The Status of *Sticta sylvatica*, an 'Exceedingly Rare' Lichen Species, in Eastern North America

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The status of *Sticta sylvatica*, an 'exceedingly rare' lichen species, in eastern North America

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Abstract. **The presence of the foliose cyanolichen *Sticta sylvatica* in eastern North America has been called into question due to the absence of high-quality, verifiable material and the common misuse of its name. Recently, specimens collected in the Great Smoky Mountains have been verified as having the typical *S. sylvatica* morphology. Although molecular data remain inconclusive regarding the entity's genetic distinctiveness from the phenotypically dissimilar *S. limbata*, we argue that the decline in the abundance of this morphological entity worldwide along with the need for further genetic study make continued conservation efforts imperative.**

***Key words*. Conservation, fungi, ITS, molecular barcoding, taxonomy.**

INTRODUCTION

Sticta sylvatica (Huds.) Ach., a foliose cyanolichen originally described from Europe, has been noted for its apparently extreme sensitivity to various types of disturbances caused by human activity (Gauslaa 1995). It is known to exist in a few scattered localities throughout western North America (Hale 1979, Brodo et al. 2001) and has been reported to grow in eastern North America (e.g., Maine, New York, New Jersey, North Carolina, and Alabama) in historical sources (Fink 1935, Munsell 1876). However, the name '*S. sylvatica*' has often been misused when referring to specimens of either *S. fuliginosa* (Dicks.) Ach. or *S. beauvoisii* Delise; thus, these historical reports must be considered suspect. During a review of herbarium material for a taxonomic revision of the genus *Sticta* (Schreb.) Ach. in the Great Smoky Mountains (McDonald et al. 2003), many specimens incorrectly identified as '*S. sylvatica*' were examined, but clear, robust, verifiable material representing this species was never seen.

Subsequently, Harris (2004) published a checklist of lichens of New York that included *Sticta sylvatica* as one of the verified taxa for the state. However, it was noted that this taxon was probably now extinct there, since it had not been collected at any point in recent history. While examining specimens for the lichen checklist of Virginia (Hodkinson et al. 2009), we again identified a specimen from eastern North America as *S. sylvatica*; this one had been collected in the mountains of Virginia in the mid-1970's. Recently, we identified several specimens as *S. sylvatica* from high elevations of the Great Smoky Mountains National Park (GSMNP) and other high peaks nearby (collected in 1972 and 1973) in the herbarium of Jonathan Dey, which was donated in 2011 to the New York Botanical Garden. It should be noted that Dey himself had previously stated that the specimens resembled *S. sylvatica*, but included them under a broad concept of *S. fuliginosa* (Dey 1978). A subsequent revision of material at NY revealed a handful of additional specimens from high elevation spruce-fir forests in the mountains of North Carolina and Tennessee, all collected in

the first half of the 20th century. Most recently, a single small specimen matching the morphology of *S. sylvatica* was collected from GSMNP, revealing that this morphological entity is still extant in eastern North America (Fig. 1).

