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NORTHERN RANGE LIMIT OF *OPUNTIA FRAGILIS* AND THE CACTACEAE IS 56°N, NOT 58°N

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ABSTRACT

Two of the most used sources for distributions of cacti (Cactaceae) indicate the family's northern range limit is either 58°N or 58°15′N for *Opuntia fragilis*. However these sources overstate the range limit by almost two degrees, an error that probably originated as a simple misreading of the latitude of Fort St. John. I discuss records of *O. fragilis* at and just south of 56°17′ N along the Peace River valley between Fort St. John, British Columbia and Peace River, Alberta, as well as why it is surprising but unlikely that specimens currently exist farther north. An error in latitude of 2° (223 km) in range can adversely affect ability to empirically estimate effects of climate change.

Key Words: Cactaceae, *Opuntia fragilis*, range, northern latitude, climate change.

Lyman Benson in *The Cacti of the United States and Canada* claimed that the most northerly population of *Opuntia fragilis* (Nutt.) Haw. was near Fort St. John, British Columbia, Canada at either 58°15′N (Benson 1982, p. 395) or 58°08′N (Benson 1982, p. 919), depending on whether you read the legend of his distribution map or the documentation in his appendix (Fig. 1). The specific locale was along the Beatton River, 8 km (5 miles) east-northeast of Fort St. John. The 13 km (07′) difference in latitudes between the two parts of his book seemed perplexing, motivating this manuscript.

Opuntia fragilis is well-known from collections near the Peace River as it flows east from Fort St. John, through the towns of Taylor, British Columbia (15 km southeast of Fort St. John), Clayhurst, British Columbia at the Alberta border (50 km east-southeast of Fort St. John), Dunvegan, Alberta (150 km east-southeast of Fort St. John), and Peace River, Alberta (250 km east of Fort St. John) at the confluence of the Peace and Smoky Rivers. Often *O. fragilis* is found growing right along the banks of the Peace River, e.g., 6.5 km west of Taylor, British Columbia (*James A. Calder & J. M. Gillett 24599* [24 May 1960] UBC-V-119569), never far from the Peace River or its tributaries (Felix Sperling, personal communication, 14 Nov 2014), except at the badlands of Kleskun Hills. Locales along the Peace River valley are at latitudes between 55°55′N (Dunvegan) and 56°17′N (Fort St. John). The latitude of 56°17′N is 205 km south of the 58°08′N northern limit listed by Benson (1982, p. 91) and 223 km south of the 58°15′N northern limit also listed by Benson (1982, p. 395). Thus, due to probably nothing more than a clerical error, Benson (1982) stated that Fort St. John and the northernmost locale for *O. fragilis* from just outside of that town were near 58°N, not 56°N. By contrast, I have no idea where Benson's discrepancy of 58°15′N versus 58°08′N arose from, even though this discrepancy got me looking at these problems.

The herbarium sheet that Benson (1982, p. 919) identified as containing "the northernmost cactus collection", *Calder & Gillett 24615* (25 May 1960) DAO-82237, does not explicitly include latitude or longitude coordinates, but merely states, "Occasional on steep open prairie slope above river at 900′. Along Beatton River about 5 miles ENE of Ft. St. John." Any error in identifying the latitude of this specimen undoubtedly occurred in subsequently looking up or transcribing the latitude of the town of Fort St. John. This flowering specimen not only has Lyman Benson's label, but also that of Bruce Parfitt, one of the two editors of the Cactaceae section of *The Flora of North America* (FNANM) (Parfitt and Gibson 2003). Parfitt and Gibson (2003) and Benson (1982) are the two volumes containing commonly cited distribution maps of *Opuntia fragilis* (also see Staniforth and Frego 2000).

