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Wintercresses (*Barbarea* W.T. Aiton, Brassicaceae) of the Canadian Maritimes

Colin J. Chapman[1,*], C. Sean Blaney[1], and David M. Mazerolle[1,2]

[1]Atlantic Canada Conservation Data Centre, P.O. Box 6416, Sackville, New Brunswick E4L 1G6 Canada
[2]Current address: Kouchibouguac National Park, 186 Route 117, Kouchibougouac, New Brunswick E4X 2P1 Canada
[*]Corresponding author: colin.chapman@accdc.ca

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Abstract

We conducted a review of herbarium collections of the Wintercress genus (*Barbarea* W.T. Aiton) from the Maritime provinces. Most specimens previously determined to be the regionally rare native species Erect-fruit Wintercress (*Barbarea orthoceras* Ledebour) are in fact the uncommon exotic Small-flowered Wintercress (*Barbarea stricta* Andrzejowski). The latter species is here reported as new to Atlantic Canada, where it is scattered but widespread in the three Maritime provinces. Only three collections (two from New Brunswick and one from Nova Scotia) were confirmed as *B. orthoceras*. Its known range extent and area of occupancy in the Maritimes has been significantly revised, and *B. orthoceras* is now considered potentially extirpated in New Brunswick and extremely rare in Nova Scotia. One collection from Nova Scotia was referred to another rare exotic species, Early Wintercress (*Barbarea verna* (Miller) Ascherson), which represents the first record for the Maritimes.

Key words: Cruciferae; Brassicaceae; new record; floristics; *Barbarea stricta*; *Barbarea orthoceras*; *Barbarea verna*; conservation; Maritimes; Canada; wintercress

Introduction

The wintercress genus (*Barbarea* W.T. Aiton) has long been a source of confusion in North America, in part due to taxonomy and to somewhat variable species with overlapping morphology (Fernald 1909; Mulligan 2002; Al-Shehbaz 2010). The sole native North American member of the genus, Erect-fruit Wintercress (*Barbarea orthoceras* Ledebour), was at one point considered a native form of the Eurasian species Bitter Wintercress (*Barbarea vulgaris* W.T. Aiton) or Small-flowered Wintercress (*Barbarea stricta* Andrzejowski; discussed in Fernald 1909). Fernald (1909), who concluded reports of *B. stricta* were misidentified individuals of *B. vulgaris* with appressed fruit, excluded the former species from the North American flora. Mulligan (1978) reported the first confirmed North American records of *B. stricta* based on specimens collected from Quebec in 1944, although the species was not included in *The Flora of Canada* (Scoggan 1978). *Barbarea stricta* has subsequently been documented in Ontario (based on a 1922 specimen; Dorofeev 1998), Colorado, Connecticut, Maine, Michigan, Massachusetts, New Hampshire, New York, Rhode Island, Vermont, and Wisconsin (Al-Shehbaz 2010). Prior to our study, only two species of *Barbarea* were listed in the flora of the Canadian Maritimes (New Brunswick [NB], Nova Scotia [NS], and Prince Edward Island [PEI]): *B. vulgaris* and *B. orthoceras* (Roland and Smith 1969; Scoggan 1978; Zinck 1998; Hinds 2000; Munro *et al.* 2014).

Barbarea vulgaris is a common and widespread weedy species of Eurasian origin, well documented from throughout NB, NS, and PEI (Erskine 1960; Roland and Smith 1969; Zinck 1998; Hinds 2000; AC CDC 2019; Figure 1). *Barbarea orthoceras* is native to boreal North America and eastern and central Asia (Al-Shehbaz 2010). Haines (2011) considers *B. orthoceras* a calciphile associated in New England with high-pH bedrock or till, although a variety of habitats, including grasslands, forests, boggy ground, and railroad embankments are reportedly suitable (Al-Shehbaz 2010). Though relatively secure in the western and northern portion of its range, *B. orthoceras* is rare in eastern North America and is of conservation concern in all jurisdictions of occurrence east of Ontario (NatureServe 2017). As of 2000, it was reported in the Maritimes from five NB locations on "stream banks, sandy beaches, gravel river strands, and rocky shores" (Hinds 2000: 225). An additional nine NB collections and two NS col-

lections initially identified as *B. orthoceras* were deposited at regional herbaria between 2001 and 2015 (AC CDC 2019; Figure 2), but in 2015 D.M.M. suspected some Maritimes records involved *B. stricta*, so we undertook a thorough specimen review to determine the regional status of *B. orthoceras*, *B. stricta,* and *B. vulgaris*.

