crows Mills, mesic forest near head of small run , 39°55' 40"N, 80°30'02"W, 14 June 2002, *J. A. Isaac &, M. Takacs 14489* (CM); ca. 1.4 km E of Crows Mills, mixed deciduous woods, 39°55'45"N, 80°29'22"W, 14 June 2002, *J. A. Isaac &, M. Takacs 14490* (CM); ca. 1.3 km N of Aleppo, *Lindera* thicket in regenerating forest, 39°49'59"N, 80°26'21"W, 24 April 2003, *J.A. Isaac 15876* (CM); 2.3 km NNE of Aleppo, regenerating forest on old pastures, 39°50'36"N, 80°27'05"W, 24 April 2003, *J. A. Isaac 15878* (CM); ca. 2 km NE of Ryerson Station, oak-maple forested slopes, 39°54'05"N, 80°27'16"W, 1 May 2003, *J. A. Isaac, R. Coxe & S. Ernst 15891* (CM); ca. 1.5 km W of Wind Ridge, 39°52'49"N, 80°27'07"W, 1 May 2003, *J. A. Isaac, R. Coxe & S. Ernst 15893* (CM); 1.9 km E of Bryan, 39°52'38"N, 80°27'20"W, 1 May 2003, *J. A. Isaac, R. Coxe & S. Ernst 15894* (CM); ca. 2.6 km ENE of Bryan, 39°52'52"N, 80°26'57"W, 1 May 2003, *J. A. Isaac, R. Coxe & S. Ernst 15895* (CM); ca. 2.8 km E of Bryan, 39°53'36"N, 80°26'31"W, 1 May 2003, *J. A. Isaac, R. Coxe & S. Ernst 15896* (CM). **Huntingdon Co.**: Martin Gap, Rothrock State Forest, between stream and road, red oak-mixed hardwood riparian forest, 44°33'59"N, 77°50'56"W, 880 ft., *B. Brokaw & A. Weber 2002-1* (CM). **Lancaster Co.**: Conestoga above Petersville, June 1862, *E. B. Weaver s.n.* (PH); Little Britain Twp., 5 August 1881, *gift of Harlan Gatchell s.n.* (PH); Haines Station, 4 July 1934, *M. E. Groff s.n.* (PH); 0.5 mi. SE of Haines Station, near S margin of county, moist woods, 7 June 1936, *E. T. Wherry s.n.* (PH); 1.5 mi. NW of Hopeland, near Segloch Run, woods, 5 May 1938, *L. F. A. Tanger s.n.* (PH). **Lebanon Co.**: Mt. Gretna, 2 July 1927, *H. A. Ward s.n.* (PH); Mt. Gretna, a) dry woods at SE corner post of camp meeting grounds b) swamp across highway NW of village, 28 July 1934, *E. T. Wherry s.n.* (PH). **Lehigh Co.**: along Cedar Creek, about opposite the Duck Farm Hotel, about on a line with Hamilton St., meadows, 27 July 1912, *H. W. Pretz 4853* (PH); along Cedar Creek between L.V.R.R. branch & Duck Farm Hotel, Griesemersville, vicinity of slight rise in marshy meadow, 27 July 1912, *H. W. Pretz 4853* (PH); about 3/8 mi. SW by S of Crackersport Crossroads, lightly wooded edge of an (at times marshy, or dry) mud-hole or depression in woods by streamlet, 21 May 1922, *H. W. Pretz 11294* (PH). **Mifflin Co.**: no further locality, July 1850, *T. C. Porter s.n.* (MO). **Montgomery Co.**: near Haverford College, June, *Charles E. Smith Herbarium s.n.* (PH). **Northampton Co.**: 0.75 mi. SW of Johnsonville, swamp, 24 August 1950, *R. L. Schaeffer, Jr. 34671* (PH). **Perry Co.**: Hemlock State Forest Park, 12 July 1936, *N. B. Kimber & E. W. Evans s.n.* (PH). **Philadelphia Co.**: on Judge Peters place, near old inclined place (now the Park), no date, *I. Burk s.n.* (PH); Tacony, Philadelphia, July 1860, *I. Burk s.n.* (PH). **Schuylkill Co.**: 0.25-0.5 mi. SSE of Schuylkill Haven, right bank of Schuylkill River, low rich woods, 6 July 1938, *P. R. Wagner 7471* (PH); S side of river, opposite (SE of) Schuylkill Haven, damp woods at base of slope, 8 August 1938, *E. T. Wherry s.n.* (PH); 1.37 mi. ENE of Auburn, rich moist woods, 16 July 1944, *D. Berkheimer 5173* (PH); 0.5 mi. ENE of Port Clinton, moist woods, 480 ft., 20 June 1946, *D. Berkheimer 7439* (PH). **Snyder Co.**: 3-3.5 mi. E of Beavertown, moist woods, 21 June 1939, *E. C. Earle 2092* (PH); 3 to 3.5 mi. E of Beavertown, damp rich woods, 21 June 1939, *P. R. Wagner 8006* (PAC). **Venango Co.**: 5 mi. NW of Franklin, springy slope, maple woods, 7 June 1942, *W. H. Wagner 826* (PH); 5 mi. NW of Franklin, maple woods, 7 June 1942, *C. E. Wood 2184* (PH); Cranberry Twp., S of U.S. 322 on Whip-poor-will Rd., in loam and clay of average to dry moisture in an open exposure, twice a year mowed lawn, 17 July 1980, *C. F. Chuey 1586* (YUO); **Westmoreland Co.**: 0.5 mi. S of Laughlintown, 9 July 1934, *E. M. Gress & H. B. Kirk s.n.* (PH); Powdermill Nature Reserve, under *Crataegus* and *Pyrus*, edge of swamp from Iron Spring, 30 May 1966, *L. K. Henry & R. Leberman s.n.* (CM); Powdermill Nature Reserve, edge of swamp, 20 July 1966, *N. D. Richmond s.n.* (CM); adjacent to Phoebe Run, near the corner of Wilcoxs property, Powdermill Nature Reserve, woods, 27 May 1984, *R. C. Leberman & R. S. Mulvihill s.n.* (CM); ca. 5.3 km E of Stahlstown, mixed deciduous woods, 11 July 2002, *B. L. Isaac, J. A. Isaac, T. Pearson & D. Byers 14480* (CM). **York Co.**: Stephenstown, Neffs Hill, 25 June 1935, *H. B. Kirk & A.B. Champlain s.n.* (PH).

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The Current Status of Two Rare Species of *Ruellia* (Acanthaceae) in Pennsylvania

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ABSTRACT. *Ruellia* is a plant genus of conservation concern in Pennsylvania. I examined the current status of *R. humilis* Nutt. and *R. strepens* L. in the state by conducting surveys to assess the stability of populations since their 1984 listing by the Pennsylvania Natural Diversity Inventory. Roughly half of the historically occurring populations are extant and half are extirpated or are no longer apparent. I attempted to characterize genetic diversity levels within and between these populations with allozyme assays, but results were inconclusive.

Introduction

Ruellia, with approximately 250 species, is the second largest genus in the monophyletic family Acanthaceae *sensu stricto* (McDade et al. 2000). Though primarily pan-tropical in distribution, the potentially monophylletic *Ruellia* (E. Tripp, unpublished data) extends into temperate latitudes including the United States. The family and genus are most easily recognized by having fruits with internal retinacula (hooked structures aiding in ballistic seed dispersal), opposite leaves with swollen internodes, and, except in Acantheae, cystoliths (calcium crystal deposits visible as short streaks on leaf surfaces with a hand lens or dissecting scope). Additionally, members of *Ruellia* possess a complex and interesting floral feature termed the filament curtain. Four fertile didynamous stamens form a partition that divides the corolla longitudinally into two compartments. This structure is presumably linked to pollinator relationships and switches (Manktelow 2000).

Acanthaceae have been of great botanical interest because of their widespread distribution, diverse habits (herbs, vines, shrubs, and trees), and varied pollinator association. Flowers of *Ruellia*, for example, vary from purple to red, yellow, white, green, and even black, and are pollinated by bees, hummingbirds, butterflies, hawkmoths, and bats. The major economic value of the family is horticultural; their stunning floral and vegetative morphologies have attracted a crowd of breeders and growers. Species of *Ruellia* and other genera such as *Acanthus, Aphelandra, Barleria, Eranthemum, Fittonia, Hypoestes, Odontonema, Pachystachys, Sanchezia,* and *Thunbergia* are found in the ornamental trade.

In the Western Hemisphere, species of *Ruellia* occupy a diversity of habitats extending from 43° N in Wisconsin to 35° S in Argentina (Ezcurra 1993). There are roughly 20 species of *Ruellia* in the United States, most of which occur across the Southeast and Texas (NatureServe 2003). A few species of *Ruellia* occur in the arid Southwest (Daniel 1984), and at least 30 species occur in Mexico. In the U.S. *Ruellia* species extend from Pennsylvania

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northwest to Minnesota, south to Nebraska, southwest to Arizona, and east to Florida (Tharp and Barkley 1949). Unlike most other Acanthaceae, many *Ruellia* bear cleistogamous as well as chasmogamous flowers. The evolution, genetic basis, and developmental pathway of cleistogamy in *Ruellia* and other plants remain unresolved (but see Long 1977 and Lord 1981 for discussions).

Ruellia humilis Nutt. is currently listed as endangered (S1) and *R. strepens* L. as threatened (S2) in Pennsylvania by the Pennsylvania Natural Heritage Program (P.N.H.P., formerly Pennsylvania Natural Diversity Inventory). *Ruellia humilis* is an S1 (critically imperiled) species in Maryland, Michigan, and North Carolina; in Wisconsin it is classified S2 (imperiled). *Ruellia strepens* is ranked S1 in Maryland, Michigan, North Carolina, and the Washington, D.C. area and S2 in Nebraska (NatureServe 2003). An imperative component of state and federal endangered species programs is the periodic re-evaluation of listed species. Since P.N.H.P. listed *R. humilis* and *R. strepens* in 1984, some new populations have been discovered; however, other sites have not been thoroughly checked (J. Kunsman, personal communication, 2003). The purpose of this study of *Ruellia* in Pennsylvania is to ascertain any changes in population status and contribute to the effectiveness of our Natural Heritage Program.

In the Northeast, *Ruellia caroliniensis* (Walt.) Steud., *R. humilis*, and *R. strepens* reach their northern limit of distribution in Pennsylvania and New Jersey. They are the three most widespread *Ruellia* species in the United States. *Ruellia pedunculata* Torr. ex Gray, a southern species, has also been reported from Pennsylvania, but in only one location near a residential area. There are no herbarium records to verify this species in Pennsylvania (Rhoads and Block 2003), thus it probably escaped from a nearby garden. *R. humilis* and *R. strepens* reach north to Minnesota and Michigan, southwest to Nebraska, south to Texas, and east to Florida. *Ruellia caroliniensis* is extirpated from Pennsylvania (Rhoads and Block 2000), but still occurs in New Jersey and Maryland. It occupies the southeastern U.S., Texas and Oklahoma, and its Midwestern distribution terminates in Illinois.

Ruellia caroliniensis, extirpated in the state, is represented by only two known herbarium specimens, both of which I have confirmed as correct identifications. One was collected at McCalls Ferry in York County along the Susquehanna River in the late 1800s (Herbarium of the Academy of Natural Sciences of Philadelphia, PH). I recently discovered a second collection at the University of Wisconsin Herbarium (WIS) in Madison. Collected by Thomas Porter (1822-1901), the label contains no data other than "Pennsylvania." Both *R. humilis* and *R. strepens* are perennials and grow in the Ridge and Valley physiographic province in Cumberland and Franklin counties in south-central Pennsylvania. The latter additionally occurs in the Pittsburgh Plateau province in Greene and Washington counties (Rhoads and Klein 1993). For this study, only the south-central populations were surveyed.

Ruellia humilis, a partial sun-loving species, is found chiefly in one site and is abundant there. The site is a privately owned, active limestone quarry (approximately 2 km^2 in area) in Franklin County (same location as *R. strepens* population number 3, Fig. 1). The quarry is semi-forested with *Juniperus virginiana* L. and *Cercis canadensis* L. and a non-native herbaceous dominant, *Bromus inermis* Leyss. Klotz and Walck (1993) designate the community type for *R. humilis* as "successional redcedar woodland" (see their 1993 publication for a detailed description of geologic affinities and community ecology of *Ruellia* in Pennsylvania). This population appears to be relatively stable over time. Some herbarium specimens document its existence just outside of this quarry, but there are no records in Pennsylvania of its occurrence outside of Franklin County. In preparing this manuscript,

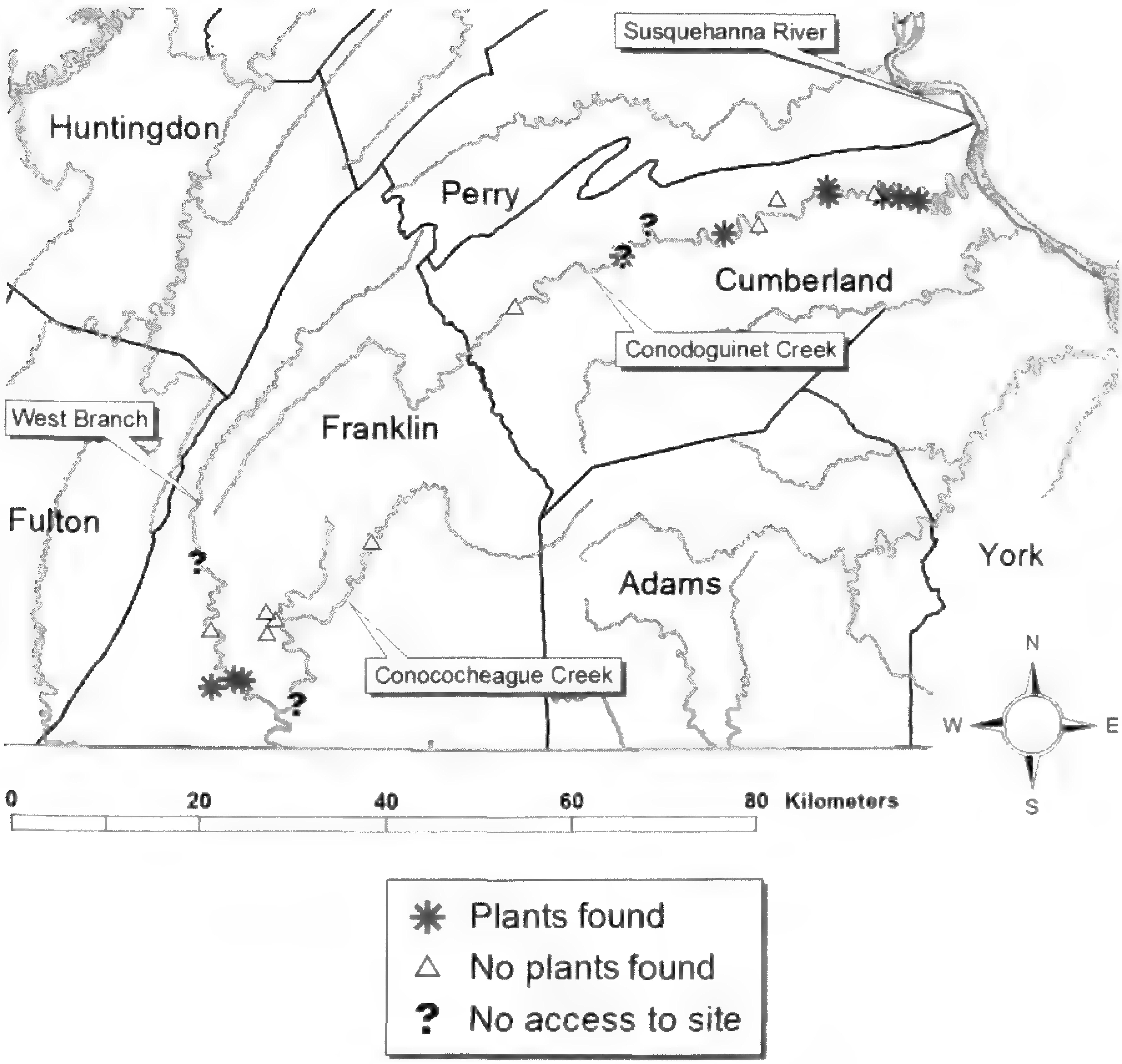

Figure 1. Map of extant *Ruellia strepens* localities in south-central Pennsylvania in 2002; not shown: Cherry Run (Franklin County), Safe Harbor (Lancaster County), and sites not surveyed by the author (see text).

I learned of a second major population of substantial size at Baker Caverns, Franklin County. Unfortunately, because it was discovered after the completion of fieldwork, it was not included in this study. *Ruellia humilis* additionally occurs near the Williamson Community Center, but I did not survey this population.

Ruellia strepens, a floodplain, shade-tolerant species, historically grew along the Conestoga River in Lancaster and Dauphin counties, but there is no documentation of its presence in Dauphin County in a half-century, and the Lancaster population was eradicated in 2001 by lawn mowing (J. Parks, personal communication, 2001). In Franklin County, it occurs on the banks and floodplains of the Conococheague Creek and its West Branch, both of which have headwaters in Franklin County (in Michaux and Buchanan State Forests) and empty into the Potomac River in northern Maryland (Fig. 1). In Cumberland County, it occurs along the Conodoguinet Creek, which begins near the Franklin/Fulton County border on the southwestern slopes of Kittatinny Mountain. The Conodoguinet flows east through Cumberland County and into the Susquehanna near Harrisburg. The community type for *R. strepens* is "xeric to mesic, calcareous, upland forest" sensu Klotz and Walck (1993). Based on specimen data (Rhoads and Block 2003; unpublished data, PH), there is an indication of a decline in the range and stability of *R. strepens* in Pennsylvania. It no longer grows in two previously occupied counties, and, based on this survey, no longer occupies many former sites in Franklin and Cumberland counties. From this survey, populations of *R. strepens* vary in size from one to approximately 55 individuals, but half of them contain 12 or fewer individuals. These smaller populations do not always appear each year (J. Parks, personal communication, 2001). Thus, a thorough update of its status is needed.

After completing my field surveys, I learned of seven new populations of *R. strepens* discovered by others between 2002 and 2003 (L. Klotz and J. Kunsman, personal communication, 2003). All seven populations are distributed in Franklin County, southwest of Chambersburg, along either the Conococheague Creek (five sites) or the West Branch Conococheague (two sites). One of these is among the most southern of *R. strepens* populations in Pennsylvania. It occurs about one minute of longitude north of the Maryland border and slightly south of the West Branch junction along the Conococheague. This site has been estimated to contain ca. 560 plants, perhaps the largest population in the state. It should be a top priority for monitoring and conservation as it may be the ancestral source population for other Pennsylvania populations. Threats to this population include logging, clearing, and invasive plant spread. The remainder of this paper addresses only the populations that I surveyed in 2002 (Table 1).

Two questions are addressed in this paper: (1) What is the current population status and distribution of *Ruellia humilis* and *R. strepens* in Pennsylvania? (2) Does this reassessment have conservation implications?

Methods

John Kunsman, botanist for the Nature Conservancy in Pennsylvania, provided previous field form data for 25 *R. strepens* sites across Cumberland, Franklin, and Lancaster counties and two sites for *R. humilis* in Franklin County (Table 1). He provided specific locality data for all sites except number 10, Cherry Run. Because he was not able to locate the field form data for this site, it was subsequently removed from this study. However, it occurs near the extreme southwestern border of Franklin County. With its exclusion, the combination of sites 13 and 20 due to proximity, and the addition of a newly discovered population (number 26, which I term Bernheisel Bridge South), 26 total sites were to be surveyed (24 *R. strepens* plus 2 *R. humilis* populations). Attempts were made to visit all 26 of these sites between 23 August and 14 September 2002. Permits were obtained from the Pennsylvania Department of Conservation and Natural Resources (D.C.N.R.) to collect voucher specimens. A voucher specimen was prepared from all populations except those with very few individuals (< 3); these have been deposited at the Academy of Natural Sciences of Philadelphia (PH). Between 45 and 90 minutes were spent surveying each site. Grounds were walked in a consistent, grid-like manner. Threats to populations were visually assessed and populations were designated as having immediate threats, minor threats, or no obvious threats. A full report of this survey was submitted to the Pennsylvania Science Office of The Nature Conservancy in Middletown.

Table 1. Recently reported (since 1984) south-central Pennsylvania *Ruellia* populations that the author surveyed or attempted to survey in 2002.