The section on *Opuntia* in *The Flora of North America* (Pinkava 2003) seems to repeat Benson's (1982) error by showing the northern range limit of *Opuntia fragilis* at around 58°N. *The Flora of North America* does not report this latitude *per se* in the text, but graphically shows the latitude on the distribution map. I took a screen capture of the distribution map (http://www.efloras.org/object_page.aspx?object_id=13216&flora_id=1; accessed 13 August 2014), then measured how far along the straight portion of the Alberta-British Columbia border, which runs along the 120th meridian from 53°48′23″N to 60°N, that the

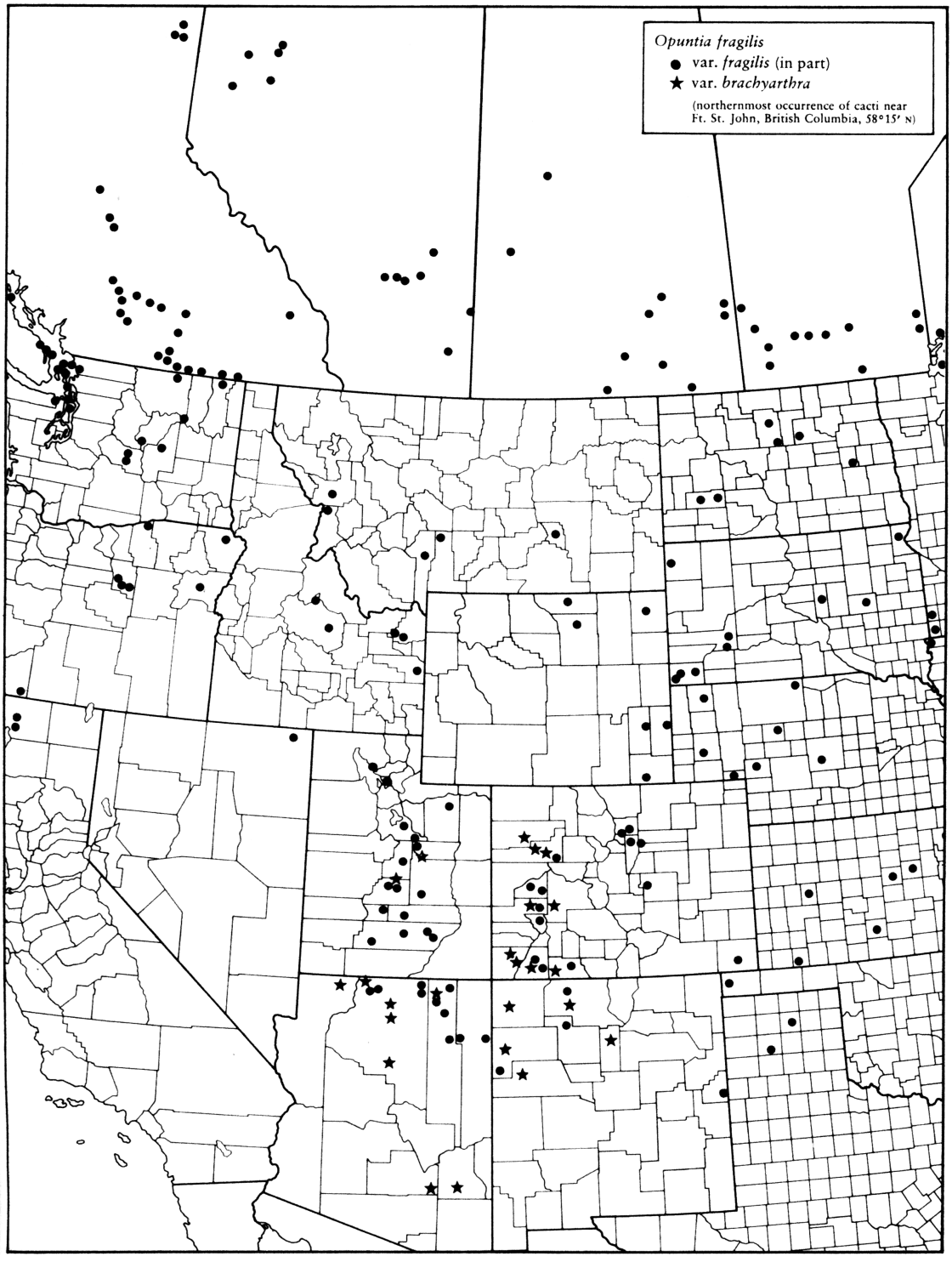

FIG. 1. Lyman Benson's (1982) distribution map of *Opuntia fragilis*, reproduced with permission of Stanford University Press. The eight northernmost dots are from the Peace River valley British Columbia and Alberta, Canada. This map does not show the eastern portion of the range, for which Benson provided a second map that included additional sites in Ontario (Canada), Minnesota (USA), Wisconsin, Michigan, Iowa, and Illinois, all of which are south of 50°N.

