An Arctic-Alpine Flora at Low Elevation in Marble Canyon, Kootenay National Park, British Columbia

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A total of 169 vascular plant species reported for Marble Canyon in Kootenay National Park, British Columbia. The canyon is situated in the lower subalpine zone at 1490 m above sea level and at least 800 m below treeline, yet it contains an unusually rich assemblage of alpine plants. It is suggested that the abundance of alpine species at this low altitude is made possible by the cold microclimate produced by the glacially-fed stream flowing through this deep and narrow canyon.

Key Words: Alpine, flora, canyon, Kootenay National Park, British Columbia.

The vascular flora of the four National Parks in the Rocky Mountains of western Canada was thoroughly documented in a series of studies during the early 1980s. Vascular plant checklists compiled during these studies give a total of 844 and 749 taxa for Banff and Jasper National Parks respectively (Holland and Coen 1982), 754 taxa for Yoho National Park (Kuchar 1978), and 677 taxa for Kootenay National Park (Achuff et al. 1984). These studies provided an ecological land classification for each park but did not specifically focus on unusual or localized habitats with a small areal extent. The present study reports on the flora of such an unusual habitat, located in the cold microclimate surrounding Marble Canyon in Kootenay National Park, British Columbia. The primary objective was to assess the uniqueness of the canyon's flora in terms of its concentration of arctic-alpine species at a relatively low altitude in the region.

Site Description

Marble Canyon (Figures 1, 2) is located next to the Banff-Windermere Parkway at 51°11'N, 116°08'W and an altitude of 1490 m. The canyon is near the lower altitudinal limit of the lower subalpine zone (Achuff et al. 1984) and the adjacent forest is dominated by Engelmann Spruce (*Picea engelmannii*), Subalpine Fir (*Abies lasiocarpa*), and Lodgepole Pine (*Pinus contorta*). Mountains in the area reach an altitude of up to 3175 m and the alpine zone (vegetation above treeline) begins at between 2200 and 2400 m.

The canyon extends upstream from the parkway about 500 m to along Tokumm Creek and reaches a maximum depth of 36 metres below the waterfall at its northwestern end. The bedrock forming the canyon walls consists of limestone and dolomite belonging to the Cathedral Formation from the Middle Cambrian period. Marble Canyon is a major tourist attraction in the park, and there is a self-guided walking trail with seven bridges crossing the canyon. The canyon and its flora are protected under the Canadian National Parks Act.

Marble Canyon is only 6 km west of the continental divide and has a moderately heavy snowfall. Snow depth at the canyon reaches an average maximum of 124 cm in March or early April (water equivalent of 358 mm) and snow typically remains on the ground until late May or early June (British Columbia Ministry of Environment 1985). There is no weather station at Marble Canyon, but at Lake Louise, Alberta, located about 30 km north of Marble Canyon at a similar altitude of 1534 m (Figure 1), mean annual temperature is -0.4°. Mean daily maximum and minimum temperatures at Lake Louise are 21° and 3° respectively in July, and -8° and -22° in January. Mean annual precipitation is 684 mm with 418 cm of snowfall (Environment Canada 1982a, 1982b).

Methods

This study was conducted in the summers of 1981-1983, while I was employed as a seasonal park naturalist in Kootenay National Park, and collections were completed under a collection permit from the Canadian Parks Service in 1992. The species reported here occur within 20 m of Marble Canyon or along the Potholes Trail, which extends ca. 300 m downstream from the canyon below the junction of Tokumm Creek and the Vermilion River (Figure 1). The size and number of collections was limited due to the small number of individuals present for many species, and in some cases, plants were photographed, rather than collected. Plant specimens are housed in the Kootenay National Park herbarium at Radium Hot Springs, British Columbia. Except where otherwise noted, nomenclature follows Moss

FIGURE 1. Map of the study area, showing Marble Canyon (inset) and Kootenay National Park (shaded area). The position of the Potholes Trail (inset) is approximate.

(1983). Common names are given according to Moss (1983) where possible; otherwise, common names are those listed by Alberta Energy/Forestry, Lands and Wildlife (1992).

