Twelve of the most thermophilous vascular plant species in Svalbard and their conservation state

Torstein Engelskjøn, Leidulf Lund & Inger Greve Alsos

An aim for conservation in Norway is preserving the Svalbard archipelago as one of the least disturbed areas in the Arctic. Information on local distribution, population sizes and ecology is summarized for 20 thermophilous vascular plant species. The need for conservation of northern, marginal populations in Svalbard is reviewed, using World Conservation Union categories and criteria at a regional scale. Thirteen species reach their northernmost distribution in Svalbard, the remaining seven in the western Arctic. Nine species have 1-8 populations in Svalbard and are assigned to Red List categories endangered or critically endangered: Campanula rotundifolia, Euphrasia frigida, Juncus castaneus, Kobresia simpliciuscula, Rubus chamaemorus, Alchemilla glomerulans, Ranunculus wilanderi, Salix lanata and Vaccinium uliginosum, the last four species needing immediate protective measures. Five species are classified as vulnerable: Betula nana, Carex marina ssp. pseudolagopina, Luzula wahlenbergii, Ranunculus arcticus and Ranunculus pallasii. Six species are considered at lower risk: Calamagrostis stricta, Empetrum nigrum ssp. hermaphroditum, Hippuris vulgaris (only occurring on Bjørnøya), Juncus triglumis, Ranunculus lapponicus and Rhodiola rosea. The warmer Inner Arctic Fjord Zone of Spitsbergen supports most of the 20 target species and is of particular importance for conservation. Endangered or vulnerable species were found in a variety of edaphic conditions; thus, several kinds of habitats need protection.

T. Engelskjøn, I. G. Alsos, Tromso Museum, University of Tromso, NO-9037 Tromsø, Norway, torstein@tmu.uit.no; L. Lund, Phytotron, University of Tromso, NO-9037 Tromsø, Norway.

The archipelago of Svalbard (74° 20' - 80° 50' N) (Fig. 1) is one of the world’s least impacted Arctic biomes, and it is an aim for Norwegian authorities to preserve it (Stortinget 2000). A plan for vegetation protection has been proposed by the Governor of Svalbard (1999; see Alsos 2000) because the prevailing practice of protecting plant species, but not their habitats, had evident shortcomings (Theisen & Brude 1998; Alsos 2000). The new plan (Miljøverndepartementet 2003) is a supplement to the national park system of Svalbard and implies protection of all plant life within circumscribed geographical areas (Fig. 2).

Svalbard harbours approximately 165 native vascular plant species (Elven & Elvebakk 1996). The Inner Arctic Fjord Zone of Spitsbergen (Fig. 1) is particularly rich in species and is favoured by frequently clear skies and elevated summer temperatures (Elvebakk 1985, 1989).

Between 20 and 30 of Svalbard’s vascular plant species can be considered warmth-demanding compared to the rest of the archipelago’s flora (Engelskjøn 1987; Elvebakk 1989). Their few, small and disjunct present-day populations are
partly relicts of larger populations thought to have been established between 9000 and 4000 years ago, when the mean July temperature was 1-2°C higher than at present (Birks 1991). The temperature decline over the last 4000 years (Birks 1991) may have suppressed sexual reproduction and caused fragmentation of populations and genetic bottle-necks (Alsos, Brochman et al. 2002; Alsos et al. 2003). Several thermophilous species rarely produce germinable seeds under the present climatic conditions and may thus have a reduced recruitment following disturbance (Nathorst 1883; Alsos et al. 2003; Cooper et al. in press). Increased human activity in the most species-rich parts of Svalbard (Hansen et al. 1996; Theisen & Brude 1998) may constitute a threat to the thermophilous species of the archipelago.

Many records of these species are more or less buried in the literature. Plant records prior to Hadač (1944) were imprecise due to lack of topographical maps. In spite of Svalbard having been frequently visited, documentation of uncommon species tended to be anecdotal. This paper is based on botanical surveys of Bjørnøya (Engelskjon & Schweitzer 1970; Engelskjon 1987), parts of Spitsbergen (Engelskjon et al. 1972; Hofmann & Thannheiser 1972; Thannheiser 1972; Dubiel 1990; Kuc & Dubiel 1995; Elven et al. 1990; Möller & Thannheiser 1997; Möller 2000; Alsos, Lund et al. 2002), Nordaustlandet (Neilson 1968), Edgeøya (Neilson 1970), Barentsøya (Hjelmstad 1981) and Svalbard as a whole (Elvebakk 1985, 1989; Engelskjon 1986; Elven & Elvebakk 1996), as well as our recent field investigations.

