

## *SOLIDAGO BRENDIAE* (ASTERACEAE: ASTEREAE) IN VERMONT

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### ABSTRACT

A small-headed specimen originally identified as *Solidago canadensis* L. was collected in Granby, Vermont, in 1973. Recently, Gilman thought the specimen might be *S. brendiae* Semple and sent it to Semple for confirmation. The specimen was scored and compared with specimens of *S. brendiae*, *S. canadensis*, *S. fallax*, and *S. rupestris* in a set of multivariate analyses and was consistently placed a posteriori in *S. brendiae*, confirming Gilman's identification. This is the first report of *Solidago brendiae* from Vermont.

Four taxa of *Solidago* subsect. *Triplinerviae* (Torr. & A. Gray) Nesom have been reliably reported from Vermont: *S. altissima* L., *S. canadensis* L. var. *canadensis*, *S. canadensis* var. *hargeri* Fern., and *S. gigantea* Ait. (Gilman 2015). Reports of others were either of taxa now placed in synonymy by Semple (2008) — *S. gigantea* var. *leiophylla* Fern. (reported by Fernald 1950) and *S. gigantea* var. *serotina* (Kuntze) Cronq. (reported by Seymour 1969) — or were based on misidentified specimens: *S. altissima* subsp. *gilvocanescens* (Rydb.) Semple, identified as *S. canadensis* var. *gilvocanescens* Rydb. by Eggleston et al. (1915) and by Dole (1937).

In reviewing the collections at the Pringle Herbarium of the University of Vermont (VT), Gilman recently encountered a specimen, labeled and filed as *Solidago canadensis* L. that seemed to match the recently described *S. brendiae* Semple (Semple 2013).

**USA: Vermont:** Essex Co.: Granby, 30 Sep 1973, *B.H. Stearns s.n.* (VT, Figures 1-2).

The specimen had been collected in Essex County in northeastern Vermont, an area that lies at the southern edge of the North American boreal forest (Thompson & Sorenson 1999). As such, it is within the potential range of *S. brendiae*, so the specimen was forwarded for review to Semple, who determined it as that species and confirmed the identification using multivariate morphometric analyses. This is the first report of *Solidago brendiae* from Vermont.

### Multivariate analyses to confirm identification of Stearns s.n. (VT)

Using the data and multivariate methods described in Semple et al. (2013, 2015), *Stearns s.n.* (VT) was compared with *Solidago brendiae* (28 specimens; only 19 in some analysis due to lack of data on several characters for nine specimens), *S. canadensis* (52 specimens), *S. fallax* (28 specimens) and *S. rupestris* (10 specimens). Although *S. rupestris* is not reported from further northeast than eastern Pennsylvania (the range included distantly scattered disjunct populations from Tennessee and Kentucky to the west and Maryland, Virginia, and Pennsylvania further east; Semple 2015, occasionally updated), the small heads of the species are similar in size to those of the collection by Stearns. One discriminant analysis was run including *S. rupestris* to confirm that the Vermont plant



Figure 1. *Solidago brendiae* from Granby, Vermont: Stearns s.n. (VT).