northern range limit appeared to be. The displayed range limit on that map is almost exactly 2° south of the Northwest Territories border, which lies at 60°N. Furthermore, the northern range limit on *The Flora of North America* distribution map seems to extend along a single latitude near 58°N, bisecting the Alberta-British Columbia border, albeit with a slight dip to the south at the provincial border, much as the Peace River does between the towns of Peace River and Fort St. John. And the east-west extent of the northern range limit on *The Flora of North America* distribution map is approximately 250 km, which is the distance between those two towns. Thus, in constructing the distribution map for *O. fragilis*, it seems that the author and editors of the *Opuntia* section of *The Flora of North America* relied on the northern range limit being around 58°N, which is wrong regardless of whether or not this information was erroneously gleaned from Benson (1982). This mean that the two most used sources to establish the northern range limit of the Cactaceae – namely Benson (1982) and Pinkava (2003) – are in error by 2° of latitude.

While not the focus of their works, other authors have also accepted Benson's (1982) erroneous northern limit of 58°N or 58°15′N for *Opuntia fragilis,* e.g., Nobel (1988), Boyle and Anderson (2002), and Ribbens (2008).

Hugo Cota-Sánchez (2002) examined many herbarium records and then wrote the definitive paper on Canadian cacti, albeit published in a small and relatively obscure journal. Cota-Sánchez (2002) recorded the correct coordinates for the most northern specimens of *Opuntia fragilis*, at 56°17′N, 120°39′W in the northeast outskirts of the town of Fort St. John. This is roughly halfway between Cecil Lake and the North Peace Regional Airport, probably just off of Cecil Lake Road. As Cota-Sánchez (2002) notes, the collection was *L.E. Pavlick & B. Taylor 79-717* (16 July 1979) V-98316, not the specimen that Benson (1982) had noted, namely *Calder & Gillett 24615* (25 May 1960) DAO-82237. My only complaints are minor regarding Cota-Sánchez's Table 1, in which he lists two herbarium specimens collected from around Fort St. John, V-98316 and V-92481, as being from Alberta (his table should say 'British Columbia'), and for the most northerly specimen, V-98316, Cota-Sánchez noted that it was located southwest of Cecile Lake (his table should say 'Cecil Lake' without the trailing 'e'). These are minor points, but there can be curious consequences of copying innocuous errors from seemingly reliable sources (Bruner 1942; Rekdal 2014a, b). Ezra Henry Moss (1959) in *Flora of Alberta* also correctly reported the northernmost latitude for *O. fragilis*, albeit from 250 km east of Fort St. John in the town of Peace River, Alberta at a locale that is negligibly farther south – approximately 2 km farther south – of the collection near Cecil Lake in Fort St. John. Moss personally collected the Peace River specimen: *E.H. Moss 6107* (17 July 1941) ALTA-12870. Table 1 lists all collections I could locate of *O. fragilis* north of Grand Prairie, Alberta, i.e., roughly from 55°N to the northern range limit at or near at 56°17′N. All of these herbarium records of *O. fragilis* in Table 1 are from the Peace River watershed and mapped on Figure 2. Figure 2 is meant as a detailed supplement to the far northern part of the distribution map provided by Benson (1982), which is reproduced herein with permission as Figure 1. The closest conspecifics to these are over 400 km away at Gibbons, Alberta, which is in the North Saskatchewan River watershed (*L.T. Lau* 44 [9 Sept 2005] ALTA-114639, Gibbons Echo Glen Park, near Sturgeon River; 53°50′N, 113°20′W) and slightly more distant locales in the Fraser River and Columbia River watersheds of British Columbia. Benson (1982) and Staniforth and Frego (2000) showed this disjunct distribution in the Peace River watershed, but Pinkava (2003) in *The Flora of North America* erroneously does not show this disjunction possibly because of the low-resolution of its range maps.