Our aim is to assess the local distribution of 20 target species in relation to their presumed edaphic and thermal demands and their need of conservation measures to protect them. Also considered are the southern geographical range extensions of some of these species and their mainly low alpine altitudinal limits in northern Scandinavia (Engelskjon 1986, 1994).

Fig. 1. Vegetation zones of Svalbard, adapted from Möller (2000). (The small island of Bjørnøya, about 250 km south of the main groups of islands, is not shown.)
Study area

Svalbard is subdivided into provinces shown in Fig. 3. Also a part of the archipelago is the small island of Bjørnøya, about midway between the Norwegian mainland and the island of Spitsbergen.

Methods

Inclusion of species

Apart from the 20 species treated here, at least 11 other vascular plant species in Svalbard may be considered thermophilous, e.g. *Arctagrostis latifolia* (Rønning 1972), *Botrychium boreale*, *B. lunaria* (Elvebakk et al. 1994), *Arenaria humifusa*, *Carex bigelowii* (Elven & Elvebakk 2002), *Cystopteris fragilis* (Rønning 1972), *Gentianella tenella* (Elvebakk 1989), *Juncus arcticus* (Lid 1925, 1967), *Taraxacum brachyceras* (Elvebakk 1989) and *Tofieldia pusilla* (Rønning 1972). However, these rare species were insufficiently documented or not seen by us. Conversely, at least two very rare species in Svalbard are adapted to cold conditions, viz. *Ranunculus glacialis* (Elven & Elvebakk 1996) and *Sagina caespitosa* (Lid 1962).

Phytogeographical terms

Zonal subdivision of Svalbard follows Möller (2000: 43) with respect to the Inner Arctic Fjord Zone of Spitsbergen (Fig. 1). In a circum-Arctic context we use the phytogeographical terms presented in Table 1.
Populations of species are recorded in Appendix 1 based on field observations, botanical literature, Norwegian university herbaria and personal communications. Unpublished finds have been included. When more than one source reports the same find, only the most precise one is quoted.

Estimates of population size are based on occurrence within the local 1 × 1 km square of the Universal Transverse Mercator (UTM ED50) grid. Populations are rated as small, medium or large, as delineated in Table 1. The term “population” here also includes subpopulations belonging to the same metapopulation. Red List categories are assessed according to the World Conservation Union (IUCN 2001) at the regional scale of Svalbard. The proportions of populations protected were reviewed according to extant and recently established protected areas (Miljøverndepartementet 2003; Fig. 2).

**Ecology**

Air temperatures for the growing season were compiled from climatological literature and from Engelskjøn (1986, 1987, 1994). Notes are provided on mineral and/or organic substrata and hydrology of the habitats of each species. Accompanying species are enumerated; nomenclature mainly follows Elvebakk & Hertel (1996), Elven & Elvebakk (1996), Frisvoll & Elvebakk (1996) and Gulden & Torkelsen (1996).

![Fig. 3. Thermophilous species per province in Svalbard (Bjørnøya not shown), given as the number of species/total number of observed populations of all 20 target species. See Fig. 1 for vegetation zones.](image)

**Table 1.** Definitions of phytogeographical terms and population size categories used in this paper.

| Term               | Definition                                                                 |
|--------------------|---------------------------------------------------------------------------|
| Boreal             | The northern, wooded latitudinal zone.                                    |
| Arctic             | The entire or most of the treeless zone.                                  |
| Low Arctic         | Southern portion of the Arctic, with prominent Betula nana, medium-sized Salix spp., Ledum palustre, Vaccinium spp. or Empetrum spp., corresponding to Elvebakk’s (1985) Low Arctic Tundra Zone. |
| High Arctic        | Northern portion of the Arctic, i.e. all lands north of the Low Arctic.   |
| Barents Sea region | Svalbard, Franz Josef Land, Novaya Zemlya, Vaygach, Kolguev and the polar Urals. |
| Small population   | A closed stand less than 15 × 15 m; alternatively, scattered individuals or ramets within only one quarter of the 1 km UTM square. |
| Medium population  | One or a few copious stands at least 15 × 15 m, or scattered individuals/ramets in more than one quarter of the 1 km UTM square. |
| Large population   | Generally distributed and/or abundant within one or more 1 km UTM squares. |
| No data            | No precise information is available on population size.                  |
Results

Table 2 summarizes worldwide northern limits, number of populations in Svalbard, and tentative Red List categories. A more detailed account is provided in Appendix 1, which also specifies populations protected under the current conservation plan for Svalbard (Miljøverndepartementet 2003).

