

Frullania stylifera (Frullaniaceae), a new addition to the liverwort flora of Canada

RICHARD T. CANERS

Royal Alberta Museum, 9810 103A Avenue, Edmonton, Alberta T5J 0G2 Canada; Department of Renewable Resources, University of Alberta, 751 General Services Building, Edmonton, Alberta T6G 2H1 Canada; email: Richard.Caners@gov.ab.ca

Caners, R.T. 2023. *Frullania stylifera* (Frullaniaceae), a new addition to the liverwort flora of Canada. Canadian Field-Naturalist 137(4): 334–342. <https://doi.org/10.22621/cfn.v137i4.3249>

Abstract

Frullania stylifera (R.M. Schust.) R.M. Schust. (Frullaniaceae) is newly reported for Canada. The species grows closely appressed to the bark of trees and shrubs and was recently documented from two areas of mature forest at Buffalo Point First Nation in extreme southeastern Manitoba, Canada. These localities represent a northern range extension for the species on the continent and include two new phorophyte hosts for North America. Features used to distinguish *F. stylifera* from other known species of *Frullania* in Manitoba are provided.

Key words: Great Lakes; Jungermanniales; liverwort; Manitoba; range extension; St. Lawrence

Introduction

The liverwort family Frullaniaceae Lorch contains the single widely distributed genus *Frullania* Raddi with hundreds of accepted species worldwide (Söderström *et al.* 2016; Brinda and Atwood 2023). There are 38 *Frullania* species in North America north of Mexico including the recently described *Frullania austinii* J.J. Atwood, Vilnet, Mamontov & Konstant. (Stotler and Crandall-Stotler 2017; Mamontov *et al.* 2020, 2021). Of these, 13 species are known to occur in Canada (Stotler and Crandall-Stotler 2017; NatureServe 2023), and five are reported for the province of Manitoba: Asa Gray's Scalewort (*Frullania asagrayana* Mont.), Hairy Scalewort (*Frullania bolanderi* Austin) *sensu lato* (cf. Mamontov *et al.* 2020), New York Scalewort (*Frullania eboracensis* Lehm.), Inflated Scalewort (*Frullania inflata* Gottsche), and Oakes' Scalewort (*Frullania oakesiana* Austin; Caners 2011, 2020; NatureServe 2023).

Frullania stylifera (R.M. Schust.) R.M. Schust. was originally described as *Frullania inflata* var. *stylifera* R.M. Schust. by Schuster (1983), based on the type specimen from Whitewater State Park, Minnesota (Schuster W14205) and two other collections from the same area (Schuster 14208, 14213; Schuster 1983). (Note: there is no common name for the species.) *Frullania inflata* var. *stylifera* was subsequently recognized as the distinct species *Frullania stylifera* by Schuster (1992) based on diagnostic morphological features,

especially the very large stylus of dorsal lobes. Until recently, the species was only known from Minnesota (Schuster 1992); however, numerous new localities were reported from interior United States by Atwood (2016), mostly from Missouri, but also Arkansas, Oklahoma, and Tennessee. Subsequently, new localities were reported in New York, Illinois, and Kansas, along with additional sites in Missouri (Atwood and Brinda 2019). A Michigan specimen (Konstantinova A4-95) without a locality is cited in Mamontov *et al.* (2020). Atwood (2016) indicated that the diversity of habitats and woody plant phorophytes reported for *F. stylifera*, combined with the widespread distribution of many of the bryophytes associated with the species, suggests that *F. stylifera* may be much more frequent than reported. In 2020, the species was reported for the first time outside the continental United States in Eurasia (Konstantinova *et al.* 2020).

For my present study, bryophyte surveys were conducted in southeastern Manitoba to expand on the flora of the region documented by Caners (2020). The survey included collections of *Frullania* that were expected to provide new insights into the regional distribution and ecology of the genus.

Study Area

I conducted bryophyte surveys in the Great Lakes–St. Lawrence Forest Region (Rowe 1972) in southeastern Manitoba, Canada, from 12 to 17 September

2022. The forest region extends across southern Canada from the Gaspé Peninsula, Quebec, in the east to southeastern Manitoba in the west (Figure 1). It represents the northern extent of humid temperate climate in eastern North America and the transition between broad-leaved temperate forests and conifer-dominated boreal forests (Rowe 1972; Baldwin *et al.* 2020). The Great Lakes–St. Lawrence Forest Region closely matches the Eastern Cool Temperate Forest Zone in the vegetation classification system of Baldwin *et al.* (2020). I prefer Rowe’s (1972) classification for my study, however, because of its more detailed division of the region into forest sections.

In Manitoba, the Great Lakes–St. Lawrence Forest Region has a restricted distribution and contains two distinct forest sections that differ in composition, terrestrial substrata, and post-glacial history (Rowe 1972; Figure 2). The Quetico Section occupies a small area on the Canadian Shield and is characterized by irregular terrain of underlying granites, sediments, and volcanic rocks (Rowe 1972). The Rainy River Section lacks rock substrates and is characterized by a mostly flat to undulating topography, extensive wetlands, and, in some areas, well-drained soils

with coarse-textured glacial deposits, outwash, and old beaches and bars of glacial Lake Agassiz (Rowe 1972; Groom 2002).