The disjunct habitat of *Opuntia fragilis* along the Peace River watershed is likely due to cacti largely needing grassland environments. The Peace River Grassland is separated from the grasslands of southern Alberta and the grasslands of the Fraser River valley of British Columbia by large swaths of forests (see figure 2 in Schmidt et al. 2014). The Peace River Grassland extends west to just beyond Fort St. John, south to Grand Prairie, and east to the town of Peace River. The northern extent of the Peace River Grassland is along the northern banks of the Peace River from just east of Fort St. John to Notikewin Provincial Park. The disjunct Peace River Grassland has been used to explain disjunct northern range limits of several plant and animal taxa (Strong and Hills 2003; Schmidt et al. 2014). Other disjunct grasslands exist further north, such as near Fort Vermillion on the Peace River (58°24′N, 116°03′W), High Level (58°30′N, 117°08′W), and the upper Yukon River valley of the southern Yukon, north of 60°N (Schmidt et al. 2014).

It is dangerous drawing inferences from negative results, but worth a try. The northern range limit of *Opuntia fragilis*, at and around 56°N along the Peace River, is bracketed by a pair of major highways: the Alaska Highway (British Columbia Highway 97) going north from Fort St. John and the Mackenzie Highway (Alberta Highway 35) going north from the town of Peace River. The Alaska Highway is the most-traveled road from southern Canada and the continental U.S. to Alaska and the Yukon. The

TABLE 1. COLLECTIONS OF *OPUNTIA FRAGILIS* NORTH OF 54°N. Herbaria: ALTA = University of Alberta; CAN = Canadian Museum of Nature; DAO = Agriculture Canada; SASK = University of Saskatchewan; UBC-V = University of British Columbia Vascular Plant Herbarium; V = Royal British Columbia Museum. A single asterisk (*) indicates that Benson (1982) examined this specimen. In June 2012, Andrew Gdaniec (personal communication, 3 Nov. 2014) recorded GPS coordinates for *O. fragilis* at Bear Flats as 56°17′N, 121°14′W (indicated with double asterisks [**]). Note that the spelling of ''Beatton'' has varied over time. The Beatton River, a.k.a. Beaton River, was named after Francis (Frank) Work Beatton (1865–1845), a fur trader for the Hudson's Bay Company at Fort St. John (British Columbia Geographical Names Office, n.d. (http://apps.gov.bc.ca/pub/bcgnws/names/2769.html), *inter alia* citing Harvey, 1945–1950). Further confounding matters, Frank Beatton's middle name has also been reported as ''Worth''. In the 1940s, his son (Frank Beaton, 1904–1973) and other family members supposedly altered the spelling of their surname to ''Beaton'' with a single 't' (Harvey 1945–1950). This table uses the currently accepted spelling ''Beatton River'', which is not necessarily the spelling on all herbarium labels. Estimated coordinates are based on Google Earth. These are my best estimates given information on herbarium labels. The northernmost latitude here of 56°18′N (V-24524) is the southernmost point on Cecil Lake, but that specimen might be from south of Cecil Lake, i.e., closer to 56°17′N. My estimate of 56°15′N for the ''high slopes N of town of Peace River'' (DAO-82222) is based on topography, where the highest slopes are in the northeast corner of town at around 490 m.a.s.l. The two specimens at the north side of the Beatton River crossing of Cecil Lake Road (V-34956 and V-54734) are possibly from the same locale. Localities are from specimen labels.