State of conservation

Red List categories are recorded in Table 2. Nine species are considered endangered or critically endangered in Svalbard; five species are vulnerable, and six species are at lower risk. According to the current protection plan, more than half of the known Svalbard populations of the following species are protected: Alchemilla glomerulans, Calamagrostis stricta, Carex marina ssp. pseudolagopina, Empetrum nigrum ssp. hermaphroditum, Hippuris vulgaris, Juncus castaneus, Luzula wahlenbergii, Ranunculus arcticus, R. wilanderi, Rhodiola rosea, and Rubus chamaemorus. Fewer than half of the populations of Euphrasia frigida, Juncus triglumis, Kobresia simpliciuscula, Ranunculus lapponicus, R. pal-

Table 2. Twenty thermophilous species in Svalbard. Population data from Appendix 1.

| Species | Extant northern limit in Svalbard | Northern limit outside of Svalbard | No. of populations | % of populations protected | Red List category at the regional level (IUCN 2001) |
|---------|----------------------------------|-----------------------------------|--------------------|---------------------------|-----------------------------------------------|
| Alchemilla glomerulans Sam. | 74° 31’ Bjørnøya | 71° 10’ Nordkapp, mainland Norway (Dahl 1934) | 1 | 100 | Critically endangered |
| Betula nana L. | 78° 15’ Adventdalen | 76° NE Greenland (Fredskild 1998) | 39 | 0 | Vulnerable |
| Calamagrostis stricta (Timm) Koeler | 79° 30’ Liefdefjorden | 74° 40’ NE Greenland (Bay 1992) | 108 | 53 | Lower risk |
| Campanula rotundifolia L. | 78° 07’ Colesbukta | 75° 50’ NE Greenland (Bay 1992) | 4 | 0 | Endangered |
| Carex marina Dew. ssp. pseudolagopina (Sørensen) Böcher | 79° 30’ Liefdefjorden | 83° N Greenland (Bay 1992) | 16 | 100 | Vulnerable |
| Empetrum nigrum L. ssp. hermaphroditum (Hagerup) Böcher | 80° 30’ Nordaustlandet | 79° 10’ NW Greenland (Simmons 1909) | ca. 80 | 54 | Lower risk |
| Euphrasia frigida Pugsley | 79° 26’ Bockfjorden | 77° 20’ NE Greenland (Bay 1992) | 7 | 28 | Endangered |
| Hippuris vulgaris L. | 74° 31’ Bjørnøya | 82° 13’ N Greenland (Fredskild 1966) | 22 | 100 | Lower risk |
| Juncus castaneus Sm. | 78° 28’ Gipsdalen | 83° N Greenland (Bay 1992) | 5 | 60 | Endangered |
| Juncus triglumis L. | 79° 30’ Wijdefjorden | 83° N Greenland (Bay 1992) | 39 | 41 | Lower risk |
| Kobresia simpliciuscula (Wahlenb.) Mack. | 78° 56’ Kongsfjorden | 82° 01’ N Greenland (Holmen 1957) | 8 | 38 | Endangered |
| Luzula wahlenbergii Rupr. | 78° 17’ Adventfjorden | 75° 55’ NE Greenland (Bay 1992) | 14 | 50 | Vulnerable |
| Ranunculus arcticus R. Br. | 79° 15’ Krossfjorden | 83° N Greenland (Bay 1992) | 25 | 84 | Vulnerable |
| Ranunculus lapponicus L. | 79° Wijdefjorden | 73° Novaya Zemlya (Lyne 1924) | 70 | 41 | Lower risk |
| Ranunculus pallasii Schlecht. | 78° 25’ Bohemanflya | 73° Novaya Zemlya (Lyne 1924) | 11 | 45 | Vulnerable |
| Raunclclus wilanderi (Nath.) Å. & D. Löve | 78° 27’ Kapp Thordsen | 73° Novaya Zemlya (Lyne 1924 – sp.?) | 1 | 100 | Critically endangered |
| Rhodiola rosea L. | 78° 45’ Prins Karls Forland | 75° 05’ NE Greenland (Bay 1992) | 30 | 100 | Lower risk |
| Rubus chamaemorus L. | 78° 38’ Ekmanfjellet | 73° Novaya Zemlya (Lyne 1924) | 9 | 67 | Extirpated (Kongsfjorden); critically endangered (Adventdalen) |
| Salix lanata L. | 78° 12’ Adventdalen | 75° Taymyr (Tolmachev et al. 1996) | 2 | 0 | Endangered |
| Vaccinium uliginosum L. | 78° 39’ Mimerdalen | 81° 55’ N Greenland (Holmen 1957) | 5 | 20 | Critically endangered |

Engelskjøn et al. 2003: Polar Research 22(2), 317–339
lasii, and Vaccinium uliginosum are protected. None of the populations of Betula nana or Campanula rotundifolia, nor the only intact population of Salix lanata, are protected.

