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Kew Diploma Student, Course 48

The Merlin Trust Horticultural Grant Report

Hunting Hardy Cacti in the Wilderness of Canada

27/05 - 17/06.2012

Travel Scholarship Report 2012

ROYAL BOTANIC GARDENS, KEW

SCHOOL OF HORTICULTURE

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3. Acknowledgements

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Hardy Plant Society, The Kenneth Black Bursary Scheme Committee

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The Alpine Garden Society Travel Award Committee

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The Kew Guild Award Scheme Committee

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Ken Hancock, private collector, author of the book: A review of the distribution of the native cacti of Canada.

4. Introduction

The following report summarises the three week travel scholarship I undertook to Canada. This trip was made with emphasis on studying wild specimens to better understand how one might cultivate them as interesting additions to a horticultural collection. It involved travelling through the wilderness of Canada for 3 weeks in May and June 2012 (Fig.1). I was fortunate to be joined by Mats Hjertson, Curator of the Museum of Evolution, Uppsala University, Sweden.

During the study trip I also took advantage of the opportunity to visit the University of British Columbia Botanical Garden & Centre for Plant Research, Vancouver and the Royal Botanical Gardens, Burlington where I was able to gather valuable information about the gardens themselves as well as data on succulents.

The report provides information on the Canadian cacti, includes an itinerary of travel and an outline of the benefits to the author. An overview of costs and expenditure are also presented.

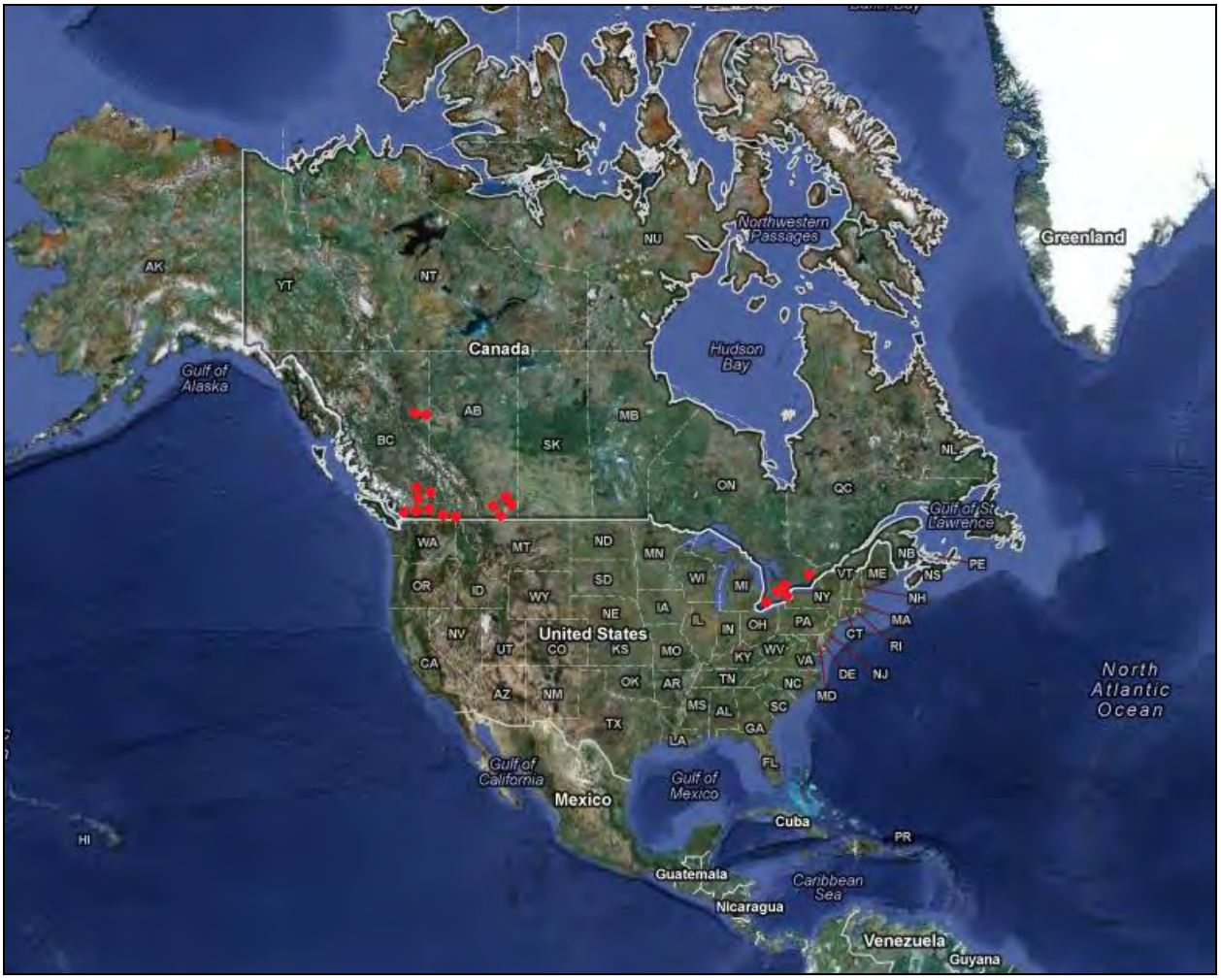


Figure 1. Map of Canada indicating the areas visited [http://maps.google.co.uk].

5.1. Aims

- To expand the knowledge of hardy cacti by observing them in their natural habitat.
- To observe cultivation techniques of Canadian cacti in Botanical Gardens to increase my personal knowledge and increase available knowledge for RBG, Kew.
- To establish a relationship and improve collaboration with other botanical institutions such as University of British Columbia Botanical Garden & Centre for Plant Research, Vancouver and Royal Botanic Gardens, Burlington, Ontario.
- To gain knowledge and personal experience in an area which I have long found interesting and to make contacts which may be beneficial for the future and especially career opportunities.
- To assemble a good photographic record.
- To gain experience in field botany, recording and conservation work.

5.2. Objectives

- To observe a range of target species of *Opuntia* and *Escobaria* in their natural habitats and try to identify potentially successful species to grow at Botanical Gardens.
- To establish connections to other Botanic Gardens for future research possibilities.
- To discuss and record cultivation techniques to increase the species diversity of collections in Botanic Gardens.
- To research further into association planting to assist in improving collections, to benefit the garden aesthetically and to improve public knowledge of Canadian cacti.
- To collect information to assist the dissertation in year three.

6. Itinerary

Table 1. Travel Scholarship Itinerary.

Day	Date	Activity
1	27/05/12 Sunday	Fly to Vancouver from London Heathrow. Overnight in Vancouver.
2	28/05/12 Monday	Fly to Fort St. John from Vancouver. Pick up rental car. Visit the location near Bear Flat, observe and record *Opuntia fragilis.* Overnight in Fort St. John.
3	29/05/12 Tuesday	Visit the population of *O. fragilis* near Clayhurst bridge. Visit a population of *O. fragilis* near Taylor. Overnight in Fort St. John.
4	30/07/12 Wednesday	Return rental car. Fly to Vancouver from Fort St. John. Processing collected data, and pictures. Overnight in Vancouver.
5	31/05/12 Thursday	Visit the University of British Columbia Botanical Garden & Centre for Plant Research. Meet staff and have tour of gardens. Pick up rental car. Overnight in Vancouver.
6	01/06/12 Friday	Start cactus expedition to Thompson-Nicola region British Columbia with Brent Hine. Visit location with alpine flora on west, moist slops near Hope. Visit location of *Opuntia x columbiana* near Lytton. Overnight in Lytton.
7	02/06/12 Saturday	Explore populations of *O. x columbiana* near Spencers Bridge, Spatsum, Ashcroft and Cache Creek. Overnight in Cache Creek.
8	03/06/12 Sunday	Explore populations of *O.xcolumbiana* in the Juniperus Beach Provincial Park, near Caraquile Loon Lake. Overnight near Pavilion Lake.
9	04/06/12 Monday	Drive through the Rocky Mountains on Highway No1 to Bassano. Overnight in Bassano.
10	05/06/12 Tuesday	Explore populations of *O. polyacantha* and *Escobaria vivipara* in the Dinosaur Provincial Park, near Chin Lake and Milk River. Overnight in Fort Macleod.
11	06/06/12 Wednesday	Drive on Highway No3 to Christina Lake. Overnight in Christina Lake.
12	07/06/12 Thursday	Explore populations of *O.fragilis* in the Gilpin Grasslands Provincial Park, the Boundary Creek Provincial Park and Kettle River Provincial Park. Overnight in Christina Lake.
13	08/06/12 Friday	Drive west on Highway No3. Explore populations of *O.fragilis* in the Osoyoos, Keremeos and Princeton. Overnight in Princeton.
14	09/06/12 Saturday	Drive on Highway No3 to Vancouver. Return rental car. Overnight in Vancouver.
15	10/06/12 Sunday	Fly to Toronto from Vancouver. Pick up rental car. Travel to Burlington. Overnight in Burlington.
16	11/06/12 Monday	Visit RBG, Burlington. Meet staff and have tour of gardens. Overnight in Burlington.
17	12/06/12 Tuesday	Visit several conservation areas around Toronto. Overnight in Burlington.
18	13/06/12 Wednesday	Drive to the Point Pelee National Park, Ontario to observe and record *O. humifusa,* the southern most mainland point in Canada and the prime location of this species. Drive back to Burlington. Overnight in Burlington.
19	14/06/12 Thursday	Drive to Kaladar and observe and record the easterly most locations of *O. fragilis*. Visit private collection of hardy cacti in Kingston own by Paul Chafe Overnight in Kingston.
20	15/06/12 Friday	Travel back to Toronto.
21	16/06/12 Saturday	Visit the Niagara Falls, the Niagara Falls Botanical Gardens and School of Horticulture and Niagara Glen Natural Reserve.
22	17/06/12 Sunday	Fly to London from Toronto.

7. General Information

7.1. Geography

Canada is a North American country consisting of ten provinces and three territories (Fig.2). Located in the northern part of the continent, it extends from the Atlantic Ocean in the east to the Pacific Ocean in the west and northward into the Arctic Ocean. It is the world's second largest country by total area, which covers 9,984,670 km^2 (3,855,103 sq. mi) and a panoply of various geoclimatic regions. Canada also encompasses vast maritime terrain, with the world's longest coastline of 202,080 kilometres (125,570 mi). The physical geography of Canada is widely varied. Boreal forests prevail throughout the country, ice is prominent in northerly Arctic regions and through the Rocky Mountains, and the relatively flat Canadian Prairies in the southwest facilitate productive agriculture. The Great Lakes feed the St. Lawrence River (in the southeast) where lowlands host much of Canada's population.

Figure 2. Map of Canada, with provinces and major city names.

7.2. Climate

Canada is often associated with cold weather and snow, but in reality, its climate is as diverse as its landscape. Generally, Canadians enjoy four very distinct seasons, particularly in the more populated regions along the US border. Daytime summer temperatures can rise to 35°C and higher, while lows of -25°C are not uncommon in winter. More moderate temperatures are the norm in spring and fall. Summers can be hot and dry on the prairies, humid in central Canada, and milder on the coasts. Spring is generally pleasant across the country. Autumns are often crisp and cool, but brightened by rich orange and red leaves on trees. Winters are generally cold with periods of snow, although they are mild and wet on the west coast, in cities such as Vancouver and Victoria.

7.3. Vegetation of Canada

Canada's vegetation is very diverse – ranging from warm temperate grasslands and forests, to cool boreal and mountain forests, to cold treeless arctic and alpine tundra, to freshwater and marine aquatic vegetation. According to Benson (1982) in Canada cacti are found in the American northern forest, the Pacific lowland forest, the Pacific montane forest, the palouse prairie and the great plains grassland floristic associations.

7.4. Cactaceae in Canada

The cactus family includes remarkable plants with several morphological and physiological adaptations that enable them to survive the harsh Canadian winters. Unlike most flowering plant families that have fairly narrow ranges of distributions in terms of environment and latitude, the Cactaceae are distributed over a wide range of environments that include the humid, wet tropics the tropical and temperate deserts, and the cold sub-arctic regions of Canada and Patagonia. A Canadian Plant Hardiness Zone Map is provided in Appendix 7. Loosely speaking, Canadian cacti are found in Zone 3 and above. The extreme low temperatures that can be tolerated for Canadian species vary from -48°C in *Opuntia fragilis,* to -25°C in *Opuntia humifusa*, to -18°C in *Opuntia polyacantha*, and -22°C in *Escobaria vivipara* (Cota-Sanchez, 2002).

The cacti of Canada include five taxa: *Escobaria vivipara, Opuntia fragilis, O. humifusa,* and *O. polyacantha* and a natural hybrid *O. x columbiana* (Fig.3). Although they are widely distributed in the southern portion of the country, some species are rare or uncommon at the provincial level, e.g., *E. vivipara* in Saskatchewan and *O. polyacantha* in British Columbia. *O. humifusa* is listed as rare at the national level but is common in the U.S (Table 2; Fig. 4).

Figure 3. A - *E. vivipara* growing near Milk River; **B** - *O. humifusa* growing in Point Pelee; **C** - *O. fragilis* growing near Kaladar; **D** - *O. polyacantha* growing in Dinosaur Provincial Park; **E** - *O. x columbiana* growing near Cache Creek (Photos: A.Gdaniec).