Site number, name	County	U.S.G.S. topographic quadrangle	Approximate number of individuals	Current threats to habitat
***R. strepens* populations**				
1 Baker Caverns	Franklin	Williamson	0	Mowing
2 Rockdale Woods	Franklin	Williamson	0	Exotic plant spread, herbicide use
3 Williamson Quarry	Franklin	Williamson	0	None
4 Fort Louden	Franklin	McConnellsburg	Not examined	Probably detroyed by fishery expansion
5 Siberia	Franklin	Chambersburg	0	None, habitat intact
6 Licking Creek	Franklin	Mercersburg	55	None, habitat intact
7 Martins Mill Bridge	Franklin	Williamson	Not examined	Private property, but habitat appears to be intact
8 North Welsh Run	Franklin	Williamson	12	None, habitat intact
9 Mercersburg Woods	Franklin	Mercersburg	0	Minor garbage dumping
10 Licking Creek 2	Franklin	Cherry Run	Not examined	Not examined
11 Conococheague Bridge	Franklin	Williamson	2	Minor foot traffic
12 Hampden School	Cumberland	Harrisburg West	25	Mowing
13 Lambs Gap Road/ /20 LGR West	Cumberland	Wertzville	50	Deer browsing
14 Cave Hill	Cumberland	Carlisle	0	None, habitat intact
15 Carlisle Woods	Cumberland	Carlisle	12	Minor foot traffic
16 Willow Grove/ Opossum Creek	Cumberland	Plainfield	Not examined	Not examined
17 Bloserville Hill	Cumberland	Plainfield	Not examined	Not examined
18 Bridge Road	Cumberland	Plainfield	1	Foot traffic, campers
19 Mountain Road	Cumberland	Newburg	0	Some exotic plant spread (*Polygonum cuspidatum*)
21 Howard Lane	Cumberland	Wertzville	17	None, habitat intact
22 Bernheisel Bridge	Cumberland	Wertzville traffic	25	Minor Appalachian Trail foot
23 Sample Bridge	Cumberland	Wertzville	0	None
24 Willow's Mill	Cumberland	Wertzville	0	Mowing, foot traffic
25 Owl Bridge	Lancaster	Safe Harbor	0	Mowing
26 Bernheisel Bridge South	Cumberland	Wertzville	10	Minor Appalachian Trail foot traffic
***R. humilis* populations**				
27 Valley Quarry	Franklin	Williamson	750	None, habitat intact
28 Johnston Run	Franklin	Mercersburg	Not examined	Not examined

In an attempt to identify the consequences of rarity in Pennsylvania *Ruellia*, while field-surveying *R. strepens* populations, samples were gathered for use in an allozyme-based study of genetic diversity. Many enzyme systems were assayed, following stain recipes from Wendel and Weeden (1989).

Results

Because this project was initiated late in the summer, *R. strepens* was not seen in open flower; it blooms primarily between May and July. Some cleistogamous flowers were visible in late August persisting on the beaks or distal portions of the capsules. *Ruellia humilis* produced chasmogamous and cleistogamous flowers concurrently through mid-September. The open flowers were visited by small fritillary butterflies as well as large and small bees, the smaller of which seemed to be less effective pollinators because they were able to bypass the anthers and stigma lobes to access the nectar (personal observation, 2002). All flowering had ceased in this species by 29 September 2002 at site 27.

Twenty-one of the 26 sites were surveyed (Table 1). The remaining five sites, numbers 4, 7, 16, 17, and 28, could not be surveyed because they were on private property and heavily posted, and the owners could not be located. Site 4 was owned by Mt. Parnell Fisheries. The manager would not grant permission for me to access his site because he was concerned any rare plant finds might deny him the opportunity to expand his fisheries in the future. Moreover, he noted that the habitat for the historic *R. strepens* population there had since been converted to a fishery.

Of the 21 sites surveyed, plants were found at 11 sites (Table 1). An estimated total of 209 *R. strepens* and 750 *R. humilis* individuals in Pennsylvania was observed. Thus, of the 26 total historic sites, population reassessment was not permitted at 6 sites (22%), extant populations were found at 11 sites (41%), and no plants were found at 10 sites (37%). Of the 21 sites successfully surveyed, 7 were under immediate levels of threat from a combination of deer browsing and habitat degradation (Table 1). Six other sites were moderately threatened by the above factors and the remaining eight were under no obvious threat to population vigor. Fifteen of the 26 sites were on private property and 11 were on public lands or lands not posted as private property.

Results from the allozyne-based study were inconclusive. No banding activity occurred in many assayed enzyme systems (AAT, ACO, ADH, CAT, GDH, HEX, IDH, ME, and RBC). Some systems showed activity at least once (GPI, MPI, PGD, PGM, SKD, and SOD), but bands were often faint and a definitive difference in enzyme mobility was difficult to detect (GPI, MPI, and SKD). When banding patterns were clear, PGM and SOD were consistently invariable, though PGD did show some variation. It is suspected that enzymatic activity was low in these samples due to prolonged freezer storage (–80° C for up to seven months) after field collection. Efforts are now underway to assess genetic diversity and gene migration patterns in these populations using amplified fragment length polymorphisms (AFLP), a technique that can utilize dried plant material and may detect variation more readily than allozymes.

Discussion

Nearly half of the historic populations of *Ruellia strepens* are no longer in existence. These data reflect a decrease in the number of extant *R. strepens* populations in Pennsylvania. Most of this decrease is likely attributable to a combination of deer browsing and habitat degradation including mowing, foot traffic, exotic plant spread, and various types of development. Possible inaccuracies in these population decrease estimates include the surveyor failing to find plants at the 10 non-extant sites, the lack of plants at the time of survey, and the unknown status of populations in the western part of the state (Greene and Washington counties). It is possible these populations may have died back before the survey or, as James Parks noted, they may not have appeared this season. No management strategies were developed for either species because most of the sites were privately owned. Though there is no evidence of large populations persisting on the inaccessible, privately owned sites, it would be worthwhile to attempt to contact the owners and look for plants. Most private property and neighboring-property owners of *Ruellia* sites who were contacted for this study were not aware of an endangered or threatened plant on their land. An attempt was made to inform them of this by showing them pressed specimens of *Ruellia*.

Recommendations to P.N.H.P. were made to change the status of *R. strepens* from a threatened to an endangered plant in Pennsylvania. The one *R. humilis* population on the limestone quarry site is under no immediate threat, as the plants are widespread across the glade and active mining is minimal and localized. However, future mining expansion could dramatically alter the current stability of the major Pennsylvania population. *Ruellia humilis* is already listed as an endangered species and no recommendations for status change were made. The changes in the populations of *R. strepens* in Pennsylvania indicated by this field study affirm the importance of periodically re-evaluating rare species, both for the benefit of the species and the credibility of state and federal endangered species programs. However, because I learned of additional, substantial *R. humilis* and *R. strepens* populations after preparing this manuscript, P.N.H.P. might choose to reconsider my recommended status change for *R. strepens*.

Identifying both the causes (e.g., natural or anthropogenic) and consequences (e.g., loss of genetic diversity) of rarity in plants is necessary for properly conserving biological diversity (Fiedler 2001). Species of *Ruellia* may be both naturally rare and further diminished by human disturbance. Rabinowitz et al. (1981) identified seven forms of rarity in plants, including plants that are broadly distributed but never abundant, narrowly distributed but abundant where found, and narrowly distributed and never abundant. *Ruellia humilis* and *R. strepens* are currently widespread across the eastern United States. Because species of *Ruellia* are relatively long-lived (at least a decade), have very high seed viability, and can mature in a single growing season (B. Lamack, personal communication, 2003), it may be that they have narrow ecological or habitat affinities that contribute to their rarity in particular areas. The aim of my ongoing research is to better understand these factors as well as the evolutionary history and flora diversification of this remarkable genus.

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An Ethnobotanical and Medical Research Literature Update on the Plant Species Collected in the Lewis and Clark Expedition of 1803-1806

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ABSTRACT. We compiled information on the medicinal and pharmacological activity of each of the 177 Lewis and Clark Herbarium (LCH) plant species, representing 129 genera, from ethnobotanical and current biomedical research literature. Medicinal uses by Native American groups have been documented for 123 species (approximately 69%) in 83 genera. We found research studies reporting pharmacological activity for only 26 (15%) of the species, although we also found reports of pharmacological activity for other species worldwide in 80 of the genera represented in the LCH. The disparity between the number of LCH species used in traditional American Indian medicine and the number that have undergone modern pharmacological evaluation suggests that future research may turn up additional compounds of use to modern medicine from Lewis and Clark's discoveries.

INTRODUCTION

Woolly mammoths, Peruvian llamas, blue-eyed, Welsh-speaking Indians — depictions of the land, creatures, and native peoples in the West often came from the imaginations of men who had never been there. Reports told of western terrain spotted with wondrous creatures: unicorns, seven-foot-tall beavers, and friendly, slim-waisted buffalo. In 1803, such myths defined the uncharted West; however, the Lewis and Clark expedition later dispelled such speculations (Burns 2004).

Thomas Jefferson took the oath of office as the third President of the United States on March 4, 1801. Even before Jefferson became president, he dreamed of exploring the land west of the Mississippi but his previous attempts to organize an expedition failed. After Jefferson was elected president, however, he was even more convinced that the future of the United States was tied to an expansion to the West.

On February 28, 1803, President Jefferson won approval for a congressional grant of $2,500 to fund an expeditionary group. Founded as an interdisciplinary effort, it would include commercial, geographical, political, and scientific interests. Meriwether Lewis and William Clark would lead the expedition, and their mission was to explore the unknown West.

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On the 6,000-mile expedition, the explorers mapped and described mountains, lakes, and rivers and documented 80 plant species that were sources of botanicals then unknown to science. Lewis and Clark collected, described, packed and sent East plant, animal, and mineral specimens, including over 200 plant specimens. This collection is now in the Lewis and Clark Herbarium at the Academy of Natural Sciences of Philadelphia (Johnston 1998; McCourt and Schuyler 2000).

Of the $2,500 allocated for the entire expedition, Lewis budgeted $55 for medicine and $696 for presents to give to Indians along the way. As the journey unfolded, however, the medicine was more important than the presents in securing beneficial relationships with the northwest natives (Loge 1996). Overall, however, Johnston (1998) believes that the Lewis and Clark expedition and botanists of the Western world owe a deep debt to those Native American tribes who shared their wealth of knowledge with the explorers, in some cases saving them from starvation and illness (Johnston 1998).

Reveal et al. (1999) document a total of 226 plant specimens in the Lewis and Clark Herbarium (LCH). They represent 177 plant species in 129 genera (Table 1). The purpose of this study is to provide answers to the following questions for each of the LCH plant species. What type of pharmacological activity is associated with each of the LCH plant species? Is the medicinal use of a plant supported by modern medical research and ethnobotanical data? How many of the plants are considered poisonous or toxic? How many of the plants lack documented modern medical research?

Methods

Moerman's (1998) landmark book, *Native American Ethnobotany*, was our primary resource for the ethnobotanical information. It documents Native American use of 4,029 plants; more than half were used medicinally. The breadth of Native American plant knowledge is shown by plant uses for food, fiber, dye, ceremonial and magical items, cleaning agents, containers, fertilizers, fuels, incense and fragrance, insecticides, jewelry, lubricants, musical instruments, preservatives, smoking, soap, waterproofing, tools, toys, and weapons. For each of the 177 LCH plant species, we indicated which of Moerman's 79 categories, from abortifacient to witchcraft medicine, describe its medicinal use and tallied the number of tribal groups for which each use has been documented.

Our source for research studies reporting pharmacological activity was the biomedical literature search system PubMed. It contains over 12 million citations from approximately 4,800 biomedical journals published in the United States and 70 other countries (United States Library of Medicine 2004).

Results

Medicinal uses by Native American groups have been documented for 123 species (approximately 69%) in 83 genera (Table 1). We found research studies reporting pharmacological activity for only about 28 (16%) of the species (Table 1), although we also found reports of pharmacological activity for other species worldwide in 80 of the genera represented in the LCH.

Antibacterial activity is present in *Alnus rubra, Arctostaphylos uva-ursi, Balsamorhiza sagittata, Ceanothus velutinus,* and *Veratrum californicum*. Antifungal compounds have been found in *Alnus rubra, Artemisia ludoviciana,* and *Balsamorhiza sagittata. Artemisia ludoviciana* has anti-malarial properties, and research has shown anti-viral capacity in *Amelanchier alnifolia, Amorpha fruticosa, Ipomopsis aggregata, Shepherdia argentea,* and *Vaccinium myrtillus.*

Anti-inflammatory properties have been discovered in *Achillea millefolium, Arctostaphylos uva-ursi, Artemisia ludoviciana, Juniperus communis,* and *Matricaria matricarioides.* Anticancer activity has been shown for extracts of *Amorpha fruticosa, Ipomopsis aggregata, Iris missouriensis, Liatris pycnostachya, Maclura pomifera, Oenothera cespitosa, Polanisia dodecandra, Rhus trilobata,* and *Vaccinium myrtillus.* Compounds in *Artemisia dracunculus* inhibit certain immune responses while substances in *Euphorbia marginata* stimulate others.

LCH species with other pharmacological effects include *Achillea millefolium* (used to treat gastrointestinal diseases; antispermatogenic), *Alnus rubra* (promotes glucose metabolism), *Arctostaphylos uva-ursi* (used to treat urinary tract diseases; inhibits melanin biosynthesis), *Equisetum arvense* (used to prevent and treat kidney stones), and *Vaccinium myrtillus* (used to treat ulcers; used for treatment of ischaemia reperfusion injury; reduces LDL-cholesterol levels; affects night-vision).

Toxicity has been observed in *Equisetum arvense* (ingestion can cause dermatitis), *Euphorbia marginata* (sap causes contact dermatitis, conjunctivitis, and keratitis), *Pinus ponderosa* (toxic to livestock), *Rubus spectabilis* (causes epidermal necrolysis when ingested), and *Veratrum californicum* (teratogenic, i.e., causes limb deformities in fetuses when ingested by pregnant females).

Discussion

Prescription drugs prolong and improve the quality of life. They also frequently reduce or replace more expensive forms of medical treatment such as hospitalization, nursing care, and surgery. With the great potential for continued pharmaceutical breakthroughs, prescription drugs will continue to play an important role in containing costs, even as overall healthcare expenditures increase (Balick and Cox 1996). According to Pharmaceutical Research and Manufacturers of America (Anonymous 2004), it typically takes 10 to15 years and over $800 million to advance a potential new medicine from a research idea to a treatment approved by the Food and Drug Administration. In the past, the discovery of a drug was a process of trial and error and serendipitous discovery; it has now become more systematic through the use of increasingly sophisticated technology (Anonymous 2004). However, does discovery of a drug always rest only on "solid" science, such as structural chemistry and pharmacology, or can traditional usage, woods lore, and knowledge handed down over many generations play a role (Balick and Cox 1996)? We favor a rational combined approach utilizing both ethnobotanical data and the results of modern laboratory and clinical research as appropriate means to identify areas of research potential.

This paper is the first medical literature summary for the 177 species of the Lewis and Clark Herbarium collection. If you were to walk into any pharmacy in the United States, Canada, or Western Europe and pick any prescription medicine at random, there is a one in four chance that the medicine you choose has an active ingredient derived from a plant (Balick and Cox 1996). Most of these plant-derived drugs were originally discovered through the study of the folk knowledge and traditional cures of indigenous peoples — much the same ethnobotanical approach (Balick and Cox 1996) practiced in 1803 to 1806 by Lewis and Clark in the American West.

Approximately one-fifth of the LCH species used medicinally by Native Americans have been subjected to modern research methods and found to have pharmacological activity. The disparity between the number of LCH species used in traditional American Indian medicine and the number that have undergone modern pharmacological evaluation suggests that future research may turn up additional compounds of use to modern medicine from Lewis and Clark's discoveries.

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Table 1. Ethnobotanical (Moerman 1998) and biomedical information on the Lewis and Clark Herbarium (LCH) plant species. Subjects of biomedical studies were dervied from research publications and abstracts compiled using the PubMed biomedical literature search system; primary sources are numbered (see endnotes on pages 89–93). Plant nomenclature follows Spamer and McCourt (2002).

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Acer circinatum Pursh	Antidiarrheal, love medicine, miscellaneous disease remedy (treatment for polio): 1	*
Acer macrophyllum Pursh	Dermatological aid, tonic, tuberculosis remedy: 1	*
Achillea millefolium L. var. *lanulosa* (Nutt.) Piper	Anthelmintic, anticonvulsive, antirheumatic used internally, breast treatment, ceremonial medicine, dietary aid, diuretic, ear medicine, emetic, heart medicine, hemorrhoid remedy, hemostat, internal medicine, laxative, poultice, sedative, witchcraft medicine: 1	Isolation of anti-inflammatory principles[1]
		Treatment of chronic hyposecretory gastritis, chronic hepatocholecystitis and angiocholitis[2]
	Antiemetic, antihemorrhagic, burn dressing, cathartic, disinfectant, herbal steam, other, reproductive aid, snakebite remedy, unspecified, urinary aid, venereal aid, veterinary aid: 2	Antispermatogenic effect in mice[3]
	Blood medicine, cough medicine, respiratory aid, stimulant, tonic, tuberculosis remedy: 3	
	Kidney aid, liver aid: 4	
	Diaphoretic: 5	
	Antidiarrheal, eye medicine, miscellaneous disease remedy (treatments for grippe, mumps, influenza and the flu), orthopedic aid, pediatric aid: 6	
	Gynecological aid, panacea, throat aid, toothache remedy: 7	
	Antirheumatic used externally: 8	
	Gastrointestinal aid: 9	
	Febrifuge: 10	
	Analgesic: 14	
	Cold remedy: 17	
	Dermatological aid: 27	
Allium geyeri S. Watson	Used as food. Not utilized as a drug.	*

* Non-LCH species in the genus investigated and found to have pharmacological properties.

† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Alnus rubra Bong.	Antihemorrhagic, cold remedy, cough medicine, emetic, internal medicine, miscellaneous disease remedy (treatment for internal ailments), respiratory aid, toothache remedy: 1 Antidiarrheal, cathartic, orthopedic aid, pulmonary aid, tonic: 2 Gastrointestinal aid: 3 Tuberculosis remedy, unspecified: 4 Analgesic: 5 Dermatological aid: 8	Contains enzymes of glucose metabolism[4] Antibacterial activity[5] Antifungal activity against nine fungal species[6] According to interviews with two elder Salishan women, the bark was used as medicine for digestive tract ailments[7]
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer var. *semiintegrifolia* (Hook.) C.L. Hitchc.	Venereal aid: 1	Extracts active against an enteric coronavirus[8]
Amphora fruticosa L.	Primarily used for fiber. Other uses include hunting and fishing items and cooking tools. Not utilized as a drug.	Strong inhibitory effects on Epstein-Barr virus[9] Active antitumor compounds, which include eight cytotoxic isoflavones[10,11]
Ampelopsis cordata Michx.	Urinary aid: 1	*
Amsinckia menziesii (Lehm.) A. Nelson & J.F. Macbr. var. *retrorsa* (Suksd.) Reveal & Schuyler	0	* Plant toxins (alkaloids) in *Amsinckia* pose a toxicity hazard[12]
Anemone canadensis L.	Analgesic, anthelmintic, ceremonial medicine, dermatological aid, eye medicine, hemostat, orthopedic aid, throat aid, witchcraft medicine: 1 Panacea: 2	†
Anemone piperi Britt. ex Rydb.	0	†

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Angelica arguta Nutt. in Torr. & A. Gray	Antidiarrheal, antiemetic, antihelmintic, carminative, cold remedy, eye medicine, febrifuge, gynecological aid, love medicine, pediatric aid, psychological aid, respiratory aid, sedative, snakebite remedy, venereal aid: 1	*
	Dermatological aid, orthopedic aid: 2	
	Analgesic, gastrointestinal aid: 4	
Arbutus menziesii Pursh	Burn dressing, ceremonial medicine, dietary aid, love medicine, miscellaneous disease remedy (treatment for diabetes), veterinary aid: 1	According to interviews with two elder Salishan women, respiratory, digestive and gynecological problems were treated with the bark[7]
	Emetic: 2	
	Cold remedy, throat aid: 3	
	Dermatological aid, gastrointestinal aid: 4	
Arctostaphylos uva-ursi (L.) Spreng.	Abortifacient, adjuvant, antidiarrheal, antirheumatic used externally, burn dressing, cold remedy, cough medicine, dietary aid, diuretic, ear medicine, emetic, gynecological aid, hunting medicine, laxative, panacea, psychological aid: 1	Disinfectant action for urolithiasis[13]
	Analgesic, blood medicine, ceremonial medicine, narcotic, orthopedic aid, tonic: 2	Antimicrobial activity of extracts most active against *Escherichia coli* and *Proteus vulgaris*[14]
	Antihemorrhagic, dermatological aid, eye medicine, oral aid, pediatric aid: 3	Investigations of iridoid substances, disinfective effect on the urinary tract[15]
	Kidney aid, unspecified, urinary aid: 4	Increases effect on antiallergetic and anti-inflammatory activities of dexamethasone ointment[16]
		Arbutin, isolated from its leaves, may increase the inhibitory action of indomethacin[17]
		Combined effects of arbutin and prednisolone on immuno-inflammation[18]
		Inhibitatory effects on melanin biosynthesis[19]
		Anti-tyrosinase activity[20]

(*continued*)

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Arctostaphylos uva-ursi (L.) Spreng. (*cont'd*)		A field study documents some traditional and contemporary knowledge of the medicinal use of plants by the Carrier people, which includes *A. uva-ursi*[21] Reduced hyperphagia and polydipsia associated with streptozotocin diabetes[22]
Argentina anserina (Lehm.) L. var. *grandis* (Torr. & A. Gray) Rydb.	Analgesic, diuretic, emetic, pediatric aid: 1 Antidiarrheal, dermatological aid: 2	†
Artemisia cana Pursh	Dermatological aid, dietary aid, tonic: 1 Unspecified: 2	* *Artemisia* species frequently utilized for treating malaria, hepatitis, cancer, inflammation and infections by fungi, bacteria and viruses[23]
Artemisia dracunculus L.	Analgesic, antidiarrheal, eye medicine, gastrointestinal aid, stimulant, tonic, unspecified, urinary aid, veterinary aid, witchcraft medicine: 1 Cold remedy, gynecological aid: 2 Dermatological aid, pediatric aid: 3 Antirheumatic used externally: 4	Natural inhibitor of complement[24] Oil has genotoxic properties[25]
Artemisia frigida Willd.	Analgesic, anticonvulsive, antihemmorhagic, cancer treatment, carminative, dermatological aid, disinfectant, eye medicine, panacea, pulmonary aid, tonic, toothache remedy, tuberculosis remedy, unspecified, venereal aid, veterinary aid: 1 Ceremonial medicine, febrifuge, gynecological aid: 2 Hemostat, stimulant, miscellaneous disease remedy (treatments for mountain fever, diabetes, flu): 3 Cold remedy, cough medicine, gastrointestinal aid: 4 Abortifacient: 5	Source of fall allergic symptoms, particularly in western United States[26] Field study documents medicinal uses of plant by Carrier people, an Athapaskan-speaking people of British Columbia[21]