Those species encountered at Marble Canyon which were suspected to occur elsewhere mainly at high altitudes (>2000 m) were selected for examination of their altitudinal distribution. The recorded altitude of herbarium collections was noted for specimens housed at the Northern Forestry Centre (CAFB, Johnson et al. 1985), the University of Alberta (ALTA) and the University of Calgary (UAC). This analysis was restricted to collections from the Rocky Mountains and foothills of British Columbia and Alberta, between 49°30' N and 53°00' N latitudes.

FIGURE 2. View of Marble Canyon in Kootenay National Park, British Columbia.

Results and Discussion

The flora of the Marble Canyon area includes an unusually rich assemblage of alpine plant species, considering that the canyon is situated at least 800 m below treeline. Of the 169 species of vascular plants recorded (Appendix), I considered 20 to be alpine because regionally, they otherwise occur at an average altitude of >2000 m. One additional species, *Arenaria longipedunculata* (Sandwort) has been collected very rarely in the Rocky Mountains, but was considered to be alpine based on its overall geographic distribution. These 21 alpine (including arctic-alpine) plant species are listed separately in Table 1. To my knowledge, thirteen of these species have not been collected elsewhere in the region at such a low altitude as Marble Canyon (1490 m).

The two most notable alpine plants recorded are *Draba lonchocarpa* (Whitlow-grass) and *Saussurea nuda* var. *densa* (Dwarf Saw-wort), which occur at an average altitude of >2300 m in the region (Table 1). The list also includes *Pinus albicaulis* (Whitebark Pine), which normally grows near timberline, and *Salix reticulata* ssp. *nivalis* (Snow Willow), a dwarf shrub that attains a height of <1 cm. The most abundant of the alpine plants is *Dryas octopetala* var. *hookeriana* (White Dryad), which forms extensive mats along the edge of the canyon and on ledges within the canyon. *Saxifraga oppositifolia* (Purple Saxifrage) is an arctic-alpine species that occurs as far north as Ellesmere Island. At Marble Canyon, it is restricted to growing on the vertical walls of the canyon, rather than its more usual habitat on mountain slopes and tundra. It is attached at one point, and dangles down into the canyon like a hanging garden. One of the hanging Purple Saxifrages had attained a length of >1 m in the early 1980s, but erosion has apparently caused its detachment and disappearance since then.

Ten additional species occur at Marble Canyon which are also found near or above treeline (>2400 m) but which are also common at lower altitudes (mean altitude of herbarium specimens 1800-2000 m). These include *Epilobium clavatum*, *Astragalus alpinus*, *Vaccinium scoparium*, *Anemone parviflora*, *Rhododendron albiflorum*, *Senecio lugens*, *Salix vestita*, *Saxifraga aizoides*, *Polygonum viviparum* and *Arctostaphylos rubra* (common names are given in the Appendix).

Most of the alpine plants noted were concentrated near the edge of the canyon, where microclimatic conditions are often much cooler than in the adjacent spruce-fir forest. On a sunny, summer day between 10:00 and 13:30 MDT (3 August 1981), air temperature in the forest increased from 16–24°C, while air temperature in the canyon, 10 m below the second bridge, was only 8–14°C. Similarly, on a warm (18–21°C) autumn afternoon (17 September 1982, 16:30-18:30 MDT), the temperature of the air surrounding *Cassiope tetragona* (White Mountain Heather) plants growing at the edge of the canyon

TABLE 1. Altitudinal distribution of alpine plant species found in or near Marble Canyon, based on herbarium collections from the region (Rocky Mountains and foothills between latitudes 49°30' and 53°00').