Table 2. Number of locations for each species according Hancock, 2002. In brackets are the number of locations visited during the Travel Scholarship.

	BC	AB	SK	MB	ON	Total locations
Escobaria vivipara	1 **(0)**	26 **(5)**	77 **(0)**	20 **(0)**	---	124 **(5)**
Opuntia fragilis	64 **(9)**	19 **(3)**	47 **(0)**	44 **(0)**	10 **(1)**	184 **(13)**
Opuntia humifusa	---	---	---	---	9 **(1)**	9 **(1)**
Opuntia polyacantha	6 **(0)**	56 **(5)**	56 **(0)**	5 **(0)**	---	123 **(5)**
Opuntia x columbiana	8 **(10)**	---	---	---	---	8 **(10)**
Provincial total	**79**	**101**	**180**	**69**	**19**	**448**

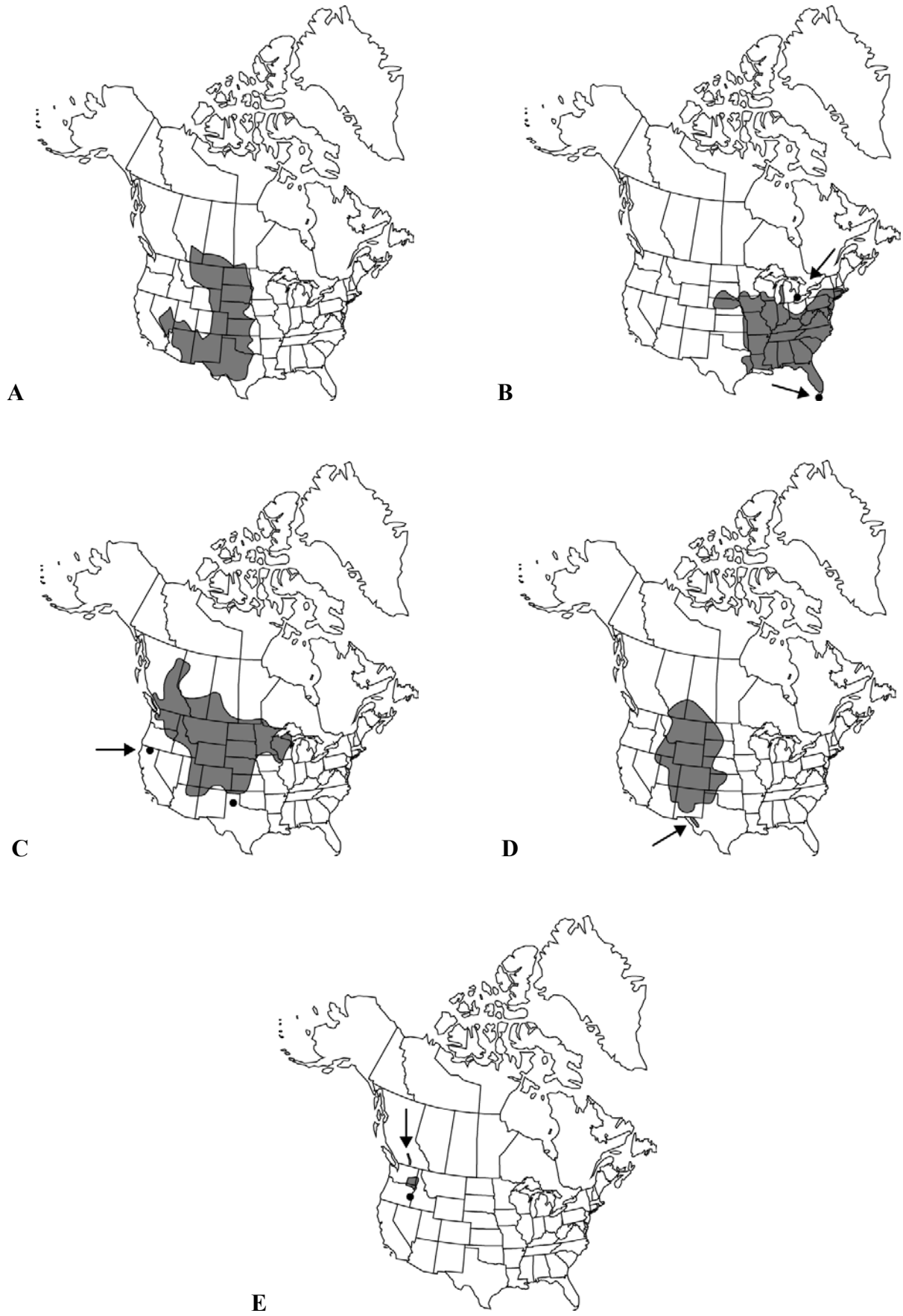


Figure 4. Maps of species distribution in North America: **A -** *E. vivipara*; **B** - *O. humifusa*; **C** - *O. fragilis*; **D** - *O. polyacantha*; **E** – *O. x columbiana* (Parfitt and Gibson, 2004).

8. Work program

8.1. Fort St. John – the north most location of Cactaceae family

Canada's westernmost province, British Columbia, while commonly considered to be wet and temperate and unlikely to be home to indigenous cacti, in fact has many regional climates.

In the dry, warm inland areas in the southern part of the province it is not surprising that cacti are aboundant. What is perhaps more unexpected is that one cactus species also occur in the far north of the province in the Fort St. John area, where my trip began.

I arrived in Vancouver on Sunday, 27th of May and then flew on to Fort Saint John. I was keen to see the northern most location of the family Cactaceae. Within a period of two days I managed to see three main populations of *Opuntia fragilis* in this area (Fig. 5). *O. fragilis* is a small prickly pear cactus that is widely distributed across North America. This species propagates primarily by detached stem segments that are dispersed by animals, by gravity and by floating in swollen streams following snowmelt.

In the Fort St. John area cacti grow on the sandy-soil upland prairies, on the south facing slopes. They experience a cold humid continental climate (extremely close to a subarctic climate), encompassing frigid winters (min. temperature -47°C) and warm summers (max. temperature 34°C). A predominately south westerly strong wind blows constantly through prairies.

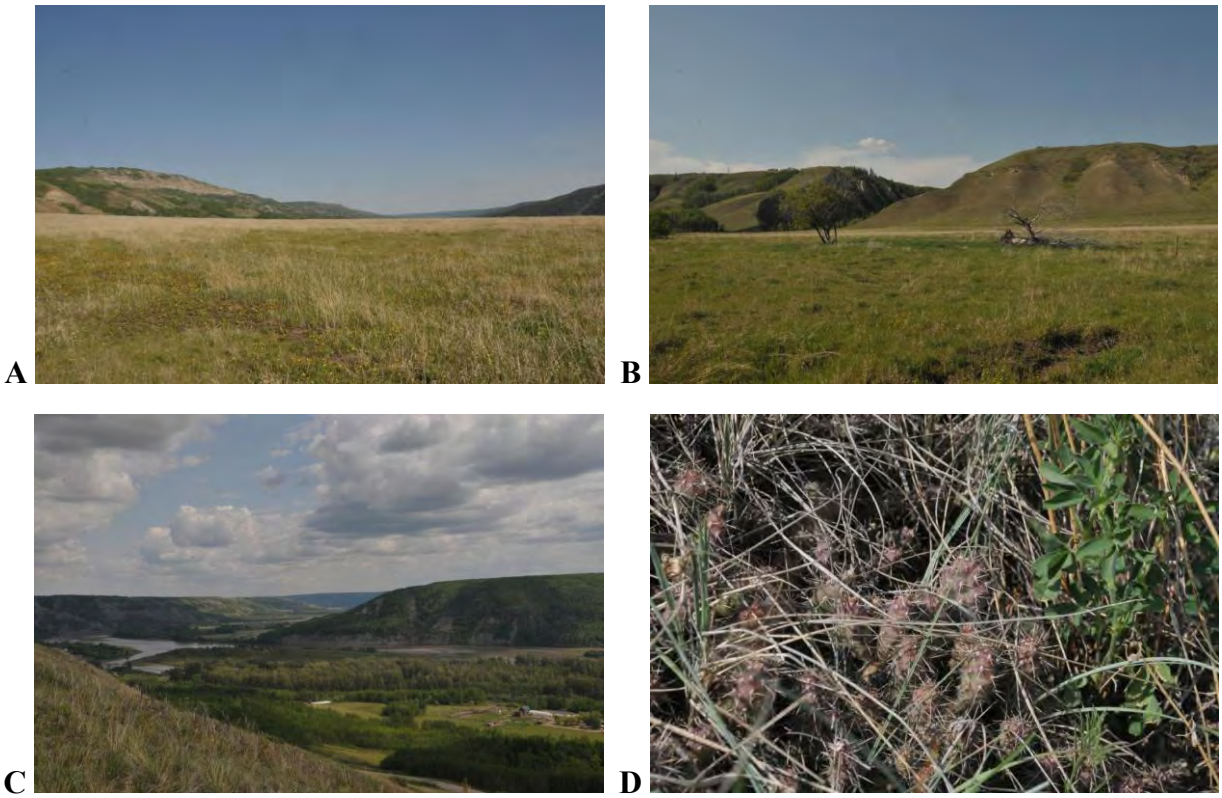


Figure 5. Habitats of *O. fragilis* near Peace River: **A-B** – Bear Flat; **C** – Fort St. John, Old Fort Road; **D** – *O. fragilis* near Clayhurst Bridge (Photos: A. Gdaniec).

8.2. UBC Botanical Garden & Centre for Plant Research

UBC Botanical Garden, at the University of British Columbia, was established in 1916 under the directorship of John Davidson, British Columbia's first provincial botanist. It is the oldest botanical garden at a university in Canada. The garden measures approximately 44 hectares (110 acres) and includes over 8000 different kinds of plants. Gardens include an Asian garden, an alpine garden, a native plants garden, a food garden and a physic (medicinal) garden (Fig. 6).

A   B

C   D

Figure 6. A-D – UBC Botanical Garden (Photos: A. Gdaniec).

During the visit I concentrated on the E.H. Lohbrunner Alpine Garden, where I was honoured to meet Curator Brent Hine. He kindly made himself available and showed me amazing collections of native cacti. The other particularly interesting place for me was the Herbarium, where I had the opportunity to see the dry specimen collection of Canadian cacti (Fig. 7). Data gathered in the Herbarium was extremely helpful for planning our cactus expedition.

A   B

Figure 7. A-B – Herbarium in UBC Botanical Garden & Centre for Plant Research (Photos: A. Gdaniec).

8.3. Thompson-Nicola region – problematic taxon

Very early in the morning on Friday 1st of June we left Vancouver and travelled east towards Thompson-Nicola region. First stop was the Coquihalla Canyon Provincial Park, next to Hope. The park is characterised by fantastic rock cliffs and very rich alpine flora (Fig. 8).

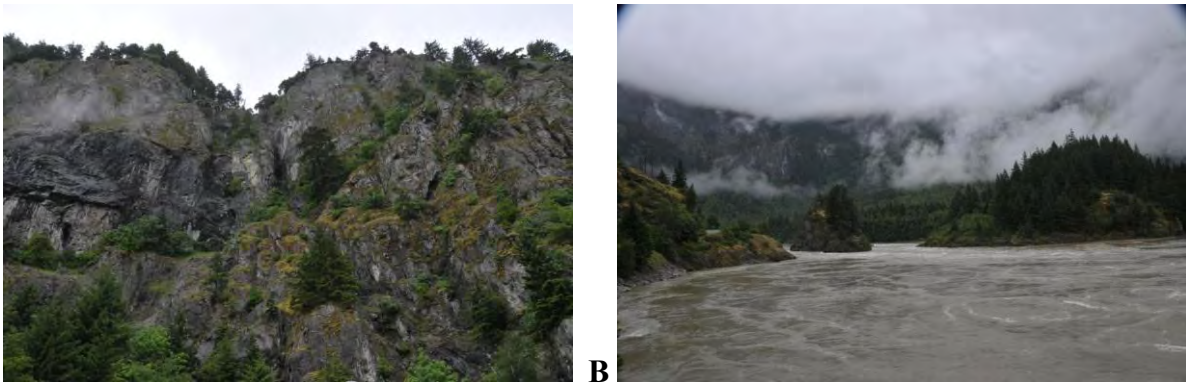


Figure 8. A-B – The Coquihalla Canyon Provincial Park, moist alpine habitats near Hope (Photos: A. Gdaniec).

After a short walk around we continued our trip north to the Thompson-Nicola Region. The southern part of this region has a semi-desert climate, with barren hillsides (Fig. 9). It experiences a dry and more continental climate because the Coastal Mountains act as a barrier to the westerly flow of moist air. The summer temperatures usually are around 30°C and occasionally rising above 40°C. The lowest recorded temperature in this area was -40°C.