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Artemisia longifolia Nutt.	0	
Artemisia ludoviciana Nutt. var. *latiloba* Nutt.	Analgesic, antidiarrheal, antirheumatic used externally, carminative, cathartic, ceremonial medicine, febrifuge, hemostat, miscellaneous disease remedy (treatment for influenza), nose medicine, orthopedic aid, other, pediatric aid, pulmonary aid, strengthener, tuberculosis remedy: 1 Disinfectant, eye medicine, gastrointestinal aid, panacea, respiratory aid: 2 Throat aid, cold remedy: 3 Veterinary aid: 4 Unspecified: 5 Dermatological aid: 8	Ethanolic leaf extracts exhibit anti-inflammatory activity[27] Antimalaric effect of an alcoholic extract in a rodent malaria model[28] Antifungal activity[6]
Aster eatonii (A. Gray) Howell	0	†
Aster oblongifolius Nutt.	Witchcraft medicine: 1	†
Astragalus canadensis L.	Analgesic, cough medicine, dermatological aid, febrifuge: 1 Antihemorrhagic, pediatric aid, pulmonary aid: 2	* Lysosomal storage diseases induced by ingestion of various *Astragalus* species[29] * *Astragalus*, containing the toxin swainsonine, causes severe adverse effects on reproductive function in livestock[30,31]
Astragalus missouriensis Nutt.	0	
Atriplex canescens (Pursh) Nutt.	Analgesic, cathartic, cough medicine, hunting medicine, miscellaneous disease remedy (treatment for itches or rashes such as chickenpox or measles), nose medicine, poison, stimulant, toothache remedy, veterinary aid: 1 Ceremonial medicine, emetic, gastrointestinal aid: 2 Dermatological aid: 5	Phytochemical studies of nucleotide sequence of cDNA[32,33] * Excretion of selenium (in *Atriplex* species) via milk is important in the deficiency state, but when in excess may cause toxicity to offspring[12]

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Atriplex nuttallii S. Wats.	Used as food. Not utilized as a drug.	
Balsamorhiza sagittata (Pursh) Nutt.	Antidiarrheal, cathartic, cold remedy, dietary aid, eye medicine, febrifuge, gynecological aid, hemostat, oral aid, urinary aid, panacea, pulmonary aid, sedative, throat aid, toothache remedy: 1 Antirheumatic used internally, burn dressing, diaphoretic, disinfectant, gastrointestinal aid, tuberculosis remedy, venereal aid: 2 Analgesic: 4 Dermatological aid: 7	Antibacterial thiophene isolated[34] Root extracts exhibited antifungal activity[6]
Bazzania trilobata (L.) S.F. Gray	Used as a dye. Not utilized as a drug.	Antifungal activity[35]
Berberis aquifolium Pursh	0	* Berbamine, a constituent of *Berberis* species, exhibits leukogenic, anti-arrhythmic, anti-hypertensive, anti-inflammatory and anti-tumor activity[36,37,38]
Berberis nervosa Pursh	0	
Blechnum spicant (L.) Sm.	Antidiarrheal, cancer treatment, dermatological aid, orthopedic aid, panacea, pulmonary aid: 1 Gastrointestinal aid: 2	*
Calochortus elegans Pursh	0	†
Calypso bulbosa L. Oakes var. *occidentalis* (Holz.) Boivin	Anticonvulsive: 1	†
Camassia quamash (Pursh) Greene	Gynecological aid: 1	*
Camassonia subacaulis (Pursh) Raven	0	†
Cardamine nuttallii Greene	0	*

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Ceanothus sanguineus Pursh	Burn dressing, dermatological aid: 1	* Alkaloids isolated from *Ceanothus* species[39]
Ceanothus velutinus Dougl. ex Hook.	Antidiarrheal, antirheumatic used externally, antirheumatic used internally, cancer treatment, ceremonial medicine, cough medicine, dietary aid, febrifuge, miscellaneous disease remedy, other, panacea, pediatric aid, venereal aid: 1 Analgesic, dermatological aid, orthopedic aid, unspecified: 2	Antimicrobial properties[40]
Cerastium arvense L.	Dermatological aid, gynecological aid: 1	†
Chrysothamnus viscidiflorus (Hook.) Nutt. ssp. *viscidiflorus*	Antirheumatic used externally, cold remedy, cough medicine, dermatological aid, diaphoretic, miscellaneous disease remedy (treatment for influenza), toothache remedy: 1	†
Cirsium edule Nutt.	Used as food. Not utilized as a drug.	*
Clarkia pulchella Pursh	0	*
Claytonia lanceolata Pursh	Used as food. Not utilized as a drug.	†
Claytonia parviflora Douglas ex Hook.	Used as food and in toys and games. Not utilized as a drug.	†
Claytonia perfoliata Donn ex Willd.	Analgesic, antirheumatic used externally, eye medicine: 1	†
Claytonia siberica L.	Eye medicine, gynecological aid, tonic, urinary aid, venereal aid: 1 Throat aid: 2 Dermatological aid: 4	†
Clematis hirsutissima Pursh	Respiratory aid, veterinary aid, witchcraft medicine: 1 Analgesic: 2	Blistering agent isolated and used by the Nez Perce and Teton Sioux nations as a horse stimulant[41,42]
Cleome serrulata Pursh	Blood medicine, ceremonial medicine, dermatological aid, eye medicine, febrifuge, gastrointestinal aid, throat aid: 1	*

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Collinsia parviflora Lindl. var. *grandiflora* (Lindl.) Ganders & Krause	Dermatological aid, veterinary aid: 1	†
Collomia linearis Nutt.	Dermatological aid: 1	†
Coreopsis tinctoria Nutt. var. *atkinsoniana* (Dougl. ex Lindl.) H.M. Parker	Antidiarrheal: 1	* Alcohol esters from *Coreposis* species and synthetic derivatives examined as lipoxygenase inhibitors and as LDL (low density lipoprotein)-stabilizing agents[30]
Cornus canadensis L.	Cathartic, dermatological aid, febrifuge, gastrointestinal aid, gynecological aid, orthopedic aid, pediatric aid, tuberculosis remedy, unspecified: 1 Anticonvulsive, cold remedy, eye medicine, tonic: 2 Analgesic: 3	*
Crataegus douglasii Lindl.	Antirheumatic, oral aid, panacea, pediatric aid: 1 Antidiarrheal, gastrointestinal aid: 2 Dermatological aid: 3	* *Crataegus* extract is used in cardiology in Germany for the treatment of mild to moderate heart failure[43]
Dalea purpurea Vent.	Dermatological aid: 1	*
Dasiphora fruticosa (L.) Rydb.	0	†
Delphinium menziesii DC. var. *pyramidale* (Ewan) C.L. Hitchc.	Dermatological aid, love medicine, poison, unspecified: 1	* Larkspurs (*Delphinium* spp.) are toxic plants that contain numerous diterpenoid alkaloids and are associated with poisoning in livestock[44]
Dodecatheon poeticum L.F. Hend.	0	†
Dryopteris carthusiana (Vill.) H.P. Fuchs	Antidote: 1	*
Egregia menziesii (Turn.) Aresch.	Used as food, fertilizer, and for hunting and fishing. Not utilized as a drug.	†

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Eleagnus commutata Bernh. ex Rydb.	Dermatological aid, pediatric aid, venereal aid: 1	†
Equisetum arvense L.	Blood medicine, laxative, pediatric aid, stimulant, toothache remedy, venereal aid: 1 Analgesic, antirheumatic used internally, diuretic: 2 Kidney aid, urinary aid, veterinary aid: 3 Orthopedic aid: 4 Dermatological aid: 5	Sterols from *E. arvense*[45] Suspected application to prevent and treat kidney stone formation with urolithiasis risk factors (citraturia, calciuria, phosphaturia, pH, and diuresis)[13] When mixed with a cholesterol diet at 4%, caused dermatitis at the neck, head and back in about 20–60% of rats[46] Seborrhoeic dermatitis induced by nicotine of horsetails[47]
Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & Baird	0	†
Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & Baird var. *graveolens* (Nutt.) Reveal & Schuyler	0	†
Erigeron compositus Pursh	Dermatological aid, orthopedic aid: 1	*
Eriophyllum lanatum (Pursh) Forbes var. *lanatum*	Dermatological aid, love medicine: 1	*
Erysimum capitatum Douglas ex Hook. var. *purshii* (Durand) Rollins	Analgesic, antirheumatic used externally, ceremonial medicine, gynecological aid, respiratory aid, toothache remedy, tuberculosis remedy: 1 Emetic: 2	*
Erythronium grandiflorum Pursh	Dermatological aid, cold remedy: 1	Contains 2-alpha-methylene butyrolactone, which is utilized in Native American food and medicinal plants[48]
Euphorbia cyathophora Murr.	0	

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† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Euphorbia marginata Pursh	Antirheumatic used externally, gynecological aid, poison: 1	Irritant contact dermatitis[49,50] Lectin is strongly mitogenic for human T-lymphocytes and induces the release of interleukin-1 beta and tumor necrosis factor-alpha from cultured mononuclear cells[51] Sap may cause acute conjunctivitis and keratitis[52]
Festuca idahoensis Elmer	Used for fiber. Not utilized as a drug.	*
Frangula purshiana (DC.) Cooper	Adjuvant, analgesic, antidiarrheal, antihelmintic, antirheumatic used internally, blood medicine, disinfectant, liver aid, tonic, unspecified: 1 Emetic, panacea, poison, venereal aid: 2 Dermatological aid: 3 Gastrointestinal aid: 5 Cathartic: 7 Laxative: 21	* Review article: anthranoid laxatives and their potential carcinogenic effects[53, 54]
Frasera fastigiata (Pursh) Heller	0	†
Fritillaria affinis (Schultes & Schultes f.) Sealy	0	*
Fritillaria pudica (Pursh) Spreng.	Used as food, decoration and seasonal indicator. Not utilized as a drug.	*
Gaillardia aristata Pursh	Breast treatment, cancer treatment, dermatological aid, eye medicine, gastrointestinal aid, kidney aid, miscellaneous disease remedy (treatment for mumps), nose medicine, tuberculosis remedy, venereal aid, veterinary aid: 1 Analgesic, orthopedic aid: 2	†

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Gaultheria shallon Pursh	Antidiarrheal, burn dressing, cough medicine, oral aid, other, reproductive aid, tonic: 1	†
	Dermatological aid, gastrointestinal aid, tuberculosis remedy: 2	
Geum triflorum Pursh var. *ciliatum* (Pursh) Fassett	Blood medicine, eye medicine, gastrointestinal aid, stimulant: 1	*
	Veterinary aid: 2	
Grindelia squarrosa (Pursh) Dunal	Abortifacient, analgesic, antihemorrhagic, emetic, gynecological aid, liver aid, miscellaneous disease remedy, orthopedic aid, pediatric aid: 1	* Triterpenoid sapogenins in the genus *Grindelia*[55]
	Expectorant, eye medicine, kidney aid, respiratory aid, tuberculosis remedy, urinary aid, and veterinary aid: 2	
	Cold remedy, dermatological aid, disinfectant, gastrointestinal aid, pulmonary aid, venereal aid: 3	
	Cough medicine: 5	
Gutierrezia sarothrae (Pursh) Britt. & Rusby	Antidote, cathartic, cough medicine, diuretic, ear medicine, emetic, eye medicine, hemostat, herbal steam, orthopedic aid, panacea, pediatric aid, pulmonary aid, respiratory aid, sedative, strengthener, venereal aid, vertigo medicine: 1	* Snakeweeds are toxic and cause abortions in cattle, sheep, and goats[56]
	Antidiarrheal, cold remedy, diaphoretic, febrifuge, miscellaneous disease remedy (treatment for measles and gastric influenza), urinary aid: 2	* Diets containing as little as 10% snakeweed will induce early embryonic toxicosis and abortion in Sprague-Dawley rats[57]
	Analgesic, antirheumatic used externally, ceremonial medicine, gastrointestinal aid, gynecological aid, snakebite remedy: 3	Isolation of an antitumor proteinaceous substance[58]
	Disinfectant, veterinary aid: 4	
	Dermatological aid: 5	
Hesperostipa comata (Trin. & Rupr.) Barkworth	0	†

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Holodiscus discolor (Pursh) Maxim	Antidiarrheal, blood medicine, burn dressing, dermatological aid, eye medicine, miscellaneous disease remedy (infusion of seeds taken for smallpox, black measles, and chickenpox), oral aid, orthopedic aid, tonic, unspecified: 1 Miscellaneous disease remedy: 2	†
Hordeum jubatum L.	Eye medicine, poison, unspecified: 1	†
Hypnum oreganum Sull.	0	†
Ipomopsis aggregata (Pursh) V. Grant	Blood medicine: 1	Potential anticancer agents[59] An extract demonstrated activity against parainfluenza virus type III[8]
Iris missouriensis Nutt.	Antirheumatic used externally, burn dressing, ceremonial medicine, kidney aid: 1 Analgesic, dermatological aid, ear medicine, gastrointestinal aid, urinary aid, venereal aid: 2 Emetic, toothache remedy: 3	Triterpenes, plant anticancer agents[60]
Juniperus communis L. var. *depressa* Pursh	Antirheumatic used externally, ceremonial medicine, diaphoretic, disinfectant, emetic, heart medicine, herbal steam, hypotensive, love medicine, miscellaneous disease remedy (taken to prevent flu and used also for treatment of flu), orthopedic aid, other, pediatric aid, sedative, unspecified, urinary aid, venereal aid: 1 Analgesic, antirheumatic used internally, blood medicine, cathartic, eye medicine, febrifuge, gastrointestinal aid, panacea, throat aid, toothache remedy: 2 Antidiarrheal, gynecological aid, pulmonary aid: 3 Dermatological aid, respiratory aid, tuberculosis remedy: 5 Cold remedy, kidney aid: 6 Cough medicine: 7 Tonic: 8	Field study on medicinal uses of plant by Carrier people, an Athapaskan-speaking people of British Columbia[27] Hypoglycemic activity of juniper berries[22,61] Used in Swedish traditional medicine to treat inflammatory diseases and/or wounds exhibiting inhibitory activity on prostaglandin biosynthesis and platelet activating factor (PAF)[62]

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Juniperus horizontalis Moench	Cold remedy, cough medicine, febrifuge, gynecological aid, herbal steam, love medicine, sedative, throat aid, veterinary aid: 1 Ceremonial medicine, kidney aid: 2	
Juniperus scopulorum Sarg.	Antidiarrheal, antiemetic, diaphoretic, dietary aid, diuretic, heart medicine, herbal steam, love medicine, poison, sedative, throat aid, tonic, venereal aid, witchcraft medicine: 1 Analgesic, cough medicine, disinfectant, kidney aid, other, panacea, tuberculosis remedy, unspecified, urinary aid, veterinary aid: 2 Antihemorrhagic, gastrointestinal aid, gynecological aid: 3 Dermatological aid: 4 Antirheumatic used externally, ceremonial medicine, pulmonary aid: 5 Febrifuge, miscellaneous disease remedy (treatment for sugar diabetes, flu and colds, cholera, kidney trouble, black measles or chickenpox): 6 Cold remedy: 7	
Koeleria macrantha (Ledeb.) J.A. Schultes	Ceremonial medicine, dermatological aid, stimulant: 1	†
Lewisia rediviva Pursh	Blood medicine, breast treatment, dermatological aid, heart medicine, miscellaneous disease remedy (treatment for diabetes), pulmonary aid, throat aid, witchcraft medicine: 1 Gynecological aid: 2	†
Lewisia triphylla (S. Wats.) B.L. Robins.	0	†
Leymus mollis (Trin.) Hara	Strengthener: 1 Unspecified: 2	†
Liatris aspera Michx.	0	
Liatris pycnostachya Michx.	0	Contains pycnolide, an antitumor constituent[63]

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† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Linum lewisii Pursh	Analgesic, carminative, disinfectant, liver aid, poultice, unspecified: 1	*
	Gastrointestinal aid, pediatric aid: 2	
	Eye medicine: 3	
	Dermatological aid: 5	
Lomatium cous (S. Wats.) Coult. & Rose	0	*
Lomatium cuspidatum Mathias & Constance	0	*
Lomatium dissectum (Nutt.) Mathias & Constance var. *multifidum* (Nutt.) Mathias & Constance	Dietary aid, eye medicine, gastrointestinal aid, other, pediatric aid, poison, stimulant, unspecified: 1	*
	Analgesic, antirheumatic used externally, ceremonial medicine, tonic: 2	
	Disinfectant, herbal steam, panacea, pulmonary aid, throat aid, tuberculosis remedy, venereal aid: 3	
	Cold remedy, cough medicine, miscellaneous disease remedy (treatment of colds and flu, influenza, smallpox), orthopedic aid, respiratory aid: 4	
	Veterinary aid: 6	
	Dermatological aid: 7	
Lomatium nudicaule (Pursh) Coult. & Rose	Analgesic, antirheumatic used externally, ceremonial medicine, cough medicine, dermatological aid, diaphoretic, febrifuge, gastrointestinal aid, gynecological aid, herbal steam, hunting medicine, internal medicine, laxative, orthopedic aid, panacea: 1	*
	Throat aid: 4	
	Cold remedy: 6	
Lomatium Raf.	Antirheumatic used externally, dermatological aid, love medicine: 1	*
Lomatium triternatum (Pursh) Coult. & Rose	Cold remedy, panacea, pulmonary aid, strengthener, throat aid: 1	*

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† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Lonicera ciliosa (Pursh) Poir. ex DC.	Anticonvulsive, cold remedy, contraceptive, reproductive aid, sedative, throat aid, tuberculosis remedy, unspecified: 1 Dermatological aid, gynecological aid, tonic: 2	*
Lonicera involucrata (Richardson) Banks ex Spreng.	Antidote, antirheumatic used externally, burn dressing, cathartic, ceremonial medicine, dietary aid, disinfectant, gastrointestinal aid, herbal steam, love medicine, oral aid, psychological aid, pulmonary aid, stimulant, throat aid, urinary aid: 1 Analgesic, cough medicine, venereal aid: 2 Eye medicine, orthopedic aid: 3 Emetic, gynecological aid: 4 Poison: 5 Dermatological aid: 9	*
Lonicera utahensis S. Watson in C. King	Blood medicine, dermatological aid, hunting medicine, laxative: 1	*
Lupinus argenteus Pursh	Dermatological aid: 1	*
Lupinus sericeus Pursh	Eye medicine: 1	*
Machaeranthera canescens (Pursh) A. Gray	Emetic, nose medicine, throat aid, witchcraft medicine: 1	* Excretion of selenium via milk from consumption of *Machaeranthera* species can counter deficiency, but in excess may cause toxicity to offspring[12]
Machaeranthera pinnatifida (Hook.) Shinners	Analgesic: 1	
Maclura pomifera (Raf.) Schneid.	Eye medicine: 1	*M. pomifera* may have limited usefulness in diagnosing pulmonary neoplasms because it binds to all the normal components of the bronchopulmonary tree and to squamous cell carcinoma, adenocarcinoma, and small-cell carcinoma[64]

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Matricaria matricarioides (Less.) Porter	0	Contains helianol, a triterpene alcohol exhibiting anti-inflammatory activity[65]
Mimulus guttatus DC.	Analgesic, dermatological aid, gastrointestinal aid, herbal steam, orthopedic aid: 1	†
Mirabilis nyctaginea (Michx.) MacM.	Anthelmintic, burn dressing, febrifuge, gynecological aid, oral aid, pediatric aid, urinary aid: 1 Orthopedic aid: 3 Dermatological aid: 4	†
Nicotiana quadrivalvis Pursh	Used as a ceremonial item and smoke plant. Not utilized as a drug.	*
Oenothera cespitosa Nutt.	Ceremonial aid, gynecological aid, unspecified: 1 Dermatological aid: 3	*O. cespitosa* contains antineoplastic agents[66]
Orthocarpus tenuifolius (Pursh) Benth.	0	*
Osmorhiza Raf.	Analgesic, antidiarrheal, blood medicine, cathartic, dermatological aid, emetic, febrifuge, hunting medicine, laxative, love medicine, pediatric aid, pulmonary aid, snakebite remedy, tonic, unspecified, venereal aid, veterinary aid: 1	*
Oxytropis besseyi (Rydb.) Blank	0	* *Oxytropis* species cause severe adverse effects on reproduction function in livestock[31,67,68]
Paxistima myrsinites (Pursh) Raf.	Analgesic, ceremonial medicine, cold remedy, dermatological aid, emetic, internal aid, kidney aid, orthopedic aid, unspecified: 1 Tuberculosis remedy: 2	†
Pedicularis cystopteridifolia Rydb.	0	*
Pedicularis groenlandica Retz.	Cough medicine: 1	*