Methods

Approximately 170 specimens from four regional herbaria (E.C. Smith Herbarium—Acadia University [ACAD], New Brunswick Museum [NBM], Nova Scotia Museum of Natural History [NSPM], Connell Memorial Herbarium—University of New Brunswick [UNB]) and one national herbarium (Canadian Museum of Nature [CAN]) were examined by C.J.C. in 2018. Specimens from Agriculture and Agri-Food Canada's National Collection of Vascular Plants [DAO] were unavailable for examination due to facility renovations. Plants were determined based on the treatments in Al-Shehbaz (2010) and Haines (2011). A simplified key is presented here:

1a. Stylar beaks narrow, longer than 1.5 mm (Figure S1); auricles of distal leaves glabrous..... ..... *B. vulgaris*

1b. Stylar beaks stout, less than 1.5 mm long (Figure S2); auricles of distal leaves at least sparsely ciliate 2

2a. Uppermost leaves dentate (Figure S3); petals less than 4.5 mm long (Figure S4); fruit mostly shorter than 28 mm long..... *B. stricta*

2b. Uppermost leaves pinnatifid (Figure S5); petals greater than 5 mm long; fruit mostly greater than 31 mm long..... 3

3a. Basal leaves with 1–4 pairs lateral lobes; fruit usually under 40 mm long; fruiting pedicels narrower than fruit ..... *B. orthoceras*

3b. Basal leaves with 4–10 pairs lateral lobes; fruit usually greater than 53 mm long; fruiting pedicels as broad as fruit ..... *B. verna*

Clear determinations could be made for most specimens, but some collections presented conflicting morphology, as is mentioned of NB (Hinds 2000), New England (Al-Shehbaz 2010), and Michigan (Voss