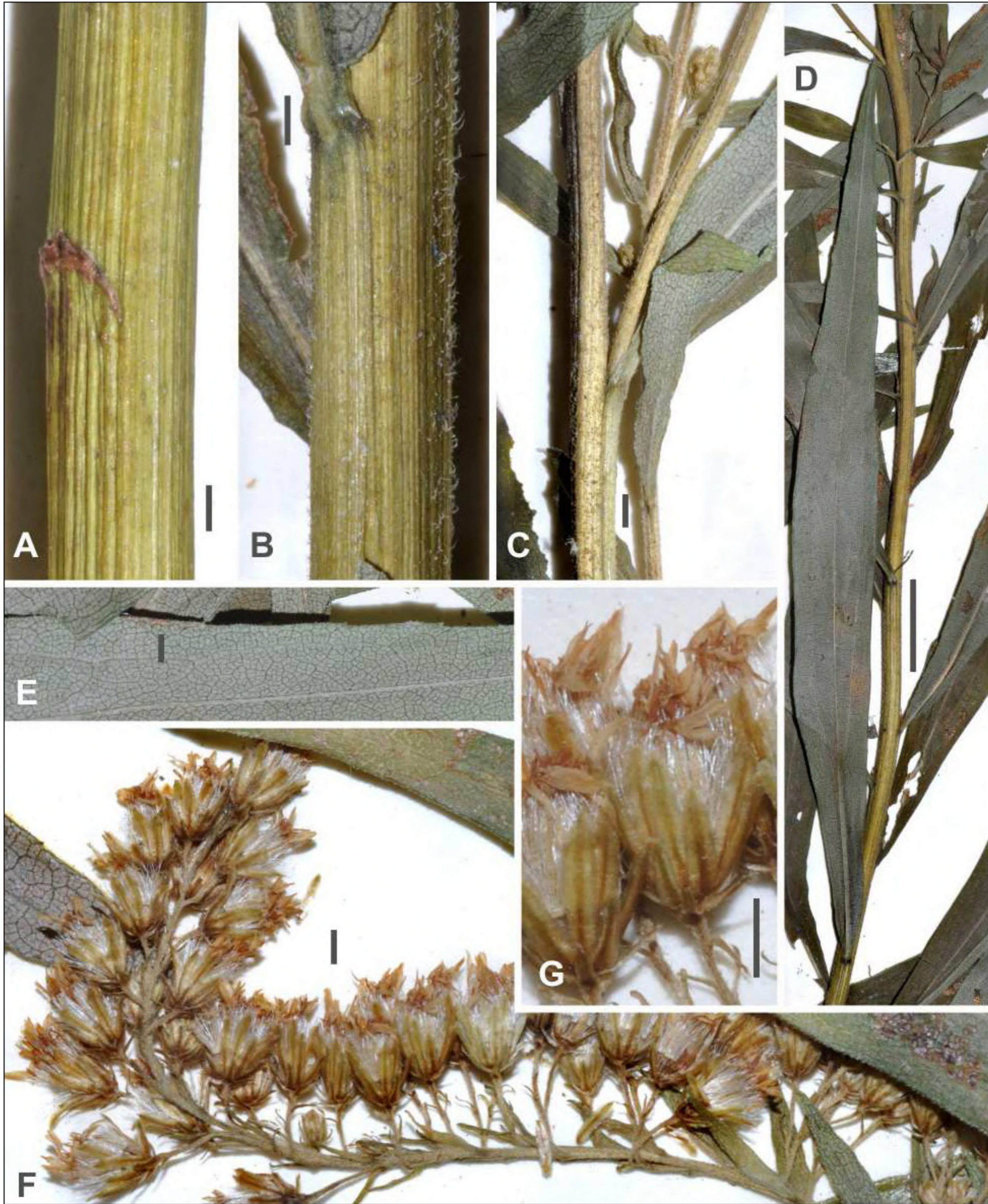


Figure 2. Details of *Solidago brendiae*, Stearns s.n. (VT). A. Lower stem. B. Mid stems. C. Stem in inflorescence. D. Upper stem leaf, adaxial surface. E. Upper stem leaf, adaxial surface, mid margin with small serrations. F. Lower inflorescence branch. G. Heads. Scale bars: = 1 mm in A-C and E-G; = 1 cm in D