Species	Altitude (m) mean	SD	range	N*	N<1500 m**
Saussurea nuda var. *densa*	2325	172	1829-2685	36	0
Draba lonchocarpa	2313	183	1905-2931	51	0
Salix reticulata ssp. *nivalis*	2263	241	1726-2591	23	0
Arnica angustifolia	2243	237	1341-2500	31	1
Saxifraga oppositifolia	2230	263	1311-2718	43	1
Juncus drummondii	2220	171	1737-2591	32	0
Erigeron humilis	2216	200	1692-2685	46	0
Veronica alpina	2195	216	1676-2555	25	0
Phyllodoce glanduliflora	2174	211	1702-2743	42	0
Pinus albicaulis	2157	203	1720-2438	17	0
Dryas octopetala ssp. *hookeriana*	2154	305	1219-2646	50	2
Cassiope tetragona ssp. *saximontana*	2147	163	1615-2374	43	0
Phleum commutatum	2138	271	1585-2591	21	0
Poa alpina	2132	294	1280-2685	90	3
Carex atrosquama	2103	268	1067-2499	73	1
Trisetum spicatum	2089	321	1372-2743	27	1
Solidago multiradiata	2086	305	1280-2652	78	5
Gentianella propinqua	2057	347	1311-2835	54	5
Carex macloviana	2054	288	1510-2530	16	0
Cassiope mertensiana	2035	229	1524-2591	28	0
Arenaria longipedunculata	(1800)	—	—	1	0

*Number of herbarium specimens examined with altitude of collection reported.
**Number of herbarium specimens collected at altitudes <1500 m.

was only 8–12°C. Thus it appears that the alpine plants of Marble Canyon may often experience daily maximum temperatures that are 8–10°C colder than in the adjacent forest.

The cool microclimate appears to be caused by the large volume of cold (<8°C), glacially fed waters that flow through the bottom of the canyon. At the upper end of the canyon, spray from the 36-m waterfall induces additional cooling of the air because of rapid evaporation and latent heat loss. This should also dramatically reduce the peak maximum summer temperatures in the alpine plant habitats. In northern Europe, the distribution of several alpine plant species, including *Cassiope tetragona*, *Saxifraga oppositifolia*, and *Dryas octopetala* was found to be restricted to areas where peak maximum summer temperatures do not exceed 24°–27°C (Dahl 1951).

Studies on the floras of the upper Great Lakes also suggest the importance of microclimate in determining the distribution of alpine plants. Given and Soper (1981) noted 48 species of arctic-alpine plants that have a disjunct distribution along the coast of Lake Superior. Twelve of these species also occur in Marble Canyon (see Appendix), although only four of these fit my more restrictive definition of "alpine". The four species are *Poa alpina*, *Phleum commutatum* (*P. alpinum* L.), *Trisetum spicatum*, and *Arenaria longipedunculata* (*A. humifusa* Wahl.). Morton and Venn (1984) also provided a list of 20 arctic species in the flora of Manitoulin Island in Lake Huron. In both cases, most of the arctic-alpine plants are concentrated near the shoreline, where the cold Great Lake waters exert a strong cooling effect on the surrounding air during the spring and summer, and where persistant coastal fog reduces the amount of solar radiation. However, several of the arctic-alpine species, notably *Arenaria longipedunculata* (*A. humifusa*), occur in cold microsites along the floors of canyons northwest of Lake Superior. In these situations, the cold microclimate is produced by the presence of late-season ice and shading by the canyon walls (Given and Soper 1981). These features should also contibute to the cold microclimate in Marble Canyon, although vascular plants are generally absent from the deepest and narrowest sections of Marble Canyon, probably because of insufficient light.

At Marble Canyon, some of the alpine plants are probably also favoured by the moister conditions found near the falls, and in areas that are continuously moistened by seepages emanating from the canyon walls. The cool, moist limestone habitats in Marble Canyon also support the growth of ferns (Appendix), notably *Cystopteris fragilis* (Fragile Fern), and a diverse moss flora of approximately 100 species (D.H. Vitt and E.H. Hogg, personal observations).

A total of 28 alien species were recorded for Marble Canyon. These are mainly weeds of European origin which thrive in the disturbed habitats near the roadside and along the trails. Several were introduced by trail reclamation activities in the early 1980s. Four of the aliens are new records for Kootenay National Park, including *Thlaspi arvense* (Stinkweed), *Galeopsis tetrahit* (Hemp Nettle), *Lamium amplexicaule* (Dead Nettle) and *Trifolium repens* (White Clover).

This study also adds nine new native species to the flora of Kootenay National Park, giving a total of at least 690 taxa. The new records include *Cryptogramma stelleri*, *Arenaria longipedunculata*, *Arnica lonchophylla*, *Aster puniceus*, *Ranunculus sceleratus*, *Carex microptera*, *Danthonia californica*, *Festuca saximontana*, and *Juncus longistylis* (for common names see Appendix).