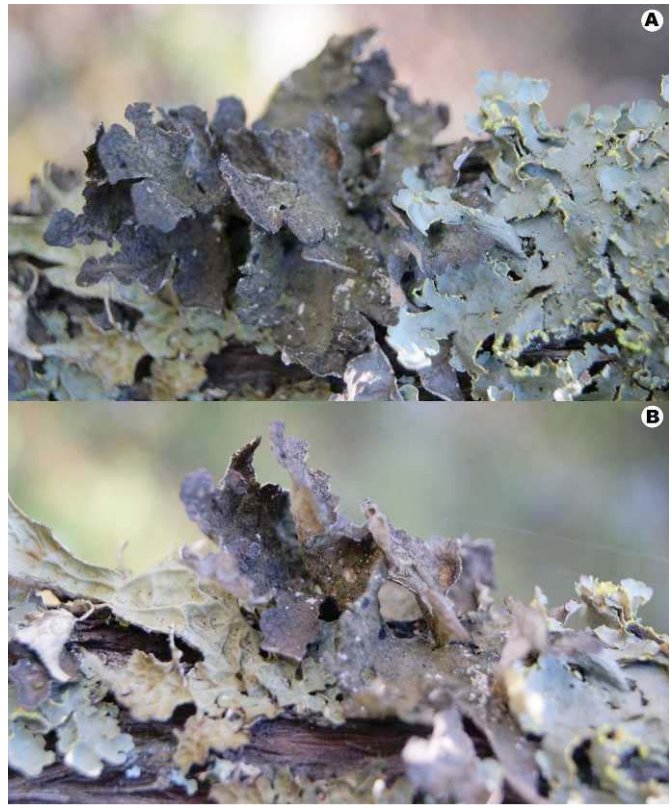

Figure 1. A modern specimen of *Sticta sylvatica* (*Lendemer 30342*, NY) from eastern USA in the field. A, upper lobe surface (see the cover of this issue for a color version). B, side view showing a portion of the lower cortex.

Results and Discussion

Morphological comparison with other species

In overall appearance, *Sticta sylvatica* is most similar to *S. beauvoisii* because both species have relatively large multi-lobed thalli. It differs from *S. beauvoisii* in having shallow to distinct ridges on the upper surface (especially toward the lobe tips), tomentum on the lower surface that is paler in color, and laminal isidia that are dispersed over the surface of the thallus (Figs. 2 & 3). The presence of laminal isidia is likely to be what has led to confusion between *S. sylvatica* and *S. fuliginosa*. The latter species differs markedly from *S. sylvatica* in its overall appearance because *S. fuliginosa* typically has a thallus composed of one to a few, large, rounded, unbranched (or sparsely branched) lobes which resemble shelves, each of which often has a holdfast-like structure of rhizines that tends to be toward one edge of the thallus (Galloway 1997). Also, *S. fuliginosa* only rarely grows on a substrate other than bark, while the specimens that we have examined from North America representing the *S. sylvatica* morphology prefer rocks and humus, with rare occurrences elsewhere (e.g., on *Sorbus* bark).

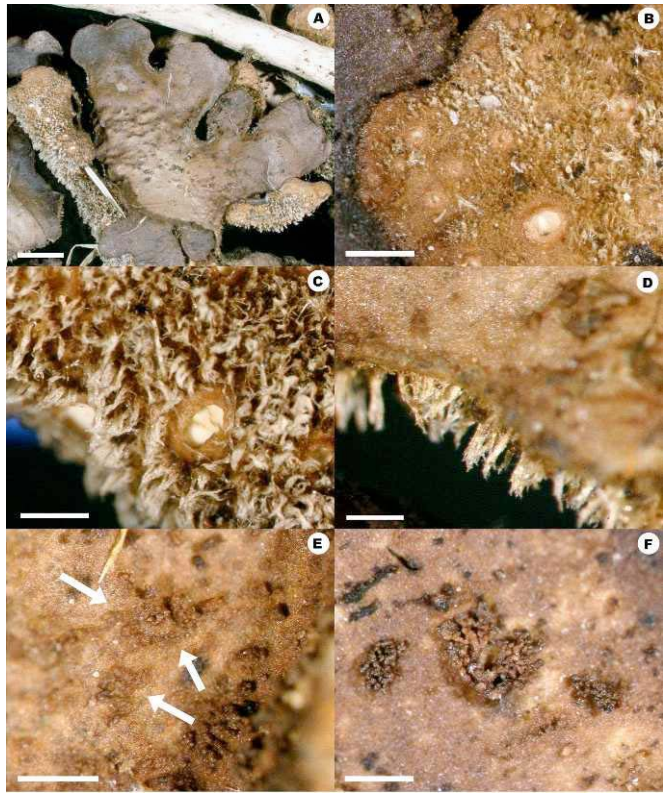

Figure 2. North American population of *Sticta sylvatica* (all from *Dey 3558*, NY). A, gross morphology of the upper lobe surface of the thallus (scale = 2 mm). B, gross morphology of the lower surface of the thallus (scale = 0.5 mm). C, detail of the tomentum and cyphellum on the lower surface of the thallus (scale = 0.5 mm). D, detail of the tomentum (scale = 0.25 mm). E, cluster of laminal isidia in early stage of development (scale = 0.5 mm). F, cluster of mature laminal isidia (scale = 0.5 mm).