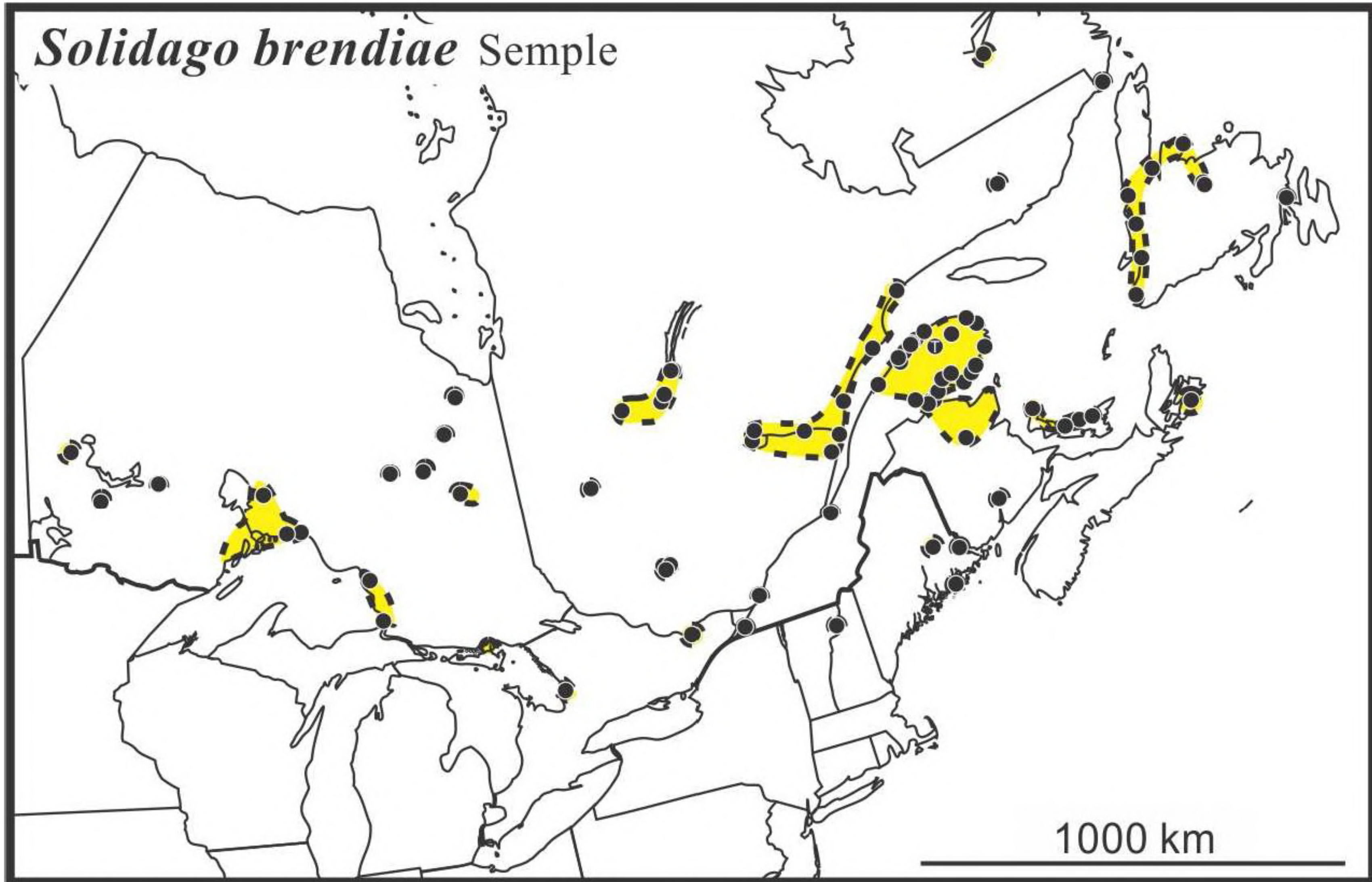


Figure 3. Distribution of *Solidago brendiae* based on all collections seen

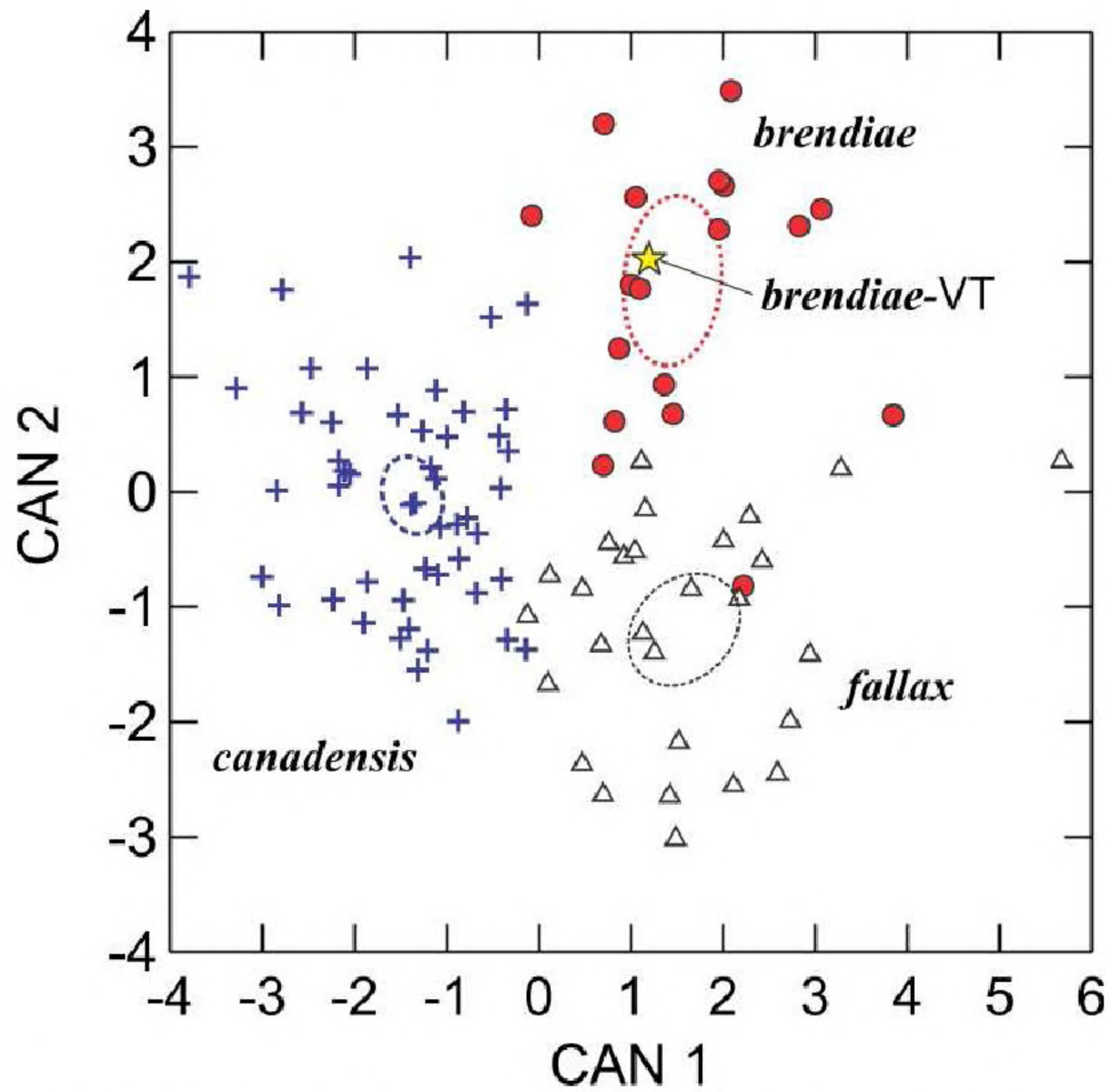


Figure 4. Two dimension plot of CAN1 versus CAN2 scores generated by the Canonical Analysis of specimens of the *Solidago brendiae*, *S. canadensis*, and *S. fallax*; 95% confidence ellipses are shown for each taxon; canonical placement of the *Stearns s.n.* (VT) from Vermont is indicated by a star.

was not a long-distant disjunct of that species. Two other analyses were run including just specimens of *S. brendiae*, *S. canadensis*, and *S. fallax*, which do or potentially might occur in northern Vermont and include specimens similar to *Stearns s.n.* In one analysis *Stearns s.n.* was not placed in an a priori group and only assigned to a group a posteriori. In the other analysis, *S. rupestris* was assigned a priori to the *S. brendiae* group.