Impact of climate

Air temperatures and heat sums for July–August and June–September are summarized for Boreal or Arctic stations in northern Norway and Svalbard (Table 3). The island of Hopen has a comparably cold climate, summer temperatures reaching only a few degrees above zero. The climate at the southern end of Spitsbergen, represented by Hornsund, is comparable to Isfjord Radio and Bjørnøya. There is a sizeable difference in summer temperature between the coastal station Isfjord Radio, on the margin of the Middle Arctic Tundra Zone, and the Longyearbyen station in the Inner Arctic Fjord Zone (Fig. 1): degree-days (sum of mean diurnal temperatures) for July–August amount to 290 and 365, respectively. The thermophilous species in Svalbard generally require a heat sum exceeding 300 degree-days for July and August. The occurrence of these species in various parts of Spitsbergen is illustrated in Fig. 3.

Edaphic requirements

Based on observations in the field, preferences of soil and hydrology are outlined for the 20 target species (Table 4). There is a considerable variation along the gradients eutrophic—oligotrophic and drained—wet.

Review of species

Thirteen thermophilous species advance farther north in Svalbard than in other Arctic lands (Table 2). Seven species occurring in Svalbard reach their northern limits in Greenland: Carex marina ssp. pseudolagopina, Hippuris vulgaris, Juncus castaneus, J. triglumis, Kobresia simpliciuscula, Ranunculus arcticus and Vaccinium uliginosum. The following 20 target species are treated in some detail with regard to their distribution

| Table 3. Temperatures (°C) and heat sums for the summer in Svalbard. Standard normals 1931–1960, if not otherwise stated. Data from Steffensen (1982) and Baranowski (1975). See also Aune (1993) for standard normals 1961–1990. Data for Tromsø and Vardø, northern Norway, included for comparison. |
|-----------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Northern latitude | Jun. | Jul. | Aug. | Sept. | Jun.–Aug. | Jul.–Aug. | Jun.–Sept. |
| Tromsø 69° 39’ | 9.4 | 12.6 | 11.5 | 7.7 | 747 | 1260 |
| Vardo 70° 22’ | 6.3 | 9.3 | 9.8 | 6.8 | 590 | 983 |
| Bjørnøya 74° 31’ | 2.0 | 4.5 | 5.0 | 3.0 | 295 | 445 |
| Hopen (1946–1965) 76° 30’ | -0.4 | 2.0 | 2.2 | 0.9 | 130 | 157 |
| Hornsund (1970–74) 76° 50’ | 2.2 | 5.3 | 4.8 | 1.7 | 315 | 432 |
| Isfjord Radio 78° 06’ | 1.8 | 4.9 | 4.4 | 1.3 | 290 | 383 |
| Longyearbyen 78° 12’ | 2.9 | 6.5 | 5.3 | 1.0 | 365 | 482 |

| Table 4. Twenty thermophilous vascular plant species in Svalbard according to edaphic gradients. |
|-----------------|----------|----------|----------|----------|----------|----------|----------|
| Drained | Moist | Wet |
| Calcareous (eutrophic) | (none) | Alchemilla glomerulans | Carex marina ssp. pseudolagopina |
| | | Kobresia simpliciuscula | Juncus castaneus |
| Mixed or intermediate (mesotrophic) | Betula nana | Euphrasia frigida | Calamagrostis stricta |
| Campanula rotundifolia | Ranunculus arcticus | Ranunculus wilanderi | Hippuris vulgaris |
| Rhododora rosea | Vaccinium uliginosum | Salix lanata | Ranunculus laponicus |
| Siliceous or humic (oligotrophic) | Empetrum nigrum ssp. hermaphroditum | Rubus chamaemorus | Ranunculus pulsatilis |
| Luzula wahlenbergii | (none) | | |

322 Twenty thermophilous vascular plant species in Svalbard
Engelskjøn et al. 2003: *Polar Research* 22(2), 317–339

and ecology in Svalbard (Table 2; Appendix 1).

*Alchemilla glomerulans*

The species occurs at one locality on Bjørnøya (Engelskjøn 1987: 103–104), which is also its northern limit. The nearest occurrences are on Jan Mayen (Lid 1964: 54) and at Nordkapp (North Cape) (Dahl 1934: 357).