The Great Lakes–St. Lawrence Forest Region has the highest total annual precipitation in Manitoba (Climate Atlas of Canada 2023) and some of the highest mean annual temperatures in the province, which are similar to those along the northern borders of adjacent Minnesota and nearby North Dakota (Climate Atlas of Canada 2023). In the Rainy River Section, the Sprague meteorological station (49°01′0″N, 95°36′0″W; 320.2 m above sea level [asl]) reports a total annual precipitation of 637.5 mm (517.0 mm as rain) and a daily average temperature of 2.7°C (1981–2010 normals; ECCC 2023a). The meteorological station closest to the Quetico Section is Pinawa (50°10′50″N, 96°03′30″W; 266.7 m asl), with a total annual precipitation of 578.3 mm (464.3 mm as rain) and daily average temperature of 2.8°C (1981–2010 normals; ECCC 2023b).

Methods

Field collections

Field collections were restricted to mixed forest

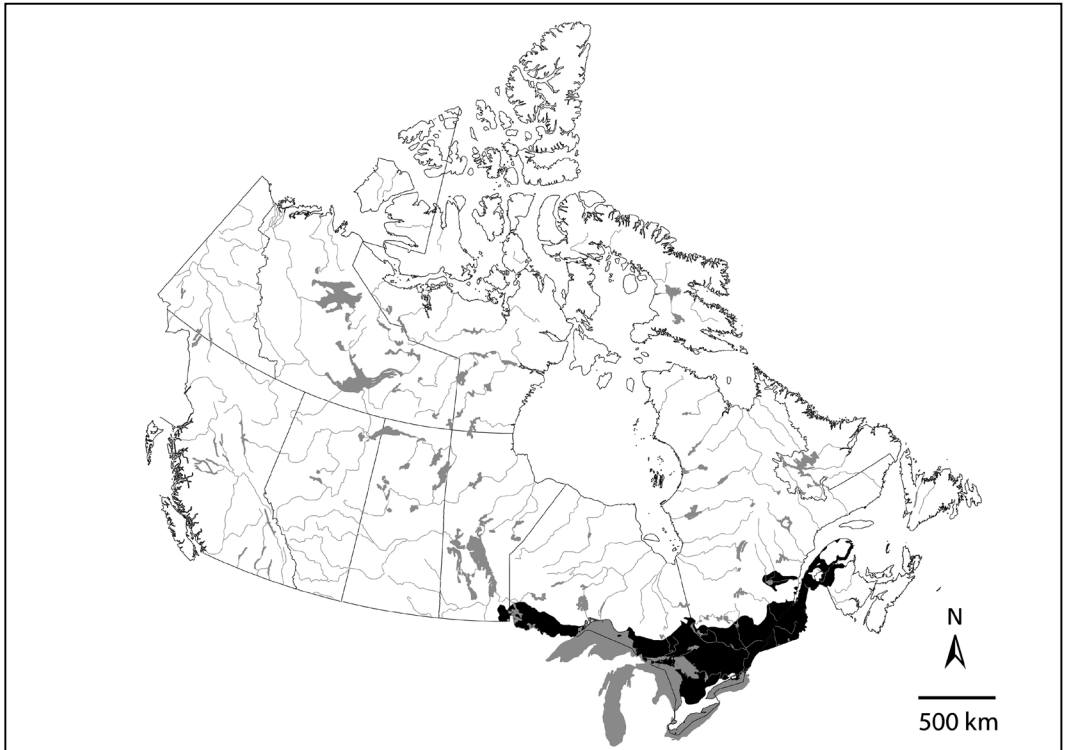


FIGURE 1. The Great Lakes–St. Lawrence Forest Region in Canada (Rowe 1972; adapted from Caners 2020), shown in black shading. Grey polygons and lines are major freshwater bodies and watercourses, respectively. The portion of the Forest Region in extreme southeastern Manitoba represents the study area in Figure 2.