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† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Pediomelum argophyllum (Pursh) J.W. Grimes	Dermatological aid, febrifuge, laxative, unspecified: 1 Veterinary aid: 2	†
Pediomelum esculentum (Pursh) Rydb.	Antidiarrheal, antirheumatic used externally, burn dressing, ear medicine, eye medicine, gastrointestinal aid, orthopedic aid, pediatric aid, pulmonary aid, throat aid, toothache remedy: 1 Unspecified: 2	†
Penstemon fruticosus (Pursh) Greene	Analgesic, antirheumatic used externally, cold remedy, dermatological aid, emetic, eye medicine, gynecological aid, kidney aid, love medicine, miscellaneous disease remedy (treatment for flu), orthopedic aid, toothache remedy, unspecified, urinary aid: 1 Gastrointestinal aid, veterinary aid: 2	†
Penstemon wilcoxii Rydb.	0	†
Phacelia heterophylla Pursh	Dermatological aid: 1	* Contact allergies/dermatitis associated with various *Phacelia* species[69,70,71]
Phacelia linearis (Pursh) Holz.	Cold remedy, unspecified: 1	
Philadelphus lewisii Pursh	Antirheumatic used externally, breast treatment, cathartic, dermatological aid, hemorrhoid remedy, pulmonary aid: 1	†
Phlox speciosa Pursh	0	†
Pinus ponderosa P. & C. Lawson	Abortifacient, analgesic, antihemorrhagic, cough medicine, ear medicine, emetic, gastrointestinal aid, gynecological aid, panacea, sedative, stimulant, veterinary aid, witchcraft medicine: 1 Antirheumatic used externally, ceremonial aid, febrifuge, pediatric aid: 2 Eye medicine: 3 Dermatological aid: 6	Ponderosa pine and broom snakeweed: poisonous plants that affect livestock[56] Effect of feeding ponderosa plant needle extracts and their residues to pregnant cattle[72]

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Plagiobothrys tenellus (Nutt. ex Hook.) Gray	0	†
Poa canbyi (Scribn.) Howell	0	* IgE-binding trypsin inhibitors in plant pollen extracts of various *Poa* species[73]
Polanisia dodecandra (L.) DC. ssp. *trachysperma* (Torr. & Gray) Iltis	Used for fiber and as a ceremonial item and smoke plant. Not utilized as a drug.	Isolation of antitumor agents (cytotoxic and antimitotic flavonols and cytotoxic triterpenes)[74,75]
Polemonium pulcherrimum Hook.	Dermatological aid: 1	*
Polygala alba Nutt.	Ear medicine: 1	*
Polygonum bistortoides Pursh	Dermatological aid: 1	*
Populus balsamifera L. ssp. *trichocarpa* (Torr. & Gray ex Hook.) Brayshaw	Antirheumatic used externally, burn dressing, ceremonial medicine, cold remedy, ear medicine, gynecological aid, love medicine, pulmonary aid, respiratory aid, veterinary aid: 1	*
	Disinfectant, orthopedic aid, throat aid, tuberculosis remedy, venereal aid: 2	
	Unspecified: 4	
	Dermatological aid: 12	
Populus deltoides Bartr. ex Marsh. ssp. *monilifera* (Ait.) Eckenwalder	Ceremonial medicine, dermatological aid: 1	*
Prunus emarginata (Dougl. ex Hook.) Walp.	Cancer treatment, dermatological aid, dietary aid, eye medicine, gastrointestinal aid, hemostat, oral aid, orthopedic aid, pediatric aid, preventive medicine, psychological aid, unspecified: 1	According to interviews with two elder Salishan women, respiratory, digestive, and gynecological problems were treated with the bark[7]
	Heart medicine, laxative, tuberculosis remedy: 2	
	Blood medicine, panacea: 3	
	Cold remedy: 4	
	Gynecological aid: 5	

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† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Prunus virginiana L. var. *melanocarpa* (A. Nelson) Sarg.	Cough medicine: 1 Unspecified: 2	
Prunus virginiana L. var. *virginiana*	Antidiarrheal: 1 Ceremonial medicine: 5	
Pseudoroegneria spicata (Pursh) A. Love	Antirheumatic used externally: 1	†
Psoralidium lanceolatum (Pursh) Rydb.	Gynecological aid, throat aid, venereal aid, witchcraft medicine: 1 Analgesic, dermatological aid, gastrointestinal aid: 2 Ceremonial medicine: 3	†
Psoralidium tenuiflorum (Pursh) Rydb.	Analgesic, disinfectant, miscellaneous disease remedy (treatment for influenza), tuberculosis remedy, veterinary aid: 1	†
Purshia tridentata (Pursh) DC.	Analgesic, anthelmintic, ceremonial medicine, cold remedy, cough medicine, disinfectant, febrifuge, gastrointestinal aid, hunting medicine, liver aid, other, respiratory aid, tuberculosis remedy: 1 Antihemmorhagic, dermatological aid, gynecological aid, laxative, miscellaneous disease remedy (treatment for smallpox, chickenpox, measles and rashes), tonic, venereal aid: 2 Cathartic, pulmonary aid: 3 Emetic: 5	†
Quercus garryana Dougl. ex Hook.	Gynecological aid, tuberculosis remedy: 1	According to interviews with two elder Salishan women, respiratory ailments were treated with the bark[7]
Quercus macrocarpa Michx.	Abortifacient, analgesic, anthelmintic, antidiarrheal, antidote, gastrointestinal aid, heart medicine, orthopedic aid, pulmonary aid: 1 Dermatological aid: 2	

* Non-LCH species in the genus investigated and found to have pharmacological properties.

† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Rhus trilobata Nutt. var. *trilobata*	Analgesic, burn dressing, ceremonial medicine, contraceptive, dietary aid, diuretic, emetic, hemostat, reproductive aid, toothache remedy, tuberculosis remedy, unspecified, veterinary aid: 1	Antineoplastic agent[76]
	Cold remedy, gynecological aid, oral aid: 2	
	Gastrointestinal aid, miscellaneous disease remedy (treatment for smallpox pustules and grippe): 5	
	Dermatological aid: 6	
Ribes aureum Pursh	Dermatological aid, unspecified: 1	†
	Orthopedic aid: 2	
Ribes divaricatum Dougl.	Cold remedy, dermatological aid, other, psychological aid, tuberculosis remedy, venereal aid: 1	†
	Eye medicine, throat aid: 3	
Ribes sanguineum Pursh	Used for fiber. Not utilized as a drug.	†
Ribes viscosissimum Pursh	Used as food. Not utilized as a drug.	†
Rosa arkansana Porter	Anticonvulsive, eye medicine, hemostat, stimulant, tonic: 1	†
Rubus parviflorus Nutt.	Alternative, antidiarrheal, antiemetic, antihemorrhagic, blood medicine, burn dressing, dietary aid, gynecological aid, miscellaneous disease remedy (young sprouts considered a valuable antiscorbutic), internal medicine, pediatric aid, pulmonary aid, tonic: 1	†
	Gastrointestinal aid: 2	
	Dermatological aid: 4	
Rubus spectabilis Pursh	Disinfectant, gastrointestinal aid, gynecological aid, pediatric aid, toothache remedy: 1	Stevens-Johnson syndrome (bullous form of erythema multiform) secondary to ingestion[77]
	Analgesic: 2	

(*continued*)

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Rubus spectabilis Pursh (*cont'd*)	Burn dressing, dermatological aid: 3	According to interviews with two elder Salishan women, digestive tract ailments and dermatological complaints were treated with the bark[7]
Salvia reflexa Hornem.	0	*
Sarcobatus vermiculatus (Hook.) Torr.	Antidiarrheal, antihemorrhagic, blood medicine, emetic, gastrointestinal aid, toothache remedy, veterinary medicine: 1 Ceremonial medicine, dermatological aid: 2	†
Scutellaria angustifolia Pursh	Eye medicine: 1	*
Sedum lanceolatum Torr.	Gynecological aid, laxative: 1	*
Sedum stenopetalum Pursh	Venereal aid: 1	*
Shepherdia argentea (Pursh)	Ceremonial medicine, febrifuge, gastrointestinal aid, laxative, unspecified: 1	Leaf extract exhibited inhibitory activity against human immunodeficiency virus (HIV)-1 reverse transcriptase[78]
Solidago rigida L.	Cathartic, dermatological aid, diuretic: 1	*
Sorbus scopulina Greene	Febrifuge, pediatric aid, unspecified, urinary aid: 1	†
Sphaeralcea coccinea (Nutt.) Rydb.	Dietary aid, disinfectant, other, panacea, strengthener: 1 Ceremonial medicine, dermatological aid: 2	†
Synthyris missurica (Raf.) Pennell	0	†
Trifolium macrocephalum (Pursh) Poir.	0	†
Trifolium microcephalum Pursh	Used as food. Not utilized as a drug.	†

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Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Trillium ovatum Pursh	Love medicine, poison: 1 Dermatological aid: 2 Eye medicine: 4	*
Trillium petiolatum Pursh	Used as food. Not utilized as a drug.	*
Triteleia grandiflora Lindl.	Adjuvant, poison, unspecified: 1	*
Uropappus lindleyi (DC.) Nutt.	0	†
Vaccinium myrtillus L.	Used as food. Not utilized as a drug.	Therapeutic value of anthocyanosides in an internal medicine department[79] Anthocyanosides reduce vascular impairments due to ischemia reperfusion injury[80] Anthocyanosides effective in promoting and enhancing arteriolar rhythmic diameter changes that play a role in the redistribution of microvascular blood flow and interstitial fluid formation[81] Activity of anthocyanoside extracts on night vision[82] Leaves potentially useful for treatment of dyslipidemia[83] Extract exerts potent protective action on LDL particles[84] Extracts exhibit antiviral action in experimental tick-borne encephalitis[85] Antiulcer activity, probably by potentiating the defensive barriers of the gastrointestinal mucosa[86] Anticancer activity of fruit extracts from *Vaccinium* species[87]
Vaccinium ovatum Pursh	Gynecological aid, miscellaneous disease remedy (treatment for diabetes): 1	

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† No pharmacological study was found of any species in the genus.

Table 1 (*cont'd*)

LCH plant species	Uses by Native Americans: number of tribal groups for which use is documented	Subject matter of selected biomedical studies
Veratrum californicum Dur.	Blood medicine, burn dressing, emetic, febrifuge, orthopedic aid, panacea, poison, respiratory aid, toothache remedy, veterinary aid: 1	Congenital deformities in lambs, calves and goats resulting from maternal ingestion[88,89]
	Cold remedy, disinfectant, gland medicine, gynecological aid, snakebite remedy, throat aid, venereal aid: 2	Antimicrobial activity of *Veratrum* alkaloids[90]
	Contraceptive: 3	
	Antirheumatic used externally, dermatological aid: 4	
Xerophyllum tenax (Pursh) Nutt.	Hemostat, orthopedic aid: 1	†
	Dermatological aid: 2	
Zigadenus elegans Pursh	Analgesic, antirheumatic used externally, dermatological aid, diaphoretic, strengthener, veterinary aid: 1	* Significant toxicity can result from ingestion of certain species of *Zigadenus*[91,92,93]
	Poison: 4	
Zizania palustris L. var. *interior* (Fassett) Dore	Used as food. Not utilized as a drug.	†

* Non-LCH species in the genus investigated and found to have pharmacological properties.
† No pharmacological study was found of any species in the genus.

Notes

[1] Goldberg, A. S., E. C. Mueller, E. Eigen and S. J. Desalva. 1969. Isolation of the anti-inflammatory principles from *Achillea millefolium* (Compositae). *Journal of Pharmaceutical Science* **58**: 938-941.

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[6] McCutcheon, A. R., S. M. Ellis, R. E. Hancock and G. H. Towers. 1994. Antifungal screening of medicinal plants of British Columbian native peoples. *Journal of Ethnopharmacology* **44**: 157-169.

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The Second Two Hundred Years Are Better: The Endearing, Enduring Plants of Lewis and Clark

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THIS is a story about a Prussian pilferer, his proclivities for gathering North American plants, and his putatively inebriant state that ushered along his work on the first comprehensive flora for North America. Not a one of the specimens in question was actually collected by him, but some of them accumulated 14,000 miles of travel by horseback, canoe, and sailing ship before rejoining their long-forgotten companions nearly a century later. They had been guests in the White House and captives in London. Others lay quietly in a Philadelphia attic for three-quarters of a century, completely forgotten. Some plants were eaten by bugs, others were eaten by humans. Researchers in the twentieth century would even go so far as to incinerate parts of some of them. And now everyone wants to see them.

THE AMERICAN ZEPHYR

Meriwether Lewis and William Clark are among the lesser known botanical collectors, even though as explorers they have been objects of infatuation ever since they tramped to the Pacific Ocean and back in the earliest part of the nineteenth century. Scholars and students alike have studied the expedition, its labors, and its booty. Later, the explorers' travails became the focus of cinematographers and editors. But the plants they collected are hardly ever seen against the dazzle of travel and discovery. The 222 specimen sheets of the Lewis and Clark Herbarium, now in the Academy of Natural Sciences of Philadelphia, are likewise eclipsed by the larger, longer story told by the Academy's entire herbarium—a million more dried, pressed plant specimens from around the globe and a century farther yet into the past. Even though the Lewis and Clark Herbarium represents just two one-hundredths of a percent of the plant specimens curated at the Academy, they nonetheless stand out as the most publicly recognized symbol of the unique historical treasures in the entire herbarium.

It is easy to gloat when you have such a treasure. Yet some historians glibly point out that in one way Lewis and Clark were dismal failures. They had not achieved the principal objective of the expedition conceived by President Thomas Jefferson and secretively funded by Congress. The ever elusive quest for a mostly water-borne passage between the Atlantic

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and Pacific Oceans was, again, a disappointment. Ultimately the passage did not cross the Great Divide of the American West. Indeed, the divide was not the single, thin range of mountains imagined to lie in the way of industrious pioneers and merchant loads. The quest for a waterway eventually would have to be won, a century later, by digging and blasting through Panama. Yet the efforts of Lewis and Clark never were overshadowed by the geography that denied them that one goal. Their every word has been pored over, rewritten, edited, and interpreted in print and film for the consumption and entertainment of the studious and curious alike. Perhaps the greatest measure of their success was reached within the realm of bibliophiles, who have ballooned the cost of the earliest publications about the expedition to levels attained by few other printed works.

The bounty of the expedition and the legacy of the plants play out the themes of American spirit and intellectual freedom on an international stage. And an "abcedarium" of taxa is represented in the Lewis and Clark Herbarium, from *Acer* to *Zizania*, half of which were new to science when they were named in 1813. The last time that all of the botanical gatherings of Lewis and Clark were in one place was in 1806, in Philadelphia. Today, 96 percent of the pressed plants that survive are still in this town. It was not always that way. Portions of the collection were scattered to the winds, and only by happenstance were nearly all of the surviving specimens reunited.

To London, To London

The Lewis and Clark Herbarium has a long, curious history. Its story began in Philadelphia, where in 1803 Meriwether Lewis went to obtain instruction in botany and other sciences and to shop for supplies for the long journey. Trained by the University of Pennsylvania's eminent professor of botany and medicine, Benjamin Smith Barton, Lewis searched for and gathered new and potentially useful plant species that he encountered from St. Louis through 10 future states, an 8,000-mile round trip. He was dismayed when he lost many plant specimens that he had stored in caches, intending to retrieve them on the journey back home rather than carry them across the continent and back; the caches were water-soaked by winter and spring floods. More of his dried, pressed plants were successfully returned to Thomas Jefferson in Washington, D.C., who forwarded them to the American Philosophical Society in Philadelphia. By the time the entire collection was grouped together around 1807, upon Lewis's arrival in Philadelphia with the balance of the expedition's collections, some 30 plants had been inexplicably, utterly lost.

Barton was assigned the task of coordinating the scientific examination of the collections from the expedition; of course, as a botanist he got the plants. But he dallied at that work, finding the pressures of his "day job" always in the way. Seven years or so later, he fell ill, and he planned to go to Europe for his health—the Academy's archives hold Thomas Jefferson's letter of introduction for Barton's visit to an Italian scholar. But Barton died in New York in 1815. He left a detailed will, written over a period of days shortly before his death, precisely dispersing his effects, but there is no mention of the Lewis and Clark plants that were in his custody in Philadelphia. He never had gotten around to working on them himself.

What Barton never knew was that nearly a quarter of the Lewis and Clark collection was missing, taken from right under his nose. The specimens weren't even in the country anymore. When Barton had dallied from the outset, he soon turned to his friend William Hamilton for help. Hamilton, who was as much of a landed country squire as the new

American national culture would tolerate, had a lush estate, The Woodlands, which survives greatly reduced in size and planted with the stones and monuments of a cemetery in the West Philadelphia part of the city. It was a horticulturist's paradise. Hamilton had gotten seeds from the Lewis and Clark expedition, too, and was growing plants that were hitherto unknown to the East, or for that matter even in the cultured gardens of Europe. His able gardener and classically trained botanist was Frederick Pursh, a Prussian of great horticultural talents, and it was Pursh to whom the Lewis and Clark plants were given for identification and study.

Barton already knew Pursh and had hired him to collect plants. Barton also knew of Pursh's proclivity for the "toddy" and that it sometimes interfered with his collecting work. But he trusted in Pursh's botanical acumen to find the nuggets in Lewis's collection, and Pursh took to the task with relish. New species were soon recognized as well, as detailed in Pursh's own notes that survive with the plant specimens. The job, partly paid for by Meriwether Lewis, went ably and successfully enough, but by 1808 Pursh had to look for other work. He left the plants to Hamilton, Barton, and their horticulturist friends. Pursh went to New York and eventually left the country for England, arriving there in 1811. What no one knew was that in Pursh's bags were samples of Lewis and Clark's gatherings, amounting to a quarter of the entire collection. These were specimens that he understood to be new and interesting to botany and which he intended to illustrate or better describe in a much-needed comprehensive flora for North America.

Some historians and botanists have quibbled over the meaning of Pursh's purloined plants. Of course he did not have permission to take them. But did he need it? Gracious and gratuitous sharing was *de rigeur* among scholars of the day, often with implied permission. And after all, Pursh had selected only a portion of every scrap of a species represented in the collection. Only in a couple of instances did he seem to have taken all of what remained of the booty of a particular species. Perhaps he knew all too well that Barton wasn't going to use them, and who else, then, was there? Historical hindsight answers for us: no one. In fact, not only did no one ever inquire about the missing material brought to England or how Pursh had gotten the specimens in order to publish his findings in 1813, but no one ever again inquired about the whole lot of Lewis and Clark's plants after the ostensibly intact collection was bundled off to the American Philosophical Society. They were in safekeeping and utterly forgotten. But for Pursh's petty larceny, Lewis and Clark's botanical legacy would be a footnote to science.

The plants that remained in Philadelphia lay unremembered and unvisited. After Barton died, they were sent back again to the American Philosphical Society, where they remained, wrapped in their bundles with Meriwether Lewis's own field notes written on blotting papers [see McCourt and Spamer, page 1 in this issue —Ed.]. After better and more extensive gatherings from the Great Plains and the American Northwest began to be available, no one bothered to inquire about the original collections from Lewis and Clark. So they sat at the Society, unstudied and unnoticed. Not until 1897 would Thomas Meehan, a botanist with the Academy and a member of the American Philosophical Society, rediscover them.

Across the Atlantic—Again

Meanwhile, the London residuum of the collection had been mounted on herbarium sheets in the British Museum, the workplace of Aylmer Bourke Lambert, who hired the wandering Prussian, Pursh. However, Pursh's propensity for drink worked peculiarly to Lambert's advantage. Pursh's fondness became known to his employers, as there is some discrete correspondence to the effect, which said either to pare down the consumption or to water it down, lest the line be crossed from good work to no work! Pursh finally published his North American flora in December of 1813, which took a while yet to come to America because of the unsettled times of the War of 1812 between England and the United States. Pursh then left to Canada, where he died in 1820 without ever again doing any substantive work.

Lambert lived on until 1842, after which his rich estate was auctioned by Sotheby's. Serendipitously, an American, Edward Tuckerman, was present and bought some of the "dregs" of the day's auctions; the largest and best collections had already been taken by British institutions. Little did Tuckerman know at the time that his "miscellaneous" American plants included numerous specimens that were the types of Frederick Pursh's new species, plus virtually all of the plants purloined from the set of Lewis and Clark's gatherings that were in bundled storage in Philadelphia. Interestingly and fortuitously for us, Lambert seems not to have absorbed into his main collections the bulk of Pursh's voucher specimens from the landmark flora that Pursh published some 30 years earlier. Otherwise, a much larger portion of this uniquely American expedition's botany may likely have remained in British collections.

In 1856, Tuckerman sent his won collection from Massachusetts to the Academy in Philadelphia in exchange for the liberty of access to what then was the most comprehensive collection of American lichens, which had become Tuckerman's own field of expertise. So Lewis and Clark's plants came home again. What Tuckerman had not gotten at auction were just 10 more of Lewis and Clark's plants that were mixed in with much larger collections purchased by the British Museum. Those 10 plants are kept today at the Royal Botanic Gardens at Kew, the only Lewis and Clark specimens known outside of Philadelphia.

Forty years later, the Academy's Thomas Meehan was clued to the possibility that Pursh's voucher specimens—Lewis and Clark's specimens included—might still repose at the American Philosophical Society, of which Meehan was a member also. In his subsequent fight with administrators to get Lewis and Clark's plants out of the attic and off to proper study at the Academy with the help of botanists at Harvard, he unwittingly had again consolidated almost all of the extant botanical materials from the expedition. For some reason, however, the bundled plants that had remained in Philadelphia and were deposited at the Academy in 1897, still were not mounted on herbarium sheets until 1921.