In 1983 three individuals (clones) were found in a sheltered gully on the northern coast of Bjørnøya with the bryophytes *Brachythecium rufum*, *Dichodontium pellucidum*, *Philonotis tomentella*, *Sanionia uncinata*, *Syntichia ruralis* and *Timmia austriaca* and the vascular species *Cerasartium arcticum*, *C. cerastoides*, *Festuca rubra* ssp. *arctica*, *Oxyria digyna*, *Ranunculus pygmaeus* and *Saxifraga cernua*. Growing at a slightly disturbed site in the vicinity of the Bjørnøya meteorological station, *A. glomerulans* might have been introduced accidentally there. However, the species occurs in natural vegetation and may be native to Bjørnøya. See the distribution map in Engelskjøn (1987: 126).

*Betula nana*

The species is confined to south of Isfjorden (Nathorst 1871: 113; Andersson 1910: 411; Resvoll-Holmsen 1913: 26, 53). At Colesdalen it occurs up to 210 m asl (Alsos, Lund et al. 2002); at Adventdalen, to 140 m asl (Engelskjøn, unpubl. data). Only seven among 39 populations were rated as large. Seed reproduction has not been observed in germination experiments (Misund 1997) or seed bank studies (Alsos et al. 2003; Cooper et al. in press).

*Betula nana* occupies depressions on well-drained, south-facing hillsides. It is associated with *Cassiope tetragona* and *Dryas octopetala* (Table 14 in Lid 1967) and in places also with *Empetrum nigrum* ssp. *hermaphroditum* or *Hierochloë alpina* (Engelskjøn & Spjelkavik 1999).

The mushroom, *Leccinum rotundifoliae* (Fig. 3 in Engelskjøn & Spjelkavik 1999), forms mycorrhiza with dwarf birch (Gulden & Torkelsen 1996: 190) and appears as an indicator of Low Arctic vegetation.

This is a polymorphic species, which seems to comprise several subspecific taxa (Hultén & Fries 1986), and probably includes the northern *B. tundrarum* (Tolmachev 1976). De Groot et al. (1997: 253) summarized some taxonomic proposals on *B. nana*.

See distribution maps in Engelskjøn (Fig. 5 in 1986) and Elvebakk (Fig. 27 in 1989). See local maps in Hadač (Fig. 10 in 1944), Engelskjøn & Spjelkavik (Fig. 1 in 1999) and Alsos, Lund et al. (2002).

*Calamagrostis stricta*

On Bjørnøya this grass is often sterile but may develop culms up to 15 cm tall in late August. On Spitsbergen *C. stricta* is characteristic of riverbanks with culms up to 27 cm in early August. It is rare in the calcareous valley of Sassendalen and absent on the alkaline soils of Eskerdalen (Engelskjøn, unpubl. data) and Gipsdalen (Elven et al. 1990). Twelve large populations were recorded in the Inner Arctic Fjord Zone; otherwise the rather numerous populations are medium-sized (32) or small (21).

On Bjørnøya *C. stricta* associates, for example, with *Dupontia psilosantha*, *Equisetum arvense*, *Festuca rubra*, *Poa pratensis* ssp. *alpigena* and, rarely, with *Cardamine pratensis* ssp. *polemonioides*, *Carex subspathacea*, *Equisetum variegatum* or *Saxifraga cernua*. On Spitsbergen the species inhabits mesotrophic to eutrophic mires, associating with *Cardamine pratensis* ssp. *polemonioides*, *Colpodium vahlianum*, *Dupontia* spp. and *Eriophorum scheuchzeri*.

Most Svalbard specimens resemble *C. holmii* Lange with short, dark panicles (see Hultén 1968: 107, 1973: 465).

See distribution maps in Rønning (map 18 in 1972), Elvebakk (Fig. 64 in 1989). See local maps in Hadač (Fig. 36 in 1944) and Engelskjøn (1987: 115).

| Abbreviations of herbaria mentioned in this paper, in accordance with Holmgren et al. (1990). Some of the institutional names have been updated. |
|---|---|
| BG | Botanical Institute, University of Bergen, Norway |
| C | Botanical Museum, University of Copenhagen, Denmark |
| CGE | Botany School, University of Cambridge, UK |
| O | Botanical Museum, University of Oslo, Norway |
| TRH | Dept. of Botany, University of Trondheim (NTNU), Norway |
| TROM | Dept. of Botany, Tromsø University Museum, Norway |
**Campanula rotundifolia**

The species is confined to Colesbukta and Colesdalen, Spitsbergen. It was discovered in 1915 (Asplund 1919: 36) and flowering started on 13 August that year (specimens in Herbarium O; see Table 5). This is probably the population of *C. rotundifolia* located on a hill facing Colesbukta, extending over 104 m². Flowering started on 15 July in the exceptionally warm summer of 1998, in mid-August 1999 and at the end of July 2002. Two additional, small populations were found on the northern side of Colesdalen, succeeded towards the interior by a nearly continuous, large population extending over approximately 2600 × 400 m. No germinable seeds or seed bank have been observed (Alsos et al. 2003; Cooper et al. in press).

