

NEW RECORDS AND A TAXONOMIC REVIEW OF
CALAMAGROSTIS PERPLEXA (POACEAE: POEAE:
AGROSTIDINAE), A NEW YORK STATE ENDEMIC GRASS

TIMOTHY G. HOWARD

New York Natural Heritage Program, 625 Broadway, 5th floor,
Albany, NY 12233-4757
e-mail: tghoward@gw.dec.state.ny.us

JEFFERY M. SAARELA

Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa,
ON K1P 6P4, Canada
e-mail: jsaarela@mus-nature.ca

BEATA PASZKO

W. Szafer Institute of Botany, Polish Academy of Sciences,
31-512 Kraków, Poland
e-mail: ibpaszko@ib-pan.krakow.pl

PAUL M. PETERSON

Department of Botany, National Museum of Natural History,
Smithsonian Institution, Washington, DC 20013-7012
e-mail: peterson@si.edu

DAVID WERIER

30 Banks Rd., Brooktondale, NY 14817
e-mail: nakita@lightlink.com

ABSTRACT. *Calamagrostis perplexa* is a New York State endemic grass species, hypothesized to be of hybrid origin, that previously was known only from a single locality. We provide a summary of its taxonomic history, report new New York records and ecological information for the taxon, and include a principal components analysis and key characterizing morphological variation in *C. perplexa* and its putative close relatives *C. canadensis*, *C. porteri*, *C. rubescens*, and *C. scribneri*. *Calamagrostis perplexa* is now known from two extant populations and a third population of unknown status; it remains a New York state endemic.

Key Words: *Calamagrostis*, endemic, grass, hybrid, New York, Poaceae, principal components analysis (PCA)

The grass genus *Calamagrostis* Adans. [Poeae (*sensu* Soreng et al. 2007): Agrostidinae Fr.] is characterized as having single-flowered spikelets, one- or three-veined glumes as long as or exceeding the floret in length (rarely slightly shorter), non-keeled lemmas that are membranous or cartilaginous (infrequently hyaline), usually with a single dorsally attached awn (rarely awnless), a callus with a crown of hairs, caryopses with short hilums and without apical hairs, and lodicules that are apically membranous (Clayton and Renvoize 1986; Watson and Dallwitz 1992). In North, Central, and South America, 131 *Calamagrostis* species are reported by Soreng and Greene (2003); 25 species are currently recognized in North America (Marr et al. 2007). Species that occur in eastern North America include the introduced *C. epigeios* (L.) Roth; the widespread *C. purpurascens* R. Br., *C. canadensis* (Michx.) P. Beauv., and *C. stricta* (Timm) Koeler; and the eastern endemics *C. coarctata* Torr. ex Eaton, *C. cainii* Hitchc., *C. porteri* A. Gray, *C. pickeringii* A. Gray, and *C. perplexa* Scribn. In this paper we review the taxonomic history of *C. perplexa*, report new records and ecological information for the species, characterize morphological variation among *C. perplexa* and its putative close relatives, and provide a brief taxonomic synopsis for the species.

Taxonomic history of *Calamagrostis perplexa*. Plant material from “Thatcher’s Pinnacles,” Danby, in Tompkins County, New York, was initially described as *Calamagrostis nemoralis* Kearney in 1898, but this name is an illegitimate homonym; a Chilean species was named *C. nemoralis* Phil. [= *C. viridis* (Phil.) Soreng] two years earlier. The taxon was given a new name in 1901 as *C. perplexa* Scribn., replacing *C. nemoralis* Kearney. *Calamagrostis perplexa* (wood reedgrass) is distinguished from other North American *Calamagrostis* species by its combination of densely hairy collars and callus hairs that are 0.7–1 times as long as the lemma (Marr et al. 2007). Hitchcock (1935) reported *C. perplexa* from four additional eastern North American locations, but subsequent study determined that these collections are other taxa (Louis-Marie 1944). *Calamagrostis perplexa* has since been confirmed only at the type location (e.g., Gleason and Cronquist 1991; Greene 1980; Hitchcock 1951; Marr et al. 2007). *Calamagrostis perplexa* was reported for Mount Fray in Columbia County, New York (McVaugh 1958); this record was recently mentioned as an unconfirmed report (Marr et al. 2007). Given its highly restricted range, *C. perplexa* is globally

ranked G1 (critically imperiled throughout its range), New York state ranked S1 (critically imperiled in New York State), and it has a New York state status of E (endangered species; Young 2007).

The evolutionary affinities of *Calamagrostis perplexa* are not clear, although some authors have suggested that the species is closely related to other North American species with which it shares bent awns, including *C. pickeringii*, *C. porteri*, *C. purpurascens*, and some individuals of *C. stricta* (e.g., Greene 1987; Louis-Marie 1944). It has also been noted that *C. perplexa* is intermediate in morphology between *C. porteri* and *C. canadensis* (Greene 1980, 1984; Kearney 1898), and Clausen (1949) treated the taxon as *C. porteri* subsp. *perplexa* (Scribn.) R.T. Clausen. Greene (1980) found that *C. perplexa* is approximately intermediate between *C. canadensis* and *C. porteri* cytologically, with a chromosome number of $2n = 70$ (cf. $2n = 84-104$ in *C. porteri* and $2n = 56$ in *C. canadensis* var. *canadensis*). Greene (1980, 1984) suggested that the species might be a hybrid of these taxa. Indeed, the geographical distributions of these putative parental taxa are potentially consistent with this hypothesis. *Calamagrostis canadensis* is widely distributed across Canada and the United States, whereas *C. porteri* has a more restricted distribution in the northeastern and central United States (Marr et al. 2007). The closest known population of *C. porteri* occurs 20 miles to the south of the Thatcher's Pinnacles *C. perplexa* population (Greene 1980), though Marr et al. (2007) note that historically *C. porteri* had a larger range. It would be worthwhile to test the hypothesis that *C. perplexa* is of hybrid origin with molecular data.