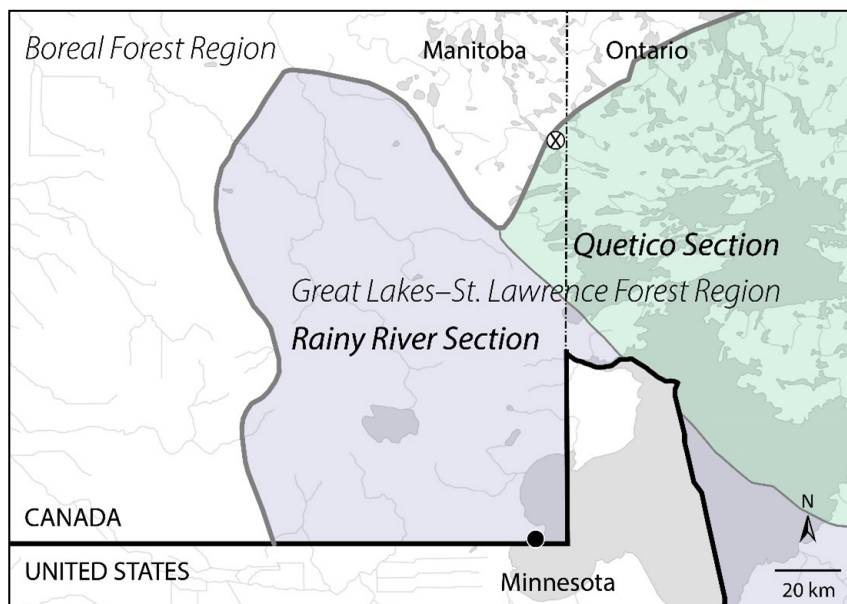


FIGURE 2. Study area and locality (closed circle) of *Frullania stylifera* in Buffalo Point First Nation, Manitoba, Canada. The site is situated in the Rainy River Section of the Great Lakes–St. Lawrence Forest Region. The \otimes represents *Frullania* collection sites from my current study in Whiteshell Provincial Park in the Quetico Section that are not *F. stylifera*. *Frullania* collection sites from Caners (2020) are not depicted. The thick grey line divides the Great Lakes–St. Lawrence Forest Region and the Boreal Forest Region (Rowe 1972). The thick black line is the international border between Canada and the United States, and the dashed line is the inter-provincial border between Manitoba and Ontario. Grey polygons are water bodies and fine grey lines are watercourses. Map adapted from Caners (2020).

and treed swamp habitats and excluded marshes, shallow open water wetlands, bogs, and fens. In the Rainy River Section, surveys were limited to Buffalo Point First Nation, which is located in the extreme southeast corner of the province, on Buffalo Bay in Lake of the Woods (Figure 2). The community is the traditional land of the Anishinaabe peoples of the region and a signatory to Treaty 3. Buffalo Point First Nation contains land parcels of varying size, but for my study only the largest parcel that includes the town site was surveyed. In the Quetico Section, surveys were limited to Whiteshell Provincial Park along the Whiteshell River (Figure 2).

All specimens were deposited at the Royal Alberta Museum herbarium (PMAE). Nomenclature for liverworts follows Stotler and Crandall-Stotler (2017) except for *F. austinii*, which follows Mamontov *et al.* (2020). Nomenclature and vernacular names for vascular plants follow VASCAN (Brouillet *et al.* 2010+), except for species that are not found in Canada, which are based on NatureServe (2023).

Results and Discussion

Two specimens of *F. stylifera* were found among the samples obtained for this study. Both were from Buffalo Point First Nation, ~100 m from each other

(Caners 8783, 8790). The species was growing in mature White Spruce (*Picea glauca* (Moench) Voss)–Paper Birch (*Betula papyrifera* Marshall)–Balsam Poplar (*Populus balsamifera* L.)–Balsam Fir (*Abies balsamea* (L.) Miller) forest that contained a large volume of dead wood. Some *Frullania* species, such as *F. stylifera*, have features that are challenging to discern in the field, requiring the collection of specimens for proper identification. I collected more than 40 *Frullania* specimens during the present study and other recent surveys of the region (Caners 2020), but no additional specimens of *F. stylifera* were detected. The collections of *F. stylifera* from Buffalo Point First Nation are the most northern for the species in North America to date, with the next closest station being the type locality in Minnesota (Schuster 1992) more than 600 km to the southeast (Figure 3).

Differentiation

Atwood (2016) reported numerous new records of *F. stylifera* from the interior United States through field collections and review of past herbarium collections that were found to be misidentified. Atwood (2016) attributed the apparent scarcity of records of *F. stylifera* to a tendency to overlook the species or to mistake it for other species, especially *F. inflata*

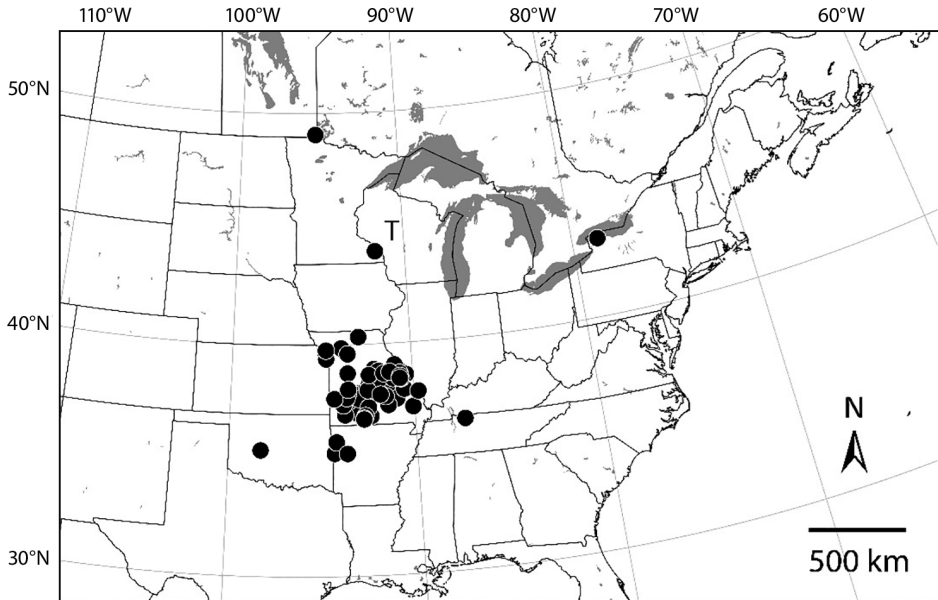


FIGURE 3. Currently known distribution of *Frullania stylifera* in North America. The closed circle in Manitoba, Canada, includes the two newly discovered collections from Buffalo Point First Nation. The other closed circles are specimen records from Atwood (2016), Atwood and Brinda (2019), and Consortium of Bryophyte Herbaria (2023). The closed circle in Minnesota, USA, marked with the letter “T”, indicates the type locality from Schuster (1983). Grey polygons are major freshwater bodies. Map generated from Shorthouse (2010).