*Campanula rotundifolia* grows on sandstone lithosol with rock gaps and some turf with mesotrophic species such as *Betula nana*, *Draba daurica*, *Dryas octopetala*, *Poa glauca* and *Poemenium boreale* as well as the ubiquitous *Bistorta vivipara*, *Luzula arcuata* ssp. *confusa* and *Salix polaris*. We noted the scarcity of calciphilous species such as *Carex rupestris* and *Saxifraga oppositifolia*, which may be explained by the low amounts of calcium carbonate in the bedrock (Major & Nagy 1966). The occurrence of *Trisetum spicatum* suggests some protection by relatively late-lying snow.

Situated 0.4 to 4 km away from the former Colesbukta mining settlement, the occurrences of *C. rotundifolia* have remained intact up to the present and are still nearly undisturbed by human activity.

Flovik (1940) found that Colesbukta plants are diploid (2n = 34). Diploid *C. rotundifolia* may be given the rank of subspecies or species *C. gieskiana* Vest (Böcher 1960; Gadella 1964; Laane 1968; Croff 1978; Shetler 1982).

See distribution map in Alsos, Lund et al. (2002).

**Carex marina** ssp. *pseudolagopina*

First found in Sassendalen (by Nathorst in 1882; Herbarium C), but misinterpreted as *Carex lagopina* (= *C. lachenali*), this taxon was rediscovered on Spitsbergen 80 years later (Schweitzer 1966: 147 and his Fig. 2) and then referred to the synonymic *C. amblyorhyncha* V. Krecz. in accordance with Böcher (1952; see Halliday & Chater 1969).

*Carex marina* ssp. *pseudolagopina* is frequent at mires and ponds in Sassendalen and Gipsdalen, 3-50 m asl, whereas stations in Dickson Land and at Liefdefjorden are few. Occurrences apparently depend on calcareous substrata with sufficient moisture.

The species *Carex marina* associates with *Cinclidium arcticum*, *Meesia uliginosa*, *Orthothecium chryseeon*, *Scorpidium cossonii*, *Tomentypnum nitens*, *Cardamine pratensis* ssp. *poleoniioides*, *Carex maritima*, *C. parallelila*, *C. saxatisis*, *C. subspathacea*, *Equisetum arvense* ssp. *boreale*, *E. variegatum*, *Eriophorum triste*, *Eutrema edwardsii* and *Juncus triglumis*. Böcher (1952: 30) pointed out the slightly halophilous and calciphilous character of *C. marina* (as *C. amblyorhyncha*) in Greenland.

See distribution maps in Böcher (Fig. 12 in 1952), Ronning (map 25 in 1972), Engelskjøn (Fig. 6 in 1986) and Elvebakk (Fig. 67 in 1989).

**Empetrum nigrum** ssp. *hermaphroditum*

Discovered at Gronfjorden (Fries 1869; cf. Elvebakk & Spjelkavik 1995: 544), *Empetrum* is frequent at Isfjorden (Engelskjøn & Spjelkavik 1999), less so at Bellsund and Van Mijenfjorden (Engelskjøn et al. 1972). It is frequent in Dickson Land (Högborum 1913; Möller & Thannheiser 1997), inner Kongsfjorden and Liefdefjorden, but is rare in northern Svalbard (Elvebakk & Spjelkavik 1995; Möller 2000), including Nordaustlandet, at 80.5°N (Brattbakk 1981 cited in Elvebakk & Spjelkavik 1995). *Empetrum* ascends to approximately 200 m asl (Hadač 1944: 55). Only nine populations among approximately 80 are considered large.

Ripe fruits were recorded in the middle of August at Van Mijenfjorden (Holmboe 1910), on 4 September at Grønafjorden (Wirén 1922), in September at Mimerdalen (Högborum 1913: 153, his Fig. 1) and on 30 July in the warm summer of 1998. Collections from various parts of Spitsbergen bear unripe fruits that could well have reached maturity, but seed reproduction of *Empetrum* in Svalbard has not been observed in seed bank studies (Alsos et al. 2003; Cooper et al. in press).