In terms of morphological characteristics, *Calamagrostis perplexa* shares hairy collars with *C. porteri* and long callus hairs with *C. canadensis*. Long callus hairs also occur in many North American *Calamagrostis* species (see descriptions in Marr et al. 2007). Hairy collars are not common in North American *Calamagrostis*. In addition to *C. porteri*, they occur only in some individuals of the western North American taxon *C. rubescens* Buckley, which Marr et al. (2007) noted appears to be closely related to *C. porteri*, and in some individuals of *C. canadensis* var. *canadensis* [fide Marr et al. (2007) and Soreng and Greene (2003)] that were originally described as *C. scribneri* Beal and recognized as such in some subsequent treatments (e.g., Hitchcock 1935, 1951; Stebbins 1930). Hitchcock et al. (1969) placed *C. scribneri* in synonymy of *C. canadensis*, but still recognized the form as *C. canadensis* var. *robusta* Vasey, the earliest name for the taxon at the varietal rank. *Calamagrostis*

scribneri might represent a hybrid between *C. rubescens* and *C. canadensis* in western North America—a scenario that could be considered analogous to the putative origins of *C. perplexa* in eastern North America, possibly involving one of the same parent taxa (i.e., *C. canadensis*). The taxonomic status of *C. scribneri* clearly deserves further study. In the absence of a robust phylogeny for North American *Calamagrostis* species, the evolution of these morphological characteristics is not clear: they could represent convergences, parallelisms, or synapomorphies.

Despite its extremely rare status in New York State and globally, there is little biological information available for *Calamagrostis perplexa*. Other rare but relatively much more common eastern North American *Calamagrostis* species have received substantially more study, including *C. porteri* subsp. *insperata* (Swallen) C.W. Greene (Bittner and Gibson 1998; Esselman et al. 1999; Havens and Holland 1998) and *C. canii* Hitchc. (Godt et al. 1996; Wiser 1991). Greene (1980) indicated that at the type locality, *C. perplexa* occurred in well-drained, rocky soil in approximately two acres of somewhat open forest dominated by *Quercus montana*, *Q. alba*, and *Acer rubrum*, and that the abundance of flowering culms varied from year to year, with the population persisting exclusively vegetative in some years. Clausen (1949) noted that he observed only a single flowering specimen in August, 1947. Greene (1980, 1984) also noted that *C. perplexa* is pollen sterile and that mature fruits have not been observed for the species. He concluded that the species probably persists vegetatively, and that the population might represent a single genetic individual (consistent with its putative hybrid origin) that has attained its current distribution via extensive rhizome growth.

New ecological information for *Calamagrostis perplexa* at the type locality. The Thatcher's Pinnacles population was visited in August 2007, and the extent of the population was observed to be similar to that described by Greene (1980), with two flowering individuals and about 500 vegetative ramets. *Calamagrostis perplexa* occurred in unevenly scattered patches on a rim and adjacent shoulder of a large valley adjacent to the very steep west-southwest facing slope of the valley wall. The site varies from being flat to having a moderate slope to the north and the soils are dry-mesic. The site was forested with about a 70–80% canopy cover. The trees were of mixed age and somewhat dwarfed with *Quercus montana* dominant. Other trees in the canopy included: *Q. rubra*, *Q. alba*, and *Carya glabra*. The

subcanopy included the species that were in the canopy as well as *Acer rubrum*, *A. saccharum*, *Amelanchier arborea*, *Fagus grandifolia*, *Fraxinus americana*, *Hamamelis virginiana*, *Ostrya virginiana*, *Pinus strobus*, and *Tsuga canadensis*. The small shrub layer was sparse and included the species in the canopy and subcanopy as well as *Acer pensylvanicum*, *Cornus florida*, *Gaylussacia baccata*, *Prunus serotina*, *Rhododendron prinophyllum*, *Rosa carolina*, *Vaccinium angustifolium*, *V. pallidum*, *V. stamineum*, and *Viburnum acerifolium*. The herb layer was patchy with *Carex pensylvanica* dominant. Other species in the herb layer included: *Anemone americana*, *Aralia nudicaulis*, *Asplenium platyneuron*, *Comandra umbellata*, *Desmodium nudiflorum*, *Eurybia macrophylla*, *Galium lanceolatum*, *Gaultheria procumbens*, *Hieracium paniculatum*, *Maianthemum canadense*, *Mitchella repens*, *Monotropa uniflora*, *Oryzopsis asperifolia*, *Poa compressa*, *Polygonatum biflorum*, *Solidago arguta*, *S. bicolor*, *S. caesia*, and *Uvularia perfoliata*.

Previously unconfirmed records. We have confirmed that the record from Columbia County mentioned by Marr et al. (2007) is indeed *Calamagrostis perplexa*. This specimen [McVaugh 2649 (PH); see below] was annotated in 1936 by M. L. Fernald as *C. perplexa*, and in 1980 by C. W. Greene as *C. stricta* subsp. *inexpansa* (A. Gray) C.W. Greene var. *lacustris* (Kearney) C.W. Greene; the latter name, *C. stricta* var. *lacustris*, was never published. Field work is needed to determine if this population persists.

In their treatment of *Calamagrostis canadensis* for North America, Marr et al. (2007, p. 726) noted that “*C. canadensis* appears to form hybrids with the nearly sympatric *C. porteri* in rocky wooded sites in central Virginia. A few of these putative hybrids have hairy collars, relatively long callus hairs, and short awns.” Based on these comments, it seemed possible that these putative hybrids might be *C. perplexa*, which would represent a considerable range extension for the taxon. We examined specimens of these putative hybrids and concluded that they are not *C. perplexa*, nor do they appear to be hybrids. Two of these Virginia specimens from near the Appalachian Trail [Botetourt Co., *C.E. Stevens* 16731 (VPI-84019); Nelson Co., *F. Watson* 567 (VPI-75470)] have been verified as *C. porteri* and 19 have been determined to be *C. canadensis* [Amherst Co., Pompey Mt., *C.E. Stevens* 11585 (VPI-62763), Cole Mt., *T.F. Wieboldt* 3326 (VPI-71724); Augusta Co., Freezeland Flat, *C.E. Stevens* 17813 (VPI-85823), Hardscrable Knob, *C.E. Stevens* 13608 (VPI-67030), Tearjacket Knob, *C.E. Stevens* 17811 (VPI-85826); Bedford Co., Flat Top Mt., *C.E.*

Stevens 16330, 16331 (VPI-83966, 83965), Thunder Hill, *C.E. Stevens 16696* (VPI-84018); Botetourt Co., Apple Orchard Mt., *C.E. Stevens 16713* (VPI-84016); Greene Co., Bearfence Rock Scramble, *T.F. Wieboldt 3322* (VPI-69014, 71767); Nelson Co., Crabtree Meadows, *C.E. Stevens 16835* (VPI-83963), Humpback Mt., *T.F. Wieboldt 3209* (VPI-77962), *C.E. Stevens 18902* (VPI-86013); Page Co., Stoney Man, *C.E. Stevens 10966* (VPI-65049); Rappahannock Co., South Marshall Mt., *C.E. Stevens 19387* (VPI-86049); Warren Co., Hogback Mt., *C.E. Stevens 1570* (VPI-54329), *C.E. Stevens 13977, 13978* (VPI-67054, 83207)].