Locality	Estimated coordinates	Collector and collection number (collection date)	Herbarium and accession number
BC, Peace River area, Cecil Lake, near Fort St. John	56°18′N, 120°35′W	*T.B. Widdowson 5462* (6 July 1954)	V-24524
BC, Fort St. John, Beatton River, SW of Cecil Lake	56°17′N, 120°39′W	*L.E. Pavlick & E.B. Taylor 79–717* (16 July 1979)	V-98316
BC, Fort St. John, hill on N side of Cecil Lake [Road?] crossing of Beatton River	56°17′N, 120°44′W	*D.H. Calverley 185* (13 July 1958)	V-34956
BC, Beatton River breaks, E of Fort St. John on road to Cecil Lake, north side of river valley	56°16′N, 120°39′W	*T.C. Brayshaw 5329* (31 July 1976)	V-54734
BC, 5 miles ENE of Fort St. John	56°16′N, 120°39′W	*J.A. Calder & J.M. Gillett 24615* (25 May 1960)	DAO-82237*
BC, Fort St. John, Bear Flat	56°16′N, 121°10′W	*T.C. Brayshaw & C.C. Chuang 6092* (20 August 1976)	V-92481**
BC, Peace River, Alaska Hwy [near Fort St. John]	56°15′N, 120°′W	*H.M. Raup & D.S. Correll 11659* (5 Sept 1943)	CAN-280525
AB, high slopes N of town of Peace River	56°15′N, 117°17′W	*H. Groh 2792* (17 August 1946)	DAO-82222
AB, town of Peace River	56°14′N, 117°19′W	*E.H. Moss 6107* (17 July 1941)	ALTA-12870
AB, E of town of Peace River	56°14′N, 117°16′W	*N.A. Skoglund 934* (19 June 1973)	SASK-57111
AB, Peace River (town)	56°14′N, 117°18′W	*B. Heywood 206* (5 Aug 1971)	ALTA 39409
AB, Peace River, Smoky River Mission,	56°13′N, 117°17′W	*J. M. Macoun 59869* (7 July 1903)	CAN 81906*
BC, 4 miles W of Taylor Flats, N of railroad bridge	56°10′N, 120°45′W	*J.A. Calder & I. Kukkonen 26788* (10 July 1960)	DAO-82243*
BC, about 4 miles W of Taylor on N bank of Peace River	56°09′N, 120°43′W	*J.A. Calder & J.M. Gillett 24599* (24 May 1960)	DAO-82235*; UBC-V-119569; UBC-V-218942; V-051524
BC, Taylor Flat, N bank Peace River	56°08′N, 120°42′W	*H.M. Raup & E.C. Abbe 3586* (12 June 1932)	CAN-81916*
BC, Clayhurst, lot BC 2051 (I.B.P. Ecological Reserve)	56°08′N, 120°01′W	*T.C. Brayshaw 5329* (29 July 1969)	V-054735; UBC-V-218941
BC, Peace River breaks near Clayhurst Ferry	56°08′N, 120°05′W	*L.E. Pavlick & E.B. Taylor 79–519* (10 July 1979)	V-098317
BC, Clayhurst Crossing	56°07′N, 120°05′W	*A.A. Rose 78529* (2 July 1978)	UBC-V-163724
AB, Dunvegan, slopes of Peace River valley	55°55′N, 118°36′W	*B. Boivin & D. Dunbar 10568* (10 Aug 1954)	ALTA-22395; DAO-82216*
AB, Dunvegan, S slope of Peace River valley	55°55′N, 118°36′W	*E.H. Moss 7548* (20 July 1947)	ALTA-12868; DAO-82221*

TABLE 1. CONTINUED.

Locality	Estimated coordinates	Collector and collection number (collection date)	Herbarium and accession number
AB, Dunvegan, S slope of Peace River valley	55°55′N, 118°36′W	*E.H. Moss 7445* (21 July 1947)	ALTA-12869
AB, Watino, Smoky River, steep dry slope	55°43′N, 117°37′W	*E.H. Moss 7690* (1 Aug 1947)	ALTA-12867; DAO-82224*
AB, Watino	55°43′N, 117°37′W	*L.C. Marvin, D. Lebedyk, G. Bilodeau, R. Serbit 3349* (4 Aug 1988)	ALTA-97013
AB, Watino, Smoky River	55°43′N, 117°37′W	*A. G. Schwartz -1033* (14 Sept 1989)	ALTA-97600
AB, Kleskun Hill, NE of Grand Prairie, dry hillside, badland	55°15′N, 118°32′W	*E.H. Moss 8120* (18 June 1948)	ALTA-12866; DAO-82218*
AB, Kleskun Hills Natural Area, N of Grand Prairie	55°15′N, 118°31′W	*R.J. Bayer, L.C. Marvin, B.G. Purdy 89016* (2 July 1989)	ALTA-102929