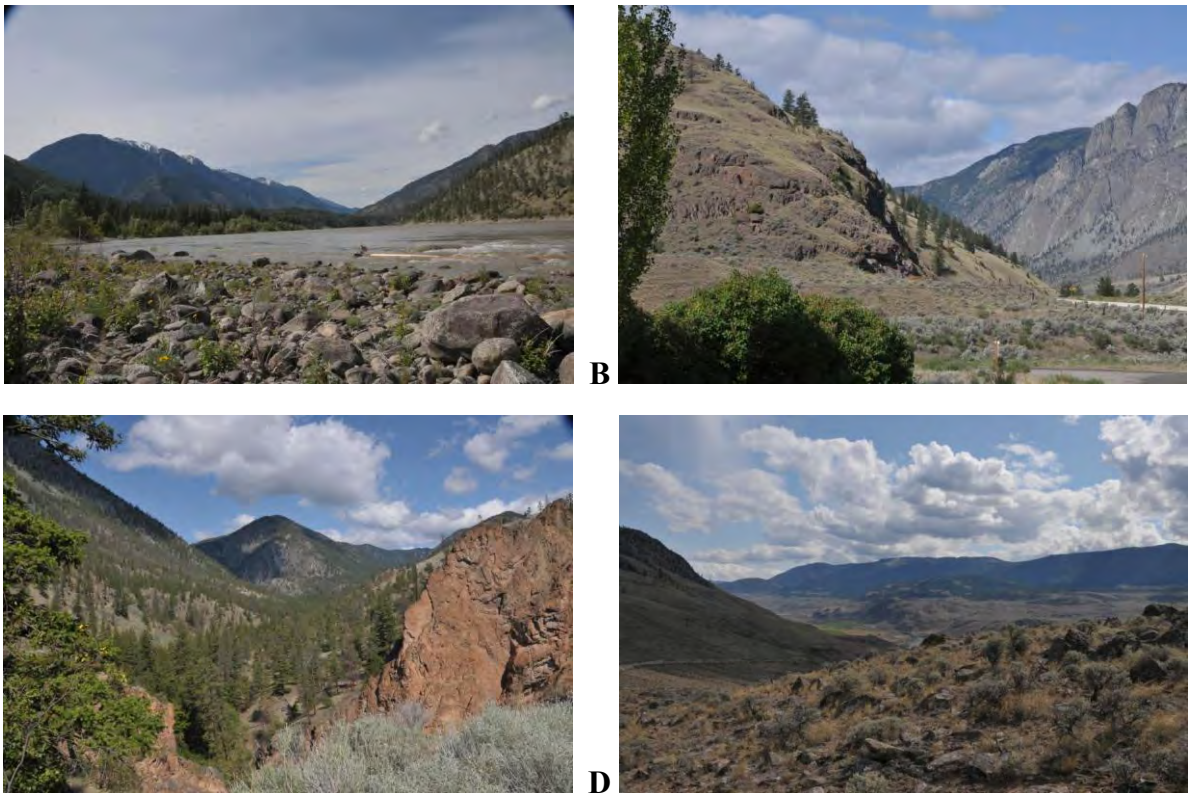


Figure 9. Habitats of *O. x columbiana*: **A** – near Lytton; **B** – near Spences Bridge; **C** – in the Epsom Provincial Park; **D** – near Ashcroft (Photos: A. Gdaniec).

This is perfect habitat for *Opuntia x coulmbiana*, which spreads north in a narrow band from the Columbia River area of the State of Washington, USA to Spences Bridge, BC. I spent 3 days in the Thompsn-Nicola Region and had the opportunity to explore 10 cactus locations. We had not expected to find the species near Lytton and managed to do this thanks to local people. We saw very rich populations near Ashroft, Caraquile and in the Juniperus Beach Provincial Park.

This species is extremely variable with pads ranging from small, narrow to big and broad, with a wide variety of spines colours and lengths. It often forms large mats on sunny south-facing slopes (Fig. 10).

O. x coulmbiana, is a very problematic taxon. Many authors suspect that this species is a natural hybrid between *O. fragilis* and *O. polyacantha*. At present the second parent does not grow in British Columbia Province and because of a lack fossil data we can not prove that it ever did. All plant reported in British Columbia as *O. polyacantha* are only one of forms of *O. x coulmbiana*. Interestingly both parents grow together in Alberta Province but do not produce hybrids. This taxon needs detailed genetic research.

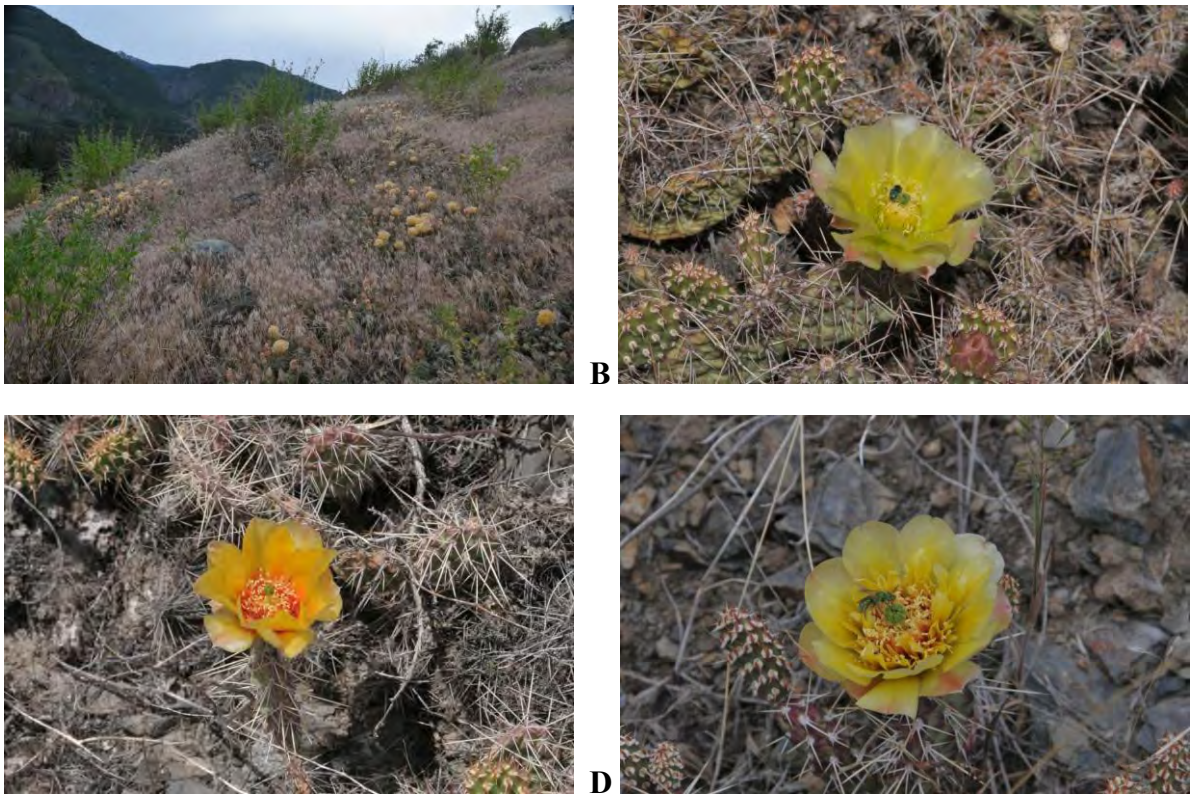


Figure 10. A – *O. x columbiana* population near Lytton; **B** – Yellow flowered *O. x columbiana* near Ashcroft; **C** – Orange flowered *O. x columbiana* in Ashcroft; **D** – Double flowered of *O. x columbiana* with pollinator near Hat Creek (Photos: A. Gdaniec).

8.4. Alberta Province – hunting *Opuntia polyacantha* and *Escobaria vivipara*

On 4th of June Mats and I started to travel east to Alberta Province. The plan was to see natural populations of *Opuntia polyacantha* and *Escobaria vivipara*. The journey through the Rocky Mountains was very scenic (Fig. 11) and it is incredible how suddenly landscape changes into the Great Plains (Fig. 12).

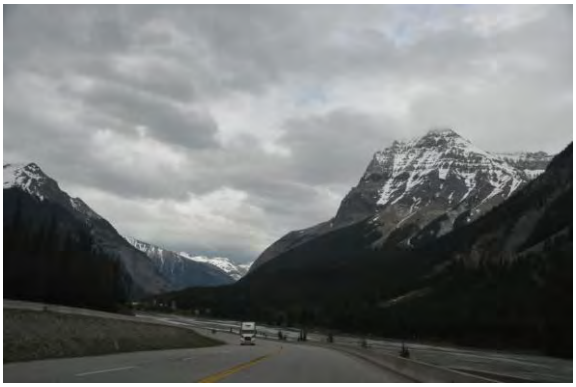
A  B 

Figure 11. A-B – Highway No 1 (Photos: A. Gdaniec).

A  B 

Figure 12. A-B – Great Plains in Alberta Province (Photos: A. Gdaniec).

The North American grasslands, or Great Plains, extend from Mexico, across the U.S., and into the three Canadian prairie provinces: Alberta, Manitoba and Saskatchewan. The northern portion of this vast ecoregion is referred to as the Northern Great Plains and covers more than 720,000 km^2. Because temperate grasslands are particularly suitable for agriculture, an estimated 99 percent of the grassland landscape is either under cultivation or livestock grazing. Diverse glacial landforms, permanent and intermittent wetlands, badlands, sand dunes, and river valleys with coulees, ravines, and cottonwood forests create a diverse landscape.

Southern Alberta, which we visited, has a dry continental climate with warm summers and cold winters. The province is open to cold arctic weather systems from the north, which often produce extremely cold conditions in winter. Arctic air masses in the winter produce extreme minimum temperatures up to −46°C. In the summer, continental air masses produce maximum temperatures reaching as much as 40°C. The climate is also influenced by the presence of the Rocky Mountains to the southwest, which disrupt the flow of the prevailing westerly winds and cause them to drop most of their moisture on the western slopes of the mountain ranges before reaching the province,

casting a rain shadow over much of Alberta. The cold winters are frequently interrupted by warm, dry chinook winds blowing from the mountains, which can propel temperatures upward from frigid conditions to well above the freezing point in a very short period. This area is the most likely region in Canada to experience tornadoes and thunderstorms, which we witnessed during our time there (Fig. 13).

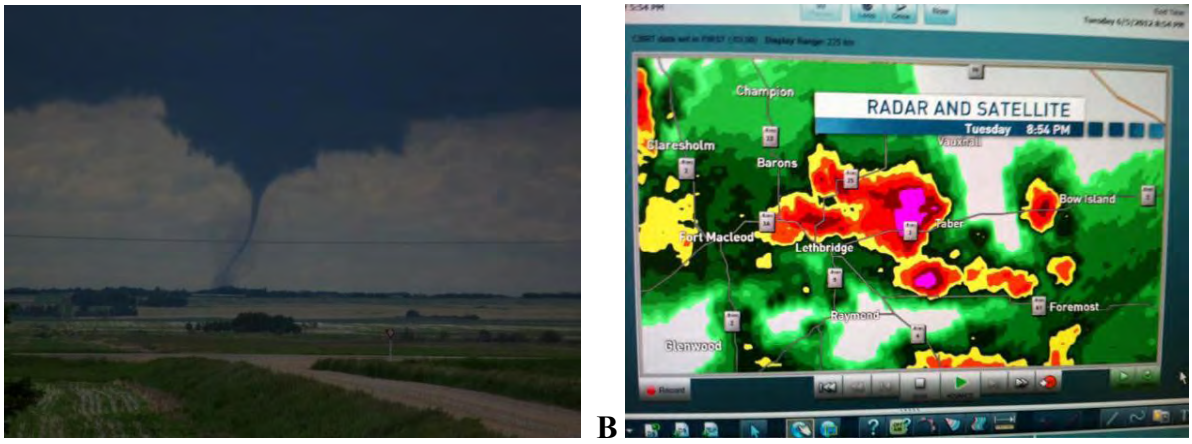


Figure 13. A – Tornado near Taber; **B** – Tornado warning [http://www.weatheroffice.gc.ca] (Photos: A. Gdaniec).

We found *E. vivipara* and *O. polyacantha* in two major locations: the Dinosaur Provincial Park and the Writing-On-Stone Provincial Park next to Milk River. Both habitats are noted for their striking badland topography (Fig. 14). A badland is a type of dry terrain where softer sedimentary rocks and clay-rich soils have been extensively eroded by wind and water. They are often difficult to navigate by foot.