Discovery of another population in New York. In August 2006, the first author encountered a small population of an unusual *Calamagrostis* species along a high ridge trail near Ellenville in Ulster County in southern New York. We have confirmed that this represents the second known population of *C. perplexa*. This newly discovered population was 190 km (117 mi.) east of the Thatcher's Pinnacles population. We revisited this site in August 2007 to better document population size and habitat information. This population occurred in patches at a section of the ridge extending over about 400 m² along a linear zone of about 65 meters. We counted 294 flowering culms in 2007. Patches occurred in openings, adjacent quartzite conglomerate rock outcrops or ledges, and under low trees with *Quercus coccinea*, *Q. rubra*, *Q. alba*, *Q. montana*, and *Carya glabra* most common. Dense stands of scrub oak (*Q. ilicifolia*) with low blueberries such as *Vaccinium pallidum* and *V. angustifolium* also characterized the site. Other woody plants present included *Acer rubrum* and *Amelanchier spicata*. The herbaceous layer was dominated by *Deschampsia flexuosa* and *Carex pensylvanica*. Other associated herbaceous plants included: *Agrostis perennans*, *Aralia hispida*, *Carex argyrantha*, *C. debilis* var. *rudgei*, *C. lucorum*, *C. swanii*, *Corydalis sempervirens*, *Danthonia spicata*, *Dennstaedtia punctilobula*, *Dichantheium acuminatum* subsp. *columbianum*, *Erechtites hieracifolia*, *Melampyrum lineare*, *Poa compressa*, *Schizachyrium scoparium*, and *Viola sagittata* var. *sagittata*.

Discovery of this geographically distinct population of *Calamagrostis perplexa* has allowed us to compare morphological characteristics of multiple specimens from the two populations. The two populations match in terms of the key characteristics, but they superficially appear very different; this is likely due to differences in canopy cover. At Thatcher's Pinnacles, *C. perplexa*

Table 1. Principal component loadings on the first three components for 18 morphological characters scored for *Calamagrostis canadensis*, *C. perplexa*, *C. porteri*, *C. scribneri*, and *C. rubescens*. For each component, values with particularly large magnitudes are shown in bold.

| Characters | PC 1 | PC 2 | PC 3 |
|--|--------------|--------------|--------------|
| 1. Panicle length (cm) | -0.15 | -0.33 | -0.19 |
| 2. Lower glume length (mm) | 0.68 | -0.59 | 0.36 |
| 3. Lower glume width (mm) | 0.66 | -0.14 | -0.14 |
| 4. Upper glume length (mm) | 0.70 | -0.57 | 0.32 |
| 5. Upper glume width (mm) | 0.75 | -0.25 | -0.16 |
| 6. Callus hairs length (mm) | -0.68 | -0.62 | 0.02 |
| 7. Ratio: lemma to lower glume length | -0.27 | -0.15 | -0.88 |
| 8. Ratio: callus hairs length to lemma length | -0.86 | -0.35 | 0.05 |
| 9. Lemma length (mm) | 0.56 | -0.72 | -0.17 |
| 10. Palea length (mm) | 0.90 | -0.20 | -0.20 |
| 11. Ratio: palea length to lemma length | 0.83 | 0.33 | -0.12 |
| 12. Rachilla extension length (mm) | 0.49 | -0.40 | -0.29 |
| 13. Rachilla extension with hairs length (mm) | -0.19 | -0.77 | -0.06 |
| 14. Lemma awn length (mm) | 0.85 | -0.21 | 0.18 |
| 15. Ratio: distance from base of lemma to awn insertion (character 16) to lemma length | -0.79 | -0.11 | 0.07 |
| 16. Distance from base of lemma to awn insertion (mm) | -0.67 | -0.35 | 0.04 |
| 17. Ligule length (mm) | -0.46 | -0.48 | 0.17 |
| 18. Number of culm nodes | -0.72 | -0.37 | -0.06 |

was almost entirely vegetative and the culms were short whereas the Ellenville population had most patches with at least some reproductive culms and the culms were quite tall (over one meter). Future work should explore levels and patterns of genetic variation within and between these populations and the Columbia County population, if it is found to persist.

Numerical analysis of *Calamagrostis perplexa* and relatives. To further characterize variation among *Calamagrostis perplexa* and its putative parent taxa (*C. canadensis* and *C. porteri*), we conducted a principal components analysis (PCA) of their morphological characteristics. We also included the morphologically similar *C. scribneri* and *C. rubescens* (see above) in this analysis. We examined a total of 220 individual specimens (Appendix) for 18 quantitative morphological characters (Table 1) using Statistica (StatSoft, Inc. 2005). A complete data set of 220 operational taxonomic units \times 18 characters is available from B. Paszko upon request. Included in the PCA were *C. perplexa* (17 individuals), with hypothesized parents

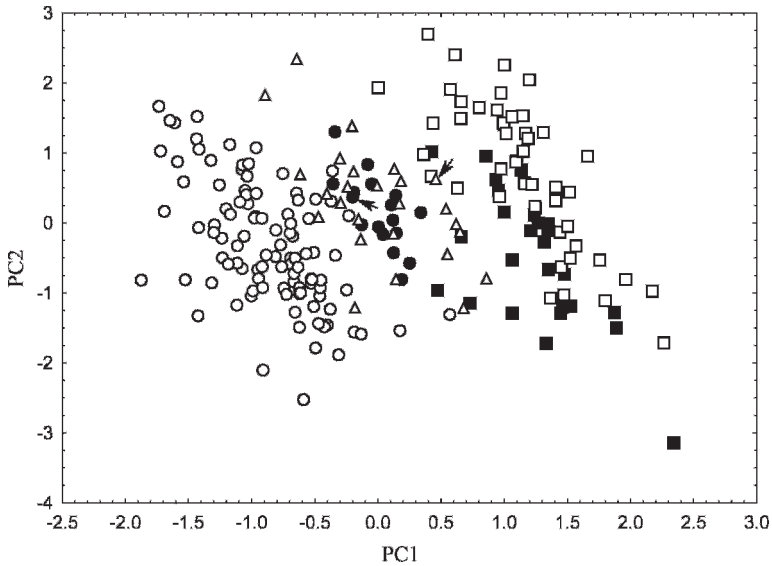


Figure 1. Plot of principal components (PC) 1 (43.8% of the total variation) and 2 (18.7% of the total variation) for *Calamagrostis perplexa* and relatives using 18 morphological characters (see Table 1). Species are indicated as follows: *C. canadensis* (○ open circles), *C. perplexa* (● solid circles), *C. porteri* (■ solid squares), *C. rubescens* (□ open squares), *C. scribneri* (△ open triangles). Arrows indicate type specimens.