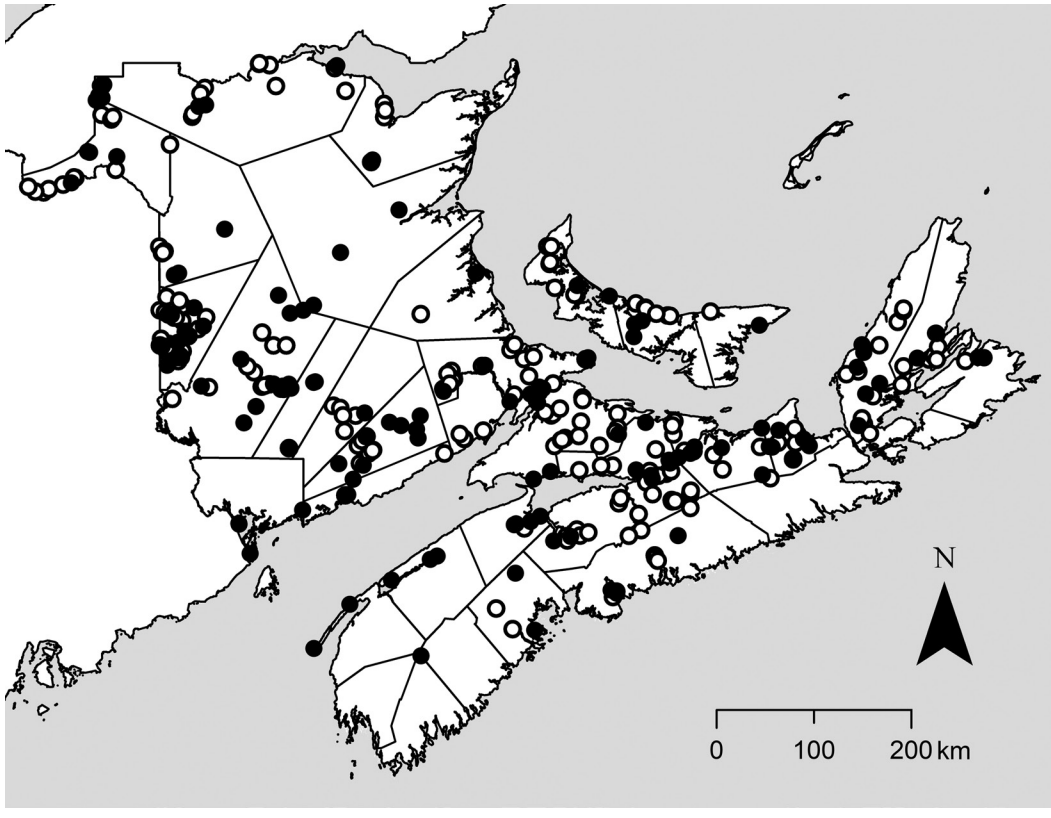

FIGURE 1. Distribution of Bitter Wintercress (*Barbarea vulgaris*) in the Canadian Maritimes based on specimens (solid circles) and Atlantic Canada Conservation Data Centre sight records (hollow circles) determined and verified during the present study.

and Reznicek 2012) material. We sent a small subset of six specimens to Ihsan Al-Shehbaz, Missouri Botanical Garden, and he confirmed all six as the species initially determined by C.J.C.

All records in this paper are either supported by voucher specimens or are photographic or sight records made by Atlantic Canada Conservation Data Centre (AC CDC) botanists.

Results and Discussion

Barbarea vulgaris W.T. Aiton

Barbarea vulgaris remains the most frequently encountered and widespread species of *Barbarea* in the Maritimes (Figure 1). As a weedy species, *B. vulgaris* is found in a variety of anthropogenic habitats such as fields and roadsides (Erskine 1960; Roland and Smith 1969; Hinds 2000). It is also frequent on river shores, where it can co-occur with *B. stricta* and potentially with *B. orthoceras*. The taxon is morphologically variable, and though many varieties have been described (treated in Fernald 1909), none are presently recognized in North America (Al-Shehbaz 2010). Some specimens present mixed or intermediate morphology in style length, uppermost leaf shape, and auricle pubescence. Hinds (2000) reported apparently intermediate NB specimens and suspected hybridization might be involved. Hybrids of *B. vulgaris* and *B. stricta* (= *B.* × *schulzeana* Haussknecht) are recorded for Europe, although occurrences are very infrequently recorded and highly sterile (Rich 1987). If hybrids were also sterile in the Maritimes, we might expect a lower frequency of plants intermediate between *B. vulgaris* and *B. orthoceras* than has been observed. These intermediates may thus be morphological extremes of the highly variable *B. vulgaris*.

Barbarea orthoceras Ledebour

We found that only one specimen initially identified as *B. orthoceras* was determined correctly. The remainder were reassigned to *B. stricta* or in very few cases *B. vulgaris*. An additional *B. orthoceras* record was discovered upon redetermination of a specimen originally identified as *B. vulgaris*. The two specimens now confirmed for NB were collected in 1944 along water-runs in an old pasture on Grand Manan Island (*C.A. Weatherby & Una F. Weatherby 7343*), and in 1964 on a roadside at the edge of a Black Spruce (*Picea mariana* (Miller) Britton, Sterns & Poggenburgh) forest in Kings County (*P.R. Roberts*