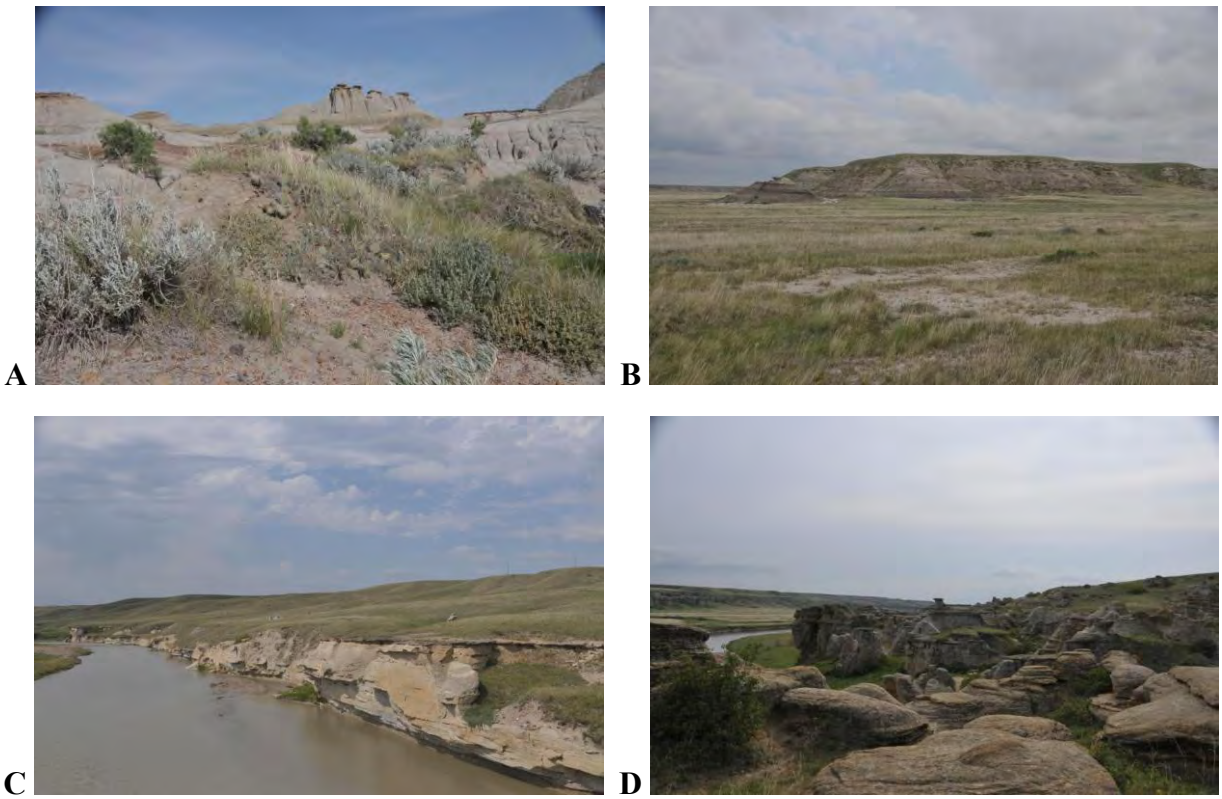


Figure 14. Habitats of *E. vivipara* and *O. polyacantha* **A** – in the Dinosaur Provincial Park; **B** – near the Poverty Rock; **C** – near Milk River, Weir Bridge; **D** – in the Writing-On-Stone Provincial Park (Photos: A. Gdaniec).

The Dinosaur Provincial Park, UNESCO World Heritage Site, is situated in the valley of the Red Deer River. The park is well known for being one of the richest dinosaur fossil locales in the world. The Writing-On-Stone Provincial Park is one of the largest areas of protected prairie in the Alberta, and serves as a nature reserve and protects a large number of aboriginal rock carvings and paintings.

O. polyacantha is a common species known by the common name plains prickly pear. It is well-distributed in Canada being found in Alberta, Saskatchewan and, as has recently been confirmed, in Manitoba. It is a low growing and spreading plant. The pads are flat and bright green. The spines are variable in number and colour. Unfortunately we were to early too see flowers (Fig. 15A-B).

E. vivipara (beehive cactus, pincushion cactus) is native to North America, where certain varieties can be found from Mexico to Canada. This is a small, globular cactus growing to a maximum height of about 15 centimetres. It is densely covered in a mat of star-shaped arrays of straight white spines. The flowers vary from bright crimson to rosy pink. We were told that fruits are very sweet and can be eaten fresh or used for jam (Fig. 15C-D).

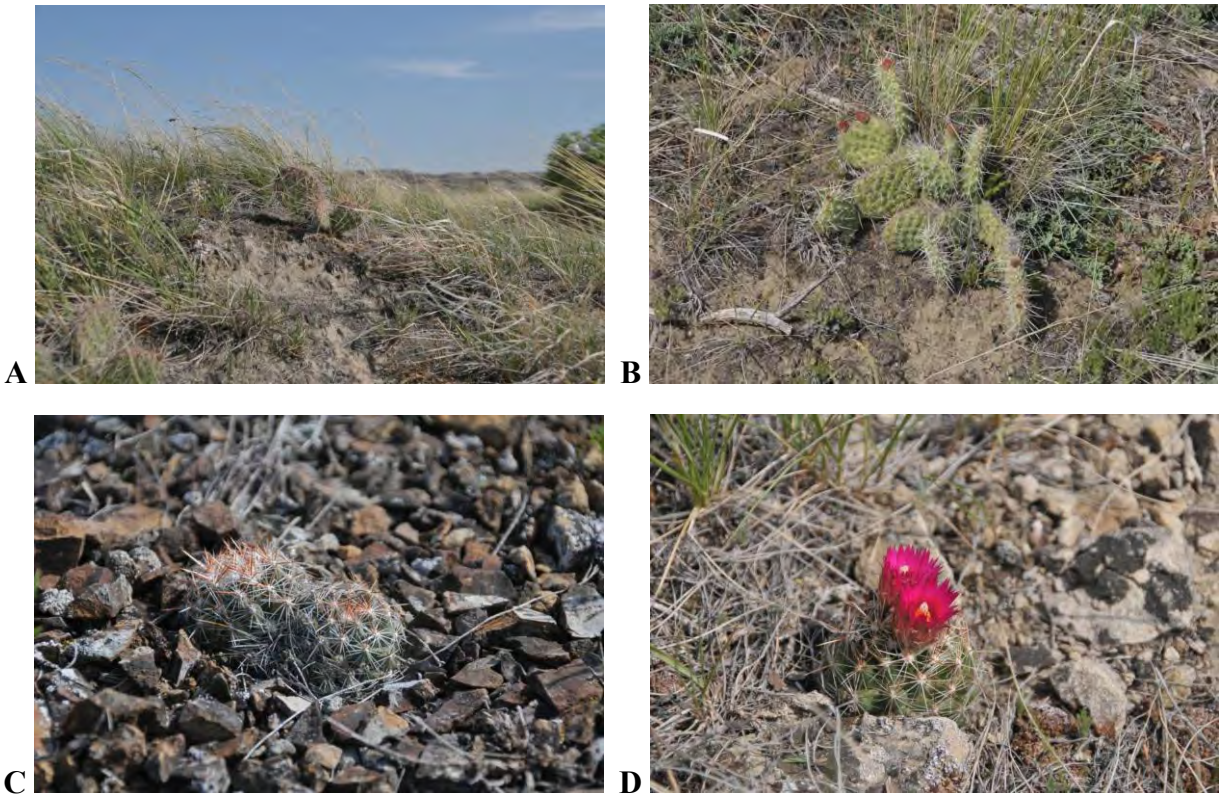


Figure 15. A – *Opuntia polyacantha* in the Dinosaur Provincial Park; **B** – *Opuntia polyacantha* near Poverty Rock; **C** – *Escobaria vivipara* in the Dinosaur Provincional Park; **D** – *Escobaria vivipara* near Milk River, Weir Bridge (Photos: A. Gdaniec).

8.5. Christina Lake/Christian Valley

On Wednesday 6th of June we drove back to Vancouver using Highway No 3. We did not expect that we would be stuck for three hours in a traffic jam because of a snowstorm (Fig. 16).

A  B 

Figure 16. A-B – Highway No 3, Kootenay Pass (Photos: A. Gdaniec).

A surprising potential addition to British Columbia's cacti was reported in 1997 in a paper by Josef Halda entitled *Pediocactus robustior* (in southern Canada). This paper reports finding of several colonies of this cactus in the foothills of the Midway Mountains, east of Christina Lake. Currently this report is very controversial. With the help of local people we found a cactus location near Christina Lake but it was *O. fragilis* (Fig. 17). What we also found out that the Midway Mountains do not exist east of Christina Lake. They run to the east of Christian Valley which is about 140km north west from Christina Lake but when we tried to find suitable locations we were forced to give up due to the weather.

A  B 

C  D 

Figure 17. A – Habitats of *O. fragilis* near Christina Lake, in the Gilpin Grasslands Provincial Park; **B** – *O. fragilis* in the Gilpin Grasslands Provincial Park; **C** – Habitat of *O. fragilis* near Kettle River, Christian Valley; **D** – *O. fragilis* near Kettle River, Christian Valley (Photos: A. Gdaniec).

8.6. *O. fragilis* populations near Osoyoos and Keremeos

Our last journeys in the British Columbia Province were to find populations of *O. fragilis* next Osoyoos and Keremeos. The Okanagan Valley is a region defined by the basin of Okanagan Lake and the Canadian portion of the Okanagan River. The region is semi-arid but the combination of a long growing season, warm temperatures, and mild winters create a climate in the valley that is ideal for fruit production. Agriculture has been focused primarily on fruit orchards and vineyards and it very serious threat for native plants community. Healthy populations of *O. fragilis* still exists in few ecological reserves (Fig. 18).

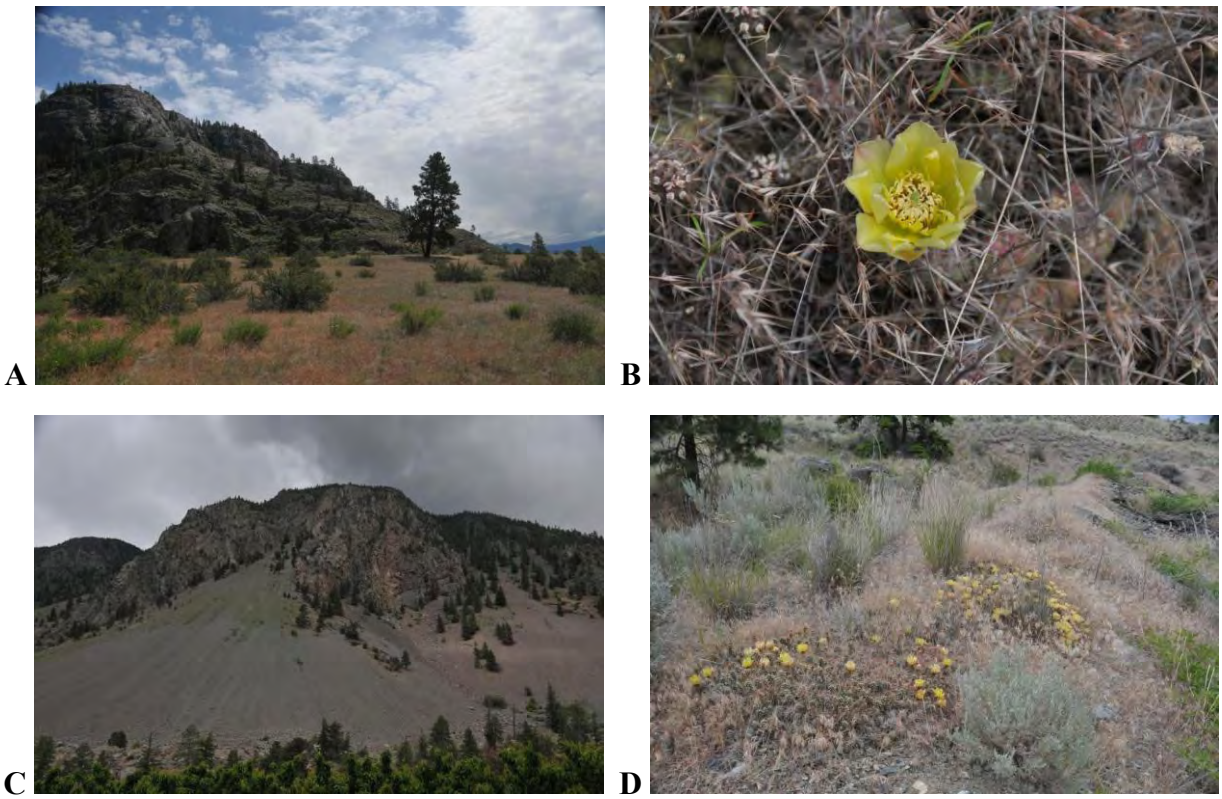


Figure 18. A – Habitat of *O. fragilis* near Osoyoos; **B** – *O. fragilis* near Osoyoos; **C** – Habitat of *O. fragilis* near Keremeos; **D** – *O. fragilis* near Keremeos (Photos: A. Gdaniec).

8.7. Royal Botanical Gardens, Burlington and surrounding areas

After two weeks of intensive exploration of the wilderness of British Columbia we flew from Vancouver to Toronto. The Ontario Province is known amongst cactologists because it is the single location of *Opuntia humifusa* in the Point Pelee Provincial Park and the east most location of *Opuntia fragilis* near Kaladar. Both species are found only in specific, isolated locations.

Our first stop was Royal Botanical Gardens (RBG), Burlington, where we met Alex Henderson, the Curator. The garden is Canada's largest botanical garden on the basis of its land holdings. It was founded in the 1930s as a combination of cultivated gardens, parks in the City of Hamilton, and protected natural lands. Most of the land area of RBG is located within the city limits of Hamilton, while RBG Centre, with its administrative, research and cultural functions, is located in the west end of neighbouring Burlington. RBG's cultivated area is comprised of five cultivated gardens holding 50 different plant collections, display gardens and seasonal exhibitions. These gardens include: The Rock Garden, The Laking Garden, Hendrie Park, RBG Centre and The Arboretum (Fig. 19). It is one of the major tourist attractions between Niagara Falls and Toronto, as well as a significant local and regional horticultural, education, conservation, and scientific resource. The 980 hectares (2,422 acres) of nature sanctuary owned by Royal Botanical Gardens is considered the plant biodiversity hotspot for Canada, with a very high proportion of the wild plants of Canada in one area. More than 1,100 species of plants grow within its boundaries including the Bashful Bulrush (*Trichophorum planifolium*) which is found nowhere else in Canada, and the largest remaining population of Canada's most endangered tree, the Red Mulberry (*Morus rubra*).