The trove from the Society's attic brought grim and giddy comments from the observers. Bugs had sometime gotten to a few specimens, feasting on the dried, nutritious plant tissue. Thomas Meehan wrote on one label, "all gone!" Frederick Pursh left a label while he was in Philadelphia, which is a transcription of Meriwether Lewis's own observations of the plant's food use by Native Americans. The bug-eaten fragments that remained in the bundle brought Meehan to wag on another label, "all eaten!"

Lewisia and *Clarkia* Redux

Lewis and Clark were not wholly anonymous collectors. When Frederick Pursh had written up the scientific botany of the expedition as part of his landmark flora for North America, he named several species for Lewis (recently deceased in 1809), such as the syringa

Philadelphus lewisii, and he named the genera *Lewisia* and *Clarkia* to recognize the two explorers' contributions to botany.

The botanical collections from Lewis and Clark have been reappraised, coincidentally, about once each century. First there was Pursh's 1813 flora, then Meehan's review of the refound plants in 1898, and a completely updated taxonomy by Reveal, Moulton, and Schuyler in 1999. The specimens are a working collection for modern botanists and environmental scientists. Of the 199 species and varieties known to have been collected by Lewis and Clark—178 species are in the herbarium today—nearly half were new to science when Pursh published them in 1813. Nurserymen of the time were keen to get their hands on the new finds from the West. Peter Hatch, in 2003, recorded that Thomas Jefferson had more than two dozen species in cultivation at Monticello, including several currants, corn, and tobacco.

Perhaps the most remarkable use of the Lewis and Clark Herbarium to date has been as the source of material for molecular studies of carbon isotopes in the pre-Industrial Revolution atmosphere at the beginning nineteenth century. This required the judicious, yet heart-pausing, removal and incineration of tiny pieces of leaf material in order to perform chemical analyses of the gases given off. Scanning electron microscopy of key tissue structures in those specimens was also performed. Future uses of these plants could include DNA matching of present-day plant populations against the specimens of two centuries ago, among other reasons to corroborate the root stock and provenance data that accompany the specimens. The inspiration is greater still. Much as Lewis and Clark, or even the polymath Thomas Jefferson, could not have imagined studies of DNA and molecular chemistry, we likely cannot imagine what investigatory techniques will be available and what scientific or ecological worth will come of these flowers, leaves, and twigs between now and 2204.

With the marking of the 200th anniversary of the Lewis and Clark expedition, renewed interest in the plants led the curatorial staff of the Academy of Natural Sciences of Philadelphia Botany Department to successfully apply for a grant from the Save America's Treasures program administered by the National Park Service and the National Trust for Historic Preservation. The grant funded repair of damaged specimens and herbarium papers, construction of a custom archival housing for each of the 222 specimens, custom metal cabinets, and remodeling of a new climate-controlled, secure room for long-term storage. The grant also funded a CD-ROM, which was the first illustrated scientific guide to the entire Lewis and Clark Herbarium.

"OCIAN IN VIEW!" —William Clark, November 7, 1805

The Lewis and Clark specimens are traveling again—nearly to the Pacific and back. When William Clark rejoiced in his journal upon seeing the Pacific Ocean, surely the farthest thing from his mind was that some of the plants he carried would ever come this way again. It is for botany as momentous a trip as when Leonardo da Vinci's *Mona Lisa* and Michelangelo's *Pieta* came to New York from France and Italy in the 1960s, the likes of which may never happen again. During the bicentennial years, selected plants will be shown at venues of the Lewis and Clark Bicentennial National Exhibition, in St. Louis, Philadelphia, Denver, Portland (Oregon), and Washington, D.C., among others. Other exhibitions also feature some of Lewis and Clark's plants, at Jefferson's Virginia home, Monticello, and in Richmond, Virginia; Tacoma, Washington; Boise, Idaho; Helena, Montana; and Topeka, Kansas. Altogether, some three dozen specimens will travel thousands of miles to allow the public to see these precious items collected by Meriwether Lewis 200 years ago. Of course, they will travel more safely and securely than they ever did on Lewis's original trek, in the care of fine-arts shippers by truck and airplane. No oilskin bags or pirogues here!

After the bicentennial hoopla dies down, the specimens will return to the relative quiet of the special collections room of the Academy of Natural Sciences of Philadelphia. Some of them will by then have traveled far enough in two centuries to have circumnavigated the globe. Scholars will continue to use them in their studies of vegetational distributions, taxonomy, and climate. Much as with the standardization of spelling and the proper teaching of spelling since Lewis and Clark's time—prolifically shown by the ingenious, multiple spellings of the same words throughout the journals of the expedition—so too are the physical and biological sciences ever growing and adjusting to new standards of understanding and utility.

When the quadricentennial rolls around, the explorers and their botanical legacy we hope will be re-discovered again with who knows what tools and methods. The plants will be waiting for these future explorers. The measures we took in conserving them two centuries earlier should have proven their worth, and we presume that the plant species will be thriving, too, in some vestige of the natural world from which Lewis and Clark picked them. None of the plant species collected by Lewis and Clark are either extinct or endangered. Their natural ranges may have shifted, but that is another story altogether. When the Lewis and Clark Herbarium has reached the end of its fourth century, we optimistically expect that from our efforts the second 200 years will be seen to have been less taxing than the first 200.

Bibliographical Notes and Further Reading

Frederick Pursh's seminal flora for North America was published in London in December 1813 with the ponderous, Latin title, *Flora Americae Septentrionalis*. As might be expected, the two volumes are now scarce and often found only in the rare-book collections of academic libraries. A facsimile reprint 16 decades later (1979) is likewise infrequently met except in specialized libraries. In either case, Pursh's English and Latin text is as dry as were the plants he described, but the reprint was accompanied by a scholarly but readable, book-length introduction by Joseph Ewan (1979).

The history of the Lewis and Clark Herbarium can be read, however, in modern literature, too. First, the adventures and achievements in botany were covered by Gary Moulton (1999). After the first specimens were returned to Thomas Jefferson and sent on to the American Philosophical Society in 1804, the history of the plants twists and turns mostly in correspondence. In and between the lines alike, one can read of innuendo and despair, as summarized by Earle Spamer and Richard McCourt (2002, *Notulae Naturae* No. 475, a publication of the Academy of Natural Sciences of Philadelphia).

Frederick Pursh's own life story and accomplishments are amply outlined by Joseph Ewan's introductory volume accompanying the 1979 reprinting of Pursh's *Flora*. Thomas Meehan's report on the first examination of the Lewis and Clark plants in a century was published in the *Proceedings of the Academy of Natural Sciences of Philadelphia* (1898). Further information on the geography of the collections appeared later that year in an article by Elliott Coues in the *Proceedings* (1898). A century later, a completely revised taxonomy was prepared for the same journal by James Reveal, Gary Moulton, and A. E. Schuyler (1999). The new taxonomy subsequently was used as the foundation for the first-ever illustrated taxonomic study of the Lewis and Clark Herbarium, a CD-ROM by Spamer and McCourt (2002).

The Lewis and Clark Herbarium was awarded a significant conservation grant in the Save America's Treasures program in 1999. When implemented, the conservational procedures were documented and later described by Richard McCourt, Catharine Hawks, and Earle Spamer (2002, *Notulae Naturae* No. 476). Mark Teece's landmark study of the carbon isotopes contained in Lewis and Clark's plants was published in *Notulae Naturae* No. 477 (2002). William Clark's joyous journal entry may be read in its original context in Gary Moulton's *Journals of the Lewis and Clark Expedition* (1990, vol. 6, p. 58 and the corresponding narratives on pp. 30-33). Peter Hatch's article on the cultivation of Lewis and Clark's seed trove is reported in Monticello's *Twinleaf Journal* (January 2003).

For those who are more attuned to the ways and means of the internet, information on the Lewis and Clark Herbarium can be found at http://www.acnatsci.org/lewisclark. Living examples of Lewis and Clark's plants can also be studied in a web site composed by James L. Reveal, at http://www.life.umd.edu/emeritus/reveal/pbio/LnC/LnCpublic.html. For those who prefer books, the modern plants also appear in four recent works by Susan H. Munger and Charlotte Staub Thomas (2003), H. Wayne Phillips (2003), A. Scott Earle and James L. Reveal (2003), and Richard McCourt and Earle Spamer (2004).

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Bartonia No. 62: 103-105, 2004

BOOK REVIEWS

Profiles of Rafinesque, by Charles Boewe (ed.). 2003. University of Tennessee Press, Knoxville. xli + 411 pp. $45 (cloth).

Constantine Samuel Rafinesque (1783-1840) considered himself a botanist, naturalist, geologist, geographer, historian, poet, philosopher, economist, philanthropist, traveler, merchant, manufacturer, collector, improver, professor, teacher, surveyor, draftsman, architect, engineer, author, and editor. We can add artist, realtor, banker, philologist, anthropologist, and who knows how many more. To a Boston psychiatrist, he was a paranoid neurotic genius. His overzealous demeanor did not ingratiate him with others, and he was often the subject of ridicule. He was gullible and devious, although the magnitude of the latter is subject to debate. At the end of his description of *Rafinesquia* (1841, *Transactions of the American Philosophical Society* 7: 429), Thomas Nuttall wrote "Dedicated to the memory of an almost insane enthusiast in natural history; sometimes an accurate observer, but whose unfortunate monomania was that of giving innumerable names to all objects of nature, and particularly to plants." Rafinesque continues to attract the attention of botanists because of the thousands of plant names he authored, many of which, along with his extant specimens, still need evaluation. His controversial accomplishments and his eccentricities make him a colorful historical figure. His life and work are unending subjects of interest; hence, the book reviewed here.

In his introduction, Charles Boewe states that the book was "assembled in the belief that it will in some measure supply the lack of the authoritative biography C. S. Rafinesque deserves but has not yet received." There are 17 articles taken or revised from other publications and three written specially for this volume by the editor. The introduction, "Evolution of the Rafinesque Biography," provides useful, sometimes bizarre, background information and an overview of the articles.

The first and longest article is Francis Pennell's "The Life and Work of Rafinesque." This article and those on Rafinesque's genealogy (Georges Reynaud), last days (Boewe), and portraits (Boewe) deal with Rafinesque "The Man." The last two clear up misconceptions about the circumstances of his death and a "Rafinesque" portrait now thought to be someone else. Articles on his eccentricity (John James Audubon) and the occupant of his tomb (Boewe) deal with Rafinesque "The Legend." Missing is an article on the organisms named for Rafinesque that continually bring him to our attention as a species of eternity. A tabular chronology of the major events of his life also is lacking.

Seven articles (three by Boewe, and one each by Arthur J. Cain, Ronald L. Stuckey, Leon Croizat under the alias Henricus Quatre, and Elmer D. Merrill), dealing with Rafinesque "The Naturalist," contain evaluations of his published work, his personality, and his interactions with others. Some of the diverse opinions expressed in these articles are as eccentric as those of Rafinesque are. Here the concern is with people and their idiosyncrasies as much as it is with natural history.

Less familiar to botanists and naturalists is the work of Rafinesque discussed in articles on linguistic activity (Vilen V. Belyi), the Walam Olum hoax (David M. Oestreicher), Indian languages (Boewe), and Mayan hieroglyphics (George E. Stuart). In the case of the Walam Olum, opinions differ on whether Rafinesque was the hoaxer or the gullible victim of a hoax.

Finally, there are articles on Rafinesque's *Medical Flora* (Michael A. Flannery), sentimental botany (Beverly Seaton), and fugitive publications (Boewe). Finding Rafinesque's "fugitive" publications is an ongoing activity of bibliophiles. Missing is an article on the status of Rafinesque's lost, extant, and "fugitive" collections, a subject of interest to many.

The thing that disappoints me most about the book is the lack of documentation for many literature citations. This includes articles in the book previously published elsewhere. For the convenience of users, I prefer to see notes and references at the end of a book. In this book we have to look for notes in 16 different places and references in 7 places, where they are at the end of the articles.

The diverse articles in this book give the reader a much more comprehensive overview of Rafinesque's life than previously available. It will appeal to historians, naturalists, and those who cannot let go of Rafinesque. It is a major rung on the ladder toward an "authoritative biography."

ALFRED E. SCHUYLER, Curator Emeritus
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November 2003

Shrubs and Vines of New Jersey and the Mid-Atlantic States: a Field Identification and Natural History Guide, by Christopher T. Martine, illustrated by Rachel A. Figley. 2002. New Jersey Forest Service, Trenton. 114 pp. $10 (paper). (Available from the Forest Resource Education Center, 370 East Veterans Highway, Jackson, NJ 08527, 732-928-0987.)

This new companion guide to the *Trees of New Jersey and the Mid-Atlantic States*, also written by Christopher Martine, provides useful aids to identifying the often-underappreciated shrubs and vines. The shrubs and vines are important members of the diverse habitats found in the mid-Atlantic region, especially in successional communities. New Jersey has a rich and complex flora due primarily to the geology but compounded by its climate, which together allow many species to persist that are at the northern or southern edge of their range. Some of the most difficult groups taxonomically are shrubs (e.g., *Crataegus*, *Rosa*, *Rubus*, *Salix*, *Viburnum*), and thus providing a treatment for an audience of naturalists and amateur botanists is a challenge. Many of the difficult groups are simplified, with some of their diversity noted but not treated. In *Crataegus*, for example, *C. uniflora* Muench is treated but *C. intricata* Lange, which is reasonably common in the state, is only noted under "similar species." Further, the notes indicate that 13 species of hawthorn exist in the state, 11 of which are small trees, and none are treated in the *Trees of New Jersey*. A reference to hawthorns can be found in the "similar species" section under flowering crabapple (*Malus* spp.), but the information given is vague and in some cases incorrect. This may limit the use of these guides by the knowledgeable botanist.

The text provides a clear description of each plant and highlights possible confusion with similar species. Illustrations provided are simple and clearly show the characters needed to identify the plant. I like the use of the entire page to provide text and illustrations, although the text could be slightly larger for those who have a vision impairment. Perhaps a second edition could use a slightly larger page format.

The reader is also informed whether the plants are rare, native, exotic or invasive. Certainly in the case of invasive species the more knowledge we provide to nature enthusiasts about these plants, and especially how to tell them apart from their native relatives, the better. Although only a generalized locator key is provided at the beginning, supplemental keys to more difficult groups are provided, which in many cases are produced with the advice of experienced field botanists in the region.

In summary, although *Shrubs and Vines of New Jersey and the Mid-Atlantic States* cannot be considered comprehensive, it does provide enough detail and interesting anecdotes for naturalists with beginner to intermediate botanical savvy.

JAMES MACKLIN, Collection Manager
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October 2004

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OBITUARIES

Roy Linden Hill, Jr. (1913-2001)

Roy L. Hill died after a short illness on 3 June 2001 in Newport, Vermont. Roy was born in Philadelphia on 16 May 1913, the son of Mabel and Roy Hill. He lived his boyhood and teenage years in Philadelphia, Wilmington, and Tamaqua. He graduated from the Wilmington Friends School in 1931. Many summers of his early years were spent at the Newlin Grist Mill outside Media, which was operated by his great-grandfather and grandfather. He received degrees in chemistry from the University of Delaware and in business from the Wharton School of the University of Pennsylvania. His professional career was spent at the Rohm and Haas Company in Philadelphia. Roy and his wife Margaret (Peg) Elizabeth Thatcher Hill became members of the Philadelphia Botanical Club in 1963. He was for some years a volunteer in the Botany Department of the Academy of Natural Sciences, during which time he completed numerous projects for the staff. He served as treasurer of the Club from 1983 until 1994. It was through Roy's endeavors that grants were obtained and funds raised in support of the Club's centennial programs in 1991. Excess monies from those events became the basis of the Club's Endowment Fund. Roy was made an Honorary Member of the Philadelphia Botanical Club in 1999.

In the 1980s, upon Roy's completion of the course of study in botany and horticulture at the Arboretum of the Barnes Foundation, he served as a volunteer there. I was privileged to work with him for several years as he engraved plant labels (a tedious chore) and placed them on trees and shrubs throughout the Arboretum grounds. One was left breathless in trying to match his energy and devotion to the tasks he carried out.

Roy's volunteer service to diverse groups was awe-inspiring. The well-known slogan of the U.S. Postal Service, "neither snow, nor rain, nor heat ... stays these couriers from ... their appointed rounds" could have been applied to Roy. He was punctilious in meeting his schedules at various organizations. He was an Arboretum Assistant at the Scott Arboretum of Swarthmore College from 1987 to 1999. He was involved with many civic groups in the Lansdowne area where he lived—the Lansdowne Allied Youth Council, the Lansdowne Street Tree Committee, the Boy Scouts, the park system, and other groups. Roy had a strong commitment to the preservation of historic trees.

Roy and Peg had a deep and abiding passion for Vermont, where eventually they built a small vacation house in Barton. He was an enthusiastic student of the local flora in the Northeast Kingdom. He and his wife enticed a number of friends from the Delaware Valley to visit the area. My husband and I went there twice to be led down trails and up mountains in pursuit of particular plants that Roy wanted to show us. I particularly remember being taken by him to large patches of *Cornus canadensis* and *Linnaea borealis*. Roy and Peg, who predeceased him, were most generous in sharing their world with others.

Roy is survived by two children, Richard W. Hill of East Lansing, Michigan, and Janet L. Hill of Barton, Vermont. He is also survived by two grandchildren, David Hill and Christine Hill.

ELIZABETH B. FARLEY
October 2003

James C. Parks (1942–2002)

The passing of James C. Parks of Millersville, Pennsylvania, just prior to Christmas, 2002, came as sad news for students he mentored and his colleagues. His ability to contribute to plant systematics and his willingness to share knowledge with students, colleagues, and the lay public is a genuine loss for botanical science. Jim cherished plants early in life and the botanical realm was woven into the very fabric of his soul; even his daughters have botanical names: Holly and Heather.

Due to retire from Millersville University in the spring of 2003, Jim acknowledged, "Far more than my several research papers, you, my students, are my legacy." However, he will influence students beyond the classroom through his contribution (along with Jim Montgomery) of the fern section to *The Plants of Pennsylvania: an Illustrated Manual* by Ann Fowler Rhoads and Timothy A. Block. At the time of his death, he was working on a taxonomic treatment of *Melanthera* (Asteraceae) for the *Flora of North America* and had planned to co-author a *Field Guide to the Fern Flora of Pennsylvania* with Jim Montgomery. Second to his passion for family, friends, and students, botany was an integral part of Jim's life. It was not unusual for Jim to devote vacation time to visit field sites. Jim generously shared his knowledge with others and contributed frequently to local organizations such as the Muhlenberg Botanical Society and the Native Plants in the Landscape Conference at Millersville. His neighbors appreciated his concern for conservation of our natural heritage and welcomed his efforts in combating establishment of industrial farms and developments.

Jim was born on 9 August 1942 in Altoona, Pennsylvania, and grew up on a small farm at the edge of the mountains on the Allegheny Front. Just beyond the back forty of the family farm, Jim often hiked in the mountains for solace and recreation; he was introduced to botany through first-hand experience at an early age. Later in life, he worked hard to have his students share that same sense of discovery. While it may be difficult to document the initiation of a career, Jim's professional focus was clearly noted in one of his papers from grade 6 where he stated that he wanted to be a biology teacher. He has devoted most of his professional career to this goal.

With limited resources and a desire to be a teacher, he used his skill in animal husbandry to enable him "to ride a pig to college every fall"—sale of a hog each fall paid his college tuition. In addition, he used the family combine to custom-cut small grains for neighboring farmers. Jim found that keeping a small tractor-pulled combine in one piece on small, unfamiliar fields was a real challenge. Proceeds from custom harvesting also helped to pay his college tuition.

After earning his undergraduate B.S. degree from Shippensburg State Teachers College in Pennsylvania, Jim taught science for one year in Seneca Falls, New York. Then he proceeded to Vanderbilt University in Nashville, Tennessee for a Ph.D. Under the guidance of Robert Kral he revised the genus *Melanthera* Rohr (Asteraceae) for his thesis; this work was published in 1973 (*Rhodora* **75**: 169-210). Jim joined the faculty at Millersville University in 1968 where he taught for 34 years. As a cornerstone in the Concepts of Botany course at Millersville, he fostered student interest in other courses he taught such as Lower Plants, Plant Systematics, and Dendrology. Moreover, he developed a Methods of Teaching Controversial Issues seminar to help students preparing to become teachers wrestle with socially sensitive issues such as evolution and biotechnology. Early on Jim recognized the role of mentors in learning and took pride in being a mentor to students with a serious interest in botany. Second to mentorship, Jim recognized field experience as a primary educational tool. He delighted in having his students learn from the paradigms evident in the field; this was reflected in his enthusiasm for nature, which he learned while walking in the mountains on the Allegheny Front as a youth.

Although Jim's professional life was grounded in teaching and introducing students to the field, he devoted considerable effort to the infrastructure of the University that would have direct impact on his efforts as a teacher and scientist. He was active in developing the glasshouse and herbarium facilities at Millersville University. As the sole curator of the Millersville University Herbarium, he expanded the collection from a few cabinets to thousands of specimens in a room of compactors. It is fitting that the Herbarium will be named in his honor.