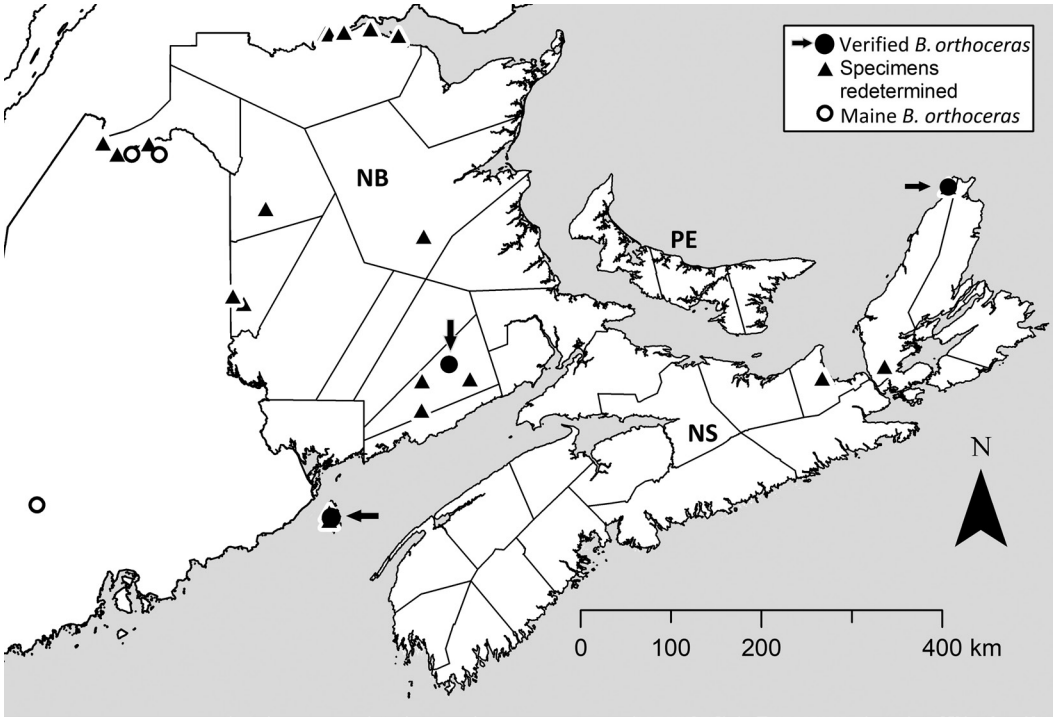

Figure 2. Distribution of the rare native Erect-fruit Wintercress (*Barbarea orthoceras*) in New Brunswick (NB), Nova Scotia (NS), and Prince Edward Island (PE) based on specimens determined and verified during the present study. Historical records from Maine provided by the Maine Natural Heritage Program were not verified, but one Maine collection at the New Brunswick Museum was redetermined as *B. orthoceras*.

& N. Bateman 64-361). C.S.B. discovered the first and only known NS population on a steep, seepy ravine slope under shrubs in northern Cape Breton in 2016 (collection number *8978*).

Barbarea orthoceras was first reported for NB based on two specimens revised by H.J. Scoggan in 1955 (*R. Chalmers 305a* [now determined as *B. stricta*] and *C.A. Weatherby and Una F. Weatherby 7343*). Scoggan appears unlikely to have considered *B. stricta* as a possible identity because it was not confirmed in North America until much later (Mulligan 1978). Indeed, his key in Scoggan (1978) describes the petals in *B. orthoceras* as "at most 5 mm long", a key character of *B. stricta* (Al-Shehbaz 2010). Hinds (2000) similarly described the petals of *B. orthoceras* as "less than 5 mm long". In fact, the petals are 5–7 mm long in *B. orthoceras*, which is the most reliable character separating it from *B. stricta* (I. Al-Shehbaz pers. comm. 8 May 2018).

One historical collection of *B. orthoceras* (initially misidentified as *B. vulgaris* and later as *B. stricta*) was uncovered from Fort Kent, Maine (*G.U. Hay, s.n.*), along the Saint John River across from Madawaska County, NB. The species is known from two additional historical records in northern Maine, however all recent collections of potential *B. orthoceras* in the state have turned out to be *B. stricta* (L. St. Hilaire and D. Cameron pers. comm. 20 February 2019). All recent records from extensive AC CDC fieldwork along northern NB rivers have also been *B. stricta*, suggesting that, if *B. orthoceras* is present on rivers in the region, it is quite rare. However, the now-confirmed records of *B. orthoceras* from pasture and roadsides in NB suggest it could be overlooked in disturbed sites because of assumptions that *Barbarea* in ruderal habitats must be *B. vulgaris* or *B. stricta*, and because botanists tend to spend less time in ruderal habitats.

Speculation aside, our study greatly decreases the known range extent and area of occupancy for *B. orthoceras* in the Maritime provinces (Figure 2). No recent records exist in NB, where its provincial status has been changed from imperilled/vulnerable (S2S3) to possibly extirpated (SH). It has been confirmed as extremely rare in NS and remains unknown on PEI.

Barbarea stricta Andrzejowski

This study confirmed the presence of *B. stricta* in Atlantic Canada, where it is scattered but widely distributed in NB, NS, and PEI (Figure 3). Haines (2011) and Cayouette (1984) describe *B. stricta* as having invaded river shores, lake shores, and wet, disturbed areas in New England, and Quebec respectively, and it has mostly been collected from similar habitats in the Maritimes. Many *B. stricta* specimens examined in this study had morphology that was at the larger extremes for the species (as also reported in Al-Shehbaz 2010), which is potentially suggestive of genetic influence from the larger *B. orthoceras*. The morphology of these plants might also be explained by the founder principle (Mayr 1942) if North American populations happened to have been founded by unusually large individuals. The morphological similarity of *B. orthoceras* and *B. stricta* would make hybridization difficult to demonstrate without molecular investigation.