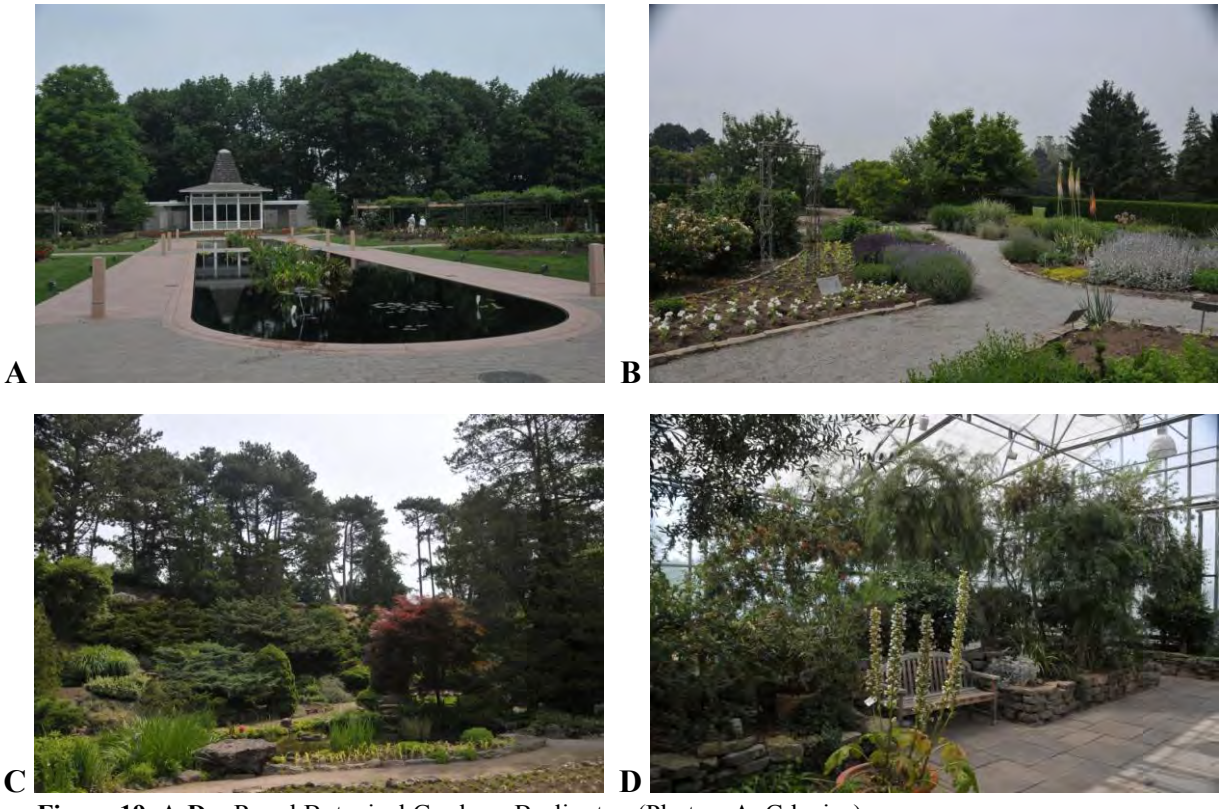


Figure 19. A-D – Royal Botanical Gardens, Burlington (Photos: A. Gdaniec).

Together with Natalie Iwanycki, the Field Botanist and Herbarium Curator, we had the opportunity to visit a few conservation areas near Toronto: the Bronte Creek Provincial Park, the Rattlesnake Point Provincial Park, the Crawford Lake Provincial Park and the Niagara Glen Nature Reserve (Fig. 20). All are part of the Niagara Escarpment. The Niagara Escarpment is a long escarpment in the United States and Canada that runs predominantly east/west from New York State, through Ontario, Michigan, Wisconsin and Illinois. The escarpment is most famous as the cliff over which the Niagara River plunges at Niagara Falls, for which it is named. In February 1990, the Niagara Escarpment was designated a World Biosphere Reserve by UNESCO.

Figure 20. Conservations areas **A-B** – Bronte Creek Provincial Park; **C** – Rattlesnake Point; **D** – Crawford Lake*;* **E-F** – Niagara Glen Nature Reserve (Photos: A. Gdaniec).

8.8. The Point Pelee National Park – single location of *O.humifusa*

The main purpose for a visit to Ontario Province was to see *Opuntia humifusa*. We found this species in its only existing Canadian location in the Point Pelee National Park. The park extends from the mainland of Essex County in southwestern Ontario. It consists of a peninsula of land, mainly of marsh and woodland habitats, that tapers to a sharp point as it extends into Lake Erie. Middle Island, also part of Point Pelee National Park, was acquired in 2001 and is located just north of the Canada–United States border in Lake Erie. Point Pelee is the southernmost point of mainland Canada, and is located on a foundation of glacial sand, silt and gravel that bites into Lake Erie. The Point Pelee has a humid continental climate with warm, humid summers, and cold winters (albeit mild by Canadian standards). It lies in a zone that is characterized by changeable weather due to the conflict between polar and tropical air masses, resulting in highly variable weather. Due to its position in Lake Erie, its climate is strongly modified by it, resulting in warmer winter (with the lowest temperatures up to -27°C) and warm summers (with the highest temperatures up to 34°C).

O. humifusa, commonly known as the eastern prickly pear or Indian fig, is found in most of eastern North America. It ranges from Montana eastward to southern Ontario and then on to Massachusetts, south to Florida and westward to New Mexico. The pads are flat and green with fairly sparse areoles with small light brown glochids. The flowers are yellow to gold in colour and are found along the margins of mature segments. In this location I noticed that *O. humifusa* is very intolerant of shade and it thrives in full sun and well-drained, sandy soil (Fig. 21).

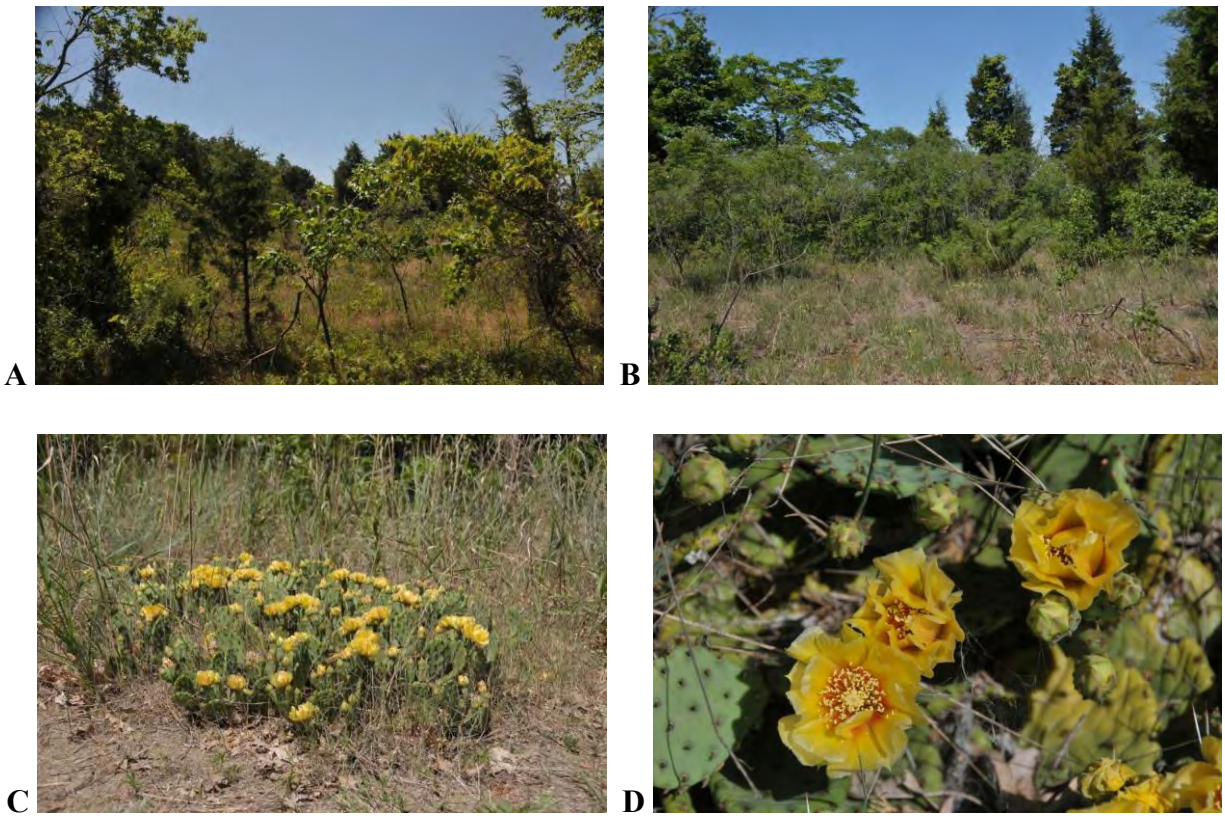


Figure 21. A-B – Habitat of *O. humifusa* in the Point Pelee Provincial Park; **C-D** – *O. humifusa* in the Point Pelee Provincial Park (Photos: A. Gdaniec).

8.9. Kaladar – isolated the east most location of *O.fragilis*

In some ways *O. fragilis* sites in Ontario are mysterious. The extreme western location are likely to be extensions of the populations in the boreal forests of Manitoba and could have been spread vegetatively either by water, or on fur or clothing. However, the next confirmed, but isolated, location is near Kaladar, almost 1000km east. There are number of theories on how the eastern Ontario *O. fragilis* got there, including being carried on fur bales or clothing, left over from a previous geological era and being brought there by First Nations. This area has a moderate humid continental climate, but with cooler summers and colder winters than most of southern Ontario.

The site which we visited is a quite bare granite outcrop. It has a southern exposure and is about 100x50m in size. Wherever grasses, lichens and mosses had established themselves in the cracks, were small colonies of *O. fragilis* (Fig. 22). This site was first discovered in the1930's and has been monitored and studied very closely but flowering specimens have never been reported. It was therefore a huge surprise when we found a single specimen with 3 flower buds. What was even more interesting is that they were only male flowers. Dioecy is very rare in Cactaceae and never reported for this species.

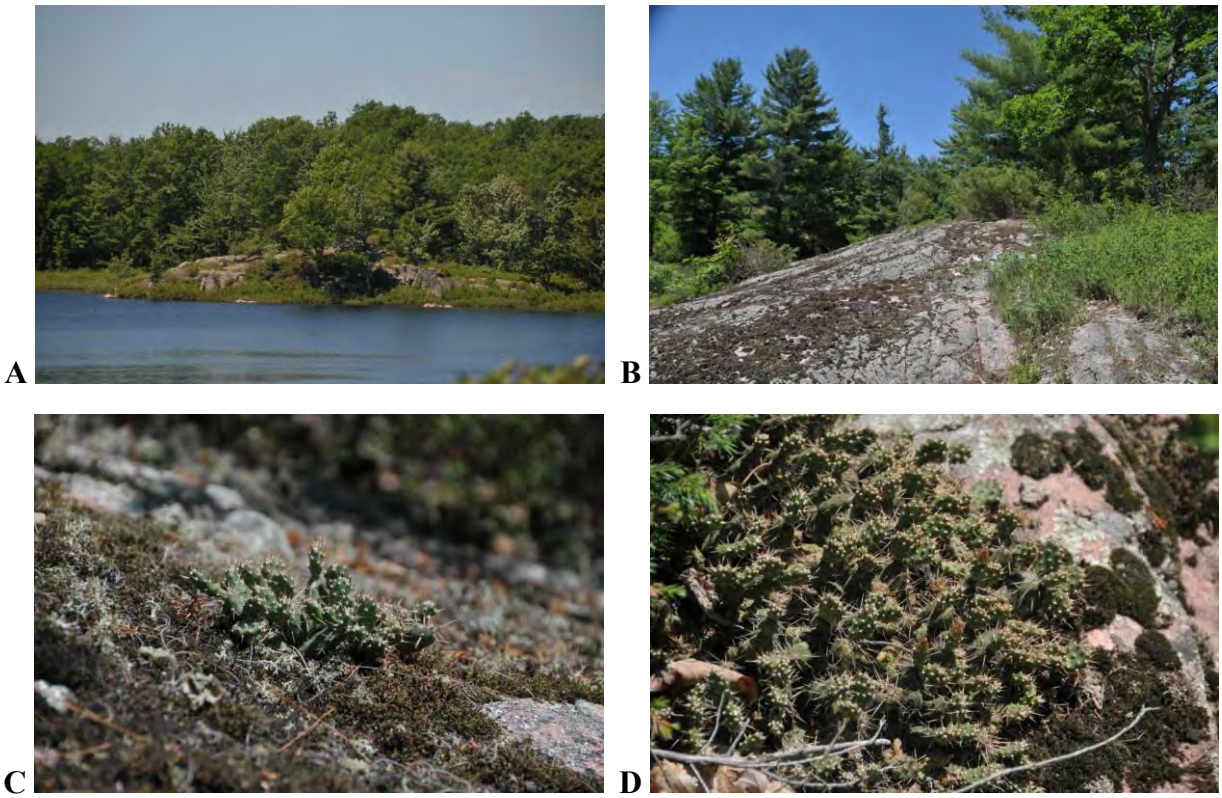


Figure 22. A-B – Habitat of *O. fragilis* near Kaladar; **C** – *O. fragilis* near Kaladar; **D** – *O. fragilis* with flower buds near Kaladar (Photos: A. Gdaniec).