and *F. eboracensis*. The latter species are known from southeastern Manitoba, with *F. eboracensis* being much more frequent and often locally abundant (Caners 2020). Confusion with *F. inflata* may relate to the species’ basionym, *Frullania inflata* var. *stylifera*. Several characters distinguish *F. stylifera* from these other species, including the size of the styli and underleaves, the shape of dorsal lobes, number of oil bodies per cell, and sexual condition (Table 1; Schuster 1992; Atwood 2017; Mamontov *et al.* 2020). *Frullania stylifera* has a very large lamellate stylus that typically measures 10–15 cells long and 4–10 cells wide (Figure 4). In comparison, the styli in *F. inflata* and *F. eboracensis* are substantially smaller, being filiform or shortly triangular and usually 3–6 cells long and 1–3 cells wide (Atwood 2017). *Frullania stylifera* has underleaves 2–3 times the width of the stem, whereas both *F. inflata* and *F. eboracensis* have underleaves usually 1.0–1.5 times the width of the stem (Atwood 2017). Dorsal lobes in *F. stylifera* are broadly reniform to ovate and with a cordate base, whereas dorsal lobes in *F. inflata* are orbicular to broadly ovate with a truncate base and in *F. eboracensis* are oval to suborbicular with a cordate base. When fresh material is available, *F. stylifera* has dorsal lobes with up to 16 oil bodies per cell (or as few as 5–8 oil bodies in scattered cells; Schuster 1992), whereas *F. inflata* and *F. eboracensis* have ~2–5 oil bodies per

cell (Atwood 2017). Furthermore, *F. stylifera* and *F. inflata* are autoicous and abundantly fertile with capitate androecia, whereas *F. eboracensis* is dioicous and infrequently fertile with spicate androecia.

The remaining *Frullania* species known to occur in Manitoba (*F. asagrayana*, *F. bolanderi sensu lato*, and *F. oakesiana*) are readily distinguished from *F. stylifera* (Table 1). *Frullania asagrayana* has ocelli of the dorsal lobes; these are lacking in *F. stylifera*. These ocelli appear in *F. asagrayana* as a line of cells that runs medially from the leaf base to about half-way along the leaf length (Atwood 2017). The ocelli are usually one or occasionally two cells wide and are seen rarely as scattered cells (Atwood 2017). *Frullania asagrayana* also has a stylus that is filiform to subulate with a suborbicular appendage and is dioicous.

Frullania bolanderi has been previously considered to have a bicentric world distribution, with centres in eastern Asia and the Pacific Coast of North America and in eastern and interior North America and western Europe (Schuster 1992; Mamontov *et al.* 2020). However, morphological differences supported by molecular data in some North American and Russian populations previously included in the circumscription of *F. bolanderi* have revealed a new species, *Frullania austinii* J.J. Atwood, Vilnet, Mamontov & Konstant. (Mamontov *et al.* 2020). Both *F. bolanderi*

TABLE 1. Key features that distinguish *Frullania stylifera* from other known *Frullania* species in Manitoba.

Feature	<i>F. stylifera</i>	<i>F. asagrayana</i>	<i>F. austinii</i> *	<i>F. eboracensis</i>	<i>F. inflata</i>	<i>F. oakesiana</i>
Dorsal lobe shape	Reniform-ovate, base cordate	Ovate, base auriculate	Widely ovate, base truncate	Oval to suborbicular, base cordate	Orbicular to broadly ovate, base truncate	Ovate to orbicular, base rotundate to truncate
Dorsal lobe size, μm	500–600 \times 700–800	700 \times 500	410–575 \times 550–720	400–600 \times 500–600	550–640 \times 360–600	300–400 \times 200–300
Ocelli	Absent	Present as a median line, rarely as scattered cells	Absent	Absent	Absent	Absent
Lobule size, μm	355–420 \times 310–400	300 \times 200	250–320 \times 250–400	260–300 \times 200–240	250 \times 250	220–240 \times 190–220
Stylus	Lamellate, 10–15 cells long, 4–10 cells wide	Filiform to subulate, with suborbicular disk like appendage with cilia and 1–2 marginal teeth	Lamellate, 6–10 cells long, 3–5 cells wide	Subulate, 3–6 cells long, 2–3 cells wide	Filiform to subulate, 4–8 cells long, (1)2–3 cells wide	Subulate, 4–5 cells long, 1–3 cells wide
Underleaf shape and size, μm	Obovate, 330–365 \times 340–380	Orbicular-ovate, 400 \times 400	Obovate, 160–200 \times 180–250	Ovate to rhombic-ovate, 200–250 \times 150–230	Orbicular to obovate, 300–320 \times 240–300	Obovate, 160–180 \times 130–160
Oil bodies, no./cell	8–16	2–4†	6–9	2–5	4–5	3–5
Asexual reproduction	Absent	Absent	Abundant flagelliform secondary branches with caducous leaves	Gemmae or caducous leaves	Absent	Absent
Sexual condition	Autoicous	Dioicous	Dioicous	Dioicous	Autoicous	Autoicous
Androecia	Capitate	Bracts in 3–5 pairs†	Subglobose to shortly spicate	Distinctly spicate†	Capitate	Capitate
Perianth	Abruptly contracted, one dorsal keel, two ventral keels, no accessory keels	Somewhat compressed at sides, with deep postical keel	One main keel, 2–3 smaller, accessory keels ventrally, on dorsal side often with 1–2(3) small keels	\pm compressed, abruptly narrowed to short, broad keel, without distinct supplementary ridges	Abruptly narrowed to beak, with one postical keel, \geq 1 supplementary keels	Gradually broadened to apex, dorsiventrally flattened, one ventral, two lateral keels of equal size
Perianth beak	With inner faces weakly papillate†	Short†	Obconical, dilated at mouth, mouth sometimes occluded with papilliform cells	Short†	Short, broad, with papilloid cells on inner surface	Short, mouth fringed with projecting papillae