Molecular data are inconclusive

A molecular sequence of the fungal 'barcode' region (ITS) from the only recent, readily verifiable specimen with a *Sticta sylvatica* phenotype from eastern North America (GenBank Acc.: JX064536; sequence generated according to protocols outlined by Hodkinson & Lendemer (2011)) is identical to a group of sequences in GenBank that were previously attributed to other species. This includes sequences from New Zealand (GenBank Acc.: AF350310) and Japan (GenBank Acc.: AB239345) from specimens previously identified as "*S. fuliginosa*;" however, further examination of the Japanese voucher specimen revealed it to be morphologically consistent with the sequenced sample of *S. sylvatica* from North America (R. Lücking, pers. comm.). This group also includes a sequence (GenBank Acc.: AY173391) derived from another GSMNP collection which was previously characterized as a "small, much-degenerated" specimen by McDonald et al. (2003). In spite of the lack of soralia, this specimen was previously identified as *S. limbata* (Sm.) Ach. (a sorediate taxon) due to the fact that its ITS sequence matched one derived from a specimen of *S. limbata* from the western United States (GenBank Acc.: AY173390; McDonald et al. 2003), save for a short low quality region at the end. The specimen associated with sequence AY173391 was re-examined and, despite its state, it does produce poorly-developed isidia, and is not incongruent with the *S. sylvatica* morphology. The specimen associated with sequence AY173390 was also examined and has more rounded lobes with marginal soralia, consistent with the concept of *S. limbata*.

The similarity of the ITS sequences between the laminally isidiate specimens (here referred to *Sticta sylvatica*) and the sorediate *S. limbata* specimen was noted by Moncada et al. (2012), and

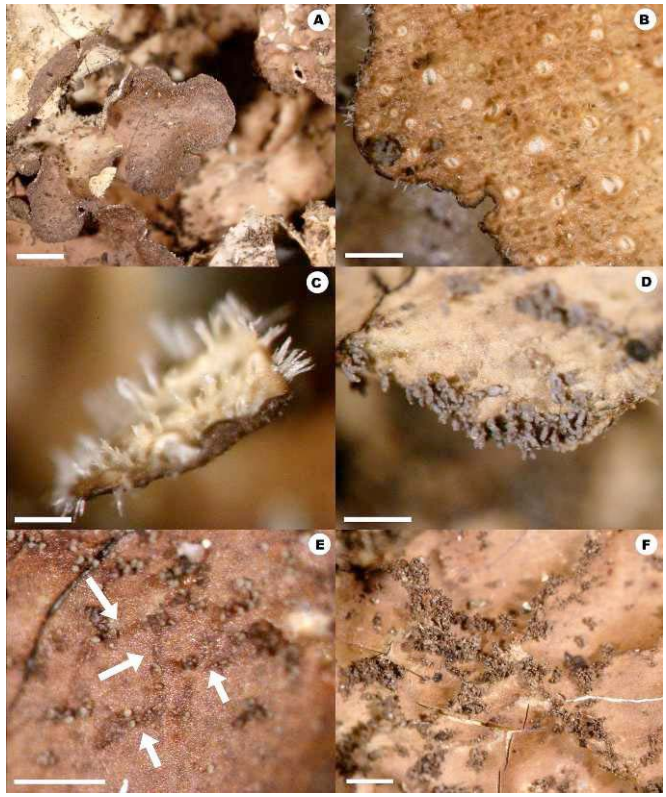

Figure 3. European population of *Sticta sylvatica* (all from *James s.n.*, NY). A, gross morphology of the upper lobe surface of the thallus (scale = 2 mm). B, gross morphology of the lower surface of the thallus (scale = 0.25 mm). C, detail of the tomentum (scale = 0.25 mm). D, marginal isidia (scale = 0.5 mm). E, clusters of laminal isidia in early stage of development along ridges on the thallus surface (scale = 0.5 mm). F, clusters of mature laminal isidia (scale = 1.0 mm).

subsequent ongoing research confirms the closeness of the relationship between the taxa that we here call *S. limbata* and *S. sylvatica* (R. Lücking, pers. comm.). Although a similarity in ITS sequences initially may suggest conspecificity, cases have been discovered in groups of non-lichenized fungi wherein the ITS fungal barcode region shows little or no variation between species that have been demonstrated by other means to be entirely reproductively isolated (Schoch et al. 2012, Skouboe et al. 1999). To date, we have not seen this phenomenon demonstrated in lichens; however, this could be due to technical limitations and the inherent difficulties of working with symbiotic organisms that are not easily grown and crossed in laboratory settings.