During my exploration of the Kaladar location I was fortunate to be joined by Paul Chafe, hardy cacti collector from Kingston. I was also lucky to see his impressive private collection. Apart from many species and cultivars of North Americas Opuntioids I could also admire hardy species of *Echinocereus*, *Pediocactus*, *Sclerocactus* and *Escobaria* (Fig. 23).

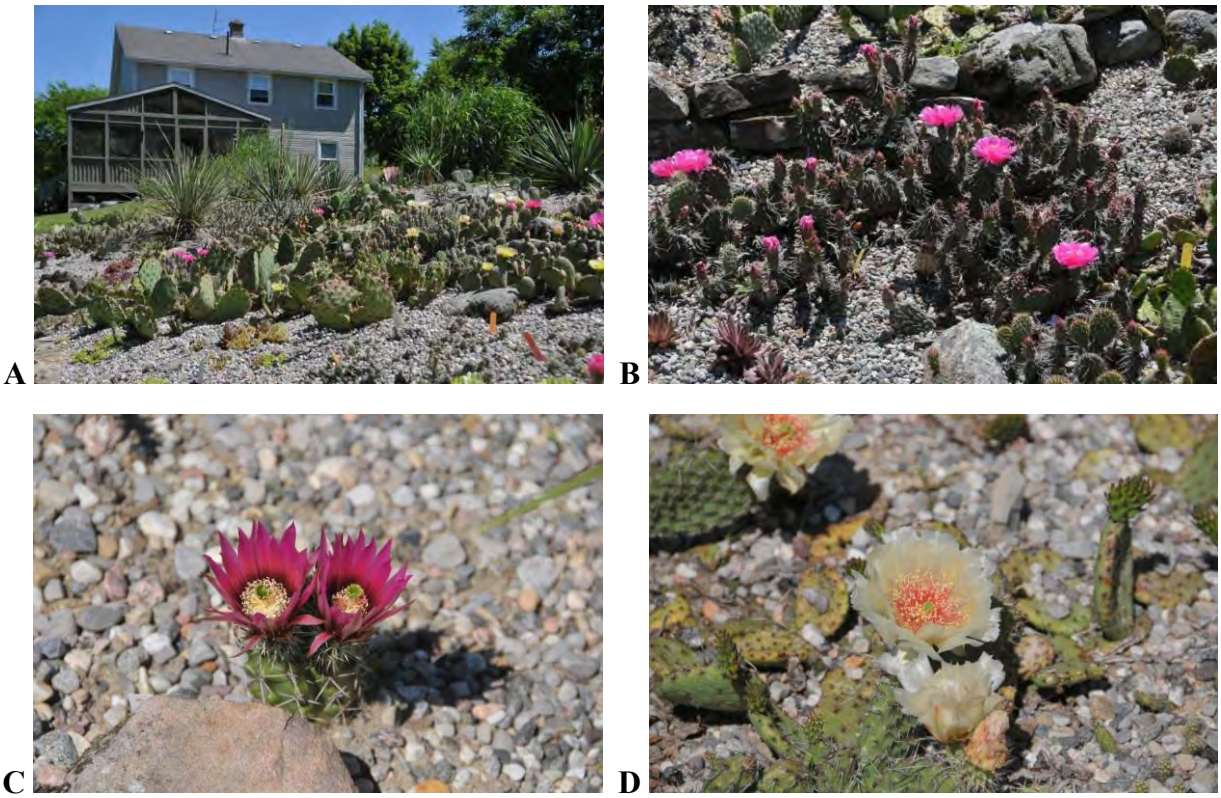
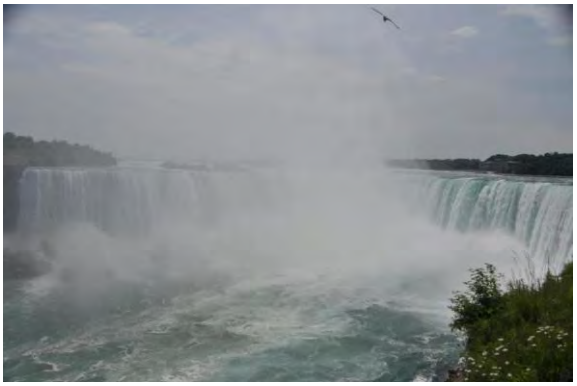


Figure 23. Paul Chafe's private collection of hardy succulents **A-B** – Collection overview; **C** – *Echinocereus fendleri*; **D** – *Opuntia polyacantha* 'Crystal Tide' (Photos: A. Gdaniec).

8.10. Niagara Falls area

During our last day on Saturday 16th of June we visited the Niagara Falls and the Niagara Parks Botanical Gardens and School of Horticulture (Fig. 24). The original gardens were established in 1936 when The Niagara Parks Commission created the 'Training School for Apprentice Gardeners'. The school training program was based on the long standing gardener apprenticeship offered at the Royal Botanic Gardens in Kew, England. The students participate in the development of the Botanical Gardens and are responsible for its maintenance under staff direction.

A  B 

C 

D 

Figure 24. A-B – Niagara Falls; **C-D** – Niagara Parks Botanical Gardens and School of Horticulture (Photos: A. Gdaniec).

9. Conservation of Canadian cacti

Despite the widespread geographic distribution and the relative abundance of some species, over collection and other human pressures, such as agricultural expansion, continue to threaten plant life. Habitat fragmentation and the removal of entire plants are major factors that deplete wild populations and lead to the loss of genetic diversity. Cacti, in general, are precious plants for collectors, and it appears that the rarer the plant, the more desirable the specimen. As a result of over collection, most Cactaceae are listed in the appendices of the Convention on International Trade in Endangered Species (CITES).

Canadian native cacti are hardy species, which make them quite popular among horticulturists, collectors, and amateur gardeners, who commonly use them in rock gardens. Out of the five species found in Canada, only *Opuntia humifusa* is nationally rare and listed as an endangered species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

During the travel scholarship I noticed that all species of Canadian cacti are threatened mostly by habitat destruction as land is changed into cultivated or grazed areas, slopes are destroyed by rock queries and dams are built in many river valleys, and inadequate park management (Fig. 25).

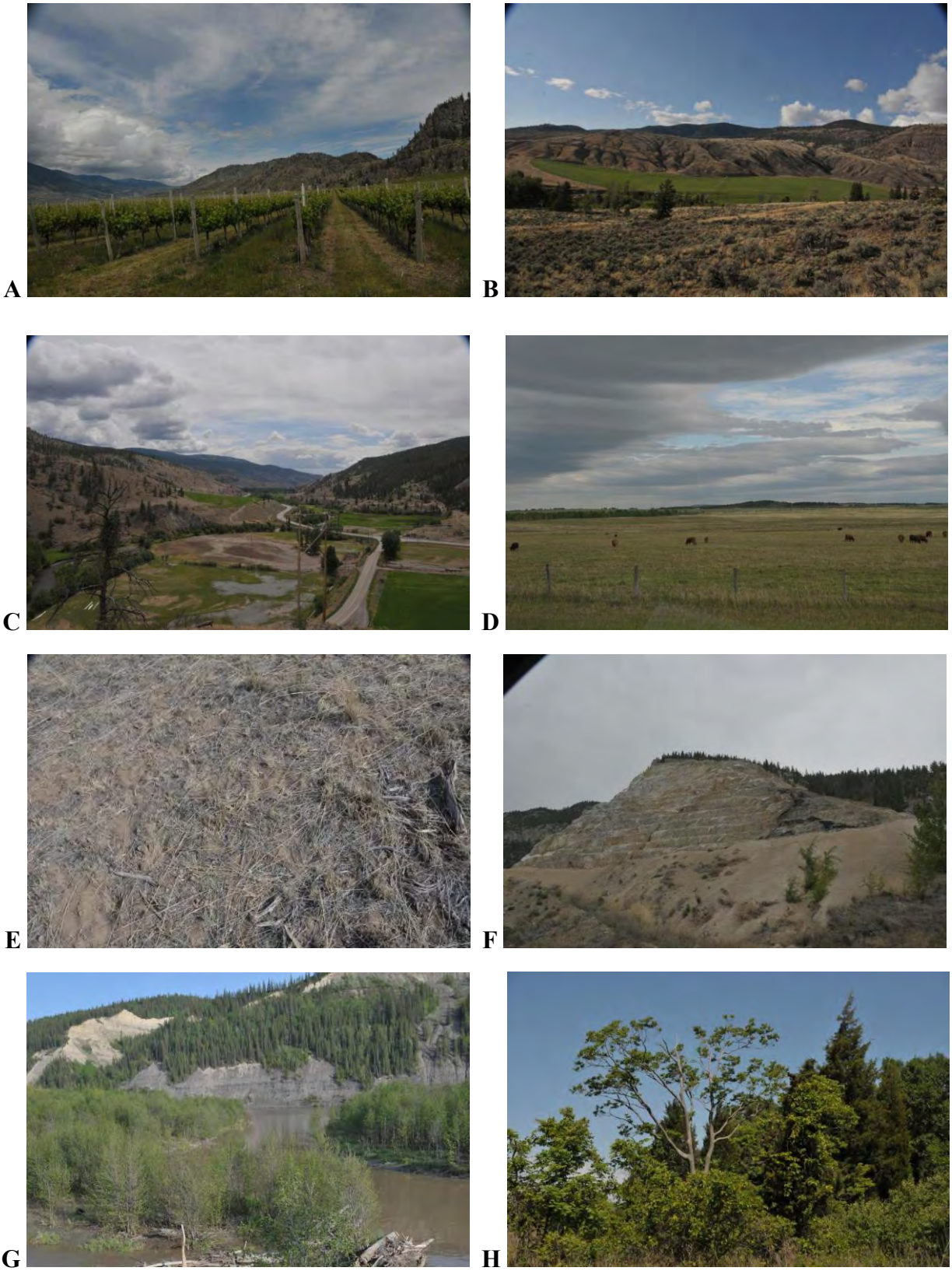


Figure 25. Habitat destruction: **A** –*Vitis vinifera* plantations near Osoyoos; **B** –cultivated fields near Ashcroft; **C** – cultivated fields near Loon Lake; **D** – cultivated fields near Taber; **E** – overgrazing and soil erosion near Ashcroft; **F** – Rock quarries near Pavilion Lake; **G** – Dam construction plans for Peace River Valley; **H** – Inadequate park management in the Point Pelee Provincial Park (Photos: A. Gdaniec).

10. Summary

My time spent in Canada was an amazing opportunity to see not only cacti but an extraordinary diversity of plant species growing in the wild and I am extremely grateful for the support of the Merlin Trust Horticultural Grant Committee which made this trip possible.

All aims and objectives have been met. Travelling through Canada has benefited my knowledge and experience in following ways:

- Development of plant identification.
- Benefit from the experience of knowledgeable people.
- Information passed on has positively influenced my learning processes and greatly assisted my understanding of succulents in general.
- Seeing cacti in their natural habitats was a fantastic experience and will be invaluable for potential dissertation studies.
- Developing many contacts and increasing my personal knowledge to aid the development of my future career.
- An opportunity for me to understand more fully a subject that I have long found interesting.

11. Personal plans for the future

The main aim of my career is to grow, research and conserve plants and develop international co-operation with those interested in them. In the future I would like to be actively involved in succulent cultivation as a horticulturist with a good science background.

The experience of this trip will be invaluable to a future career with succulent plants and will form a basis for future study. My 29 years of previous experience in growing and researching cacti followed by 3 months placement in The Tropical Nursery, RBG, Kew – Dry Tropics Section, 2 weeks training in The Jardin Exotique, Monaco and 4 weeks consultancy work for the Gibraltar Botanical Gardens ‘'The Alameda' will be a good base for a dissertation.

Next year I also would like to visit professional succulent collectors like Graham Charles and John Pilbeam. In my third year at Kew I am planning to volunteer in one of the largest and oldest European succulent nurseries in Haage, Germany. In the future I would like to visit Singapore Botanical Garden to understand a different challenge in growing succulents as the hot and humid weather necessitates a cooling programme under glass to enable cultivation.

12. Cost and expenditure

Table 3. Costs of the Travel Scholarship – Canada 2012.