C. porteri (27 individuals) and *C. canadensis* (102 individuals); and *C. scribneri* (25 individuals), with hypothesized parents *C. rubescens* (49 individuals) and *C. canadensis* (Figure 1). The first principal component (PC1) had relatively high (positive or negative) loadings for palea length, lemma awn length, upper glume width, number of culm nodes, and upper glume length; PC2 had relatively high loadings for rachilla extension with hairs and lemma length (Table 1). The plot of PC1 versus PC2 shows that individuals of *C. perplexa* are intermediate in many morphological features between *C. canadensis*, which has shorter paleas and shorter lemma awns, and *C. porteri*, which has longer paleas and longer lemma awns (Figure 1), consistent with earlier observations (see above). Based on the morphological characters we have scored, individuals of *C. scribneri* cannot be distinguished from *C. perplexa*. Individuals of *C. scribneri* are intermediate between *C. canadensis*, which has shorter paleas, and *C. rubescens*, which has longer paleas and shorter callus hairs. These data clearly distinguish individuals

of *C. perplexa* from either *C. canadensis* or *C. porteri*, and *C. scribneri* is discernable from either *C. canadensis* or *C. rubescens*. These data argue for a detailed investigation of the variation within the hypothesized hybrids, *C. perplexa*, and *C. scribneri*. A key separating the five species is given below.

A KEY TO *CALAMAGROSTIS CANADENSIS*, *C. PERPLEXA*, *C. PORTERI*,
C. RUBESCENS, AND *C. SCRIBNERI*

1. Collars glabrous or scabrous, not hairy or with a few scattered hairs *C. canadensis*
1. Collars hairy, the hairs short and numerous (2)
 2. Plants from west of the 100th meridian (3)
 3. Callus hairs 0.2–0.6 × as long as the lemma, the hairs 0.7–1.5 (–2.1) mm long; paleas (2.0–) 2.2–3.4 (–4.3) mm long *C. rubescens*
 3. Callus hairs 0.6–1.1 × as long as the lemma, the hairs (1.5–) 1.6–2.7 (–3.1) mm long; paleas (1.8–) 2.0–2.7 (–3.1) mm long *C. scribneri*
 2. Plants from east of the 100th meridian (4)
 4. Paleas (2.0–) 2.1–2.5 (–2.6) mm long; lemma awns (2.0–) 2.1–2.5 (–2.7) mm long; callus hairs 0.65–1.0 × as long as the lemma, the hairs (2.0–) 2.2–2.8 (–3.1) mm long *C. perplexa*
 4. Paleas (2.5–) 2.6–3.7 (–4.6) mm long; lemma awns (2.3–) 2.7–3.8 (–4.4) mm long; callus hairs 0.4–0.75 × as long as the lemma, the hairs (1.2–) 1.5–2.3 (–2.7) mm long *C. porteri*

Calamagrostis perplexa Scribner, Circ. Div. Agrostol. U.S.D.A. 30: 7. 1901. *Calamagrostis nemoralis* Kearney, Bull. Div. Agrostol. U.S.D.A. 11: 26. 1898. *nom. illeg. hom. Calamagrostis porteri* A. Gray subsp. *perplexa* (Scribner) R.T. Clausen, Cornell Univ. Agric. Exp. Sta. Mem. 291: 11. 1949. TYPE: U.S.A. New York: on high ground, in woods of pine, rock-oak, hickory, etc. on Thatcher's Pinnacle, Danby, near Ithaca, 1 Aug 1884, *W.R. Dudley s.n.* (HOLOTYPE: US-556697!; ISOTYPE: GH!).

A key to *Calamagrostis* in North America and a description of *C. perplexa* are provided in Marr et al. (2007). Illustrations of *C. perplexa* are provided in Marr et al. (2007, p. 727) and Holmgren (1998, p. 717).

ADDITIONAL SPECIMENS EXAMINED: New York: Columbia Co., 2 mi. E of Hillsdale, Mt. Fray, 1 Jul 1934, *R. McVaugh 2649* (PH-916455); Tomkins Co., high hill W of Danby, 1 Aug 1884, *W.R. Dudley s.n.*(GH); near Ithaca, 1885, *W.R. Dudley s.n.* (US-556697; on same sheet as the holotype); Ithaca, 1889, *W.R. Dudley s.n.* (US-1867170); Thatcher's Pinnacle, 15 Aug 1917, *K.M. Wiegand & R.N. Jones 7544* (GH); Pinnacle, Danby, near Ithaca, Aug 1889, *W.R. Dudley s.n.* (US-844039); summit of Thatcher's Pinnacles, 20 Jul 1969, *R.W. Simmers 1530* (GH-four sheets); Town of Danby, on the shoulder and rim of the east side of the Cayuga Inlet Valley, Thatcher's Pinnacles, about 310 meters northwest from summit of most northern pinnacle, UTM: North American Datum 1983, zone 18, 4,686,085N 375,742E, 12 August 2007, *D. Werier 3243* (BH); Ulster Co., Town of Wawarsing, Shawangunk Ridge State Forest, from Ellenville follow Route 52 E for about 4 mi. to the Shawangunk Ridge Trail crossing, follow trail S for about 1.2 mi, UTM zone 18, 549284mE, 4611492mN, 1780 ft., 9 Aug 2006, *T.G. Howard 465* (US); approximately 1.5–2 miles S of Hwy 52 on Shawangunk Ridge trail, 41°39'13.0"N, 74°24'29.3"W, 542 m, 15 Aug 2007, *P.M. Peterson, J.M. Saarela & T.G. Howard 20925* (US, CAN); Town of Wawarsing, Shawangunk Mountains, along ridge just north of Sullivan County line, southeast about 2.5 km from the village of Spring Glen, UTM: North American Datum 1983, zone 18, 4,611,490N 549,270E, 9 August 2007, *D. Werier 3242* (BH).

ACKNOWLEDGMENTS. Field work by J.M.S. and P.M.P. was supported by a grant from the Smithsonian Institution's Restricted Endowment Fund and the Department of Botany, and by the Canadian Museum of Nature. Field work by T.G.H. was supported by the New York State Biodiversity Research Institute and the Eastern New York Chapter of The Nature Conservancy. Troy Weldy, Tom Rawinski, Matthew Paul, and Ethan Pierce assisted in the field; Steve Young helped with the initial determinations of collections from the new site, and located the Columbia County specimen at PH. The Smithsonian Institution's Office of Research Training and Services is thanked for providing a Short-term Visitor grant to B.P. We are grateful to Ken Marr (v) for helpful discussion and Thomas Wieboldt (vpi) for specimen loans. Christopher T. Martine and an anonymous reviewer provided helpful comments on an earlier version of the manuscript.