It should additionally be noted that, because populations from the type region of *Sticta sylvatica* in Great Britain (Hudson 1762) have not been sequenced, we cannot state with certainty that the extra-European populations are conspecific with *S. sylvatica* s. str. Without molecular data, the possibility that there are geographically-defined semi-cryptic species or morphologically similar but unrelated taxa remain viable hypotheses (see Hodkinson & Lendemer 2011; Moncada et al. 2014). Therefore, until more variable genetic markers are developed, and populations of *S. sylvatica* s. str. are sequenced, we assert that the taxon is best treated as currently circumscribed (based on phenotype) and conserved as such.

Preserving a rare morphological entity

The paucity of modern records, despite recent search efforts in the southern Appalachian Mountains by the authors and their colleagues, may indicate that the morphological entity known as *Sticta sylvatica* has suffered a decline or nearly become extirpated from eastern North America (Fig. 4). Such a decline may be due to the drastic, ecosystem-wide changes that are presently occurring in

high elevation spruce-fir forests in the southern Appalachians (see discussion in Lendemer et al. 2013). If this is the case, then it fits within the broader context of regional decreases in, or extinctions of, *S. sylvatica* elsewhere. Brodo et al. (2001) noted that the taxon is 'exceedingly rare' in the western part of the continent as well. A similar phenomenon can be seen in European countries, such as Luxembourg (where verifiable specimens have not been collected since the nineteenth century) and Belgium (where the most recent record is from 1923) (Diederich et al. 1992). The species is now also considered to be extinct from both the Czech Republic (Liška et al. 2008) and Slovakia (Pišút 2005), and is red-listed for Germany, Austria, Switzerland (Clerc et al. 1992), Norway (Tønsberg et al. 1996) and the European Union as a whole (Ihlen et al. 2001).

The eastern North American entity known as *Sticta sylvatica* is likely to be extinct in large parts of its historical range, and we assert that it should be ranked as 'endangered' and integrated into both site and habitat specific conservation management plans in the region. The modern record from North Carolina indicates that it is present in at least one state in the eastern portion of the continent. Considering the lack of modern data for the other states in which it is reported (NY, TN, and VA), we suggest that it be given an appropriate conservation rank that would denote its rarity, lack of modern records, and the potential that extant populations do exist.

Although molecular data are inconclusive regarding the species-level status of this taxon, we argue that this need not serve as an impediment to conservation. The taxon is clearly definable based on phenotype and molecular data simply do not allow a definitive conclusion, but do not contradict the hypothesis that *Sticta sylvatica* represents a distinct, cohesive biological species. Even if this were not the case, the notion that the North American material could potentially be different from European populations or even include more than one species would increase the necessity for preservation, so that a species is not inadvertently extirpated from our region due to ignorance.

This article is intended to raise awareness of this taxon in eastern North America and possibly help to preserve a species whose worldwide future remains uncertain. It is also intended to focus attention on the dire need for a detailed inventory of the lichen biota of the southern Appalachians to create a dataset paralleling those of other organismal groups (Tripp & Lendemer 2012). Although we utilize a species-based conservation approach here, it is critical to emphasize that *Sticta sylvatica* fits well within the developing picture of southern Appalachian lichens in the twenty-first century. Historically, the region has long been recognized as a biodiversity hotspot for many groups of organisms including lichens (Hodkinson 2010; Lendemer & Tripp 2008). However recent studies in Great Smoky Mountains National Park have revealed previously unknown and unexpected levels of diversity (Lendemer et al. 2013; Tripp & Lendemer 2012). The diversity uncovered in the Great Smoky Mountains is clearly not anomalous, but rather representative of the region as a whole (e.g., Hodkinson 2010). The large patchwork of protected forests in the southern Appalachians includes extensive old-growth and spans an elevation gradient of nearly six thousand feet, thus encapsulating in a small geographic area many of the life zones present from Alabama to Maine. In modern times the region likely has served as a refuge for an eastern North American lichen biota that has been significantly negatively impacted by three centuries of continuous change from anthropogenic influences (Lendemer et al. 2013). Thus, the continued, and increased, protection of this region is integral to the maintenance of regional and continental lichen biodiversity.