We failed to locate historical specimens of *B. stricta* in NS or PEI, suggesting it may have dispersed more recently to these provinces. However, it was introduced in NB as early as 1877 (*R. Chalmers 305a*; now the earliest Canadian record), where collections were misidentified as *B. orthoceras*, or more rarely as *B. vulgaris*. Early introduction of *B. stricta* and overlapping habitat requirements of *Barbarea* species suggests ample opportunity for hybridization in NB. However, because Hinds (2000) appears not to have considered *B. stricta* as a possibility in identifying NB material, his specimens of "intermediate morphology" between *B. vulgaris* and *B. orthoceras* may simply have represented *B. stricta*.

Barbarea verna (Miller) Ascherson

We referred one collection from Kentville, NS (*J.S. Erskine s.n.*) to Early Wintercress (*Barbarea verna* (Miller) Ascherson). Originally identified as *B. vulgaris*, it was distinguished by its leaves with five to seven pairs of lateral lobes, pinnatifid uppermost leaves, and conspicuously ciliate leaf auricles (Al-Shehbaz 2010; Haines 2011). In fruit, *B. verna* can also be distinguished by its large fruit (5.3–7 cm), and pedicels as broad as the fruit they subtend (Al-Shehbaz 2010). This European species is cultivated as a salad plant in North America, where it escapes to disturbed habitats such as fields and meadows (Mulligan 2002; Haines 2011). This represents the first Maritimes record of this rarely reported introduction, otherwise known in Canada only from Newfoundland and British Columbia (Brouillet *et al*. 2010+).

Voucher specimens

Barbarea orthoceras Ledebour—NEW BRUNSWICK: Charlotte Co., Grand Manan, Between Long Pond & Red Pt., weed along water-runs in old pasture, 6 August 1944, *C.A. Weatherby and U.F. Weatherby 7343* (CAN); Kings Co., Lower Millstream, roadside at Black Spruce forest edge, 28 May 1964, *P.R. Roberts & N. Bateman 64-361* (UNB); NOVA SCOTIA: Inverness Co., Pleasant Bay, Lower Delaneys Brook, 46.966519°N, 60.654339°W, steep, seepy ravine slope under shrubs, not seen elsewhere between High Capes & Delaneys Point, with Red-osier Dogwood (*Cornus sericea* L.), Tall Meadow-rue (*Thalictrum pubescens* Pursh), 14 July 2016, *C.S. Blaney 8978* (NSPM);