Over the past few decades, Jim became interested in pteridophytes. This interest may have been the result of Jim's participation in a field course given in 1978 by Don Farrar at the University of Virginia's Mountain Lake Biological Station. Shortly after the field course, Jim worked with Don on locating fern gametophytes in the Northeast. They published (with Bruce McAlpin) the first findings of *Vittaria* and *Trichomanes* gametophytes in Pennsylvania (*Rhodora* **85**: 83-92). In 1984, they reported the most northern record for *Vittaria* gametophytes (*Rhodora* **86**: 421-423). In a subsequent publication (*Rhodora* **91**: 201-206), Jim presented an intensive study of the distributions of *Vittaria* and *Trichomanes* including many new records. In addition, Jim used allozyme analysis to study the largest genets known (1.1 km^2 in spatial extent) for bracken fern in Virginia. This work was published in 1993 with Charlie Werth in the *American Journal of Botany* (**80**: 537-544). Later that year, Jim and his wife Vicki traveled to the U.K. to work with Adrian Dyer and Stuart Lindsay at the Royal Botanic Gardens in Edinburgh, Scotland. There he used allozymes and frond and spore morphology in *Cystopteris* to determine if *C. dickieana* was, in fact, a separate species; it was not (*Edinburgh Journal of Botany* **57**: 83-105). During this sabbatical leave, Jim traveled with Adrian to the tenth Simposio Nacional de Botánica Criptogámica at La Laguna, Tenerife, to collect material and talk to several Spanish pteridologists. Back in the States, Jim worked with Kate Moser, an undergraduate at Millersville, on a study of *Cystopteris tennesseensis* (*Pennsylvania Academy of Sciences* 71: 78-83); this species had never before been reported in Pennsylvania. We will miss the unwritten chapters of Jim's forays into pteridophytes.

Throughout his career, Jim was concerned with the loss of biodiversity and generously gave time and wisdom to a variety of agencies. In 1994, Jim went to Edinburgh to participate in a meeting on the Ecology and Conservation of Scotland's Rare Ferns. In Pennsylvania, he was an active member of the Vascular Plant Technical Committee of the Pennsylvania Biological Survey, which advises the Pennsylvania Department of Conservation and Natural Resources on the status of rare and endangered plants in the state. As a member of the Shenks Ferry Wildflower Preserve Advisory Committee, he developed educational materials and helped with the management of this valuable resource. His legacy will be evident in the natural heritage of southeastern Pennsylvania.

Students and colleagues will be indebted for his insights on humanity and the natural world. We will miss his thought-provoking comments, historic perspective, and wry sense of humor. He will rest easily knowing that his students are now mentors for the next generation of botanists.

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Bartonia No. 62: 113-128, 2004

2000–2002 FIELD TRIPS

by TED GORDON, Southampton, New Jersey
except where otherwise indicated

2000 Field Trips

6 May: Bowmans Hill Wildflower Preserve, Bucks County, Pennsylvania. This trip to the wildflower preserve was during the height of the spring wildflower bloom. We walked various trails at the preserve and observed the following species: *Mertensia virginica, Trillium grandiflorum, Trillium cernuum, Trillium cuneatum, Trillium erectum, Trillium luteum, Trillium sessile, Viola sororia, Viola striata, Uvularia sessilifolia, Antennaria plantaginifolia, Antennaria solitaria, Packera aurea, Caulophyllum thalictroides, Jeffersonia diphylla, Podophyllum peltatum, Arabis laevigata, Cardamine concatenata, Silene virginica, Stellaria pubera, Sedum ternatum, Carex pensylvanica, Carex prasina, Euphorbia purpurea, Cercis canadensis, Lupinus perennis, Adlumia fungosa, Dicentra cucullaria, Geranium maculatum, Hydrophyllum canadense, Hydrophyllum virginianum, Meehania cordata, Erythronium americanum, Maianthemum canadense, Maianthemum racemosum, Polygonatum biflorum, Polygonatum pubescens, Veratrum viride, Floerkea proserpinacoides, Sanguinaria canadensis, Stylophorum diphyllum, Phlox stolonifera, Polemonium reptans, Claytonia virginica, Actaea pachypoda, Aquilegia canadensis, Caltha palustris, Hepatica nobilis* var. *obtusa, Thalictrum thalictroides, Houstonia caerulea, Mitella diphylla, Tiarella cordifolia,* and *Dirca palustris.* Report by leader: Bill Olson.

3 June: Pine Barrens of Atsion and vicinity, Burlington County, New Jersey. Joint trip with the New Jersey Audubon Society. The morning was spent along Quaker Bridge Road near the Atsion Ranger Station, where a mix of habitats produced the expected species of *Gaylussacia* and *Vaccinium*, as well as *Quercus stellata* and *Q. marilandica*. Lowland woods along the Wesickaman Creek had extensive stands of *Osmunda cinnamomea, O. regalis, Thelypteris palustris*, and *Woodwardia areolata*. Sedges seen here included *Carex intumescens, C. stricta, C. stipata, C. striata, C. vulpinoidea, C. folliculata*, and *C. canescens*. A variety of grasses was found, including *Danthonia sericea, Panicum scoparium*, and the distinctive *Piptochaetium avenaceum* (= *Stipa avenacea*). Also seen were *Polygonatum biflorum, Chimaphila maculata*, and *Akebia quinata* (chocolate-vine), this last species on a tree near the ranger station where it has been for years without spreading. After lunch, the group moved south a few hundred yards to explore some grassy fields south of the Mullica River. Here we found large patches of *Minuartia caroliniana* (= *Arenaria c.*) in bloom, as well as *Krigia virginica, Linaria canadensis*, and *Opuntia humifusa*. A large patch of *Iris prismatica*, still in reasonably good bloom on the east side of Route 206, was much admired. Explorations along the west side of Route 206 were not particularly productive, with some areas flooded, other areas desiccated, and still others mowed. We did find *Utricularia subulata* in bloom in a wet swale with *Proserpinaca pectinata* and *Drosera intermedia*. Attendance: 18. Leader: Karl Anderson.

10 June: Lonely Road Meadow, Sellersville, Buck County, Pennsylvania. Fifteen hardy souls braved unseasonably hot weather to visit a floodplain meadow along the East Branch Perkiomen Creek near Sellersville. They were treated to the sight of a large population of slender blue iris (*Iris prismatica*) in full bloom. *Iris prismatica*, which has a coastal distribution ranging from Nova Scotia to Georgia, is currently known from only three sites in Pennsylvania and is classified as an endangered species in the state. Other rarities seen on the trip included downy phlox (*Phlox pilosa*) and brown sedge (*Carex buxbaumii*), both with a recommended status of endangered, and cloud sedge (*Carex haydenii*), recommended as endangered. Mead's sedge (*Carex meadii*), another plant that has been recommended for endangered status that was not previously known from the site, was also documented. Altogether 13 species of *Carex* were identified in the meadow. Annual mowing by the owners maintains this diverse herbaceous community that was formerly a hayfield. Report by leader: Ann Rhoads.

17 June: Tacony Creek Park, Philadelphia County. We entered the park close to the junction of Cheltenham Avenue, Crescentville Road, and Tacony Parkway near the Montgomery/Philadelphia county line. On the west side of Tacony Creek there were many non-native trees (including *Acer platanoides, Ailanthus altissima, Paulownia tomentosa, Prunus avium*) and shrubs (including *Aralia elata, Ligustrum obtusifolium*). The ground cover was primarily *Alliaria petiolata* and *Lonicera japonica*. On the east side of the creek, the forest was dominated by native trees (*Fagus grandifolia, Quercus rubra, Q. velutina*), and shrubs (*Cornus florida, Corylus amricanus, Viburnum acerifolium, Rhododendron periclymenoides*). Many more native vines and herbs that were not encountered on the west side included *Amphicarpa bracteata, Anemone quinquefolia, Apocynum cannabinum, Eurybia divaricata* (= *Aster divaricatus*), *Athyrium felix-femina, Carex laxiculmis, C. laxiflora, C. pensylvanica, Cimicifuga racemosa, Circaea lutetiana, Collinsonia canadensis, Cypripedium calceolus, Danthonia spicata, Desmodium paniculatum, D. perplexum, Dioscorea villosa, Elymus hystrix, Eupatorium fistulosum, Festuca obtusa, Geranium maculatum, Heuchera americana, Lonicera sempervirens, Luzula multiflora, Lysimachia ciliata, Monotropa uniflora, Osmorhiza longistylis, Panicum cladestinum, Phegopteris hexagonoptera, Podophyllum peltatum, Polygonum virginianum, Sanguinaria canadensis, Sanicula canadensis, Scutellaria elliptica, Silene stellata, Smilacina racemosa, Smilax glauca, S. rotundifolia, Solidago caesia*, and *Thelypteris novaboracensis*. The striking floristic differences between the east and west sides of the creek suggest that plants in late-successional forests can outcompete most non-native plants. Also there was less evidence of deer browsing here than we have seen in other parts of Fairmount Park, although some leaves of *Podophyllum* were browsed. Report by leader: Ernie Schuyler.

18-22 June: Sage College, Albany, Albany County, New York. Joint field meeting of the Philadelphia Botanical Club, the Torrey Botanical Society, and the Northeast Section of the Botanical Society of America. Monday field trips began at the Albany Pine Bush Preserve, a 2,600-acre protected remnant of a pitch pine-scrub oak community that covered tens of thousands of acres in colonial times. Carefully controlled burns now attempt to duplicate the historic "natural" conditions and maintain the area's unique and diverse flora. In the afternoon, a trip to the escarpment overlooking the Hudson Valley and Albany gave an opportunity for about half of the group to find lime-loving plants among fossils of the Devonian limestones and shales, while the other half joined special trips for ferns, lichens, or graminoids. Tuesday was spent at the famed Ice Meadows along the northern Hudson

River, Warren County. Ice buildup on the shores over the winter and floodwaters of early spring create natural meadow conditions here, which support a very diverse plant community. Various orchids, lilies, grasses, and sedges that are rare or missing in the rest of New York were observed here. Trips on Wednesday were to a 300-acre nature preserve owned by Skidmore College, Saratoga County. It has a rich and varied flora, due to a combination of limestone ledges, limy soils, and non-limy glacial deposits. This preserve has a large population of *Hydrastis canadensis*, unusual in that there are thousands of healthy plants. This plant is rarely observed in eastern upstate New York. Fern experts in the group added two unusual *Botrychium* species, so the Skidmore fern list now stands at 30, not counting sterile hybrids. On the way back to Albany a brief stop was made to see 500-million- year-old fossilized blue-green alga formations. The last stop was at a town park with a very healthy stand of lupine and a highly visible host of small blue butterflies, probably the rare and federally-protected Karner blue. Participants: 42. Chairperson: Edward Miller. Report by Karl Anderson.

15 July: Pleasant Mills and Batsto back-country, Wharton State Forest, Atlantic and Burlington Counties, New Jersey. At Nescochague Bog, an open, savanna-like swale of hummocks between the creek and West Mill Road, about 1.75 miles northwest of Pleasant Mills Church, we observed a large *Narthecium americanum* population, discovered by the leader on 16 August 1996. Whether this occurrence is identical to the "Pleasant Mills" collections by J. Darrach in 1861 and C. F. Parker in 1877 can never truly be known. Among the associated species were *Carex exilis, Sphagnum pulchrum, Schizaea pusilla, Scleria muhlenbergii, Lobelia canbyi**, *Muhlenbergia torreyana, Calamovilfa brevipilis, Rhynchospora cephalantha, R. gracilenta, R. alba, R. fusca, Carex livida, Lophiola aurea**, *Sabatia difformis**, *Pogonia ophioglossoides**, and *Utricularia striata**. Although the 29 July 1997 wildfire has slowed shrub and cedar sapling invasion, it may have expunged a fine occurrence of *Rhynchospora oligantha*, discovered here in 1996. In a streamside swale dominated by *Muhlenbergia torreyana*, ca. 0.2 mi. to the northwest, we saw five plants of *Asclepias rubra**, *Lobelia canbyi**, *Carex livida, Hypericum densiflorum**, *H. denticulatum**, *H. canadense**, *Schoenoplectus pungens* var. *pungens, Pontederia cordata**, *Dioscorea villosa, Iris prismatica*, and a single specimen of *Platanthera blephariglottis* about to bloom. We stopped at Forge Pond to the south to examine club-mosses: *Lycopodiella alopecuroides, L. appressa, L. caroliniana* var. *caroliniana* (= *Pseudolycopodiella caroliniana*), and *L.* ×*copelandii* (*L. alopecuroides* × *L. appressa*). In the afternoon we visited "Batsto Oxbow," a sphagnous savanna of hummocks on the east bank of the Batsto River about 1.5 miles north of the village. Among scattered clusters of cedar and hardwood, the site contained some five pockets of bog asphodel, an occurrence reported in 1996 by the leader to the New Jersey Heritage Program. There is no doubt that this savanna is the site of Chrysler's 1930 collection of *Narthecium* designated as "frequent," and likely that of earlier botanists in the second half of the nineteenth century. At its downstream border, a backwater cove enables portions of the savanna to flood periodically. This flushing appears to have held in check invasion by trees and shrubs and has helped to maintain habitat stability over many decades. All species listed above for Nescochague Bog were seen here as well. In addition, we saw *Carex collinsii, Juncus caesariensis, Rhynchospora oligantha, Tofieldia racemosa**, *Eleocharis tuberculosa**, *Utricularia cornuta**, *U. purpurea**, *U. geminiscapa**, and *U. juncea**. Thanks to William F. Standaert for maintaining a comprehensive list of species seen. (* = plants in anthesis.) Attendance: 12. Leader: Ted Gordon.

22 July: Old Mine Road, Sussex and Warren Counties, New Jersey. The morning of this trip was spent in the vicinity of the seventeenth-century copper mine at Pequaharry and along the shore of the Delaware River nearby. Some interesting plants included *Thelypteris phegopteris, Phyrma leptostachya, Acer spicatum* growing next to *Acer pensylvanicum, Sium suave, Equisitum fluviatile*, and *Lycopodium hickeyi* (= *L. obscurum* var. *isophyllum*) growing near *L. obscurum* var. *obscurum*. After lunch, we drove north to the Flatbrook, where we found *Cystopteris bulbifera* in profusion, as well as *Asplenium rhizophyllum, Thelypteris hexagonoptera, Equisetum hyemale*, and several other ferns and fern allies. Sedges seen here included *Carex hystericina, C. lupulina, C. intumescens, C. lurida, C. argyrantha*, and *C. stricta*. In bloom were *Cimicifuga racemosa, Myosotis scorpioides, Mimulus ringens*, and *Alisma subcordatum*. The final stop was at a rocky hillside about four miles north of the Flatbrook, where we found *Cystopteris fragilis, C. protrusa, Matteucia struthiopteris*, and *Athyrium thelypteroides*. We also puzzled over the wide-leaved, glaucous, basal rosettes of *Carex platyphylla* and took note of *Heuchera americana, Ulmus rubra*, and *Staphylea trifolia*. Attendance: 5. Leader: Karl Anderson.

29 July: Pine Barrens at Hog Wallow, Rutgers Experimental Station, and Buck Run Vicinity, Burlington County, New Jersey. Attracted by the white spikes of several tall *Platanthera blephariglottis*, we stopped to examine the road shoulder on the east side of Route 563 between Hog Wallow and Pineworth. A species of a bulrush rare in the Pine Barrens, *Scirpus georgianus* (= *S. atrovirens* var. *georgianus*) has persisted here for many years. We noted in flower *Chamaecrista nictitans, Desmodium ciliare, Drosera rotundifolia, Eupatorium pilosum, Euthamia graminifolia* var. *graminifolia, Hypericum canadense, Erigeron annuus, Hypochoris radicata, Lachnanthes caroliniana, Solidago odora*, and, about to flower, *Juncus scirpoides, J. acuminatus*, and *J. debilis* var. *debilis*. After visiting the Rutgers University laboratory and greenhouse facilities at the Phillip E. Marucci Cranberry/Blueberry Research Center on Oswego Lake Road (= Penn Place Road), we botanized the border of a reservoir and canal adjacent to the experimental cranberry bogs. Here we saw a few *Platanthera blephariglottis* and several *P. cristata* with deep orange flowers and an isolated cluster bearing light yellow flowers. A single orchid appeared to be *P.* ×*canbyi* (*P. cristata* × *P. blephariglottis*), bearing a whitish yellow plume and a spur about as long as the ovary. Also in flower were *Cephalanthus occidentalis, Hypericum crux-andreae* (= *H. stans*), *H. hypericoides, H. gentianoides, Cuscuta gronovii, Apocynum cannabinum, Decodon verticillatus, Drosera intermedia, Lobelia nuttallii*, and *Ilex laevigata* in immature fruit. At Harrisville in the Wharton State Forest, we saw the golden rays of a long-established occurrence of *Pityopsis falcata* (= *Chrysopsis f.*) in bare stretches of sand. Other dry sites had *Scleria triglomerata, Danthonia spicata, D. sericea* and *Euphorbia ipecacuanhae*. Northeast of Martha Furnace in the savannas and cedar swamps associated with Buck Run, we saw—already past flowering—*Orontium aquaticum, Pogonia ophioglossoides, Carex livida, Trientalis borealis, Narthecium americanum, Tofieldia racemosa, Danthonia epilis*, and *Eriocaulon compressum*. In flower were our three *Drosera, Eriocaulon decangulare, Platanthera clavellata, Xyris difformis* var. *difformis, Utricularia cornuta, U. geminiscapa, U. striata, Sarracenia purpurea, Polygala brevifolia, P. cruciata, Sabatia difformis*, and a few *Rhynchospora alba, R. chalarocephala*, and *R. gracilenta*. Also noted were *Juncus caesariensis, Scirpus cyperinus, Schoenoplectus subterminalis* (= *Scirpus s.*), *Oclemena nemoralis* (= *Aster n.*), *Smilax laurifolia*, and *Schizaea pusilla*. We recorded two significant herpetological sightings: a mature northern pine snake (*Pituophis melanoleucus melanoleucus*) in the water of a cedar-hardwood swamp above Buck Run and a timber rattlesnake (*Crotalus horridus*

horridus) crossing the sand road south of Martha. The latter was only observed (and photographed) by Dan Jassby and Boel Denne-Hinnov. Thanks to William F. Standaert for compiling a comprehensive list of species observed. Attendance: 31. Leader: Ted Gordon.

30 July: McCarthy's Lake, Franklin Township, Gloucester County and Cedar Lake, Buena Vista Township, Atlantic County, New Jersey. We met in the parking lot east of Piney Hollow Road in anticipation of walking the dry pond bottoms of the old cranberry bogs that are McCarthys Lake. Since all lakes in the area were filled to capacity, most of us elected to focus on the edges of this impoundment. Here we noted *Eleocharis tuberculosa, Rhexia virginica, Proserpinaca palustris, Myriophyllum humile, Wolffia columbiana, Lemna minor, Lindernia dubia* var. *anagallidea*, and many common Pine Barrens plants. In the afternoon, we examined Cedar Lake Wildlife Management Area. The lake was full of water and only the tips of *Juncus militaris* were exposed. The dense mats of *Rhynchospora scirpoides* seen last year were reduced to scattered individuals, hidden by the lush, emergent rush flora. A colony of *Eupatorium resinosum* seen last year was relocated, but it too was considerably less abundant. These dramatic fluctuations in population size over the past two years were clearly related to the cyclic events of severe drought and flooding. Other species observed included *Cephalanthus occidentalis, Galium tinctorum, Gratiola aurea, Lachnanthes caroliniana, Ludwigia sphaerocarpa, Potamogeton natans, Lysimachia terrestris, Eleocharis acicularis, E. robbinsii, Rhynchospora scirpoides, R. chalarocephala, R. fusca, R. macrostachia, R. capitellata, R. alba, Utricularia purpurea*, and *U. geminiscapa*. Leader: Joe Arsenault.

26 August: Bowmans Hill Wildflower Preserve, Bucks County, Pennsylvania. A nice collection of ferns is featured at the wildflower preserve. The group saw *Onoclea sensibilis, Osmunda claytoniana, Osmunda cinnamonea, Osmunda regalis* var. *spectabilis, Thelypteris noveboracensis, Thelypteris palustris* var. *pubescens, Thelypteris simulata, Athyrium filix-femina, Diplazium pycnocarpon, Deparia acrostichoides, Polystichum acrostichoides, Polystichum braunii, Dryopteris campyloptera, Dryopteris marginalis, Dryopteris carthusiana, Dryopteris intermedia, Dryopteris ×triploidea, Cystopteris tenuis, Cystopteris protusa, Cystopteris bulbifera, Adiantum pedatum, Woodwardia areolata* and *Woodwardia virginica*. Report by leader: Bill Olson.

27 August: Great Bay Wildlife Management Area, Ocean County, New Jersey. Joint trip with the New Jersey Audubon Society. At Tip Seaman County Park in Tuckerton, we found *Tripsacum dactyloides, Juncus acuminatus, J. pelocarpus*, and *Schoenoplectus pungens* (= *Scirpus p.*). At the salt marshes along Great Bay Boulevard, we found *Schoenoplectus robustus* (= *Scirpus r.*), *Fimbristylis caroliniana* or *F. castanea, Spartina cynosuroides, Amaranthus cannabinus, Sabatia stellaris, Symphyotrichum tenuifolium* (= *Aster tenuifolius*), *Typha angustifolia, Samolus floribundus, Eleocharis rostellata*, and *Pluchea odorata*, in a small pocket of high marsh. Continuing south, we examined a lush growth of *Toxicodendron radicans* on a Native American shell mound, and looked briefly but unsuccessfully for *Polygonatum biflorum*, noted on this mound in previous years. We did find *Salicornia bigelovii, S. europaea*, and *S. virginica* here, as well as the ever-present *Spartina alterniflora, S. patens*, and *Distichlis spicata*. As we neared the shore of Great Bay, plants of beach and strand included *Ammophila breviligulata, Salsola kali, Suaeda linearis, Bassia hirsuta, Cakile edentula, Cyperus filicinus, C. esculentus, Eupatorium hyssopifolium, E. album*, and *Strophostyles helvola*. On our final stop we visited nearby Stafford Forge Wildlife Management Area. Here *Eupatorium leucolepis, Polygala cruciata, Chrysopsis mariana, Gratiola aurea, Xyris difformis*, and *Oclemena nemoralis*

(= *Aster n.*) were in bloom, and *Juncus biflorus, Vaccinium macrocarpon, Drosera intermedia, Sarracenia purpurea,* and other species typical of the Pine Barrens were found. Attendance: 20. Leader: Karl Anderson.