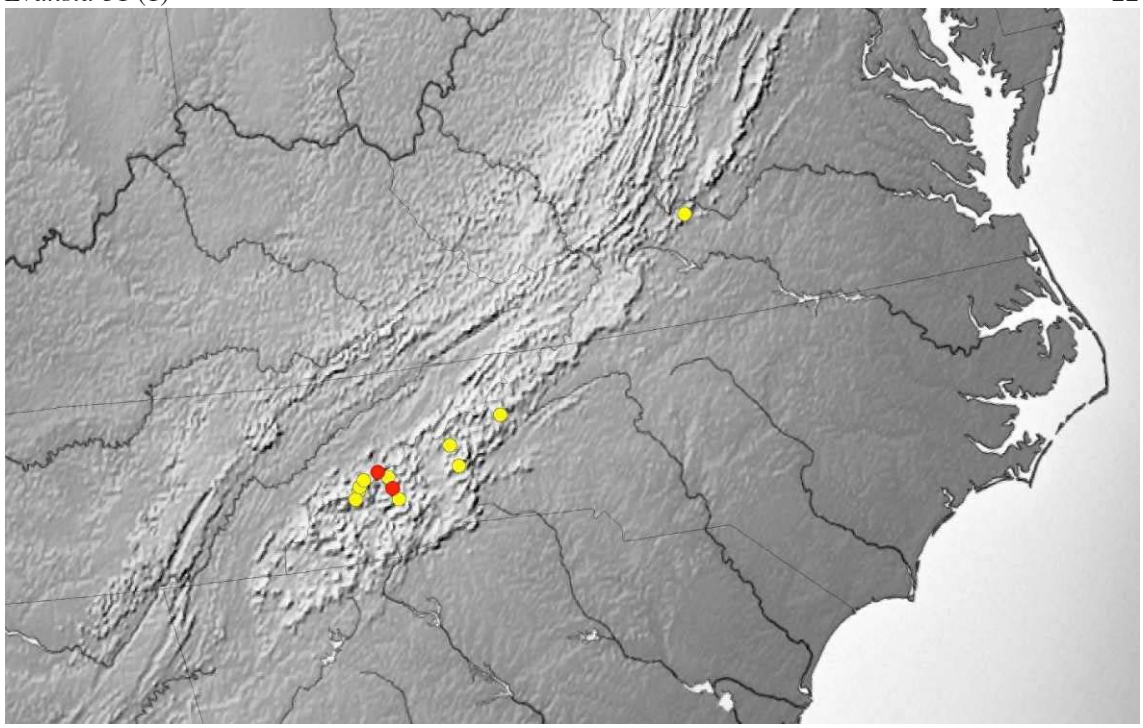

Figure 4. Historical and modern records of *Sticta sylvatica* in the southern Appalachians. Lighter dots represent collections from before 1980, while darker dots represent collections from after 1980. See the cover of this issue (inset) for a color version.

Selected specimens examined

STICTA BEAUVOISII Delise

NORTH AMERICA. U.S.A. NORTH CAROLINA. BUNCOMBE CO.: Bullhead Gap in the Great Craggy Mountains, 1972, on *Fagus* bark, *J. P. Dey 1454* (NY). **TENNESSEE. SEVIER CO.:** GSMNP, La Conte Trail from Newfound Gap, June 1935, *A. J. Sharp s.n.* (NY). **VIRGINIA. NELSON CO.:** Wintergreen Mountain Resort, access trail to Appalachian Trail at end of Hemlock Drive, 10 May 2003, on bark at tree base, *W. R. Buck 44261* (NY).

STICTA FULIGINOSA (Hoffm.) Ach.