Expenditures	**GBP £**
TRANSPORT	
Flight London to Vancouver Flight Toronto to London	£ 1153.00
Flight Vancouver to Toronto	£ 192.00
Flight Vancouver to Fort St. John (return)	£ 490.00
Car hire (quotation) £39/day - 18 days	£ 705.00
Fuel	£ 530.00
ACCOMMODATION	
Accommodation: approx £35 per persons per night for 21 nights	£ 735.00
FOOD	
Subsistence: approx. £15 per person per day for 22 days	£ 330.00
EXTRAS	
Entrance to parks, gardens, toll roads etc. Approx £10 x 15 days	£ 150.00
Total	**£ 4285.00**

Received grants:

a) The Merlin Trust Horticultural Grant

Amount Received £ 1300.00

b) The Royal Horticulture Society Bursary

Amount Received £ 1000.00

c) The Hardy Plant Society, The Kenneth Black Bursary

Amount Received £ 500.00

d) The Alpine Garden Society Travel Award

Amount Received £ 1000.00

e) The Kew Guild

Amount Received £ 400.00

Signed:	**Date:**

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Appendix 1 – Taxonomy of Canadian cacti (Cota-Sanchez, 2002)

Although the taxonomic diversity of the Cactaceae in Canada is low, the family is distributed in the central and southern portions of the country, and its west to east range includes the provinces of British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario. The Canadian flora includes four species in two genera: *Escobaria* Britton and Rose and *Opuntia* Mill. (Benson, 1982; Scoggan, 1979). These species have developed extreme resistance to cold and represent extreme examples in this typically xerophytic family.

The genus *Escobaria* includes small, globose cacti of the subfamily Cactoideae and is represented in Canada by only one species: *E. vivipara* (Nuttall) Buxbaum with its typical var. *vivipara*. *Coryphantha vivipara* (Nuttall) Britton and Rose is under the synonymy of *E. vivipara* (Anderson, 2001; Hunt, 1999). The second genus, *Opuntia*, belongs to the subfamily Opuntioideae and includes three species distributed in Canada. These species have been cited as *O. compressa* (Salisbury) Macbride, *O. fragilis* (Nuttall) Haw., and *O. polyacantha* Haw. (Scoggan, 1979); however, *O. compressa* is an invalid name (Benson, 1982) and is in synonymy. It is now recognized as *O. humifusa* (Rafinesque) Rafinesque (Anderson, 2001; Hunt, 1999: McGregor, 1986). Because of this, the binomial *O. humifusa* is used in this paper. The names of the other two species (*O. fragilis* and *O. polyacantha*) are unchanged, but there are several varieties for each species. In Canada, we have only the typical variety of each species, i.e., *O. fragilis* and *O. polyacantha*. For additional taxonomic and nomenclatural information a propos of these and other taxa, the reader is advised to consult Anderson (2001), Benson (1982), and McGregor (1986) and references cited therein. Scientific names and taxonomic authorities for the species outside the Canadian range mentioned in this paper are maintained according to the original reference from which they were obtained.

Appendix 2 – Taxonomic key to native cacti of Canada (Cota-Sanchez, 2002)

The taxonomic key below is adapted from Anderson (2001), Harms (1983), and McGregor (1986) and includes the major distinctive morphological characters useful in the identification of Canadian cacti.

1a. Plants clustering; stem globular, solitary or tufted only from base; tubercles prominent, conical, bearing an apical areole; areoles hairy, with 3–7 central spines and 12–16 radial spines; glochids absent. Flowers bright pink to violet; perianth parts lanceolate, less than 1 cm wide; outer perianth parts greenish, ciliate-fringed, purplish red. Fruit an ellipsoidal, smooth, fleshy berry ……..…..…..…. ***Escobaria vivipara***

1b. Plants low to prostrate; stems branched, consisting of flattened and pad-like segments with constricted joints; glochids present ……...…...……. **2**

2a. Plants creeping. Spines without barbs. Fruit fleshy at maturity, not spiny (but glochids usually present in the areoles) ……..……..……...…….....…… ***Opuntia humifusa***

2b. Plants creeping or prostrate. Spines weakly to strongly barbed. Fruit dry at maturity, spiny …...……. **3**

3a. Stem segments usually less than 5 cm long to 2.5 cm wide, thick and not strongly flattened, terminal pads easily detached; areoles 3–6 mm apart; glochids brown to tan, conspicuous; spines 1–6, barbed, spreading straight, from 1–3 cm long. Flowers yellowish, sometimes greenish 3–4 cm long, up to 4 cm in diameter. Fruit ovoid, green ……...…….. ***O. fragilis***

3b. Stem segments round to broadly obovate, mostly over 5 cm long, 3 cm wide, not readily separable; areoles more distant (8–10 mm apart); glochids yellow, inconspicuous; spines 6–10, needle-like, 1–2.5 cm long. Flowers yellow, 4.5–6 cm long. Fruit ovoid, tan or brown ……...……..…….…... ***O. polyacantha***

Appendix 3 – Species descriptions (Parfitt and Gibson, 2004)

Escobaria vivipara (Nuttall) Britton & Rose in N. L. Britton and A. Brown, Ill. Fl. N. U.S., ed. 2. 2: 571. 1913.

beehive cactus, pincushion cactus

Cactus viviparus Nuttall, Cat. Pl. Upper Louisiana, no. 22. 1813; *Coryphantha missouriensis* (Sweet) Britton & Rose var. *marstonii* (Clover) L. D. Benson; *C. vivipara* var. *arizonica* (Engelmann) W. T. Marshall; *C. vivipara* var. *bisbeeana* (Orcutt) L. D. Benson; *C. vivipara* var. *kaibabensis* P. C. Fischer; C. *vivipara* var. *neomexicana* (Engelmann) Backeberg; *C. vivipara* var. *radiosa* (Engelmann) Backeberg; *C. vivipara* var. *rosea* (Clokey) L. D. Benson; *Escobaria vivipara* (Nuttall) Buxbaum

Plants usually unbranched or with age in some populations to 30 branches, most branches of largest clumps often immature, stems usually stiff and erect, smooth in immature plants to sparsely and coarsely needle-covered in adult plants. **Roots** ± diffuse, less than $^{1}/4$ of stem diam. **Stems** usually more than $^{1}/2$ above ground (sometimes deep-seated and flat-topped in winter, in cold climates and/or in immaturity), oblate, spheric, ovoid, obovoid, or cylindric with age, 2.5-20 × 3-11 cm; tubercles 8-25 × 3-8 mm, stiff or ± flaccid; areolar glands absent; parenchyma not mucilaginous (except possibly in far north); druses in pith and cortex present, some large, 0.7-1 mm diam., lenticular, usually conspicuous in old parts of stem; pith $^{1}/5$-$^{2}/3$ of lesser stem diam.; medullary vascular system present. **Spines** 11-55 per areole; radial spines 10-40 per areole, weakly appressed or tightly appressed, pectinately arranged in subadults of some populations, either bright white, ashy white, pale tan, pale pinkish gray, or reddish brown (rarely stramineous), tips dark bright pinkish brown, reddish brown, dark brown, orange-brown, or pinkish orange on all or only largest spines (dark tips rarely absent), 7-22 × 0.08-0.6 mm; subcentral spines sometimes present in adaxial parts of clusters; central spines straight, snowy white, ashy white, reddish brown, sepia, purplish gray, pinkish gray, brownish red, pinkish brown, horn colored, pale tan, dark purplish brown, or stramineous, opaque or vitreous, fading, then blackening with age; outer central spines 3-14 per areole; inner central spines (0-)1(-4) per areole, appressed or strongly projecting, in "bird's-foot" arrangement or radiating like spokes, longest spines 9-25 × 0.2-0.7 mm. **Flowers** slightly subapical, 20-57 × 25-67(-90?) mm; outer tepals conspicuously fringed; inner tepals 21-56 per flower, usually spreading, recurved, pale rose-pink to reddish pink or magenta, sometimes with darker midstripes, sometimes shading to white or pale greenish, proximally magenta, often darkest distally, 15-35 × 1.3-6 mm; outer filaments magenta or basally white (rarely entirely white or greenish white), seldom contrasting with inner tepals and, if so, then paler; anthers bright dark yellow (rarely orange-yellow); stigma lobes 5-13, erect or ascending, white to magenta, 2.5-5.5 mm. **Fruits** green, exposed portions slowly turning dull brownish red, ovoid to obovoid, 12-28 × 7-20 mm, juicy; floral remnant persistent. **Seeds** bright reddish brown, comma-shaped or nearly obovoid, (1-)1.3-2.4(-3) mm, pitted. $\mathbf{2}\boldsymbol{n} = 22$.

Flowering spring-late summer (Apr-Aug); fruiting 2-5 months after flowering. Desert scrub to conifer forest, mostly low hills or mountaintops, diverse substrates; 200-2700 m; Alta., Man., Sask.; Ariz., Calif., Colo., Kans., Minn., Mont., Nebr., Nev., N.Mex., N.Dak., Okla., S.Dak., Tex., Utah, Wyo.; Mexico (Chihuahua, Coahuila, Sonora).

Opuntia humifusa (Rafinesque) Rafinesque, Med. Fl. 2: 247. 1830.

eastern pricklypear

Cactus humifusus Rafinesque; *O. austrina* Small; *O. calcicola* Wherry; *O. compressa* var. *austrina* (Small) L. D. Benson; *O. humifusa* var. *ammophila* (Small) L. D. Benson; *O. humifusa* var. *austrina* (Small) Dress; *O. impedata* Small ex Britton & Rose; *O. rafinesquei* Engelmann

Shrubs, forming clumps or often prostrate, usually only 1 or 2 stem segments tall, to 0.5 m (except in Florida where they may be erect and reach to 2+ m with short trunk), flattened to obovoid, sometimes from tuberlike rootstocks. **Stem segments** not disarticulating, dark or bright shiny green, wrinkling when stressed, circular to broadly oblong to obovate, 5-17.5 × 4-12 cm, fleshy, usually tuberculate, glabrous; areoles 4-6 per diagonal row across midstem segment, oval to circular, 2-4 mm diam., not raised, sometimes somewhat sunken; wool tan to brown. **Spines** often absent or 1-2(-3) per areole, spreading, whitish to brownish, terete, straight, and usually stout, 25-60 mm; occasionally also 1 deflexed spine present. **Glochids** in dense crescent of adaxial edge of areole and in dense tuft overtopping crescent in age, yellow to red-brown, to 4 mm. **Flowers:** inner tepals pale to bright yellow throughout, 20-30 mm diam.; filaments yellow to orange; anthers pale yellow to cream; style and stigma lobes white. **Fruits** greenish, tardily becoming apricot to brownish red, elongate, 30-50 × 12-20 mm, fleshy, tapering at base; pulp green and sour, becoming reddish and sweet under ideal conditions; areoles 10-18. **Seeds** tan, 3.5-4.5 mm diam., thickish; girdle protruding to 1 mm. **2*n*** = 22, 44.

Flowering spring-summer (Feb-Aug). Sandy habitats, openings on dry, sometimes wooded hillsides; 0-1000 m; Ont.; Ala., Ark., Conn., Del., Fla., Ga., Ill., Ind., Iowa, Kans., Ky., La., Md., Mass., Mich., Minn., Miss., Mo., Nebr., N.J., N.Y., N.C., Ohio, Okla., Pa., R.I., S.C., S.Dak., Tenn., Tex., Va., W.Va., Wis.

Opuntia fragilis (Nuttall) Haworth, Suppl. Pl. Succ. 82. 1819.

brittle pricklypear, little pricklypear

Cactus fragilis Nuttall, Gen. N. Amer. Pl. 1: 296. 1818; *Opuntia brachyarthra* Engelmann & J. M. Bigelow; *O. fragilis* var. *brachyarthra* (Engelmann & J. M. Bigelow) J. M. Coulter

Shrubs, low, forming mats, 2-10 cm. **Stem segments** easily detached when terminal, dark green, subspheric to subcylindric, to flattened and elliptic obovate, (1.5-)2-5.5 × (1-)1.5-3 cm, low tuberculate (pronounced when dried), glabrous; areoles 3-5 per diagonal row across midstem segment, oval, 3 × 2.5 mm; wool white. **Spines** 3-8 per areole, in most areoles spreading, gray with brown tips, straight, ± acicular, terete, the longest 8-24 mm; depressed spines at base of areoles 0-3, 1-3 mm. **Glochids** in crescent at adaxial margin of areole, tan to brown, inconspicuous, to 3 mm. **Flowers:** inner tepals yellow, sometimes basally red, 20-26 mm; filaments white or red; anthers yellow; style white; stigma lobes green. **Fruits** tan, 10-30 × 8-15 mm, dry, glabrous; areoles 12-22, distal areoles bearing 1-6 short spines. **Seeds** tan to gray, flattened, warped, oblong to subcircular, 5-6 mm diam.; girdle protruding 1-1.5 mm. **2*n*** = 66.

Flowering summer (late Jun-early Jul). Barren areas in grasslands, woodlands, sandy or gravelly soils, on outcrops of granite, limestone, or quartzite; 0-2400 m; Alta., B.C., Man., Ont., Sask.; Ariz., Calif., Colo., Idaho, Ill., Iowa, Kans., Mich. , Minn., Mont., Nebr., N.Mex., N.Dak., Okla., Oreg., S.Dak., Tex., Utah, Wash., Wis., Wyo.

Opuntia polyacantha Haworth, Suppl. Pl. Succ. 82. 1819.