**Table 1.** F-matrix for the discriminant analysis of three species groups: *S. brendiae*, *S. canadensis* and *S. fallax*; *Stearns s.n.* (VT) not assigned to an a priori group.

	<i>brendiae</i>	<i>canadensis</i>	<i>fallax</i>
<i>brendiae</i>	0.000		
<i>canadensis</i>	28.842	0.000	
<i>fallax</i>	14.122	30.007	0.000

Wilks' lambda = 0.2085 df = 5 2 105; Approx. F= 24.0358; df = 10 202; prob = 0.0000

**Table 2.** Results of the Classificatory Discriminant Analysis of three species-level groups *S. brendiae*, *S. canadensis* and *S. fallax*; *Stearns s.n.* (VT) and one *S. brendiae* specimen not assigned to an a priori group; cases in row categories classified into columns.

Classification matrix				
	<i>brendiae</i>	<i>canadensis</i>	<i>fallax</i>	% correct
<i>brendiae</i>	25	1	0	96
<i>canadensis</i>	5	45	2	87
<i>fallax</i>	5	2	23	77
Total	35	48	25	86
Not Grouped	2	0	0	

Jackknifed classification matrix				
	<i>brendiae</i>	<i>canadensis</i>	<i>fallax</i>	%correct
<i>brendiae</i>	25	1	0	96
<i>canadensis</i>	5	44	3	85
<i>fallax</i>	4	4	22	73
Total	34	49	25	84

**Table 3.** F-matrix for the discriminant analysis of three species groups: *S. brendiae*, *S. canadensis* and *S. fallax*; *Stearns s.n.* (VT) assigned to the *S. brendiae* a priori group; between groups F-matrix df = 7 90.

	<i>brendiae</i>	<i>canadensis</i>	<i>fallax</i>
<i>brendiae</i>	0.000		
<i>canadensis</i>	21.307	0.000	
<i>fallax</i>	14.064	24.462	0.000

Wilks' lambda = 0.1516 df = 7 2 96; Approx. F= 20.1675; df = 14 180; prob = 0.0000

**Table 4.** Results of the Classificatory Discriminant Analysis of three species-level groups *S. brendiae*, *S. canadensis* and *S. fallax*; *Stearns s.n.* (VT) assigned to the *S. brendiae* a priori group; cases in row categories classified into columns.

Classification matrix				
	<i>brendiae</i>	<i>canadensis</i>	<i>fallax</i>	% correct
<i>brendiae</i>	17	0	2	89
<i>canadensis</i>	2	48	2	92
<i>fallax</i>	0	1	27	96
Total	19	49	31	93

Jackknifed classification matrix				
	<i>brendiae</i>	<i>canadensis</i>	<i>fallax</i>	% correct
<i>brendiae</i>	17	0	2	89
<i>canadensis</i>	3	47	2	90
<i>fallax</i>	3	2	23	82
Total	23	49	27	88

In all three analyses, *Stearns s.n.* was placed a posteriori in the Classificatory Discriminant Analysis into *Solidago brendiae*. In the analysis including *S. rupestris*, *Stearns s.n.* was assigned a priori to *S. brendiae* and placed a posteriori into *S. brendiae* with 89% probability (11% probability to *S. canadensis*, and 0% to *S. fallax* and *S. rupestris*). The results of the analysis including *S. rupestris* are not discussed further.

In the analysis without *Solidago rupestris* and with *Stearns s.n.* not assigned to an a priori group, outer and inner phyllary length traits were not included in the analysis, which meant all 27 specimens of *S. brendiae* were included. The following traits were selected in the Stepwise Discriminant Analysis as strongest in separating the three a priori groups in order of decreasing F-to-remove values in parentheses: number of disc florets (14.14), number of ray florets (11.54), upper leaf length (10.56), mid leaf width at the widest point (10.53), and involucre height (8.30). Table 1 presents the F-matrix results and Table 2 presents the a posteriori Classification Matrix and Jackknife Classification Matrix results. *Stearns s.n.* was assigned a posteriori to *S. brendiae* and with 69% probability (23% probability to *S. canadensis*, and 8% to *S. fallax*).