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APPENDIX. *Continued.*

Scientific name	Common name[4]	Collection number[7]
Danthonia californica	California Oat Grass[5]	MC 5
Deschampsia cespitosa	Tufted Hair Grass	MC 6
Elymus innovatus	Hairy Wild Rye	MC 7
Festuca rubra	Red Fescue	MC 8
Festuca saximontana	Rocky Mountain Fescue[5]	MC 9
Glyceria striata	Fowl Manna Grass	MC10
Hordeum jubatum	Foxtail Barley	
Oryzopsis asperifolia	White-grained Mountain Rice Grass[5]	MC11
Phleum commutatum (*P. alpinum* L.[1])	Mountain Timothy	MC82
**Phleum pratense*	Timothy	MC61
Poa alpina[1,2]	Alpine Bluegrass	MC13
**Poa annua*	Annual Bluegrass	
**Poa compressa*	Canada Bluegrass	MC68
Poa palustris	Fowl Bluegrass	MC14
**Poa pratensis*	Kentucky Bluegrass	MC15
Trisetum spicatum[1]	Spike Trisetum	MC16
IRIDACEAE (Iris Family)		
Sisyrinchium montanum	Blue-eyed Grass	
JUNCACEAE (Rush Family)		
Juncus balticus	Wire Rush	MC25
Juncus drummondii	Drummond's Rush[5]	MC83
Juncus longistylis	Long-styled Rush[5]	MC26
JUNCAGINACEAE (Arrow-grass Family)		
Triglochin palustris	Slender Arrow-grass	MC24
LILIACEAE (Lily Family)		
Stenanthium occidentale	Bronze-bells	MC46
Tofieldia pusilla	False Asphodel	
Zygadenus elegans	White Camas	
ORCHIDACEAE (Orchid Family)		
Habenaria hyperborea	Northern Green Orchid	
Listera borealis	Northern Twayblade	
Dicotyledoneae		
BETULACEAE (Birch Family)		
Betula glandulosa	Dwarf Birch	MC31
Betula occidentalis	Water Birch	
BORAGINACEAE (Borage Family)		
**Lappula squarrosa*	Blue-bur	MC66
CAMPANULACEAE (Bluebell Family)		
Campanula rotundifolia	Harebell	
CAPRIFOLIACEAE (Honeysuckle Family)		
Linnaea borealis	Twin-flower	
Lonicera involucrata	Bracted Honeysuckle	
Lonicera utahensis	Red Twin-berry	
Viburnum edule	Low-bush Cranberry	MC45
CARYOPHYLLACEAE (Pink Family)		
Arenaria longipedunculata (*A. humifusa* Wahl.[1])	"Alpine" Sandwort[6]	MC84
**Cerastium vulgatum*	Mouse-ear Chickweed	
Minuartia dawsonensis	Dawson Sandwort	CAFB 840836
**Stellaria longipes*	Long-stalked Chickweed	MC69
CHENOPODIACEAE (Goosefoot Family)		
**Chenopodium album*	Lamb's-quarters	
Chenopodium capitatum	Strawberry Blight	

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APPENDIX. List of vascular plant species for Marble Canyon and vicinity, Kootenay National Park, British Columbia.