Mackenzie Highway is the most-traveled road from southern Canada to the Northwest Territories. Given the amount of traffic on these two highways and that most botanical collections are made along or near roads, it is noteworthy that *O. fragilis* has never been documented north of 56°17′N. Under the tab labeled 'strengths', the Royal BC Museum's botany collection website (http://royalbcmuseum.bc.ca/nh-collections/botany-plants/; Royal BC Museum, n.d.) states, ''Regions of the province that can be easily accessed by road have been frequently visited by botanists over the last century, and are relatively well-represented in our collection. These regions include the southeast quarter of BC, the Alaska Highway corridor, Vancouver Island, and National and Provincial Parks.'' Both the Alaska and Mackenzie Highways provide seemingly suitable habitat for *O. fragilis*, especially the Mackenzie Highway as it passes through grasslands in the Notikewin River valley. The Alaska Highway remains just west of the Rocky Mountains from Fort St. John to Fort Nelson at 58°48′N. The Mackenzie Highway is parallel to and 10–15 km west of the Peace River from the town of Peace River to the town of High Level at 58°31′N. No specimens of *O. fragilis* have been collected nor even reported from either of these stretches of highway, despite decent herbarium collections from these locales. One of the anonymous reviewers wrote, ''collections from 1988 and 1989 from Watino and Kleskun Hills Natural Area were made during an expedition that continued up to BC, Alaska, NWT and the Yukon. No more northerly populations of *Opuntia* were collected.'' The Watino and Kleskun Hills collections are *L.C. Marvin, D. Lebedyk, G. Bilodeau, R. Serbit 3349* (4 Aug 1988) ALTA-97013 and *R.J. Bayer, L.C. Marvin, B.G. Purdy 89016* (2 July 1989) ALTA-102929, respectively, both of which are listed in Table 1. Provincial and federal park staffs usually have a great notion of their floras. However, there have been no collections nor reports of *O. fragilis* from Notikewin Provincial Park, at the confluence of the Notikewin and Peace Rivers, between 57°08′N and 57°19′N, i.e., 100–120 km north of the town of Peace River (Joyce Gould, personal communication, 13 Aug. 2014). Lack of *O. fragilis* is especially noteworthy because of the extensive grasslands (much of which is farmed) along the lower Notikewin River (Schmidt et al. 2014). For these reasons, it is unlikely that *O. fragilis* is present, let alone abundant, north of 56°17′N, at least near the Alberta-British Columbia border.

Given that in the Peace River watershed *Opuntia fragilis* is largely known from slopes and dry banks closely overlooking rivers, Table 2 provides a list of places northwest of Fort St. John where existing roads cross rivers, including the Beatton River, Halfway River, and Cameron River. These might be decent places to search for range extensions of the Cactaceae. Slopes of river valleys may provide suitable habitat for cacti because of lower density plant cover and draining of water and cold air. The Beatton River should be especially promising given the extensive grasslands surrounding it (Schmidt et al. 2014). It is possible that animals transport *O. fragilis* while traveling along riparian corridors. When leaving habitats of *O. fragilis*, I always check articles of clothing for hitchhiking cladodes, which readily abscise then attach to any clothing below ankle level, hence the common name 'brittle prickly-pear' and the specific epithet '*fragilis*' (see Figure 2 in Staniforth et al. 2002). *Opuntia fragilis* does not seem to have any specific edaphic requirements, growing quite well on slopes and flat areas, in sand and in clay, as well as on granitic outcrops, even growing in dense patches of moss and lichen (Moss 1959; Maw and Molloy 1980; Staniforth and Frego 2000; Cota-Sánchez 2002). *Opuntia fragilis* is so well hidden under thick mosses and lichens near Kaladar, Ontario that the easiest way for me to relocate plants is to walk barefoot. *Opuntia fragilis* also disperses asexually when cladodes (pads) detach,