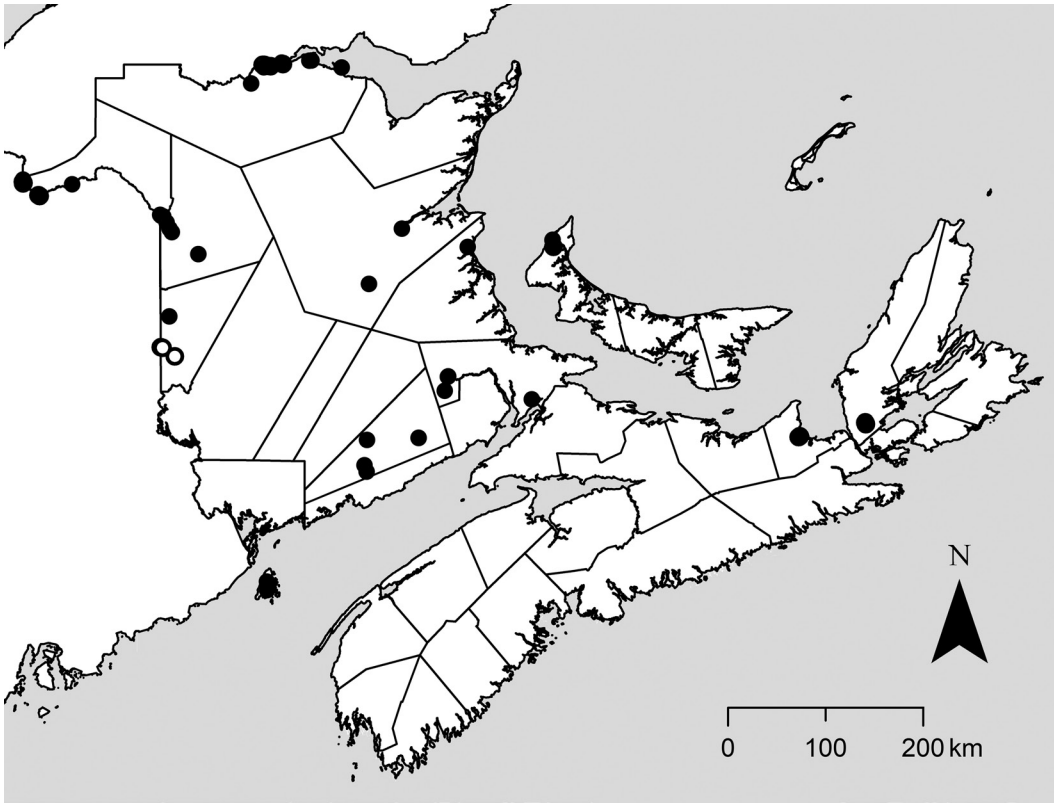

Figure 3. Distribution of the uncommon exotic species Small-flowered Wintercress (*Barbarea stricta*) in the Canadian Maritimes based on specimens (solid circles) and Atlantic Canada Conservation Data Centre photographic or sight records (hollow circles; the western sample is shown in Figure S3) determined, verified, or revised during the present study.

MAINE: Aroostook Co., Fort Kent, 8 July 1904, *G.U. Hay s.n.* (NBM).

Barbarea stricta Andrzejowski—NEW BRUNSWICK: Madawaska Co., St. Francis River, 47.182855°N, 68.896639°W, wet mud, in grassy meadow along shore of floodplain island, 11 July 2013, *D.M. Mazerolle DM4032* (NBM, UNB, DAO); Madawaska Co., St. Francis River, 47.285603°N, 69.050753°W, sandy riverbank with sparse alders, 9 July 2013, *C.S. Blaney & D.M. Mazerolle 8267* (NBM); Madawaska Co., St. Francis River, 47.276528°N, 69.049497°W, sandy-bouldery shore under Eastern White Cedar (*Thuja occidentalis* L.), 9 July 2013, *C.S. Blaney 8268* (NBM); Madawaska Co., St. Francis River, 47.26046°N, 69.050219°W, silty sand-gravel rivershore, 9 July 2013, C.S. Blaney 8270 (NBM); Restigouche Co., Campbellton, 20 July 1877, *R. Chalmers 305a* (CAN); Victoria Co., Grand Falls, 47.05527°N, 67.759561°W, 31 July 2018, *D.M. Mazerolle DM7808* (NBM); Restigouche Co., Heron Island, 47.9823°N, 66.11649°W, sandy hummocks, 29 September 1982, *H.R. Hinds 5798* (UNB); Restigouche Co., Eel River, 48.02520°N, 66.39349°W, gravel shore, 5 August 1982, *H.R. Hinds 5400* (UNB); Restigouche Co., Morrissey Rock, 47.983327°N, 66.832622°W, alongside railway tracks, 10 August 1965, *P.R. Roberts & B. Pugh 65-5384* (UNB); Restigouche Co., Restigouche River, 47.990321°N, 66.769302°W, sandy floodplain terrace above river bank, on island in upper estuary near head of tide, 18 September 2013, *D.M. Mazerolle DM4143* (NBM); Restigouche Co., Tidehead, 47.985532°N, 66.767721°W, silty bar in fresh tidal zone, 18 September 2013, *C.S. Blaney 8485* (NBM); Restigouche Co., Eel River, 48.023715°N, 66.412898°W, graminoid floodplain meadow on elevated terrace along brackish tidal river, 26 August 2015, *D.M. Mazerolle DM6967* (NBM, UNB); Restigouche Co., Upsalquitch River, 47.883333°N, 66.951000°W, 12 July 1957, *E.C. Smith 16312* (ACAD); Victoria Co., Arthurette, 46.81718°N, 67.43563°W, gravelly north shore, 27 July 1982, *H.R. Hinds 5361* (UNB); Victoria Co., Grand Falls, 47.059342°N, 67.778800°W, 31 July 2018, *C.J. Chapman 1152* (NBM); Victoria Co.,