30 September: Monmouth County exploration, New Jersey. We visited three sites in Howell Township. A wetland area off Louise Drive was a pitch pine lowland including *Scleria minor, Rhynchospora torreyanum,* and *Sphagnum compactum.* At Shark River Station the group saw *Scleria triglomerata, Rhynchospora torreyanum, Aletris farinosa,* and *Sphagnum pylaesii.* After lunch, we took a short walk on the trail around the Manasquan Reservior. Species seen there included *Spiranthes cernuua, Agalinis purpurea, Rhynchospora capitellata,* and *Solidago odora.* Report by leader: Bill Olson.

2001 Field Trips

20 January: Winter Botany Walk in the Pinelands of New Jersey. Cancelled due to snow. Leader: Bill Olson.

5 May: Nockamixon State Park, Bucks County, Pennsylvania. A small group of six participants gathered to explore the south shore of Lake Nockamixon in Nockamixon State Park, Bucks County. The group traversed the slope along the lake looking at large stands of native yew (*Taxus canadensis*). Unfortunately the decline of eastern hemlock (*Tsuga canadensis*) in the canopy due to infestation by hemlock woolly adelgid is raising some question as to whether the *Taxus* will survive at this site. A trek along the lakeshore led to a stand of nodding trillium (*Trillium cernuum*) in full bloom. On the way we stopped to admire blunt-leaved hepatica (*Hepatica nobilis* var. *obtusa*), bloodroot (*Sanguinaria canadensis*), narrow-leaved toothwort (*Cardamine angustata*), yellow fumewort (*Corydalis flavula*), false mermaid (*Floerkia proserpinacoides*), wild-ginger (*Asarum canadense*), wild sarsaparilla (*Aralia nudicaulis*), doll's-eyes (*Actaea pachypoda*), creeping phlox (*Phlox subulata*), plantain-leaved pussytoes (*Antennaria plantaginifolia*), and other spring wildflowers. Several sedges were also identified on the wooded slopes including *Carex pensylvanica, C. albicans, C. laxiflora,* and *C. albursina.* At the edge of the parking lot white ash (*Fraxinus americana*) and hackberry (*Celtis occidentalis*) were in full glorious bloom. Report by leader: Ann Rhoads.

26 May: Menantico and Peaslee Wildlife Management Areas (W.M.A.), Cumberland County, New Jersey. The trip began at the intersection of Route 49 and Union Road (Route 671) adjacent to Cumberland Pond. The group walked a few hundred yards to the west along Route 49 and botanized along the roadside. Here the group saw a mixture of oak species: *Quercus alba, Q. coccinea, Q. falcata, Q. ilicifolia, Q. marilandica, Q. montana* (= *Q. prinus*), *Q. stellata,* and *Q. velutina.* The three pines of the pine barrens, *Pinus rigida, P. echinata,* and *P. virginiana,* were also noted. The highlight along the roadside was a specimen of *Chionanthus virginiana* in full bloom. The group then visited Menantico Ponds W.M.A. This small preserve (349 acres) is situated south of Route 49 in the Menantico Creek watershed adjacent to railroad tracks. Much of it is comprised of abandoned sand mining pits. On both sides of the tracks were vast expanses of exposed sand, and here large stands of *Hudsonia tomentosa,* some in bloom, were noted. Mixed in were stands of *H. ericoides,* and some material appeared intermediate between the two species, suggesting hybridization. Just east of Route 55, a sandy, open field was botanized. Here the group also noted good cushions of the two *Hudsonia* species, as well as *Carex pensylvanica, Carya pallida, Helianthemum canadense, H. propinquum, Mirabilis nyctaginea, Panicum addisonii, P. meridionale, Petrorhagia prolifer*, and *Quercus prinoides*. In dry pine woods nearby, *Polygonatum biflorum* and *Uvularia sessilifolia* were noted. We studied the differences between *Toxicodendron radicans* (poison-ivy) and *T. pubescens* (poison-oak), both growing along the railroad tracks. Just west of the Menantico Creek crossing was a stand of *Lonicera sempervirens* in bloom. At Cumberland Pond we saw a few specimens of *Quercus michauxii*. In a bog in back of the pond along the Lawrens Branch were excellent stands of *Arethusa bulbosa* and *Eriocaulon compressum* in bloom. In the adjacent oak-pine woods we saw stump sprouts of *Castanea dentata*. Our last stop was an Atlantic white-cedar swamp in the headwater of the Middle Branch in the Peaslee W.M.A., a preserve that now totals more than 25,000 acres. Here we saw the state's largest specimen of *Chamaecyparis thyoides*, with a circumference of over 10 feet.. Other species noted were *Carex collinsii, C. atlantica* ssp. *capillacea* (= *C. howei*), *Chionanthus virginicus, Ilex laevigata, Smilax laurifolia*, and *Trientalis borealis*. Attendance: 9. Leader: Gerry Moore.

2 June: Fairmount Park, southwest of the Recycling Center and sorthwest of Chamounix Mansion, Philadelphia County. Our field survey produced the following list of species: *Carya cordiformis, Phellodendron levallei, Poa triviale, Poa* sp., *Athyrium filix-femina, Ilex crenata, Parthenocissus quinquefolia, Viburnum dentatum, Maianthemum racemosum* ssp. *racemosum* (= *Smilacina racemosa*), *Podophyllum peltatum, Magnolia acuminata, Lonicera japonica, Galium aperine, Cedrela sinensis* (= *Toona s.*), *Liquidambar styraciflua, Impatiens capensis, Symplocarpa foetidus, Circaea quadrisulcata, Rubus allegheniensis, R. phoenicolasius, Prenanthes altissima, Eupatorium pupureum, Osmorhiza longistylis, Parmelia sulcata, Physcia tenella, Vitis vulpina, Liriodendron tulipifera, Carex blanda, C. radiata, Allium vineale, Solidago canadensis, Rosa multiflora, Dioscorea villosa, Ailanthus altissima, Polygonum virginianum, Duchesnia indica, Sanicula canadense, Sambucus canadensis, Acer negundo, Pilea pumila, Philadelphus coronarius*, aster sp., *Eurybia divaricata* (= *Aster divaricatus*), *Tilia* sp., *Oxalis stricta., Prunus avium, Bromus arvensis, Hedera helix, Arisaema triphyllum, Rumex crispus, Gymnocladus dioica, Ranunculus ficaria, Dactylis glomerata, Lepidium virginicum, Artemesia vulgaris, Polygonum perfoliatum, Geum canadense, Celastrus orbiculatus, Polygonum cuspidatum, Leersia virginica, Quercus rubra, Ligustrum obtusifolium, Viburnum dentatum, V. acerifolium , V. prunifolium, V. plicatum, Cystopteris fragilis, Platanus hybrida, Acer psuedoplatanus, Onoclea sensibilis, Viola cucullata, Hydrangea paniculata, Juncus tenuis, Poa trivialis, Hamamelis virginiana, Phytolacca americana, Boehmeria cylindrica, Thelypteris novaboracensis, Dennstaedtia punctilobula, Pinus strobus, Polygonum perfoliatum, Betula lenta, Castanea dentata, Lindera benzoin, Nyssa sylvatica*, and *Toxicodendron radicans*. The field trip was followed by an open house of the Botany Department of the Academy of Natural Sciences for a chance to meet department personnel and to tour the Academy's herbarium. Leader: David Hewitt.

16 June: Miller Farm, Chester County, Pennsylvania. We braved wind and intermittent rain from tropical storm Allison to explore fields and meadows of this Brandywine Conservancy-owned property. After a brief talk by Thom Larson on the history of the property, we walked down through an unmown hayfield to the wetland corridor draining the eastern edge of the site. Here we looked at wetland plants and discussed how to tell various species of *Carex* apart. Larson also described the methods employed in keeping the various field and wetland habitats from succeding to shrubland and woodland. Unfortunately, colonies of gaywings, *Polygala paucifolia*, had already bloomed, but we were able to see them in fruit. In addition, we were rewarded by a blossoming display of a tremendous population of *Hypoxis hirsuta*. Other notable plants seen were *Spiraea tomentosa, Dryopteris cristata, Eupatorium pilosum, Andropogon gyrans, Rubus hispidus*, which in some spots was the dominant ground cover, and *Stellaria alsine*. We also found a new addition for the property, *Gratiola neglecta*. Carices seen included *Carex albicans, C. amphibola, C. annectens, C. blanda, C. debilis* var. *debilis, C. digitalis, C. glaucodea, C. gracilescens, C. hirsutella, C. lurida, C. pensylvanica, C. radiata, C. scoparia, C. spicata, C. swanii, C. stricta, C. styloflexa, C. vestita*, and *C. vulpinoidea*. Due to impending inclement weather, the trip concluded at noon. Attendance: 6. Leaders: Jack Holt and Janet Ebert.

24-28 June: Wesley College, Dover, Kent County, Delaware. Joint field meeting with the Northeast Section of the Botanical Society of America and the Torrey Botanical Society. Dr. William Kroen of the Biology Department at Wesley College provided assistance as the local host. William McAvoy of the Delaware Natural Heritage Program planned the itinerary for the three days of field trips. They included sites in central Delaware (Killens Pond State Park, Cape Henlopen State Park, Blackbird State Forest) and eastern Maryland (Adkins Arboretum at Tuckahoe State Park, Big Marsh at Echo Outdoor School). The plant communities included examples of upland forest, swamp forest, shrub swamp, seasonal pond (Delmarva bay), fresh marsh, salt marsh, dune, and beach. William McAvoy led a field trip at one of the sites each day and provided the species lists and maps distributed to the participants. The other trip leaders were Jack Holt and Janet Ebert (Botanical Consultants, Chadds Ford, Pennsylvania), Keith Clancy (Delaware Native Plant Society), and Brent Steury (National Park Service, Washington, D.C.). Evening lectures were given by William McAvoy and Keith Clancy, by Robert Naczi and Susan Yost (Claude E. Phillips Herbarium, Delaware State University), and by Victor Soukup (University of Cincinnati and Ohio Native Plant Society). In addition, Arthur Tucker (Delaware State University) hosted a tour of the new Phillips Herbarium building and James McClements of Dover invited the participants to examine his cultivated collection of American and Eurasian forest perennial herb species. Chairmen: Tim Draude and Larry Klotz. Attendance: 65, representing 11 northeastern states plus Florida, California, and the District of Columbia. Report by Karl Anderson.

11-20 July: Newfoundland, Canada. Joint meeting with the New Jersey Audubon Society and the Torrey Botanical Society. This tour visited areas on Newfoundland's west coast, from Gros Morne National Park to Saint Anthony. Habitats studied included boreal forest, fens, bogs, serpentine exposures, coastal limestone barrens, ponds, shores, and roadsides. Over 300 plant species were included in a partial list of species seen; of these about 250 were species that are non-existent or rare in the Philadelphia area. Of seventeen species of orchids seen, fifteen were in bloom, including *Cypripedium reginae, Orchis rotundifolia, Platanthera orbiculata*, and the endemic *Platanthera straminea*. We saw four species of saxifrages, of which *Saxifraga aizoon, S. aizoides*, and *S. cespitosa* were in bloom, and a good variety of low arctic specialties such as *Bartsia alpina, Potentilla crantzii, P. usticapensis, Primula egalikensis, Tofieldia pusilla, Epilobium latifolium, Dryas integrifolia, Lesquerella purshii*, and *Arnica terranovae*. In addition to plants, participants enjoyed good weather, lovely scenery, and good looks at moose, humpback whales, and other wildlife. Visits were made to the Norse settlement site at L'Anse aux Meadows and to the visitor center at Port au Choix, site of ongoing archaeological investigations into Maritime Archaic and Paleo-Eskimo cultures. Attendance: 8. Leader: Karl Anderson.

28 July: Pancake Turfcut near Waretown and Lochiel Creek near Barnegat, Ocean County, New Jersey. In the early 1970s, co-leader Ted Gordon introduced the term "turfcut" to designate a man-made plant community in early succession harboring a diverse assemblage of showy or rare pioneer species. These persistent communities were created by the removal—often down to the mineral soil—of the low shrub layer or turf (e.g., sheep laurel, teaberry, dwarf huckleberry) from the moist areas that border Atlantic white-cedar swamps or pitch pine lowlands. The chunks of turf were used by charcoal burners to cover their pits, by road builders to stabilize steep slopes, and by farmers to stabilize dikes around their cranberry bogs. Our first stop was at Pancake turfcut between the Garden State Parkway and the abandoned Tuckerton Railroad right-of-way about 2 miles northwest of Waretown. We rediscovered two small stands of the federally threatened *Rhynchospora knieskernii* along a damp sand road that bisects the site. The globally rare *Narthecium americanum* was mostly concentrated in three stands along this road with a few isolated clumps further in the interior of the tract. Only about 20 severely retarded plants were in bloom, which suggested that habitat conditions were not optimal for sexual reproduction. The turfcut also contained thousands of plants of the globally rare *Schizaea pusilla*; the occurrence may be the largest in the Pine Barrens. Additional wetland plants included *Rhynchospora alba, R. capitellata, R. gracilenta, R. fusca, Carex exilis, C. striata, Cladium mariscoides, Eleocharis tuberculosa, Andropogon glomeratus, Muhlenbergia uniflora, Eriophorum virginicum, Drosera filiformis, D. rotundifolia, Vaccinium macrocarpon, Xyris difformis, Lobelia nuttallii, Polygala cruciata, Pogonia ophioglossoides, Calopogon tuberosus, Lycopodiella alopecuroides, L. appressa*, and *Pseudolycopodiella caroliniana*. Although impacted by the regeneration of *Pinus rigida* and *Chamaecyparis thyoides*, this turfcut, created in the early 1950s, continues to produce a remarkable herb flora. We next visited a *Helonias bullata* occurrence along Lochiel Creek 0.7 mile west of the stream's junction with Route 9 and 1.5 miles north of Barnegat. Over the past several years, a portion of this swamp-pink population has shown a substantial decline in flowering. This is most likely a result of water deprivation related to upstream construction of a series of detention basins linked to housing development at Rose Hill Estates. In contrast, the flowering of a fine second colony of swamp-pink below the dam of an abandoned cranberry bog was not impeded; these plants were receiving a steady flow from two small tributaries of Lochiel Creek. In the adjacent bog that has regenerated to a sphagnous cedar swamp with scattered openings, we saw in flower *Rhexia virginica, Sabatia difformis, Xyris torta, Polygala brevifolia, P. cruciata, Utricularia striata, U. subulata, Drosera intermedia, D. rotundifolia, D. filiformis*, and *Platanthera clavellata*. Also recorded here were *Rhynchospora alba, R. capitellata, R. gracilenta, Eleocharis tuberculosa, Carex bullata, C. collinsii, C. striata, C. atlantica, Dulichium arundinaceum, Schoenoplectus pungens, Andropogon glomeratus, Sarracenia purpurea, Orontium aquaticum, Eriocaulon aquaticum, Sparganium americanum, Triantalis borealis, Hypericum canadense, Eupatorium perfoliatum, Thelypteris simulata, Decodon verticillatus, Uvularia sessilifolia, Viburnum nudum* var. *nudum, Lindera benzoin, Xerophyllum asphodeloides, Juncus caesariensis, Utricularia purpurea, Schizaea pusilla, Sphagnum papillosum, S. cuspidatum, S. tenerum, S. pulchrum*, and *S. magellanicum*. Our most significant discovery was a few clumps of the state endangered *Eleocharis tortilis* on the upper edge of sphagnous depressions in the bog. It appears that this sedge, with its peculiar, spirally twisted culms, was last collected in Ocean County by Bayard Long in 1915 in swampy woods nearby to the east. We were unsuccessful in finding more plants of swamp-pink in a wider search of the bog and the swamp upstream of it. Attendance: 18. Leaders: Alfred E. Schuyler and Ted Gordon.

11 August: Atsion, Burlington County and Rockwood-West Mill Tract of Wharton State Forest, Atlantic County, New Jersey. At Atsion near the abandoned Jersey Central railroad tracks, we saw *Fimbristylis puberula, Rhynchospora torreyana, Juncus biflorus*, and *Croton willdenowii* (= *Crotonopsis elliptica*). What once was a vigorous *Gentiana autumnalis* population here has been reduced to a few scattered, sterile and budding individuals wilted by an extended period of drought. We traveled in 4-wheel-drive vehicles to the iron-ore swales and pitch pine lowland southeast of Atsion and east of Dutchtown to see an occurrence of *Xyris caroliniana*, discovered by the leader in 1998 on a relatively dry patch of sand. This state-endangered yellow-eyed grass has never been known from more than two or three sites in the barrens. A couple of the solitary plants examined had the characteristic deeply set, lustrous brown sheaths below, dilated to form an elongated, bulb-like base, a feature that makes this *Xyris* readily distinguishable from other members of the genus. Also seen nearby were *Calamovilfa brevipilis, Aristida virgata* (= *Aristida purpurascens* var. *virgata*), *Agalinis purpurea* var. *racemulosa* (= *A. virgata*), *Carex livida, Leiophyllum buxifolium*, and additional colonies of both *Gentiana autumnalis* and *Fimbristylis puberula*. Via a narrow, potholed trail we reached an extensive, peaty, iron-ore swale along Gun Branch just south of Rockwood. The diverse species assemblage of this shallow depression included *Xyris difformis, X. torta, Eriocaulon decangulare, Carex striata, Dulichium arundinaceum, Eleocharis tuberculosa, E. tenuis, E. olivacea, Rhynchospora capitellata, R. cephalantha, R. chalarocephala, R. alba, R. fusca, R. gracilenta, Cyperus dentatus, Cladium mariscoides, Muhlenbergia torreyana, Erianthus giganteus, Panicum verrucosum, P. virgatum, P. longifolium, Andropogon glomeratus, Glyceria obtusa, Juncus pelocarpus, J. canadensis, J. scirpoides, J. effusus, Sagittaria englemanniana, Iris prismatica, Lobelia canbyi, Lophiola aurea, Lachnanthes caroliniana, Hypericum canadense, H. denticulatum, Triadenum virginicum, Rhexia virginica, Woodwardia virginica, Chamaedaphne calyculata*, and *Vaccinium macrocarpon*. By trails only recently improved by the Forest Fire Service, we drove southeast toward Pleasant Mills to observe the impacts of the 29 July 1997 wildfire on 1,900 acres of the landscape between Sleeper Branch of Bear Swamp and the Noscochague Creek. Everywhere in profusion were *Amphicarpum purshii, Calamovilfa brevipilis*, and *Cyperus dentatus*; *Muhlenberia torreyana* and *Rhynchospora cephalantha* were noted in several bog-ore basins. A couple of these swales also contained small pockets of *Rhynchospora knieskernii*. Attendance: 20. Leader: Ted Gordon.

19 August: Stafford Forge Wildlife Management Area (W.M.A.), Ocean County, New Jersey. We visited three impoundments in the southern section of this W.M.A. Water levels were very low, but this did not appear to have a negative effect on the flora. Some of the plants seen in bloom were *Eupatorium leucolepis, Polygala cruciata, Chrysopsis mariana, Gratiola aurea, Xyris difformis, X. torta, X. smalliana, Rhexia virginica, Oclemena nemoralis* (= *Aster n.*), *Eurybia compacta* (= *Aster gracilis*), *Utricularia cornuta, U. purpurea, Rhynchospora alba, R. capitellata, R. chalarocephala, Juncus biflorus, Vaccinium macrocarpon, Drosera filiformis, D. intermedia, D. rotundifolia*, and *Sarracenia purpurea*. A small savanna near the northernmost pond was explored, and *Schizaea pusilla* was found, as were *Eriophorum virginicum, Lycopodiella appressa, L. caroliniana*, and abundant foliage and fruit of *Pogonia ophioglossoides*. Ted Gordon pointed out *Xyris fimbriata*, a new plant for most of the participants. The day ended with a side trip to the edge of a salt marsh north of New Gretna, where *Lythrum lineare, Sabatia dodecandra, Agalinis purpurea, Kosteletzkya virginica*, and *Schoenoplectus americanus* (= *Scirpus a.*) were found. Attendance: 12. Leader: Karl Anderson.

31 August: Thompson Park, Jamesbury, Middlesex County, New Jersey. A large number of coastal plain species was found in a wet spring area in the park, including *Andropogon glomeratus, Clethra alnifolia, Eupatorium dubium, Eupatorium hyssopifolium, Eupatorium pilosum, Hypericum gentianoides, Lechea pulchella, Lycopodiella appressa, Panicum verrucosum*, and *Rhynchospora capitellata*. The dredge material from Manalapan Lake in the park, deposited adjacent to this wetland area, had an interesting flora including *Andropogon gerardii, Bidens aristosa, Echinacea purpurea, Helenium autumnale, Helenium flexuosum, Panicum virgatum, Tripsacum dactyloides*, and *Verbesina alternifolia*. Some of the group wandered into the wooded area of the wetlands near the spring and found *Botrychium dissectum, Lycopodium digitatum, Onoclea sensibilis, Osmunda cinnamomea, Thelypteris noveboracensis, Thelypteris palustris* var. *pubescens*, and *Woodwardia areolata*. Report by leader: Bill Olson.