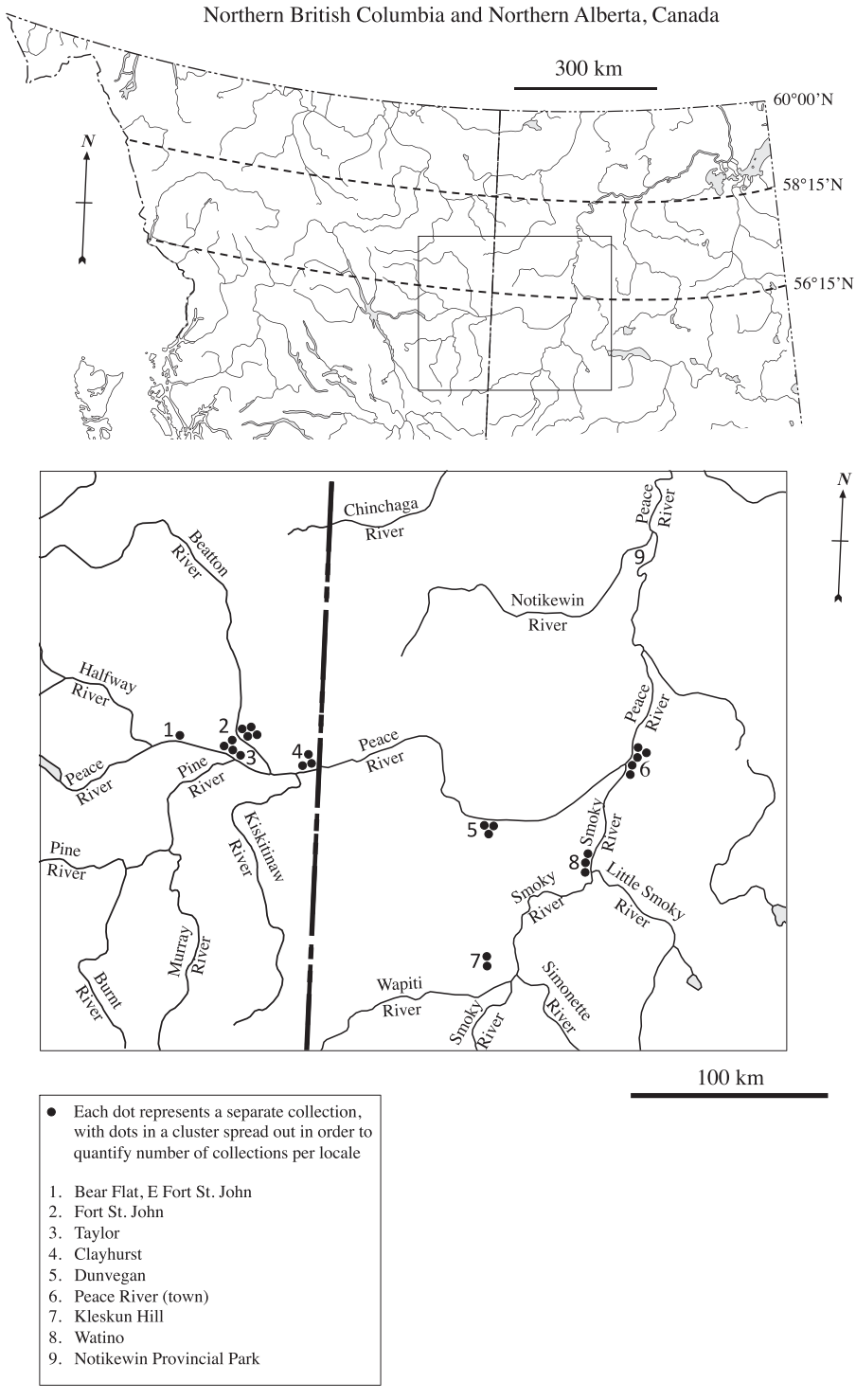

FIG. 2. Distribution map of *Opuntia fragilis* in the Peace River valley, from the herbarium records in Table 1. Underlying base map from *The Atlas of Canada* (http://atlas.gc.ca).

TABLE 2. POTENTIAL ROADSIDE HABITATS FOR *OPUNTIA FRAGILIS* NORTH (AND WEST) OF FORT ST. JOHN.

Locality		Coordinates
Beatton River road crossings:		
Beatton River Road (Mile 73 Road) crossing of Beatton River		57°17′N, 121°28′W
Tommy Lake Road (Mile 115 Road) crossing of Beatton River		57°17′N, 121°43′W
Mile 126 Road crossing of Beatton River		57°04′N, 122°08′W
Mile 135 Road parallels Beatton River		
	between	57°07′N, 122°17′W
	and	57°09′N, 122°18′W
Alaska Highway (BC 97) crossing of Beatton River		57°05′N, 122°35′W
Cameron River and Halfway River road crossings:		
Upper Halfway Road crossing of Cameron River		56°32′N, 121°48′W
Upper Halfway Road parallels Halfway River		
	between	56°30′N, 122°04′W
	and	56°28′N, 122°20′W

roll down riverside slopes, and eventually get carried downstream, where they later root near the high water mark (Frego and Staniforth 1985). Unless physically ruptured, detached *O. fragilis* cladodes had 100% survival and re-rooting after floating in an agitated flask of distilled water for 40 d (Frego and Staniforth 1985). This would explain the preponderance of records of *O. fragilis* along the Peace River watershed, implying that downstream dispersal is more common than upstream dispersal. However, specimens of *O. fragilis* have been documented upstream of the town of Taylor along both the Peace and Beatton Rivers, as well as upstream of the town of Peace River along both the Peace and Smoky Rivers. Nonetheless the lack of any records of *O. fragilis* downstream of the town of Peace River, i.e., to the north, is surprising, especially with no records from Notikewin Provincial Park. This virtually begs for a downstream canoe trip along the Peace River from the town of Peace River, searching for suitable habitats and cactus plants along the floodplain, possibly as far north as the grasslands around Fort Vermillion (58°24′N) and the grasslands along the lower Notikewin River (57°00′N–57°16′N).