EUROPE. FRANCE. BRETAGNE. FINISTÈRE: Forêt du Cranou, 16 April 1931, on mossy hardwood bark, *T. E. Hasselrot s.n.* (NY). **NORTH AMERICA. CANADA. NOVA SCOTIA. SHELBURNE CO.:** near Duck Pond, near East Sable River, 09 January 2008, on *Acer* bark, *F. Anderson 1318* (NY). **U.S.A. NORTH CAROLINA. HAYWOOD CO.:** GSMNP, top of Purchase Knob, 05 September 2000, on *Aesculus octandra* bark, *A. Ciegler 22008* (NY). **MACON CO.:** Wayah Bald ~8 mi. W of Franklin, 26 September 1989, on hardwood bark, *R. C. Harris 24634* (NY); Nantahala National Forest, slope of Wyah Bald along Appalachian Trail, 12 Oct 1998, on mossy bark, *R. J. Hill 525-A* (NY). **SWAIN CO.:** GSMNP, Indian Gap, June 2000, on *Fagus* bark, *J. P. Dey 29871* (NY). **YANCEY CO.:** Mount Mitchell, 15 June 1929, on hardwood bark, *H. W. Youngken 10* (NY). **TENNESSEE. SEVIER CO.:** GSMNP, along the Appalachian Trail from Newfound Gap to The Jumpoff, 04 October 1958, on hardwood bark, *R. A. Pursell 3430* (NY); Clingmans Dome, 31 August 1960, on mossy hardwood bark, *G. T. Johnson s.n.* (NY); Mt. Sequoyah, along the Appalachian Trail, 1973, on *Betula* bark, *J. P. Dey 6515* (NY). **VIRGINIA. WISE CO.:** High Knob, Jefferson National Forest, trail to High Knob Lake, 13 September 1991, on *Fraxinus* bark, *R. C. Harris 26994* (NY). **OCEANIA. AUSTRALIA. NEW SOUTH WALES. NORTHERN TABLELANDS:** head of Hyland Creek, 22 km NW of Dorrigo, 14 October 1978, on

Casuarina bark, *D. Verdon 3926* (NY). **SOUTHERN TABLELANDS:** ~10 km ESE of Captains Flat, Parkers Gap, 31 October 1978, on *Acacia* bark, *D. Verdon 4129* (NY).

STICTA SYLVATICA (Huds.) Ach.

EUROPE. UNITED KINGDOM. SCOTLAND. ARGYLL: north side of Loch Melfort, 24 June 1976, on moss, *P. W. James s.n.* (NY). **SWITZERLAND. VALAIS:** *Schleicher 203* (NY). **NORTH AMERICA. CANADA. BRITISH COLUMBIA. CAPITAL REG. DIST.:** Victoria, May 1893, *J. Macoun s.n.* (NY; Lichenes Boreali Americani). **U.S.A. NORTH CAROLINA. AVERY CO.:** Grandfather Mt., June 1936, *G. P. Anderson s.n.* (NY); 13 June 1936, on soil, *E. B. Harger 35* (NY). **BUNCOMBE CO.:** Craggy Dome in the Great Craggy Mountains, 1972, on mossy rock, *J. P. Dey 1549* (NY); Craggy Pinnacle in the Great Craggy Mountains, 1972, on *Sorbus* bark, *J. P. Dey 1668* (NY). **HAYWOOD CO.:** GSMNP, McKee Branch Trail between junction with Caldwell Fork Trail and Cataloochee Divide Trail, 08 October 2011, on vine, *J. C. Lendemer 30342 with N. Davoodian, Z. Reuter & A. Moroz* (NY); Mt. Sterling, 1972, on mossy rock, *J. P. Dey 3558* (NY)*;* on mossy soil, *J. P. Dey 3581* (NY); vicinity of Eagles Nest near Waynesville, 13 September 1910, on rock, *P. C. Standley 5831* (NY). **SWAIN CO.:** GSMNP, Forney Ridge, along Andrews Bald Trail, 1972, on rock, *J. P. Dey 2687* (NY). **YANCEY CO.:** Deep Gap between Deer Mountain and Potato Hill, 1972, on mossy rock, *J. P. Dey 1158* (NY). **OREGON. LANE CO.:** near Clear Lake, 1 mi. E of Heceta Junction, 3 mi. N of Florence, 22 January 1972, *A. Rossman 727* (NY). **TENNESSEE. COCKE CO.:** GSMNP, Gabes Mountain Trail, 28 July 1999, *T. McDonald 1004* (MIN). **SEVIER CO.:** GSMNP, Myrtle Point of Mount LeConte, 1973, on *Sorbus* bark, *J. P. Dey 6736* (NY); La Conte Trail from Newfound Gap, June 1935, *A. J. Sharp s.n.* (NY). **VIRGINIA. BEDFORD CO.:** Peaks of Otter, June 1936, *G. P. Anderson s.n.* (NY); 1975-76, *M. Slaughter s.n.* (EIU).

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