Scientific name	Common name[4]	Collection number[7]
PTERIDOPHYTA		
EQUISETACEAE (Horsetail Family)		
Equisetum arvense	Common Horsetail	MC74
Equisetum scirpoides	Dwarf Scouring Rush[5]	MC51
LYCOPODIACEAE (Club-moss Family)		
Lycopodium annotinum	Stiff Club-moss	
Lycopodium complanatum	Ground Cedar	
OPHIOGLOSSACEAE (Adder's-tongue Family)		
Botrychium lunaria	Moonwort	
POLYPODIACEAE (Fern Family)		
Cryptogramma stelleri	Rock Brake	MC67
Cystopteris fragilis	Fragile Fern[5]	MC52
SELAGINELLACEAE (Little Club-moss Family)		
Selaginella densa	Prairie Selaginella	MC94
Selaginella selaginoides[1,2]	Spiny-edged Little Club-moss	MC27
SPERMATOPHYTA		
GYMNOSPERMAE		
CUPRESSACEAE (Cypress Family)		
Juniperus communis	Ground Juniper	
PINACEAE (Pine Family)		
Abies lasiocarpa	Alpine Fir	
Picea engelmannii	Engelmann Spruce	
Pinus albicaulis	White-bark Pine	MC95
Pinus contorta	Lodgepole Pine	
ANGIOSPERMAE		
Monocotyledoneae		
CYPERACEAE (Sedge Family)		
Carex atrosquama	Dark-scaled Sedge[5]	MC75
Carex capillaris[1]	Hair-like Sedge[5]	MC17
Carex concinna[2]	Beautiful Sedge[5]	MC76, 77
Carex disperma	Two-seeded Sedge[5]	MC18, 21
Carex gynocrates[2]	Northern Bog Sedge[5]	MC65
Carex macloviana	Thick-spike Sedge[5]	MC78
Carex microglochin	Short-awned Sedge[5]	MC19
Carex microptera	Small-winged Sedge[5]	MC79
Carex norvegica	Norway Sedge[5]	MC80
Carex scirpoidea[1,2]	Rush-like Sedge[5]	MC 20, 22, 23
Kobresia simpliciuscula	Simple Bog-sedge[5]	MC81
GRAMINEAE (Grass Family)		
**Agrostis stolonifera*	Hair Grass	MC 1
Bromus inermis ssp. *pumpellianus*	Northern Awnless Brome	MC 2
Calamagrostis canadensis	Bluejoint	MC 3
Calamagrostis purpurascens[1]	Purple Reed Grass	MC 4

APPENDIX. *Continued.*

Scientific name	Common name[4]	Collection number[7]
COMPOSITAE (Composite Family)		
Achillea millefolium	Common Yarrow	
Agoseris aurantiaca	False Dandelion	
Anaphalis margaritacea	Pearly Everlasting	
Antennaria pulcherrima	Showy Everlasting	
Antennaria rosea ssp. *pulvinata*[3]	Rosy Everlasting[5]	MC70
Arnica angustifolia	Alpine Arnica[5]	MC44
Arnica cordifolia	Heart-leaved Arnica[5]	
Arnica lonchophylla	Spear-leaved Arnica[5]	
Aster ciliolatus	Lindley's Aster	CAFB 840895
Aster conspicuus	Showy Aster	CAFB 840897
Aster puniceus	Purple-stemmed Aster	
Aster sibiricus	Arctic Aster[5]	
Aster subspicatus	Leafy-bracted Aster[5]	MC62
**Chrysanthemum leucanthemum*	Ox-eye Daisy	
**Cirsium arvense*	Canada Thistle	
Erigeron elatus	Tall Fleabane[5]	MC64
Erigeron humilis	Purple Fleabane[5]	P
**Matricaria matricarioides*	Pineapple-weed	
Petasites palmatus	Palmate-leaved Coltsfoot	MC85
Petasites sagittatus	Arrow-leaved Coltsfoot	
Saussurea nuda var. *densa*	Dwarf Saw-wort[5]	P
Senecio lugens	Black-tipped Groundsel[5]	
Senecio pseudaureus	Thin-leaved Ragwort[5]	
Solidago multiradiata	Rocky Mountain Goldenrod[5]	MC47, 48
Taraxacum cf. *ceratophorum*[1]	Northern Dandelion[5]	P
**Taraxacum officinale*	Common Dandelion	
CORNACEAE (Dogwood Family)		
Cornus canadensis	Bunchberry	
CRUCIFERAE (Mustard Family)		
**Capsella bursa-pastoris*	Shepherd's-purse	
Draba lonchocarpa	"Spear-fruited" Whitlow-grass[6]	MC86
**Sisymbrium altissimum*	Tumbling Mustard	
**Thlaspi arvense*	Stinkweed	
ELAEAGNACEAE (Oleaster Family)		
Shepherdia canadensis	Canadian Buffalo-berry	
EMPETRACEAE (Crowberry Family)		
Empetrum nigrum[1]	Crowberry	MC37
ERICACEAE (Heath Family)		
Arctostaphylos rubra	Alpine Bearberry	MC32
Arctostaphylos uva-ursi	Common Bearberry	
Cassiope mertensiana	Western Mountain-heather[5]	MC33
Cassiope tetragona ssp. *saximontana*	White Mountain-heather[5]	MC34
Gaultheria hispidula	Creeping Snowberry	
Ledum glandulosum	Glandular Labrador Tea	MC54
Ledum groenlandicum	Common Labrador Tea	MC35
Menziesia ferruginea	False Azalea[5]	
Phyllodoce glanduliflora	Yellow Heather	MC36
Rhododendron albiflorum	White-flowered Rhododendron	
Vaccinium myrtillus	Low Bilberry	MC39
Vaccinium scoparium	Grouse-berry	MC40
GENTIANACEAE (Gentian Family)		
Gentianella propinqua	Felwort[5]	MC38
GROSSULARIACEAE (Gooseberry Family)		
Ribes lacustre	Bristly black current	