LITERATURE CITED

- BITTNER, R. T. AND D. J. GIBSON. 1998. Microhabitat relations of the rare reed bent grass, *Calamagrostis porteri* subsp. *insperata* (Poaceae), with implications for its conservation. *Ann. Missouri Bot. Gard.* 85: 69–80.
- CLAUSEN, R. T. 1949. Checklist of the vascular plants of the Cayuga quadrangle 42°–43° N., 76°–77° W. *Cornell Univ. Agric. Exp. Sta. Mem.* 291: 3–87.

- CLAYTON, W. D. AND S. A. RENVOIZE. 1986. Genera Graminum: Grasses of the World. Her Majesty's Stationary Office, London, U.K.
- ESSELMAN, E. J., L. JIANQIANG, D. J. CRAWFORD, L. WINDUSS, AND A. D. WOLFE. 1999. Clonal diversity in the rare *Calamagrostis porteri* ssp. *insperata* (Poaceae): Comparative results for allozymes and random amplified polymorphic DNA (RAPD) and intersimple sequence repeat (ISSR) markers. *Molec. Ecol.* 8: 443–451.
- GLEASON, H. A. AND A. CRONQUIST. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd ed. The New York Botanical Garden, Bronx, NY.
- GODT, M. J. W., B. R. JOHNSON, AND J. L. HAMRICK. 1996. Genetic diversity and population size in four rare southern Appalachian plant species. *Conservation Biol.* 10: 796–805.
- GREENE, C. W. 1980. The systematics of *Calamagrostis* (Gramineae) in eastern North America. Ph.D. dissertation, Dept. Biology, Harvard Univ., Cambridge, MA.
- . 1984. Sexual and apomictic reproduction in *Calamagrostis* (Gramineae) from eastern North America. *Amer. J. Bot.* 71: 285–293.
- . 1987. *Calamagrostis pickeringii* in Maine. *Rhodora* 89: 333–337.
- HAVENS, K. AND D. L. HOLLAND. 1998. Factors affecting reproductive success in a rare grass, *Calamagrostis porteri* subsp. *insperata*. *Ann. Missouri Bot. Gard.* 85: 64–68.
- HITCHCOCK, A. S. 1935. Manual of the Grasses of the United States. Misc. Publ. No. 200, U.S. Dept. Agriculture, Washington, DC.
- . 1951. Manual of the Grasses of the United States, 2nd ed. Misc. Publ. No. 200, U.S. Dept. Agriculture, Washington, DC. [revised by A. Chase]
- HITCHCOCK, C. L., A. CRONQUIST, M. OWNBEY, AND J. W. THOMPSON. 1969. Vascular Plants of the Pacific Northwest. Part I. Vascular Cryptogams, Gymnosperms, and Monocotyledons. Univ. Washington Press, Seattle, WA.
- HOLMGREN, N. H. 1998. Illustrated Companion to Gleason and Cronquist's Manual. The New York Botanical Garden, Bronx, NY.
- KEARNEY, T. H. 1898. A revision of the North American species of *Calamagrostis*. *Bull. Div. Agrostol. U.S.D.A.* 11: 7–62.
- LOUIS-MARIE, FR. 1944. The Ancylotheran *Calamagrostis* of eastern North America. *Rhodora* 46: 285–305.
- MARR, K. L., R. J. HEBDA, AND C. W. GREENE. 2007. *Calamagrostis* Adans., pp. 706–732. In: M. E. Barkworth, K. M. Capels, S. Long, L. K. Anderton, and M. B. Piep, eds., *Flora of North America North of Mexico*, Vol. 24. Magnoliophyta: Commelinidae (in part): Poaceae. Part 1. Oxford Univ. Press, New York and Oxford, U.K.
- MCVAUGH, R. 1958. *Flora of the Columbia County Area*, New York. Univ. State of New York, Albany, NY.
- SORENG, R. J. AND C. W. GREENE. 2003. *Calamagrostis* Adans., pp. 191–227. In: R. J. Soreng, P. M. Peterson, G. Davidse, E. J. Judziewicz, F. O. Zuloaga, T. S. Filgueiras, and O. Morrone, eds., *Catalogue of New World Grasses* (Poaceae). IV. Subfamily Pooideae. *Contr. U. S. Nat. Herb.* 48.

- , J. I. DAVIS, AND M. A. VOIONMAA. 2007. A phylogenetic analysis of Poaceae tribe Poeae *sensu lato* based on morphological characters and sequence data from three plastid-encoded genes: Evidence for reticulation, and a new classification for the tribe. *Kew Bull.* 62: 425–454.
- STATSOFT, INC. 2005. STATISTICA (data analysis software system), version 7.1. Statsoft, Inc., Tulsa, OK. Website (<http://www.statsoft.com>).
- STEBBINS, G. L. 1930. A revision of some North American species of *Calamagrostis*. *Rhodora* 32: 35–57.
- WATSON, L. AND M. J. DALLWITZ. 1992. *The Grass Genera of the World*. C.A.B. International, Wallingford, U.K.
- WISER, S. K. 1991. Two North Carolina locations for *Calamagrostis cainii* Hitchc., previously considered endemic to Mt. LeConte, Tennessee. *Castanea* 56: 147–149.
- YOUNG, S. M., ed. 2007. *New York Rare Plant Status Lists*. New York Natural Heritage Program, Albany, NY.

APPENDIX

SPECIMENS USED IN PRINCIPAL COMPONENTS ANALYSIS OF *CALAMAGROSTIS CANADENSIS*, *C. PERPLEXA*, *C. PORTERI*, *C. RUBESCENS*, AND *C. SCRIBNERI**Calamagrostis canadensis*