*Features for *F. austinii* are based on Mamontov *et al.* (2020).

†Features based on Schuster (1992).

All features not marked * or † are based on Atwood (2017).

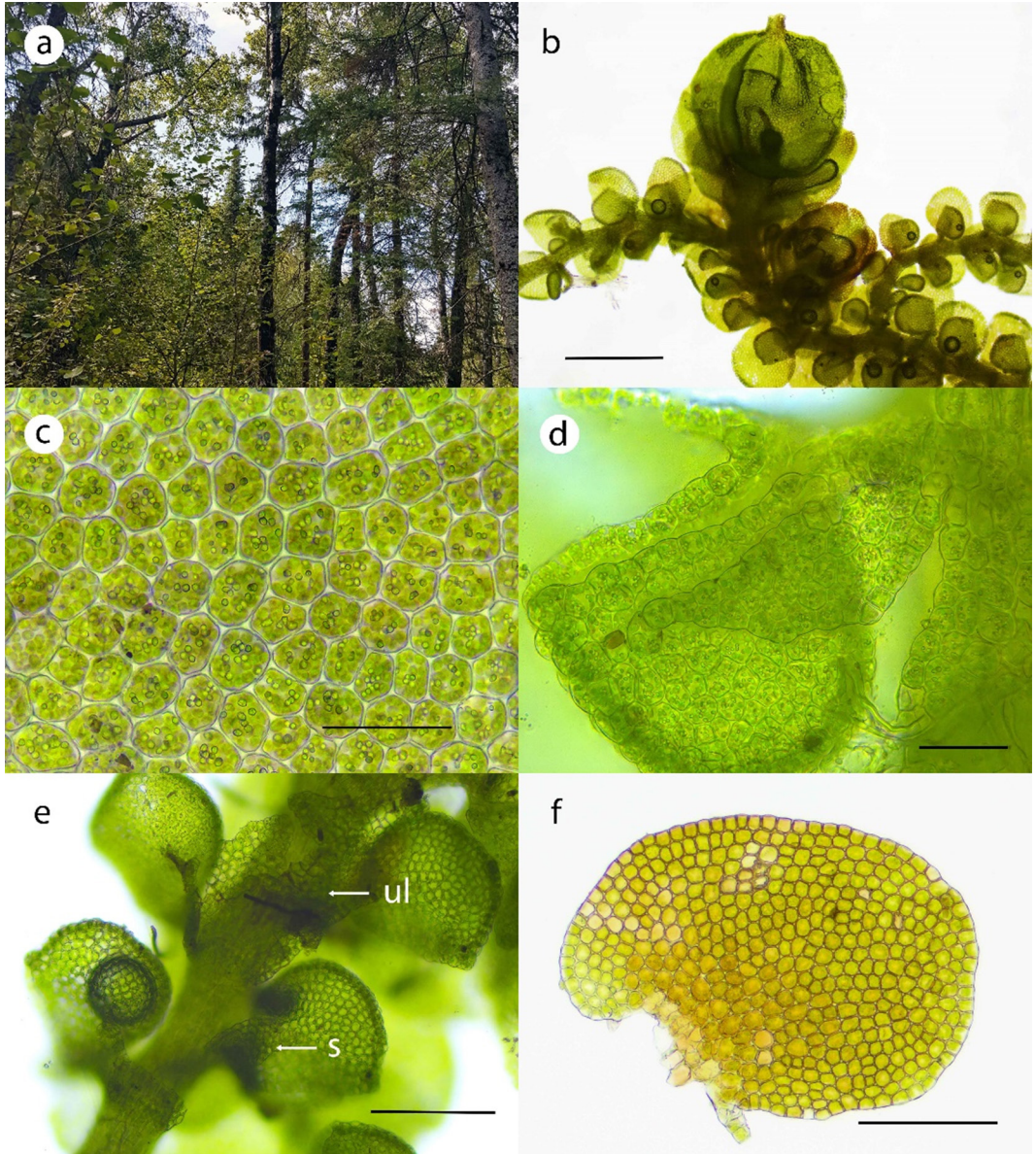


FIGURE 4. Images of *Frullania stylifera* from Buffalo Point First Nation, Manitoba, Canada. a. Forest habitat where specimens were collected (*Caners* 8783, 8790). b. Portion of a plant with capitulate androecium below the perianth (scale bar = 0.5 mm; from specimen *Caners* 8783). c. Median cells of a dorsal lobe, each containing numerous oil bodies (scale bar = 50 μ m; from specimen *Caners* 8790). d. Close-up of a lamellate stylus (scale bar = 50 μ m; from specimen *Caners* 8790). e. Ventral view of a plant showing the stylus (s) adjacent to an underleaf that was removed, galeate lobules (typical of the genus), and an underleaf (ul) that is approximately twice the diameter of the stem (scale bar = 200 μ m; from specimen *Caners* 8790). f. Dorsal lobe with cordate base (scale bar = 200 μ m; from specimen *Caners* 8783). Photos: Richard Caners.

and *F. austinii* occur in North America, with the latter being widespread in the east (including the populations that were previously included within *F. bolanderi*) and the former being restricted to the west (Mamontov *et al.* 2020). The western distribution of

F. austinii in North America has not been determined, and the presence of both species within a region is possible (Mamontov *et al.* 2020). *Frullania austinii* was recently confirmed for Manitoba, and it is likely that all material from the province named *F. bolanderi*

is *F. austinii* (R.T.C. unpubl. data). *Frullania austinii* consistently has rigidly erect, flagelliform shoots with caducous leaves that are lacking in *F. stylifera*. Furthermore, *F. austinii* has slightly smaller lamellate styli that are 6–10 cells long and 3–5 cells wide, dorsal lobes with truncate bases, and dioicous sexual condition (Mamontov *et al.* 2020).

Frullania oakesiana is small relative to *F. stylifera* and other *Frullania* species in Manitoba. The species is similar to *F. stylifera* in being autoicous, but differs in having small, subulate styli that are 4–5 cells long and 1–3 cells wide at the base. The lobules of *F. oakesiana* are large relative to the size of the dorsal lobes. *Frullania oakesiana* also has dorsal lobes that are ovate to orbicular in shape and rounded or truncate at the base, with 3–5 oil bodies per cell. *Frullania stylifera* in comparison has much smaller lobules relative to the size of dorsal lobes and differs in the shape of the dorsal lobes and number of oil bodies (Table 1).

Phorophytes