*Empetrum* associates with *Betula nana* south of Isfjorden (Engelskjøn & Spjelkavik 1999). It is acidiphilous (Elvebakk & Spjelkavik 1995; Möller 2000) but was also observed on slightly calcifer-
ous substrata: at Berzeliusdalen with *Dryas octopetala* in a carpet of *Racomitrium canescens* coll. and at lower Reindalen with *Cassiope tetragona, Dryas octopetala, Hierochloë alpina* and sparse *Carex rupestris*. In the middle part of Reindalen *Empetrum* occurs on peaty banks with *Sphagnum aongstroemii, Tomentypnum nitens, Cassiope tetragona* and *Salix polaris*.

Svalbard plants are tetraploid with 2n = 52 (Flovik 1940; Engelskjøn 1979) and monoecious. *E. hermaphroditum* Hagerup, which is invariably tetraploid and has a northern distribution, was treated as a species (Fredskild 1998) or as a subspecies (Hultén 1968; Böcher et al. 1978). See distribution maps in Elvebakk (Fig. 67 in 1989) and Elvebakk & Spjelkavik (Fig. 2 in 1995). See local maps in Hadač (Fig. 11 in 1944) and Elvebakk & Spjelkavik (Figs. 4, 5 in 1995).

**Euphrasia frigida**

This annual plant was discovered at Bockfjorden by Skifte (1960, TROM, see Rønning 1961; Elvebakk & Spjelkavik 1981). In 1998 *E. frigida* was found some 150 km farther south, in Colesdalen (Alsos & Lund 1999), and in 2003 a 1 × 2 m patch was found at Ossian Sarsfjellet, Kongsfjorden (TROM). The nearest occurrences are at 71° N on Jan Mayen (Lid 1964: 60) and at Nordkapp (Dahl 1934: 382).

Detailed flora studies in Colesdalen in 2002 revealed small patches and scattered individuals of *E. frigida* within nine 100 × 100 m squares. Three habitats were located north of the settlement at Colesbukta, the remaining ones in the south-facing, northern valley slope approximately 2 km landward. The largest stand observed was 10 × 70 m, but most were a few square metres (Alsos, Lund et al. 2002).

Rønning (1961: 11) reported *Euphrasia* “in the hollows near the hot springs where the soil temperature is high”. At Colesbukta and in Colesdalen *E. frigida* grows in *Salix polaris* communities; in Colesdalen it also grows with *Bistorta vivipara, Festuca rubra* ssp. *arctica* and *Trisetum spicatum*, indicating eutrophic and snow-protected conditions (Fig. 1 in Alsos & Lund 1999). There is no geothermal heat at the Kongsfjorden and Colesbukta sites.

See distribution map in Elvebakk (Fig. 11 in 1989). See local map in Alsos, Lund et al. (2002).

**Hippuris vulgaris**

This aquatic species is confined to shallow pools on Bjornøya (Engelskjøn 1987). The northernmost station of *H. vulgaris* is in north Greenland, 82° 13' (map no. 150 in Bay 1992), whereas the stations closest to Bjornøya are Nordkapp (71° 7' - 8', Dahl 1934) and Karmakula in Novaya Zemlya (72° 24' N, Lyne 1924: 129). Two Bjornøya populations are rated as large; elsewhere they are medium-sized or small.

*Hippuris* grows in carpets of *Straminergon stramineum* or *Warnstorffia tundræ*, accompanied by *Cardamine pratensis* ssp. *pulemonoides, Dupontia psilosantha, Equisetum arvense* ssp. *boreale, Ranunculus hyperboreus* and *Saxifraga rivularis*.

See the distribution map in Engelskjøn (1987: 127).

**Juncus castaneus**

The northernmost representatives are located in north Greenland (Fredskild 1966; Bay 1992).

On Spitsbergen *J. castaneus* is restricted to Gipsdalen, Sassendalen and a few places south of Isfjorden. The drawing in Rønning (Fig. 39b in 1996) is not representative since the selected culm carries only undeveloped (aborted?) capsules.

The stand at Gipsdalen is very local (Eriksen Norberg, pers. comm. 1999), growing on calcareous mud with *Scorpidium cossonii*. According to Schweitzer (1966: 147), *J. castaneus* associates with *Ranunculus × spetsbergensis* at De Geerdalen. One collection from Longyeardalen consisted of 12 culms with half-ripe capsules as of 6 August 1924. To our knowledge this locality has not been seen recently and the plants may have been extirpated.

See distribution maps in Rønning (map 11 in 1972) and Elvebakk (Fig. 17 in 1989).