In the analysis without *Solidago rupestris* and with *Stearns s.n.* assigned a priori to the *S. brendiae* group, outer and inner phyllary length traits were included in the analysis which meant only 19 specimens of *S. brendiae* were included. The following traits were selected in the STEPDISC analysis as strongest in separating the three a priori groups in order of decreasing F-to-remove values in parentheses: upper leaf length (18.21), number of ray florets (12.68), inner phyllary length (11.04), involucre height (6.64), upper leaf margin number of serrations (6.47), number of disc florets (12.32), disc floret lobe length (5.42). Table 3 presents the F-matrix results and Table 4 presents the a posteriori Classification Matrix and Jackknife Classification Matrix results. *Stearns s.n.* was placed a posteriori into *S. brendiae* with 99% probability (1% probability to *S. canadensis*, and 0% to *S. fallax*). The results of the canonical analysis (dimension reduction technique) are shown in Figure 3;

for clarity, the position of *Stearns s.n.* is shown by a yellow star which is nested within the 95% confidence limits ellipse of the *S. brendiae* group (red dots), to which it was assigned a priori.

#### Comments on *Stearns s.n.* (VT)

The circumstances of the Vermont collection are of interest. Frank C. Seymour, author of the *Flora of Vermont*, ed. 4 (Seymour 1969) was Associate Curator of the Pringle Herbarium. He was also associated with the Vermont Botanical and Bird Club, which in the early 1970's was preparing a new Check List of the Plants of Vermont (Atwood et al. 1973). In the interest of "filling in the blanks" by obtaining new county records, Seymour made numerous trips with students to under-collected areas of the state to collect voucher specimens for the Check List. *Solidago brendiae* was collected on one such trip, 30 September 1972. Seymour was careful to label specimens with their actual collector, and inspection of specimens at VT shows that students on the Granby trip included B.H. Stearns, R.D. Paul, and S.R. Bassett. Specimens collected by them or by Seymour himself in Granby on 30 September 1972 included at least the following (there may be others: a complete database of Vermont specimens at VT is not prepared as yet): *Abies balsamea*, *Acer saccharum*, *Actaea pachypoda*, *Agrimonia striata*, *Aralia racemosa*, *Betula alleghaniensis*, *Dichanthelium acuminatum* var. *implicatum*, *Diphasiastrum complanatum*, *Doellingeria umbellata*, *Eleocharis ovata*, *Fagus grandifolia*, *Galeopsis tetrahit* var. *bifida*, *Hypericum boreale*, *Hypericum perforatum*, *Juncus bufonius*, *Larix laricina*, *Lobelia inflata*, *Picea glauca*, *Pilosella aurantiaca*, *Prunella vulgaris* subsp. *lanceolata*, *Rubus idaeus* var. *strigosus*, *Scirpus cyperinus*, *Scirpus georgianus*, *Solidago rugosa*, *Sorbus americana*, *Spiraea alba* var. *latifolia*, *Spiraea tomentosa*, *Taraxacum officinale*, *Triadenum fraseri*, *Uvularia sessilifolia*, *Vaccinium myrtilloides*, *Veronica officinalis*, and *Zizia aurea*.

All of these species, with the exception of *Scirpus georgianus*, are very common plants in the region and throughout Vermont and give little clue to pinpointing an exact location within the township of Granby where *Solidago brendiae* may now occur. Any of them may have been collected on roadsides or adjacent forests. Granby has no paved roads but an extensive network of logging roads, and the forest products industry is the major economic activity. It is of typical areal size for Vermont towns (ca. 39 square miles) with a population of fewer than 100.

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