CANADA. E Coast, Hudson Bay, Great Whale River, 5 mi. from mouth, *M.T. Doull* 2580 (us-1648366); James Bay, S Twin Island, *M.T. Doull a* (us-1648369). Alberta: 6 mi. N of entrance to Waterton Lakes National Park, along dry flood-bank of Dungarvan Creek in the Foothills Parkland, *W.G. Dore 12151A* (us-2076127); Pigeon Lake, E of Ma-Me-O Beach, *G.H. Turner 4677* (us-1938744); Fort Saskatchewan, *G.H. Turner 4607* (us-1938737); 1 mi. NE of Fort Saskatchewan, *G.H. Turner 4516* (us-1938719); Jasper National Park, on the Banff–Jasper Hwy., 4 mi. N of Athabaska Falls, rocky NW shore of Leach Lake, *W.A. Weber 2504* (us-1849264); Jasper National Park, Horseshoe Lake trail, just below lake, *P.M. Peterson, J.M. Saarela & S.F. Smith 18434* (us-3514300); Jasper National Park, 9 mi. NW of Bubbling Springs on Hwy 93 along Sunwapta River, *P.M. Peterson, J.M. Saarela & S.F. Smith 18431* (us-3514299); The Rocky Mountain Park, Lake Wapta, *J. Macoun 64818* (us-556041); The Rocky Mountain Park, above Laggan, *J. Macoun 64817* (us-747061); Rocky Mts., Elbow River, *J. Macoun 18673* (us-844121); the Northern Rocky Mts., vicinity of Banff, Bow Valley, *W.C. McCalla 2305* (us-368531); Jasper Park, Mt. Edith Cavell, *J.M. Macoun 98153* (us-1060935); Jasper Park, Cabin Lake, *J.M. Macoun 98158* (us-1060930). British Columbia: the Canadian Rockies, the vicinity of Field, Kicking Horse Valley, *S. Brown 498* (us-1085728); Moose Lake, *N. Hollister 20* (us-622657); Lake House, Skagit River, *J.M. Macoun 77224* (us-844161). Manitoba: Riding Mountain National Park, Long Lake, *W.J. Cody & W.A. Wojtas 25075* (us-3081644); Knife Lake, 120 mi. SW of Churchill, *J.M. Gillett 2275* (us-1982642). New Brunswick: Shediac Cape, *F.T. Hubbard 722* (us-726648), *724* (us-726649). Newfoundland and Labrador: Traversspine River, *J.M. Gillett & W.I. Findlay 5622* (us-2206696); N Labrador, Saglek Bay, *R.A. Bartlett 53* (us-1366430); Bay of Islands, Dark Harbor, *A.C.*

Waghorne 10 (us-844159); *A.C. Waghorne 31* (us-556698); Bay of Islands, Humber Arm, Silurian Hills back of Birchy Cove (Curling), *M.L. Fernald & K.M. Wiegand 2540* (us-1024241); Valley of Exploits River, Grand Falls, *M.L. Fernald & K.M. Wiegand 4569* (us-1024240); Humber District, Grand Lake, Blue Grass Brook Point, *L.E. Ruoleau 2221* (us-2119734); Humber District, Grand Lake, Hinds Brook Point, *L.E. Ruoleau 2274* (us-2119737); St. Barbe District, Bonne Bay, White Point, *L.E. Ruoleau 425* (us-2119706); Port-aux-Basques, *A.S. Hitchcock 23983* (us-1388296); Grand Falls, *A.S. Hitchcock 23652* (us-1388294). Northwest Territories: Fort Simpson, *W.J. Cody & J.M. Matte 8784* (us-2523928); Norman Wells, sedge-grass border of lake, *W.J. Cody & R.L. Gutteridge 7876* (us-2306101); Mackenzie District, Carcajou River, Mile 23E Canol Road, *W.J. Cody & R.L. Gutteridge 7776* (us-2306091); Mackenzie District, Yellowknife, Joliffe Island, *W.J. Cody & J.B. McCause 3110* (us-2238582); The Region of Great Bear Lake, Head of Hornby Bay, N of the Arctic Circle, NE end of the McTavish Arm, Great Bear Lake, *H.T. Shacklette 3206* (us-2010737); Mackenzie Basin, the Wood Buffalo Park, Moose (Eight) Lake district, Ranger Station, *H.M. Raup 1752* (us-1722305), *1764* (us-1722301); Mackenzie Basin, the Wood Buffalo Park, E shore of Lake Mamavi, *H.M. Raup 1756* (us-1722319), *1757* (us-1722304); Mackenzie District, Yellowknife, N of old townsite, *W.J. Cody & J.B. McCause 3022* (us-2238578). Nova Scotia: Yarmouth Co., Yarmouth, *M.L. Fernald & B. Long 19927* (us-1100087); St. Paul Island, bog above Petrie's Pond, *L.M. Perry & M.V. Roscoe 56* (us-1502774); Canso, *J. Fowler 12* (us-844118). Ontario: Thunder Bay District, H.E.P.C. right of way, 1 mi. E of Port Arthur, McGregor Twp., *C.E. Garton 1232* (us-2075985); Wellington Co., Morristown, *W.G. Dore & L.V. Bush 46-66* (us-2013398), *46-67* (us-2013399); Wellington Co., E of Morristown, Puslinch Twp., *W.G. Dore & L.V. Bush 46-60* (us-2013393); W of Kitigan, O'Brien Twp., *C.V. Morton & E. LePage 11560* (us-2306542); Kingston, *J. Fowler s.n.* (us-260837); Bruce Co., Pine Tree Point, Lake Huron, *W.G. Dore 8941* (us-1982563); The Georgian Bay Islands opposite Shawanaga Twp., Parry Sound District, Hemlock Island (500A), *E.D. McDonald Jr. 21* (us-2013764); Galt, *Herriot s.n.* (us-844140); Island 74, French River, *L.H. Dewey 9* (us-1814610); Ottawa, Rideau Canal, *W.G. Dore 130* (us-1648380). Prince Edward Island: Queens Co., Hillsborough River, Mt. Stewart, *M.L. Fernald, E.B. Bartram, B. Long & H.S. John 6857* (us-1024088). Québec: Du Golfe Saint-Laurent, Archipel de Mingan, Ile aux Calculeaux, *Fr. Marie-Victorin & Fr. Rolland-Germain 20541* (us-1295069); Du Bic, Comté de Rimouski, Bic, *J. Rousseau 26693* (us-1435584); Vicinity of Maniwaki, *Fr. Rolland 7134* (us-1011279); Grand Etang, along the Gaspé Coast, *Macoun 26* (us-844119); Bonaventure Co., Little Cascapedia River, *J.F. Collins & M.L. Fernald 21* (us-493639); Gaspé Co., Table-top Mt., *M.L. Fernald & J.F. Collins 161* (us-605991); Iles de la Madeleine, Ile du Havre-aux-Maisons, *Fr. Marie-Victorin & Fr. Rolland-Germain 9032* (us-1061039, us-1116498); Kamouraska Co., Ste-Anne-de-la-Pocatière, *W.G. Dore 364* (us-1648381); Gaspé Co., Mt. Albert, *W.G. Dore 47-791* (us-1935424); La Gaspésie, Riviere Ste-Anne des Monts, *Fr. Marie-Victorin, Fr. Rolland-Germain, J.B. Brunel & Z. Rousseau 17800* (us-1024029); La Cote-Nord, Du Golfe Saint-Laurent, Sept Iles, *Fr. Marie-Victorin & Fr. Rolland-Germain 18206* (us-1295175); Gaspé Co., Table-topped Mt., Head of White Rock Slide, *M.L. Fernald & J.F. Collins 377* (us-1329627); 9 mi. W of