Frullania stylifera has been collected from the bark of several tree and shrub host species. Schuster (1992) reported the type collection of the species from exfoliating bark of sumac (*Rhus* L.). More recently, Atwood (2016) reported new records of species from the bark of oak (*Quercus* L.), particularly Post Oak (*Quercus stellata* Wengenheim), and from hickory (*Carya* Nuttall), Black Walnut (*Juglans nigra* L.), hackberry (*Celtis* L.), maple (*Acer* L.), Persimmon (*Diospyros virginiana* L.), ash (*Fraxinus* L.), Eastern Red Cedar (*Juniperus virginiana* L.), Osage Orange (*Maclura* Nuttall), and arrow-wood (*Viburnum* L.). The specimens collected from Buffalo Point First Nation were growing on the bark of Beaked Hazelnut (*Corylus cornuta* Marshall; *Caners* 8783) and the trunk of Paper Birch (*Betula papyrifera* Marshall; *Caners* 8790). These are two new phorophyte species for *F. stylifera* in North America and globally. In Russia, the species has been collected from European Aspen (*Populus tremula* L.), Broadleaf White Birch (*Betula platyphylla* Sukaczew), European Bird Cherry (*Padus avium* Miller), and willow (*Salix* L.) (Konstantinova *et al.* 2020).

Conclusions

Frullania stylifera is currently known from temperate broadleaved forests of interior and eastern United States (Atwood 2016) and Europe (Konstantinova *et al.* 2020), as well as from the boreal zone of the mountains of south Siberia in Asian Russia where it is restricted to coniferous and mixed forests (Konstantinova *et al.* 2020). The diversity of habitats in which *F. stylifera* has been reported in North America and globally suggests that it could be found across larger areas of Canada, including the large expanse of

Great Lakes forest to the east of the study area (Figure 1) and possibly into the more northerly boreal forest where *F. eboracensis* is reported, albeit infrequently (BRYOQUEL 2023; Consortium of Bryophyte Herbaria 2023). The study area where *F. stylifera* was found in Manitoba has the highest total annual precipitation and approaches the highest mean annual temperatures in the province (Climate Atlas of Canada 2023). Whether the species extends into more northerly areas of boreal forest with lower total annual precipitation and annual temperatures remains to be investigated. Several bryophytes with a temperate world distribution that are common in eastern North America seem to reach their northern and/or western distribution limits in the study area (Caners 2017, 2020) suggesting that conditions beyond these occurrences are likely unsuitable for them.

Expanded surveys for *F. stylifera* in southern Manitoba are likely to reveal additional records. The forest habitat in which the species was found at Buffalo Point First Nation is abundant in the Great Lakes–St. Lawrence Forest Region. However, the occurrence of *F. stylifera* in Manitoba is currently the most northern record for the species in North America and is presumably close to its northern range limits in the province. Inspection of past herbarium specimens, especially *F. inflata* and *F. eboracensis*, may reveal misidentified specimens of *F. stylifera*, as observed by Atwood (2016). The confirmation of new records by examining herbarium specimens could inform the potential distribution of the species in Canada and help to determine its northern limits.