29-30 September: Maurice River Cove and Delaware Bay, Cumberland County, New Jersey. Joint trip with the Torrey Botanical Society. The trip began on a warm, sunny day at the intersection of Route 47 and the Maurice River Causeway just east of Maurice River Station. Here along the roadside and pine-oak woods adjacent to the railroad tracks, we noted several species of oak: *Quercus alba, Q. coccinea, Q. marilandica, Q montana* (= *Q. prinus*), *Q. stellata*, and *Q. velutina*. Most interesting was *Q.* ×*saulii*, a cross between *Q. alba* and *Q. montana*. Mac Alford, a student of *Dioscorea* from Cornell University, identified material from here as *D. hirticaulis*. We also noted five taxa of *Eupatorium* in bloom: *E. album, E. hyssopifolium, E. pilosum, E. rotundifolium* var. *rotundifolium*, and *E. rotundifolium* var. *ovatum*. In an open field at the intersection of Route 47 and Whitney Point Road, fall herbs were in excellent bloom: *Agalinis purpurea, Doellingeria umbellata, Lobelia puberula, Spiranthes cernua, Symphiotrichum dumosum, S. lateriflorum*, and *Veronica noveboracensis*. Adjacent to the field, the group had an excellent opportunity to distinguish between *Morella caroliniensis* (= *Myrica pensylvanica*) and *M. cerifera*, as both were growing together. In the adjoining woods, a few specimens of *Quercus michauxii* were noted. The group then visited the Moores Beach area and walked all the way out to the beach. Species that were noted in the salt marsh and beach habitats included *Ambrosia artemisiifolia, Chamaesyce polygonifolia, Chenopodium ambrosiodes, C. berlandieri, Cycloloma atriplicifolium, Kochia scoparia, Limonium carolinianum, Polygonum prolificum, Suaeda calceoliformis, Solidago sempervirens, Symphiotrichum subulatum*, and *Trichostema dichotomum*. Along Moores Beach, a good number of monarch butterflies (*Danaus plexippus*) were noted, many of them on the blooms of *Solidago sempervirens*. On our last stop at the edge of a salt marsh along Thompsons Beach Road, we noted an excellent stand of *Euthamia minor* (= *Solidago microcephala*), along with *Cyperus filicinus, Suaeda linearis*, and *Pluchea odorata*.

The second day of the trip was quite cool and rainy as we traveled to Bivalve and noted a good stand of *Setaria magna* growing in the tidal marshes. This grass was quite distinctive, as it was taller than the *Phragmites australis* also present in the marsh. Other plants noted here included *Eleocharis parvula, Hibiscus moscheutos, Polygonum cespitosum, P. lapathifolium, P. pensylvanicum, Ruppia maritima, Schoenoplectus robustus, Setaria faberi*, and *Typha latifolia*. The group then visited the woods and tidal marshes along Hansey Creek Road. Here we focused on *Carya, Pinus*, and *Quercus*, noting *C. glabra, C. pallida, C. tomentosa* (= *C. alba*), *P. rigida, P. echinata, P. taeda, P. virginiana, Q. alba, Q. coccinea, Q. falcata, Q. marilandica, Q. nigra, Q. phellos, Q. montana*, and *Q. velutina*. Linda Kelly discovered a population of *Pyrrhopappus carolinianus* in this area. Attendance: 14. Leader: Gerry Moore.

2002 Field Trips

22 June: Martha Furnace and Oswego River Savannas, Wharton State Forest, Burlington County, New Jersey. At the town site of old Martha, a cellar hole, scattered fragments of furnace slag, a tailrace, and the presence of *Catalpa bignonioides, Juglans nigra, Ulmus americana*, and *Robinia pseudoacacia* were vivid reminders of former human habitation. Here a small glade of less than an acre of man-altered soil has produced what may be the most diverse fern flora in all of the Pine Barrens. We recorded 12 species of ferns: *Asplenium platyneuron, Botrichium dissectum* (both forma *obliquum* and forma *dissectum*), *B. virginianum, Dryopteris carthusiana, D. cristata, Ophioglossum pusilum* (= *O. vulgatum* var. *pseudopodium*), *Osmunda cinnamomea, O. regalis* var. *spectabilis, Thelypteris palustris* var. *pubescens, Onoclea sensibilis, Polytrichum acrostichoides*, and *Woodwardia areolata*. Seen here in former years, *Dennstaedtia punctilobula, Athyrium felix-femina*, and *Dryopteris neveboracensis* eluded us. However, *Pteridium aquilinum* var. *latiusculum* and *Schizaea pusilla* were observed nearby. At Martha we also saw *Vitis aestivalis* var. *aestivalis, Triodanis perfoliata, Apocynum ×floribundum, Holcus lanatus, Poa compressa*, and in the oak-pine forest overlooking the Oswego River, *Panicum columbianum, Danthonia sericea*, and *Piptochaetium evanaceum* (= *Stipa evanacea*). Upstream of the furnace site in sphagnous seeps, muck flats, and savannas that stretch along the river from the foot of Calico Ridge to just north of Cutts Pumphouse, we observed several bright yellow bands of *Narthecium americanum*, the fuzzy stars of *Lophiola aurea*, massive goblets of *Sarracenia purpurea*, the white buttons of *Eriocaulon compressum* and *E. decangulare*, scattered culms of *Danthonia epilis*, and flowering patches of *Utricularia cornuta, U. striata*, and *U. subulata* (including forma *cleistogama*). Several lovely pink blossoms of *Calopogon tuberosus* and *Pogonia ophioglossoides* dotted the landscape. A highlight was the rediscovery of a population of the rare *Utricularia resupinata*, occurring as numerous delicate, tiny, violet flecks on black muck. Unable to locate a known occurrence of viscid asphodel here, we went north to Buck Run Savanna where we noted two specimens of this lily just starting to flower. The *Flora of North America* (Vol. 23, 2002) has noted that all specimens of *Triantha* (= *Tofieldia*) collected in Burlington County have been annotated *Triantha glutinosa* × *T. racemosa*, representing "a surviving disjunct remnant with attributes of both species." It appears that *T. racemosa* does not occur in the state. Thanks to William Standaert for maintaining a list of species observed. Attendance: 23. Leader: Ted Gordon.

29 June: Nescopeck State Park, Luzerne County, Pennsylvania. Ann Rhoads and Tim Block of the Morris Arboretum, who have conducted an inventory of the Nescopeck Valley for the Pennsylvania Bureau of State Parks, led the trip. Although Ann and Tim had compiled a list of over 600 species of vascular plants from the area, club members were able to add several new records. The first stop was in the acidic oak-heath forest typical of south-facing slopes on Wisconsinan glacial till, where the globally rare variable sedge (*Carex polymorpha*) is abundant. Other species noted in this area were climbing fern (*Lygodium palmatum*), which is abundant in low areas along Nescopeck Creek, fly-poison (*Amianthium muscaetoxicum*), and beaked and American hazelnut (*Corylus cornuta* and *C. americana*), which grow in mixed populations along woods roads and trails. Several species with a more northern distribution in the state were noted such as bush-honeysuckle (*Diervilla lonicera*), dewdrop (*Dalibarda repens*), and northern wood-sorrel (*Oxalis acetosella*).

The unglaciated lower slope of Mt. Yaeger on the south side of the valley was the target for the afternoon. Unlike the south-facing slopes on the opposite side of the valley, the lower slopes of Mt. Yaeger support a northern hardwood forest characterized by sugar maple (*Acer saccharum*), basswood (*Tilia americana*), and beech (*Fagus grandifolia*). Here the group saw mountain maple (*Acer spicatum*), fly-honeysuckle (*Lonicera canadensis*), purple-flowering raspberry (*Rubus odoratus*), dwarf raspberry (*Rubus pubesens*), Canada violet (*Viola canadensis*), and barrens strawberry (*Waldsteinia fragarioides*). The find of the day was a small population of ginseng (*Panax quinquefolius*), first spotted by David Lauer. Report by Ann Rhoads.

13 July: Intermittent ponds—Decou Pond and Sykes Branch, Woodland Township, Burlington County, New Jersey; Micajas and Hidden Ponds, Stafford Township, Ocean County, New Jersey. We visited two intermittent ponds in pitch pine lowland about 1.5 miles west of Coyle Airfield in the West (Upper) Plains and about 1 mile south of Route 72. Ringed primarily by *Chamaedaphne calyculata, Vaccinium corymbosum* (including var. *caesariensis*), and *Pinus rigida*, Decou Pond (= Deacon Pond), largest of at least seven open ponds in the vicinity, was completely devoid of water. Readily observed on its sandy bottom interspersed with muckier zones were *Eleocharis olivacea, Drosera intermedia, Carex striata, Sphagnum cuspidatum*, immature *Juncus pelocarpus*, young *Rhynchospora alba, Xyris difformis, Panicum verrucosum, Eleocharis robbinsii, Rhexia virginica, Lachnanthes caroliniana, Eriocaulon aquaticum*, and a few leaves of *Nymphoides cordata* prostrate on muck. In a much smaller, though similar, dried-up pond associated with an intermittent feeder of Pope Branch about 260 yards to the north of Decou Pond, we found only the first eight species listed above, along with numerous *Acer rubrum* seedlings. *Eleocharis robbinsii*, common in Decou Pond, appeared to be missing here. About 1 mile to the southeast, we surveyed the desiccated headwater of Sykes Branch, a tire-marred, intermittent stream corridor bisecting an open lowland pitch pine swale on the state-owned West Plains Natural Area. Here we relocated a natural occurrence of the globally threatened *Rhynchospora knieskernii*, discovered by the leader in August 1992. A mere dozen culms of this beaked-rush were noted on peaty sand in deep tire ruts in association with *Rhynchospora capitellata, Amphicarpum purshii, Lobelia nuttallii*, and *Calamovilfa brevipilis*. It appears that periodic wildfire, light vehicular traffic by hunters, and inundation following precipitation have helped to retard shrub succession. This in turn has helped to maintain the pioneer conditions so essential for sustaining this and perhaps similar populations of Knieskern's beaked-rush. After eating lunch by the bridge over the upper Oswego at historic Cedar Bridge Inn, a hostelry well known to early Philadelphia botanists, we headed about 3.5 miles southeast of the fire house in Warren Grove to Micajas Pond on the edge of the East (Lower) Plains within the Stafford Forge Wildlife Management Area. During the past decade, this headwater pond, situated in the intermittent west prong of Long Branch of Cedar Run, has been known to produce severely fluctuating populations of *Rhynchospora knieskernii*. During severe drought in 1995, an estimated 10,000 fruiting culms of this sedge were seen; on this occasion of even more devastating drought, we found only about 150 culms, all confined to the upper third of the desiccated basin. Among the associated species were *Rhynchospora fusca, R. gracilenta, R. capitellata, R. alba, R. torreyana, Gratiola aurea, Hypericum canadense, Eleocharis olivacea, Dichanthelium wrightianum* (= *Panicum w.*), and *Scleria reticularis*.

At Hidden Pond, a natural, open, intermittent pond in the east prong of Long Branch some 400 yards to the northeast, we noted about 300 culms of *Rhynchospora knieskernii*, far below the 9,000 tufts recorded upon discovery in 1996. Underlain by Downer loamy sand and nestled between two gentle slopes occupied by pine-oak forest, Hidden Pond was, as all of the other sites visited, completely desiccated. All species observed in Micajas Pond were also seen here with the exception of *Rhynchospora torreyana*. Additional species recorded were *Muhlenbergia torreyana, Panicum virgatum, Xyris difformis*, and *Lobelia nuttallii*. Thanks to Bill McLaughlin for assistance with this report. Attendance: 13. Leader: Ted Gordon.

20 July: Ker-Feal (country home of Albert and Laura Barnes), West Pikeland Township, Chester County, Pennsylvania. On this Barnes Foundation property, we identified numerous cultivated trees and shrubs around the house, barn, and long driveway. These included *Abies concolor, Acer ginnala, Acer griseum, Acer mandshuricum, Acer tataricum, Berberis tricanthophora, Cercidophyllum japonicum, Cotoneaster acutifolia, Eleagnus umbellata, Exochorda giraldii, Gymnocladus dioica, Hovenia dulcis, Hydrangea petiolaris, Ilex crenata, Lonicera pileata, Metasequoia glyptostroboides, Neilia sinensis, Platanus hybrida, Pseudolarix amabilis, Pyracantha coccinea, Spiraea douglasii, Syringa vulgaris*, and *Tetradium daniellii* (*Euodia d.*). The driveway was lined with *Ulmus rubra*, most of which were dying. We also recorded wild plants in the woods and fields on the northwest portion of the property where there was a mixture of natives and exotics. Some of the common woody exotics were *Acer platanoides, Berberis thunbergii, Celastrus scandens, Euonymus alatus, Lonicera japonica, Malus* sp., *Morus alba, Phellodendron* sp., *Prunus avium, Rhodotypos scandens*, and *Viburnum dilatatum*. Of the 200+ plant species recorded, over 70 were aliens. A comprehensive plant list, compiled by Jack Holt and Alfred E. Schuyler, is available from the latter. Leader: Alfred E. Schuyler

24 August: Bar-hopping along the Brandywine, Pennsylvania. Exploration of the floodplain of the Brandywine Creek near Chadds Ford was cut short at noon by rain. From the parking lot of the Brandywine Conservancy, we ventured into some older floodplain woods south of Route 1 where we saw *Elymus riparius, Solidago flexicaulis, Tilia americana*, and an uncommon introduction, *Allium oleraceum*, distinguished from *A. vineale* by its later fruiting period and the extremely long sheath clasping the head of bulblets. After going under Route 1, we went onto a muddy gravel bar on the upstream side of an old dam. On the recently exposed mud grew *Lemna minor, Spirodela polyrhiza, Myriophyllum spicatum, Zosterella dubia, Heteranthera reniformis*, and *Potomogeton nodosus* and on recently-barred, gravelly flats, *Lindernia dubia, Penthorum sedoides, Ludwigia palustris, Veronica anagallis-aquatica, Rorippa palustris, Alisma subcordatum*, and *Eragrostis hypnoides*. Growing at an elevation just a few inches higher than the above-listed species were *Amaranthus blitum, A. spinosus, Epilobium coloratum, Bidens frondosa, Mimulus ringens, Echinochloa muricata*, and *Chenopodium* *ambrosioides*. The prize species seen during this part of the walk was a small population of the state rarity *Rotala ramosior* growing on a muddy shore just north of the bar. We crossed a powerline cut dominated by aliens into an extensive shrub swamp and open marsh community. Because the drought had drawn down the water table, we were able to cross areas that normally would have been at least knee-deep in water and mud. The vegetative zones created by fluctuating water tables were also quite evident here. The highest and driest parts of the wetland were dominated by trees, principally willow and ash, with extensive colonies of *Crataegus crus-galli* (cockspur hawthorn). These gave way along the edges and in the higher parts of the open marsh to large colonies of *Cephalanthus occidentalis*, occasionally mixed with *Rosa palustris* and enormous colonies of the sedge *Cyperus esculentus* mixed with *Eragrostis cilianensis*. Plants of *Panicum rigidulum*, *Scirpus cyperinus*, and *Carex lupulina* dotted the edges of the open drawdown. In the center of the drawdown, the mud was bare and extensively cracked; here the only common species was *Nuphar advena*. Attendance: 6. Leaders: Janet Ebert and Jack Holt.

21-22 September: Maurice River Watershed and Delaware Bay, Cumberland County, New Jersey. Joint trip with the Torrey Botanical Society. The group entered the Menantico Ponds Wildlife Management Area from Orange Street in the Millville Industrial Park and walked along the railroad tracks toward Menantico Creek. Along the railroad we noted *Toxicodendron pubescens* and *T. radicans* in fruit. In some tidal ponds adjacent to the creek, *Elatine americana* and *Eriocaulon parkeri* were noted. During this drought year, populations of these two species were considerably smaller and the water was more brackish than in previous years. It was the first year the leader had noted blue crabs (*Calinetes sapidus*) in these ponds. A vernal pond just off Route 47 south of Brickboro was then visited. The pond, devoid of water, was dominated by *Gratiola aurea* in bloom. Associated species were *Hypericum canadense, H. mutilum, Lycopodiella appressa* (= *Lycopodium appressum*), *Panicum longifolium, Rhynchospora capitellata, Scleria reticularis, Vaccinium macrocarpon*, and *Xyris difformis*. The group then walked west through pine-oak woods and botanized abandoned sand mining pits. Here large stands of *Eriocaulon aquaticum, Myriophyllum humile*, and *Schoenoplectus subterminalis* were seen. The group continued westward and then north along abandoned railroad tracks through a salt marsh adjacent to the Maurice River. At times, this site was nearly impenetrable due to large thickets of *Baccharis halimifolia*. On the following day, the group visited the woods and tidal marsh along Hansey Creek Road. Many of the species noted in 2001 were again seen this year, among them *Pyrrhopappus carolinianus* in bloom and excellent stands of *Agalinis purpurea, Lechea pulchella* (= *L. legettii*) and *Quercus nigra*. The group then headed to the Thompson Beach area and botanized along the road leading into the salt marsh. All of the typical salt marsh species seen last year at Moores Beach were also noted here. Growing right in the sand in the road, we found a small population of the rare *Sesuvium maritimum* in bloom. Attendance: 15. Leader: Gerry Moore.

28 September: Fall flowers at the Jenkins Arboretum, Chester County, Pennsylvania. Jenkins Arboretum is a combination of a remnant of the once continuous eastern hardwood forest and a built naturalistic landscape using predominately flora native to eastern North America. As a new botanical garden, which opened to the public in 1976, Jenkins was not a converted estate garden but a carefully planned and planted arboretum. Due to the large numbers of ericaceous plants indigenous to the site such as *Rhododendron periclymenoides, Vaccinium palidum*, and *Kalmia latifolia*, Ericaceae became the Arboretum's area of specialization. Specifically, species and hybrid rhododendrons from all over the world are the majority of accessions, which number in the range of 4 to 5 thousand plants. In addition to Club members, we were joined by an entire herbaceous perennials class from Temple University. The field trip in late September highlighted the usual eupatoriums, fall asters, and goldenrods but it was the richness and diversity of deciduous and evergreen rhododendrons that made the experience unique. Jenkins Arboretum's goal of creating a garden-like feel in concert with nature was a major highlight. Also, where else can one go botanizing so easily and most of the plants are already identified and labeled? Report by leader: Harold E. Sweetman, Executive Director.

Bartonia No. 62: 129-130, 2004

PROGRAM OF MEETINGS
September 2002–May 2005

Date	*Subject*	*Speaker*
2002		
26 Sep	Members' Reports on Summer Botanizing	
24 Oct	Fifty-six Orchids of New Jersey: a Video Film Presentation	David Snyder
21 Nov	Spatial and Temporal Views of tidal Freshwater Plants: Their Seed Banks and Germination Ecology	Mary Leck
19 Dec	What Can Mites Tell Us About the Systematics of Western Hemisphere Pitcher Plants?	Robert F. C. Naczi
2003		
23 Jan	Saving an American Treasure—the Lewis and Clark Herbarium During the Next 200 Years	Richard M. McCourt
27 Feb	Between a Rock and a Soft Place: Plant Habitats Scrutinized	Rick Mellon
27 Mar	Pollination, Breeding system, and Cushion Structure of the Alpine Forget-me-not (*Eritrichium nanum*)	Heinrich Zoller
24 Apr	Around the World: 80 Days and 80 Plants, with Stops in Zimbabwe, China, British Isles, and the Americas	Harold Sweetman
22 May	Philadelphia Botany and Horticulture in the Time of Lewis and Clark	Joel T. Fry
25 Sep	Members' Reports on Summer Botanizing	
23 Oct	Mosses and the Conservation of Natural Communities	Terry O'Brien
20 Nov	The Forest Primeval	Ann F. Rhoads
18 Dec	The Lost Worlds of Venezuela: Flora of the Tepuis and Tabletop Mountains	Lena Struwe
2004		
22 Jan	The Bryophytes of New Jersey	Bill Olson
26 Feb	The Lichens of New Jersey	James Lendemer
25 Mar	Plant Diversity and Exotic Species Invasion in Southern Appalachian Riparian Systems	Rebecca L. Brown
22 Apr	The Flora of Coastal Plain Seasonal Ponds on the Delmarva Peninsula	William McAvoy
27 May	Exotic Trees in Our Landscapes, and Rutgers' Urban Forestry Program	John Kuser
23 Sep	Members' Reports on Summer Botanizing	
28 Oct	Botanical Exploration in South Africa and Namibia	Ted Gordon
18 Nov	Peter Collinson and His Philadelphia Friends	Elizabeth P. McLean
19 Dec	Installation of the Benjamin Smith Barton Historical Marker	Philadelphia Chapter, Lewis & Clark Trail Heritage Foundation

2005

27 Jan	Highlights of the Madagascar Flora	Lucinda McDade
24 Feb	Ectomycorrhiza Underground Networking, or Fungi and the Wood Wide Web	Lena Johnson
24 Mar	Cedar Glades: History, Ecology, and Conservation	Jeffrey L. Walck
28 Apr	Flora of the Warren Grove Gunnery Range, Burlington County, New Jersey	Walter Bien
26 May	The Historical Ecology of Eastern Oak Forests: Past, Present, and Future	Marc Abrams

Bartonia No. 62: 131-138, 2004

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