Wakefield, *F.E. Carues 81* (us-1723490); Upper slopes of Mt. Albert, *J.R. Swallen 9746* (us-1935130), *9776* (us-1935147); Rupert River and Mistassini Lake, Northern Tesekan Lake, *A. Dittily & E. Lepage 11369* (us-2240396); Megantic Co., Caribou Hill, Blake Lake, *M.L. Fernald & H.B. Jackson 12012* (us-2011350); Fort Chimo area, *J.A. Calder 2713* (us-1982637). Saskatchewan: Lake Athabaska, small island, *F. Harper 63* (us-1085365); Along the line of the Grand Trunk Pacific Railway, Round Valley Lake, *J. Macoun & W. Herriot 44152* (us-844151); Near Prince Albert, *J. Macoun 13091* (us-844117); Prince Albert, *J. Macoun 13091* (us-844141). Yukon: Dawson, below summit of Dome, along Ry, *A.S. Hitchcock 4407* (us-844060); About 3/4 of a mile from NE of Mayo, *J.A. Calder & J.M. Gillet 4135* (us-2303142); Along Yukon River between Whitehorse and Dawson, about 50 mi. below Hootalingua, *A.S. Hitchcock 4330* (us-844059).

UNITED STATES. Alaska: Dillingham, *I.N. Gabrielson s.n.* (us-2479007); Katmai National Monument, Rock cliff, S side of island, Coville Lake, 2 mi. NW from Coville River, *V.H. Cahalane 752* (us-2205042); Prince William Sd., Hinchinbrook J., *I.L. Norberg s.n.* (us-2238656); Alaska Peninsula, King Cove, *W.J. Eyerdam 1564* (us-2238649); Fairbanks, Chatinika, *A.S. Hitchcock 4598* (us-844096); Hot Springs on the Tanana River, *A.S. Hitchcock 4520* (us-844104); The Brooks Range, Mts. NW of Walker Lake, upper Kopuk River, *L.H. Jordal 3982* (us-2040880); Koyukuk R., Middle Fork, Bettles, *E.O.G. Hultén s.n.* (us-2382194); Skagway, *J.M. Gillett & D.A. Mitchell 3697* (us-2303163); Mosse Pass Valley, Kenai Peninsula, *J.A. Calder 6378* (us-2303169); Lower Yerrick Creek, *L.A. Spetzman 797* (us-3465309); Along the Yukon River, *A.S. Hitchcock 4690* (us-844068); Along the Yukon River, Holy Cross, *A.S. Hitchcock 4680* (us-844066), *4683* (us-844067); Nome, sandy hill, half mi. of beach, *A.S. Hitchcock 4761* (us-844070); Nome, along a dike, *A.S. Hitchcock 4777* (us-844072); Yukon Valley, Yukon Flats, *A.J. Collier 107* (us-379793). Yukon Valley, White River, *M.W. Gorman 1149* (us-377202).

Calamagrostis perplexa

UNITED STATES. New York: Columbia Co., 2 mi. E. Hillsdale, *R. McVaugh 2649* (PH-916455); Tompkins Co., Thatcher's Pinnacle, W Danby, near Ithaca, *W.R. Dudley s.n.* (us-556697, ×2); Ithaca, *W.R. Dudley s.n.* (us-1867170, ×2); Thatcher's Pinnacle, Danby, Ithaca, *W.R. Dudley s.n.* (us-844039, ×2); Danby Twp., summit of Thatcher's Pinnacle, *R.W. Simmers Jr. 1530* (GH-244392; GH-244393; GH-247516, ×2; GH-247517), High Hill, W Danby, *W.R. Dudley s.n.* (GH-261464); Thatcher's Pinnacle, Danby, *K.M. Wiegand & R.N. Jones 7544* (GH-247515); Ulster Co., Town of Wawarsing, Shawangunk Ridge State Forest, *T.G. Howard 465* (us-3483671); 1.5–2 mi. S of Hwy 52 on Shawangunk Ridge Trail, *P.M. Peterson, J.M. Saarela & T.G. Howard 20925* (CAN, us-35276461).

Calamagrostis porteri

UNITED STATES. *E.S. Steele & Mrs. Steele s.n.* (us-490318). New York: Chemung Co., W side of N Peak of Maby Hill, *S.J. Smith 7854* (us-2078851). Ohio: Jackson Co., Liberty Township, *F. Bartey & L. Pontius 21* (us-1645016); Vinton Co., Vinton Furnace Experimental Forest, *F. Bartley 2315* (us-2238723).

Pennsylvania: unknown collector (us-556710); Bedford Co., 4 3/4 mi. NNE of Chaneyville, *D. Berkheimer 3969* (us-2116347); Centre Co., 4 mi WNW of Bellefonte, *H.A. Wahl 1538* (us-2012430); Huntingdon Co., Pulpit Rocks, *T.C. Porter s.n.* (us-135195), *s.n.* (us-556709); *T.C. Porter 440* (us-821585); Warriors Mask, *T.C. Porter s.n.* (us-78269). Virginia: Blue Ridge near Luray, Stony Man Mt., *N. Hotchkiss 1612* (us-1259986); 5 mi. W of Crescent Ridge, Skyline Drive, *L.E. Hicks & F. Bartley 2168* (us-2184909); Stony Man Mountain and Vicinity in the Blue Ridge near Luray, *E.S. Steele & Mrs. Steele 103* (us-418453); Amherst Co., Blue Ridge Mts., Punchbowl Mt., *C.E. Stevens 1412* (us-2619848); Augusta Co., Blue Ridge Mts., Turk Gap, *C.E. Stevens 1429* (us-2619849); Bath Co., vicinity of Millboro, in the Allegheny Mts., *E.S. Steele s.n.* (us-726956), *s.n.* (us-643309); Giles Co., Salt Pond Mt., *H.H. Iltis & L. Carr 1998* (us-1867935); Page Co., Luray, Blue Ridge Mts., along Appalachian Trail, near Skyline, *F.J. Herman 11401* (us-1866099); *ibid.*, near Skyline, 7 mi. SE, *F.J. Hermann 11406* (us-2478624); Shenandoah National Park, Appalachian Trail to Hawksbill Mt., *R.C.Y. Chou 524* (us-2012488); Blue Ridge Mts., Mt. Marshall, Skyline Drive, *H.A. Allard 754* (us-1678986); Rockingham Co., Second Mt., *C.E. Stevens 1283* (us-2619846); Shenandoah Co., Massanutten Range, Three Top Mt., *H.A. Allard 5615* (us-1787766). West Virginia: Hardy Co., Sugar Knob, *H.A. Allard 9399a* (us-1872753); Pendleton Co., near Reddish Knob, *C.E. Stevens 1255* (us-2619847).