Starvation pricklypear

Cactus ferox Nuttall; *Tunas polyacantha* (Haworth) Nieuwland & Lunell; *Opuntia heacockiae* G. Arp; *O. juniperina* Britton & Rose; *O. polyacantha* var. *juniperina* (Britton & Rose) L. D. Benson; *O. polyacantha* var. *rufispina* (Engelmann & J. M. Bigelow) L. D. Benson; *O. polyacantha* var. *trichophora* (Engelmann) J. M. Coulter; *O. trichophora* Engelmann

Shrubs, low, 10-25 cm, with ± prostrate branches. **Stem segments** not easily detached, green, elliptic to narrowly to broadly obovate to circular, 4-27 × 2-18 cm, low tuberculate; areoles 4-14 per diagonal row across midstem segment, subcircular, 3-6 mm; wool tan to brown. **Spines** at all or only distal areoles of stem segment, terete to flattened, stout to acicular to bristlelike, straight to curling, of 1 or 2 kinds; if 1 kind: 0-18 per areole, spreading and curling in various directions, sometimes straight, erect, ascending to deflexed, yellow to dark brown to black, turning gray, pink-gray to gray-brown, longest (35-)40-90(-185) mm; if ± 2 kinds: major spines (0-)1-5, reflexed to porrect, yellow-brown to brown to gray, longest 20-150 mm; minor spines (0-)5-11, deflexed, white to white-gray, longest 4-16 mm. **Glochids** inconspicuous, in narrow, tidy crescent at adaxial edge of areole or in broad, brushy crescent and tuft, yellow to reddish, aging brown, to 10 mm. **Flowers:** inner tepals yellow to magenta throughout, 25-40 mm; filaments white, yellow, or red to magenta (flowers may superficially appear bicolored); anthers yellow; style white to pale pink; stigma lobes green. **Fruits** tan to brown, ± cylindric, 15-45 × 12-25 mm, dry at maturity, glabrous, sometimes burlike; areoles 10-33, each or only distal areoles bearing 3-16 spines, 4-20 mm. **Seeds** tan to gray, flattened, warped, oblong to subcircular, 3-7 × 2-4 mm; girdle protruding 1-2 mm. **2*n*** = 22, 44.

Flowering late spring. Grasslands, pinyon-juniper woodlands, clay, sandy or gravelly soils; 500-2000(-2800) m; Alta., Sask.; Ariz., Colo., Idaho, Kans., Mont., Nebr., Nev., N.Mex., N.Dak., Okla., S.Dak., Tex., Utah, Wyo.

Opuntia x columbiana Griffiths, Bull. Torrey Bot. Club. 43: 523. 1916.

Opuntia erinacea Engelmann & J. M. Bigelow var. *columbiana* (Griffiths) L. D. Benson

Shrubs, low, forming mats, 10-30 cm. **Stem segments** easily detached to firmly attached, green, flattened, narrowly to broadly obovate, 3.5-9 × 2.5-5 cm, low tuberculate, glabrous; areoles 4-6(-7) per diagonal row across midstem segment, oval, 3.5 × 2.5 mm; wool white. **Spines** in most areoles, straight, acicular, terete; major spines 0-1 per areole, reflexed to porrect (rarely ascending), gray-white to brown, (15-)25-40(-60) mm; intermediate spines 0-3, reflexed, 12-20 mm; minor spines 2-4, reflexed, yellow-gray, 3-6 mm. **Glochids** loosely packed, in small tuft or crescent at adaxial margin of areole, yellowish, inconspicuous, to 4 mm. **Flowers:** inner tepals yellow throughout, 30-45 mm; filaments white to red; anthers yellow; style white; stigma lobes green. **Fruits** rarely set, top-shaped to barrel-shaped, 15-20 × 15 mm, glabrous; areoles 10-15, most bearing 3-12 spines or distal spines bearing 1-3 spines. **Seeds** tan, large, 5-7 mm; girdle protruding 1-1.5 mm. **2*n*** = 66.

Flowering summer (late Jun-early Jul). Dark basaltic cliffs and derived sands; 100-800 m; B.C.; Idaho, Oreg., Wash.

Appendix 4 – Economic uses (Cota-Sanchez, 2002)

As in many regions of Central and South America, indigenous people in Canada have used cacti as an important source of food and medicine. The native cacti of Canada are also commonly used in horticulture. Following is a summarized account of the past and current uses of these plants.

***Escobaria vivipara*.** Indigenous people in Saskatchewan eat the fleshy, juicy fruits as part of their diets (Harms, 1983). Similarly, the Blackfoot Indians, who occupy areas of the eastern part of the Rocky Mountains (southeastern corner of Alberta, the southwestern of Saskatchewan and central Montana), use the fruits as a drug and as food (Johnston, 1970). The fruits are eaten to treat diarrhea and are also consumed fresh or boiled to make candy (Moerman, 1988).

***Opuntia fragilis*.** The flesh of this plant was used by the Okanagan-Colville to treat skin infections and was eaten for its diuretic properties. The stems were used as food by the Okanagan-Colville and Shuswap (Moerman, 1988). A novel use of this plant was that of the Okanagan-Colville, who used the spines as fishhooks (Moerman, 1988). This species is frequently used in landscaping by gardeners (Bernshaw, 1984).

Opuntia humifusa. In the Plains regions of the U.S., the Dakota, Lakota, Nanticoke, and Pawnee tribes apply the peeled stems of *O. humifusa* to injured areas to treat various types of wounds, warts, and snakebites. This species was also used as a source of dyes (Moerman, 1988). Because of its hardiness, it is highly appreciated by gardeners (Klinkenberg, 1987).

Opuntia polyacantha. In Saskatchewan, the stem pads are used as food for humans and livestock (Harms, 1983). Various North American tribes have used the stems and fruits of this species for different purposes. As part of their diet, the Blackfoot Indians ate stems after removing the spines and cuticule, and fresh portions of the stem were used to treat wounds and warts (Johnston, 1970). Other uses of this plant include as an ointment for dermatitis by the Okanagan-Colville and as a dye (from the red fruits) by the Navajo (Moerman, 1988). Johnston (1970) also reports one of the most striking uses of this species: the Blackfoot used it to heal wounds by sticking spines into the affected part of the body and then igniting them. According to their beliefs, the spines that sparked and burned the brightest were the most effective in the healing process.

Appendix 5 – General maps of Canada

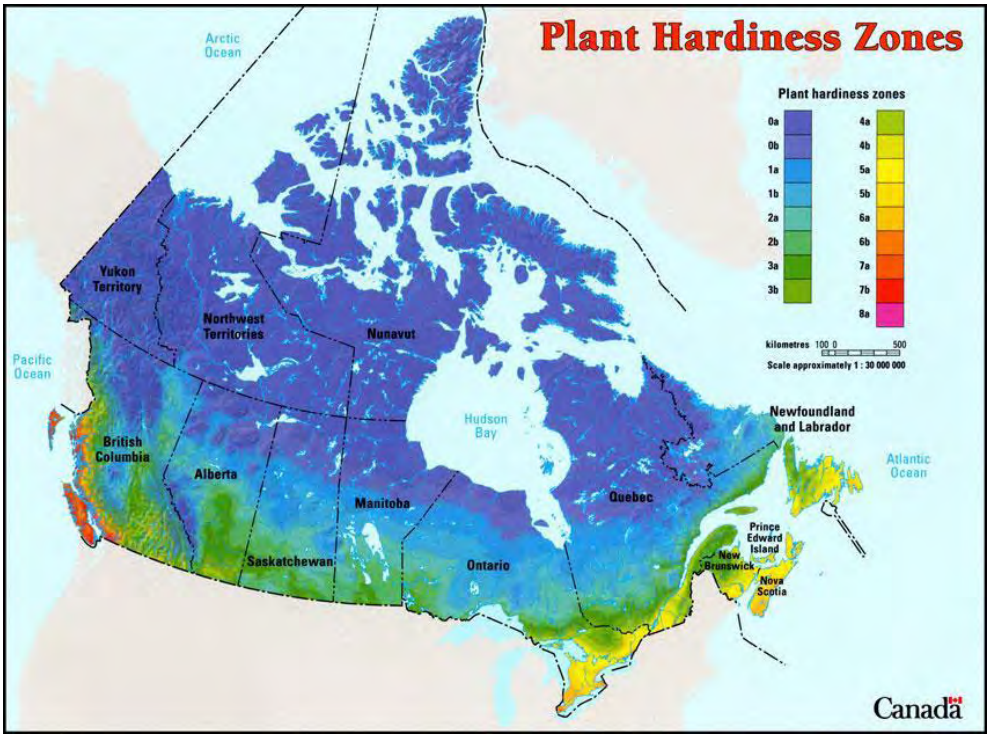

Figure 26. Map of plant hardiness zones in Canada.

Figure 27. Contour map of Canada.

Appendix 6 – Maps of species distribution in British Columbia and Ontario (Hancock, 2002)

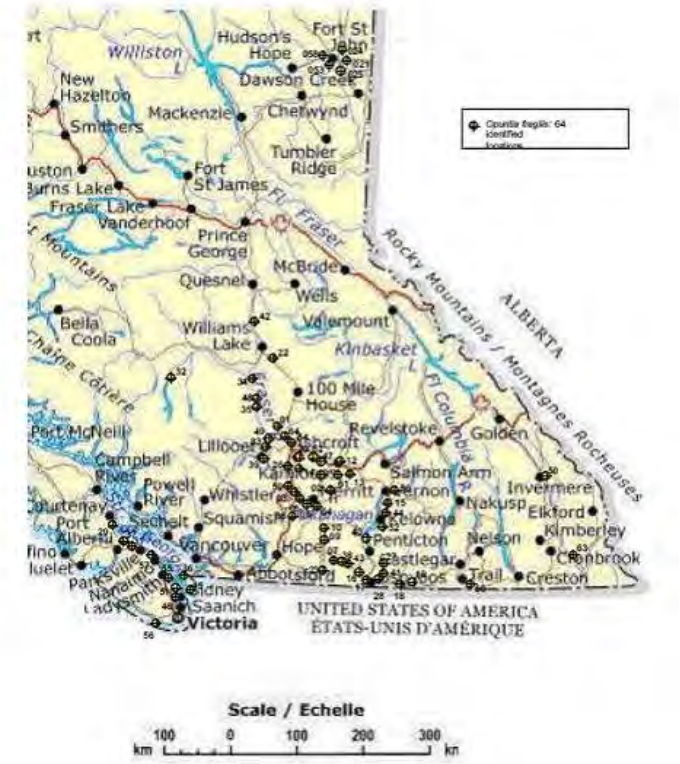

Figure 28. Map of locations of *O. fragilis* in British Columbia.

Figure 29. Map of locations of *O. polyacantha*, *O. xcolumbiana* and *E. vivipara* in British Columbia.

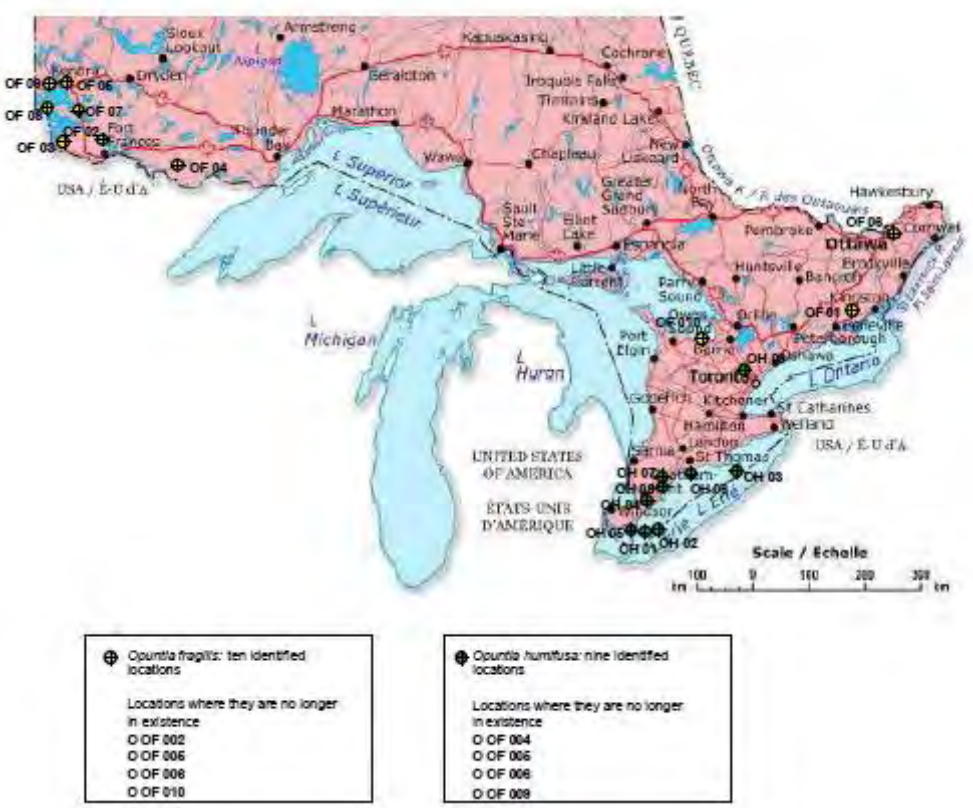

Figure 30. Map of locations of O. fragilis and *O. polyacantha* in Ontario.