Grand Falls, 47.064978°N, 67.788144°W, 31 July 2018, *C.J. Chapman 1158* (UNB); Northumberland Co., Upper Blackville Bridge, 46.629606°N, 65.865519°W, eroding sandy-gravel shore slope, 14 August 2007, *C.S. Blaney & D. Whittam 6646* (UNB); Northumberland Co., Beaubears Island, Miramichi, 46.978856°N, 65.561207°W, On open backshore of east point of island, 7 September 2005, *D. McLeod & C. Merrithew 5271* (UNB); Carleton Co., Big Presque Isle Stream, 46.424062°N, 67.703127°W, moist depression in densely vegetated weedy Balsam Poplar (*Populus balsamifera* L.)/Black Ash (*Fraxinus nigra* Marshall) floodplain, 7 July 2015, *D.M. Mazerolle DM6711* (NBM, UNB); Kent Co., Kouchibouguac NP, 46.86312°N, 64.95513°W, garbage dump, 11 June 1977, *B. Lyons & D. LaFontaine 564* (UNB, ACAD); Kings Co., Hatfield Point, 45.63523°N, 65.88335°W, rocky and gravelly shore, 28 June 1980, *H.R. Hinds 3234* (UNB); Kings Co., Hammond River, 45.471532°N, 65.9056750°W, rich soil in understorey of Silver Maple (*Acer saccharinum* L.) floodplain forest, on floodplain island, 23 August 2017, *D.M. Mazerolle DM7598* (NBM); Westmorland Co., North River, 46.038486°N, 65.138669°W, rich, silty upper river bank, 19 July 2017, *C.S. Blaney 9148* (NBM); Westmorland Co., North River, 46.041878°N, 65.135242°W, silty river bank, 19 July 2017, *C.S. Blaney 9153* (NBM); Westmorland Co., Petitcodiac River, 45.949465°N, 65.166692°W, muddy gravel river bar, 8 September 2017, *C.S. Blaney 9198* (NBM); NOVA SCOTIA: Antigonish Co., Antigonish Harbour, 45.659103°N, 61.895856°W, open, cattle-grazed White Spruce (*Picea glauca* (Moench) Voss) forest on gypsum at edge of saltmarsh, 30 June 2014, *C.S. Blaney 8575* (ACAD); Antigonish Co., Antigonish Harbour, 45.658474°N, 61.899508°W, muddy edge of brackish marsh, 30 June 2014, *C.S. Blaney 8578* (ACAD, NSPM, DAO, UNB); Inverness Co., Glenora, 45.742390°N, 61.293412°W, edge of rich shrubby floodplain terrace, 31 July 2015, *D.M. Mazerolle DM6879* (ACAD, NSPM, DAO); PRINCE EDWARD ISLAND: Prince Co., Miminegash River, 46.860973°N, 64.169513°W, forb and graminoid floodplain meadow, 28 July 2017, *D.M. Mazerolle DM7483* (ACAD, DAO).

Barbarea verna (Miller) Ascherson—NOVA SCOTIA: Kings Co., Kentville, sandy grassy slope, 22 May 1950, *J.S. Erskine s.n.* (NSPM).

Author Contributions

Writing—Original Draft: C.J.C.; Writing—Review & Editing: C.S.B., D.M.M., and C.J.C.; Conceptualization: C.S.B. and D.M.M.; Investigation: C.J.C.; Methodology: C.J.C.; Funding Acquisition: C.S.B., D.M.M., and C.J.C.

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Supplementary Material:

Figure S1. Bitter Wintercress (*Barbarea vulgaris*), with characteristic slender, relatively long stylar beaks (>1.5 mm long).

Figure S2. Small-flowered Wintercress (*Barbarea stricta*), with short and stout stylar beaks (<1.5 mm long) and appressed siliques.

Figure S3. Small-flowered Wintercress (*Barbarea stricta*), with dentate upper stem leaves and ciliate auricles.

Figure S4. Small-flowered Wintercress (*Barbarea stricta*), with relatively short petals (<4.5 mm long).

Figure S5. Large-fruit Wintercress (*Barbarea orthoceras*), with pinnatifid uppermost stem leaves. Specimen: National Herbarium of Canada, Canadian Museum of Nature (CAN 60422).