There are conservation concerns for *Opuntia fragilis*, especially at what is almost the most northerly locale in the northern portions of Bear Flat, east of Fort St. John. If the Site C dam is constructed as planned on the Peace River in southwest Fort St. John, just downstream of the confluence of the Peace and Moberly Rivers, substantial potential habitats for *O. fragilis* will be destroyed. See the BC Hydro map (https://www.sitecproject.com/about-site-c/maps) for extent of flooding from this dam. Construction of the Site C dam won final approval by the British Columbia government on 15 December 2014. Not only will the Bear Flat population be inundated, but so will other potential habitats along the Peace, Moberly, and Halfway Rivers. This is of special concern because *O. fragilis* is only found very close to the Peace River and its tributaries this far north, with the only known exception being the Kleskun Hill plants at 55°15′N.

It is highly unlikely to find more northerly cacti far to the east of the Rocky Mountains simply because winters are colder and wetter in the Canadian prairies (see Agriculture Canada's cold hardiness maps at http://www.planthardiness.gc.ca/?m=1; Natural Resources Canada, n.d.). Benson's (1982) distribution map only includes one specimen from the prairies north of 52°N, which is from the vicinity of Battleford, Saskatchewan (town at 52°45′N, 108°20′W). Consistent with this, Hancock (2013) notes that the most northern cactus in Saskatchewan is *Opuntia fragilis* from just east of Battleford, which is also consistent with the distribution map in *The Flora of North America* (Pinkava 2003). The Canadian Rockies themselves are of sufficiently high elevation to lack cacti. But the Pacific coast of Canada and the Alaskan panhandle, with their moderate temperatures due to the Kuroshio Current, may, in theory, have specimens of *O. fragilis*, a species that is relatively common just above sea level near the U.S.-Canadian border along Puget Sound and the Strait of Georgia. Benson (1982, p. 397) stated that *O. fragilis* is "reportedly on rocky headlands of southernmost Alaskan islands in situations similar to those along Puget Sound, but not found there during a special search in 1959." Even if the southernmost islands in Alaska were to have *O. fragilis*, this would still be south of Fort St. John and the town of Peace River. The southernmost point in Alaska is on Dall Island at 54°40′N and even Ketchikan is at 55°22′N. Benson's (1982) distribution map shows *O. fragilis* along the east coast of Vancouver Island to approximately Campbell River. The most northern of the coastal herbarium records of *O. fragilis* is from Mitlenatch Island, British Columbia (*J.A. Calder & K.T. MacKay 30484* (14 June 1961) DAO-82236), at

49°57′N, which is at the confluence of Johnstone Strait and the Strait of Georgia, just east-southeast of Campbell River. Thus, while people have speculated about *O. fragilis* in coastal Alaska (see Benson's quote, above), the Yukon (Bernshaw and Bernshaw 1984), and even north of the Arctic Circle (Brethauer 2000), its occurrence in those places seems extremely unlikely.

It is important to correctly identify northern range limits so that they can provide crucial data for studies on climate change. There have been several studies using museum records of both plants and animals testing whether species have extended their ranges or altered their reproductive timing (phenology) in the face of warmer temperatures (e.g., Angert et al. 2011; Chen et al. 2011; Buizer et al. 2012; Panchen et al. 2012; Walker et al. 2012; Fisichelli et al. 2014). An error of either 205 km or 223 km in species range may not be huge for a bird or whale that can travel quickly. But for a diminutive cactus such as *Opuntia fragilis*, a range error of more than 200 km could falsely indicate that this species range is not affected by climate change. The range limit of *O. fragilis*, in particular, and cacti, in general, may eventually extend farther north with global climate change, but the current baseline for the range limit of *O. fragilis* should be 56°17′N.

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