Voucher specimens

CANADA, MANITOBA: c.fr. [*cum fructibus*, meaning “with sporophytes”], Buffalo Point First Nation. On the bark of a large Beaked Hazelnut (*Corylus cornuta* Marshall). 49.01°N, 95.29°W. Elevation: 330 m. *R.T. Caners* 8783 (PMAE), identified by R.T. Caners and verified by John J. Atwood (Missouri Botanical Garden).

CANADA, MANITOBA: c.fr., Buffalo Point First Nation. On the bark of a large Paper Birch (*Betula papyrifera* Marshall). 49.01°N, 95.29°W. Elevation: 330 m. *R.T. Caners* 8790 (PMAE), identified by R.T. Caners and verified by John J. Atwood.

Specimens examined

The following specimens of *F. stylifera* from Missouri Botanical Garden (MO) were examined:

USA, MISSOURI: **Montgomery County**. Grand Bluff's Conservation Area, Grand Bluff's Natural Area, forested bluff top ~0.8 mile [1.3 km] NE of Bluffton, persimmon grove with 3–4" [7.6–10 cm] dbh (diameter at breast height) trees on SW slope, on tree trunks with *Frullania eboracensis*, 38.7069°N, 91.60897°W,

850–900 feet [262–274 m], 24 July 2018, *John J. Atwood 3672* (MO-6898570), determined by J. Atwood (2018). **Camden County**. Open field with exposed limestone along county road H, ca. 2 miles [3.2 km] west of Richland, Sec. 14, R14W, T36N, 37.85°N, 92.4288°W, 23 September 1960, *Paul L. Redfearn, Jr. 7516* (MO-3957657), determined by J.J. Atwood (2015). **Cedar County**. Bark of oak, ~1 mile [1.6 km] SW of Bear Creek, Sec. 21, T34N, R25W, 37.6852°N, 93.676°W, 22 July 1960, *Paul L. Redfearn, Jr. 6859A* (MO-3956669), determined by J.J. Atwood (2015).

Acknowledgements

I thank Herman Green, Land Manager and Councillor, Buffalo Point First Nation, for permission to conduct surveys at Buffalo Point and for discussion about the community lands. Manitoba Environment, Climate and Parks provided research and collection permits for Whiteshell Provincial Park (Provincial Parks Permit PP-PHQ-22-019). John Atwood (Missouri Botanical Garden) verified the collections of *Frullania stylifera* and provided information about this and related species. The Royal Alberta Museum (Government of Alberta) funded the study. Comments from two reviewers and *The Canadian Field-Naturalist* Associate Editor and Editor-in-Chief improved the original manuscript.