APPENDIX. *Continued.*

Scientific name	Common name[4]	Collection number[7]
LABIATAE (Mint Family)		
**Galeopsis tetrahit*	Hemp Nettle	
**Lamium amplexicaule*	Dead Nettle	MC58
**Prunella vulgaris*	Heal-all	
LEGUMINOSAE (Pea Family)		
Astragalus alpinus	Alpine Milk Vetch[5]	MC87
Hedysarum sulphurescens	Yellow Hedysarum[5]	
Lathyrus ochroleucus	Cream-coloured Vetchling[5]	MC88
**Medicago lupulina*	Black Medick	
**Medicago sativa*	Alfalfa	
**Melilotus alba*	White Sweet Clover	
**Melilotus officinale*	Yellow Sweet Clover	
Oxytropis monticola	Late Yellow Locoweed	MC89
**Trifolium hybridum*	Alsike Clover	
**Trifolium pratense*	Red Clover	
**Trifolium repens*	White Clover	
**Vicia cracca*	Tufted Vetch[5]	
LENTIBULARIACEAE (Bladderwort Family)		
Pinguicula vulgaris[1,2]	Common Butterwort	P
ONAGRACEAE (Evening Primrose Family)		
Epilobium angustifolium	Fireweed	
Epilobium ciliatum	Northern Willowherb[5]	MC50
Epilobium clavatum	"Alpine Club" Willowherb[6]	MC90
PARNASSIACEAE (Grass-of-Parnassus Family)		
Parnassia fimbriata	Fringed Grass-of-Parnassus	MC56
PLANTAGINACEAE (Plantain Family)		
**Plantago major*	Common Plantain	
POLYGONACEAE (Buckwheat Family)		
Polygonum viviparum[1]	Bistort	MC43
PYROLACEAE (Wintergreen Family)		
Moneses uniflora	One-flowered Wintergreen	
Orthilia secunda	One-sided Wintergreen	
Pyrola asarifolia	Common Pink Wintergreen	
Pyrola chlorantha	Greenish-flowered Wintergreen	
RANUNCULACEAE (Crowfoot Family)		
Anemone parviflora[1]	Small Wood Anemone[5]	MC41
Ranunculus scleratus	Cursed Crowfoot	MC59
ROSACEAE (Rose Family)		
Amelanchier alnifolia	Saskatoon	
Dryas drummondii	Yellow Dryad	
Dryas octopetala ssp. *hookeriana*	White Dryad	MC42
Fragaria virginiana	Wild Strawberry	
Geum aleppicum	Yellow Avens	
Potentilla fruticosa	Shrubby Cinquefoil	
Rosa acicularis	Prickly Rose	MC91
Rosa woodsii	Wild Rose	MC92
Rubus idaeus	Wild Red Raspberry	
Spiraea lucida	White meadowsweet	
RUBIACEAE (Madder Family)		
Galium triflorum	Sweet-scented Bedstraw	MC93
SALICACEAE (Willow Family)		
Populus balsamifera	Balsam Poplar	
Populus tremuloides	Aspen	
Salix farriae	Farr's Willow[5]	MC55