Calamagrostis rubescens

UNITED STATES. California: Mariposa, *J.W. Congdon s.n.* (us-844036); Mts. about the head waters of the Sacramento River, *C.G. Pringle 73* (us-821595), *254* (us-821594); Plains of Mendocino, *C.G. Pringle s.n.* (us-1912084), *59* (us-723033); Santa Cruz Co., vicinity of Gazos Creek Road, *J.H. Thomas 3539* (us-2973804); Santa Cruz Portland Cement Company quarry, *V.F. Hesse 1667* (us-2973787); Santa Cruz, *D. Anderson s.n.* (us-844033). Colorado: N Colorado, Honnold, *F. Tweedy 4359* (us-432480); Near Hahns Peak, *Wooton s.n.* (us-1502661). Nevada: Mountain City (Mill Creek), *A. Nelson & J.F. McBride 2212* (us-544962). Oregon: Powder River Mts., *C.V. Piper 2526* (us-843979); Canon City, Blue Mts., *D. Griffiths & B. Hunter 164a* (us-844006); 9 mi. above Wallowa Lake, *C.L. Shear 1795* (us-844007); *E.P. Sheldon 8637* (us-844009); Portland, *L.F. Henderson 2150* (us-844012); Hidaway Springs, Blue Mts., *W.C. Cusick 3486* (us-844015); Portland, Hd. of 25 Mile Creek, *M.W. Gorman 599* (us-844017); Kerby to Tennessee Pass, Siskiyou Forest, *A.S. Hitchcock 23546* (us-1299097); Meacham, *M.E. Peck & J.C. Nelson 5672* (us-836541). Washington: E Washington, Stehekin, *D. Griffiths & J.S. Cotton 240* (us-844880); *L.F. Henderson 2151* (us-843989); Pullman, *C.V. Piper 1919* (us-230304); Wenatchee Valley, *Sandberg & Leiberg 535* (us-843987, us-843995); Near Bingen, Columbia River, *W.N. Suksdorf 2825* (us-843991); SE Washington, Blue Mts., *R.M. Horner 537* (us-843993); W Klickitat Co., Bingen, *W.N. Suksdorf 2825* (us-529618); Spokane Co., E of Rockford, *J.R. Swallen 6241* (us-2303657). Wyoming: Snowy Range, *J.R. Swallen 6598* (us-2303982, us-2434071); Grand Teton National Park, Cottonwood Creek outlet to Jenny Lake, near park boundary, *H. Bailey & V. Bailey 4161* (us-2115969); Teton National Park, E shore of Jenny Lake, *A.A. Beetle 5004* (us-2152283); Jackson

Hole, near Menors Ferry, *E.D. Merrill & E.N. Wilcox* 362 (us-843958); Jackson Hole, Mosquito Creek, *A.S. Hitchcock* 23124 (us-1296308); Jackson, *A.S. Hitchcock* 23113 (us-1296317); Yellowstone National Park, near Levis River, *E.D. Merrill* 118 (us-844602); Yellowstone National Park, Mammoth Hot Springs, *E.A. Mearns* 2620 (us-487219); Yellowstone National Park, Mammoth Hot Springs, road to Yancey, *A.S. Hitchcock* 1976 (us-844055); Yellowstone National Park, hillside near Yancey, *A.S. Hitchcock* 2025 (us-843953), 2026 (us-838801); Yellowstone National Park, near Old Faithful, *A.A. Beetle* 5109 (us-2152286); Yellowstone National Park, *H.L. Bolley* 1897 (us-843955, us-2150994); Yellowstone National Park, Firehole R., *A.S. Hitchcock* 2128 (us-843956); Yellowstone National Park, Madison Canyon, on the bank of Madison River, *A. Nelson & E. Nelson* 6760 (us-365691); Wyoming National Forest, Grey's River, *Schofield & Woods* 226 (us-1160118); Teton Co., Elbow, Jackson Hole, Teton Mts., *A.A. Beetle* 5298 (us-2152298); Uinta Co., Teton Pass, *E.D. Merrill* 77 (us-843888).

Calamagrostis scribneri

UNITED STATES. Idaho: Coeur d'Allene Lake, *J.H. Sanberg* 564 (us-844050). Montana: Spanish Creek, *T.A. Williams* 2009 (us-844047); Spanish Creek, *P.A. Rydberg* 3083 (us-844045), 3100 (us-844048); Belt Park, *F.A. Spragg* 743 (us-844770); Elk Creek, *F.L. Scribner* 365 (us-135193); Dry Fork of Belt Park, *P.A. Rydberg* 3346 (us-843949); *F.H. Knowlton* s.n. (us-844049); Flathead National Forest, White River near falls, *J.E. Kirkwood* 2267 (us-1295489); Gallatin Co., Bridger Pass, *W.N. Suksdorf* 63 (us-1061911); Park Co., E of Bridger Range, *J.R. Swallen* 6402 (us-2303793). Washington: Pullman, *C.V. Piper* s.n. (us-843893); Mount Paddo (Adams), hillsides, *W.N. Suksdorf* 145 (us-844386); Mount Paddo (Adams), *W.N. Suksdorf* 145 (us-844388); Kittitas Co., Wenatchee Mt., *J.S. Cotton* 1756 (us-556018); Skamania Co., Chiquash Mts., *W.N. Suksdorf* 1023 (us-821560, us-844387); High Mts., *W.N. Suksdorf* 1023 (us-844389). Wyoming: 14 mi. post, S from Mammoth Hot Springs, *E.A. Mearns* 3718 (us-487823); Jackson's Lake, *A. Chelson* 6563a (us-556705); Yellowstone Park, *G.W. Letterman* 44 & 45 (us); Yellowstone National Park, Tower Falls, *E.A. Mearns* 3547 (us-487723); Yellowstone Park, Slough Creek, *F. Tweedy* 585 (us-556704); Albany Co., Woods Landing, Head of Wood's Creek, *A. Nelson* 3954 (us-844335); Wood's Creek, *A. Nelson* 3950 (us-358953).