Literature Cited

- Atwood, J.J.** 2016. New stations for *Frullania stylifera* (Frullaniaceae) outside of the type locality. *Evansia* 33: 96–100. <https://doi.org/10.1639/0747-9859-33.2.96>
- Atwood, J.J.** 2017. XX. Frullaniaceae Lorch. In *Bryophyte Flora of North America Provisional Publication*. Edited by R.H. Zander. Missouri Botanical Garden, St. Louis, Missouri, USA. Accessed 20 May 2023. <https://www.mobot.org/plantscience/bfna/V3/Frullaniaceae.htm>.
- Atwood, J.J., and J.C. Brinda.** 2019. Liverworts and hornworts of the Interior Highlands exsiccatae — fascicle 5. *Missouriensis* 37: 11–15.
- Baldwin, K., L. Allen, S. Basquill, K. Chapman, D. Downing, N. Flynn, W. MacKenzie, M. Major, W. Meades, D. Meidinger, C. Morneau, J.-P. Saucier, J. Thorpe, and P. Uhlig.** 2020. *Vegetation Zones of Canada: a Biogeoclimatic Perspective*. Information report GLC-X-25. Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie, Ontario, Canada.
- Brouillet, L., F. Coursol, S.J. Meades, M. Favreau, M. Anions, P. Bélisle, and P. Desmet.** 2010+. VASCAN, the Database of Vascular Plants of Canada. Biodiversity Centre, Montréal, Quebec, Canada. Accessed 11 December 2023. <https://data.canadensys.net/vascan/>.
- Brinda, J.C., and J.J. Atwood.** 2023. A synopsis of *Frullania*. In *The Bryophyte Nomenclator*. Accessed 11 December 2023. <https://www.bryonames.org/nomenclator?group=Frullania>.
- BRYOQUEL.** 2023. La base de données des bryophytes du Québec – Labrador. *Frullania eboracensis*. Société québécoise de bryologie. Accessed 25 May 2023. http://www.societequebecoisedebryologie.org/hepatiques/Frullania_eboracensis.html.
- Caners, R.T.** 2011. Saxicolous bryophytes of an Ordovician dolomite escarpment in Interlake Manitoba, with new species records for the province. *Canadian Field-Naturalist* 125: 327–337. <https://doi.org/10.22621/cfn.v125i4.1261>
- Caners, R.T.** 2017. *Fabronia ciliaris*, a moss new to Canada from southeastern Manitoba. *Canadian Field-Naturalist* 131: 246–251. <https://doi.org/10.22621/cfn.v131i3.1961>
- Caners, R.T.** 2020. Bryophytes at the western limits of Canada's Great Lakes forest: floristic patterns and conservation implications. *Northeastern Naturalist* 27 (Monograph 17): 1–37. <https://doi.org/10.1656/045.027.m1701>
- Climate Atlas of Canada.** 2023. Map of total annual precipitation for the Kenora region. Prairie Climate Centre, University of Winnipeg, Winnipeg, Manitoba, Canada. Accessed 8 May 2023. <https://climateatlas.ca>.
- Consortium of Bryophyte Herbaria.** 2023. *Frullania eboracensis*. Accessed 25 May 2023. <https://bryophyteportal.org/portal/>.
- ECCC (Environment and Climate Change Canada).** 2023a. Normals data for 1981 to 2010. Canadian climate normals: Sprague. ECCC, Ottawa, Ontario, Canada. Accessed 8 May 2023. https://climate.weather.gc.ca/climate_normals/index_e.html.
- ECCC (Environment and Climate Change Canada).** 2023b. Normals data for 1981 to 2010. Canadian climate normals: Pinawa WNRE. ECCC, Ottawa, Ontario, Canada. Accessed 8 May 2023. https://climate.weather.gc.ca/climate_normals/index_e.html.
- Groom, H.D.** 2002. Aggregate resources in the rural municipalities of Ste. Anne and Turtle Mountain and in the Buffalo Point area. Pages 295–302 in *Report of Activities 2002*, Manitoba Industry, Trade and Mines. Manitoba Geological Survey, Winnipeg, Manitoba, Canada.
- Konstantinova, N.A., Y.S. Mamontov, and A.A. Vilnet.** 2020. *Frullania stylifera* (R.M. Schust.) R.M. Schust. (Hepaticae), new to Eurasia. *Journal of Bryology* 42: 152–159. <https://doi.org/10.1080/03736687.2020.172211>
- Mamontov, Y.S., J.J. Atwood, and A.A. Vilnet.** 2021. On the diversity and distribution of the genus *Frullania* in Northern Holarctic. *BIO Web of Conferences* 38: 00079. <https://doi.org/10.1051/bioconf/20213800079>
- Mamontov, Y.S., A.A. Vilnet, J.J. Atwood, and N.A. Konstantinova.** 2020. Molecular phylogenetic study of *Frullania* subsect. *Inflatae* (Frullaniaceae, Marchantiophyta) in the Holarctic with description of new subgenus and three new species. *Nova Hedwigia Beihefte* 150: 201–242. <https://doi.org/10.1127/nova-suppl/2020/201>
- NatureServe.** 2023. Species: *Frullania*. NatureServe Explorer. NatureServe, Arlington, Virginia, USA. Accessed 24 May 2023. <https://explorer.natureserve.org/>.
- Rowe, J.S.** 1972. *Forest Regions of Canada*. Canadian Forest Service publication 1300. Department of the Environment, Ottawa, Ontario, Canada. Accessed 3 July 2024. https://publications.gc.ca/collections/collection_2019/eccc/Fo47-1300-eng.pdf.
- Schuster, R.M.** 1983. Notes on Nearctic Hepaticae, XVI.

New taxa of *Frullania* from eastern North America. *Phytologia* 53: 364–366.

Schuster, R.M. 1992. The Hepaticae and Anthocerotae of North America East of the Hundredth Meridian. Volume 5. Field Museum of Natural History, Chicago, Illinois, USA.

Shorthouse, D.P. 2010. SimpleMappr, an online tool to produce publication-quality point maps. Accessed 8 May 2023. <https://www.simplemappr.net>.

Söderström, L., A. Hagborg, M. von Konrat, S. Bartholomew-Began, D. Bell, L. Briscoe, E. Brown, D.C. Cargill, D.P. da Costa, B.J. Crandall-Stotler, E.D. Cooper, G. Dauphin López, J.J. Engel, K. Feldberg, D.S. Glenny, S.R. Gradstein, X.-L. He, J. Heinrichs, J. Hentschel, A.L. Ilkiu-Borges, T. Katagiri, N.A. Kon-

stantinova, J. Larrain Benoit, D.G. Long, M. Nebel, T. Pócs, F. Puche, M.E. Reiner-Drehwald, M.A.M. Renner, A. Sass-Gyarmati, A. Schäfer-Verwimp, J.G. Segarra-Moragues, R.E. Stotler, P. Sukkharak, B.M. Thiers, J.C. Uribe, J. Váña, J.C. Villarreal Aguilar, M.J. Wigginton, L. Zhang, and R.-L. Zhu. 2016.

World checklist of hornworts and liverworts. *PhytoKeys* 59: 1–828. <https://doi.org/10.3897/phytokeys.59.6261>

Stotler, R.E., and B. Crandall-Stotler. 2017. A synopsis of the liverwort flora of North America north of Mexico. *Annals of the Missouri Botanical Garden* 102: 574–709. <https://doi.org/10.3417/2016027>

Received 23 June 2023

Accepted 23 February 2024

Associate Editor: J.M. Saarela