**Juncus triglumis**

The species occurs in one place at Recherche fjorden and more frequently around Isfjorden, Kongsfjorden and Wijdefjorden, inhabiting calcareous fens from 5 to 70 m asl and associating with *Cinclidium sp., Loeskypnum badium, Orthothecium chryseon, Paludella squarrosa, Scorpidium cossonii, S. turgescens, Carex marina* ssp. *pseudolagopina, C. parallela, C. saxatilis,
Eutrema edwardsii and (rarely) Kobresia simpliciuscula.

The variety *albescens* Lange has been identified from Svalbard. It is regarded as a subspecies by some authors (Elvebakk 1989; Elven 1994; Elven & Elvebakk 1996; Rønning 1996). Others found the varieties of *J. triglumis* vaguely circumscribed (Sørensen 1933: 159–161; Jørgensen et al. 1958: 47–48). The geographical ranges of *J. triglumis* and *ssp. albescens* are overlapping according to Hultén & Fries (1986).

At Mimerdalen (Elvebakk 1993: 250; Frisvoll & Elvebakk 1996: pl. XXI) discuss the nomenclature of *J. triglumis* and *ssp. albescens*. See distribution maps in Rønning (map 10 in 1972) and Elvebakk (Fig. 18 in 1989). See local map in Hadač (Fig. 36 in 1944).

Kobresia simpliciuscula

Two stations were reported at the inner branches of Isfjorden: Mimerdalen, 2 km from the sea (Lid 1925: 316) and Gipsdalen, 10–20 m asl (Engelskjøn 1986) as well as one at Kongsfjorden, 50–130 m asl (Elvebakk 1993). With approximately 10 tufts, the Gipsdalen population was found the varieties of *K. simpliciuscula* (Lange has been identified from Svalbard. It is regarded as a subspecies by some authors (Elvebakk 1989; Elven 1994; Elven & Elvebakk 1996; Rønning 1996). Others found the varieties of *J. triglumis* vaguely circumscribed (Sørensen 1933: 159–161; Jørgensen et al. 1958: 47–48). The geographical ranges of *J. triglumis* and *ssp. albescens* are overlapping according to Hultén & Fries (1986).

At Mimerdalen *K. simpliciuscula* occurred with *Carex paralela* and *Juncus triglumis* (Lid 1925), and the specimens are admixed with *Scorpidium cossonii*, an indicator of calcareous substratum (Elvebakk 1993: 250; Frisvoll & Elvebakk 1996: 114). At Gipsdalen *K. simpliciuscula* grew on calcareous mud accompanied by *Orthothecium chryseon*, *Scorpidium cossonii*, *Bistorta vivipara*, *Carex marina* ssp. pseudolagopina, *Carex paralela*, *C. saxatilis*, *Eutrema edwardsii*, *Juncus triglumis*, the ubiquitous *Salix polaris* and some *Draba oxyccarpa*, *Dryas octopetala* and *Saxifraga hirculus*.

At Kongsfjorden *Kobresia* occurred on calcareous substrata, as indicated by the admixed *Dictyochum flexicaule*, *Hypnum bambergeri*, *Scorpidium turgescens*, *Tomentypnum nitens*, *Juncus triglumis* and *Tofieldia pusilla*. The fens with *K. simpliciuscula* were “dominated by *Carex saxatilis*” (Elvebakk, note on herbarium label).

In 2001 and 2002 four small populations of *Kobresia simpliciuscula* were discovered in Adolphukta (in Bünsow Land) and at Wijdefjorden (Ny-Friesland) (Elvebakk, pers. comm. 2002). Details on these localities will be given by Elvebakk et al. (in prep.).

See distribution maps in Rønning (map 18 in 1972), Engelskjon (Fig. 7 in 1986) and Elvebakk (1993).

Luzula wahlenbergii

The first find in Svalbard was at Bjørndalen (Nathorst 1883: 37) and subsequent finds are all from the siliceous parts of Nordenskiöld Land and Nathorst Land, not above 50 m asl. Only one among 14 populations may be rated as medium-sized; otherwise they are small.

*Luzula wahlenbergii* associates with *Onkophorus wahlenbergii*, *Sphagnum aongstroemii*, *S. teres*, *Straminergon stramineum*, *Warnstoria armentosa*, *Calamagrostis stricta*, *Petasites frigidus* and *Ranunculus pallasii*. Tundra mires structured by bryophytes are vulnerable to roadbuilding and terrain wear, for instance at Reindalen (Spiljakvik 1991). Although being threatened by local road construction, *L. wahlenbergii* was found within the Longyearbyen settlement as late as 1996 (Brosø, pers. comm. 1997).

See distribution maps in Rønning (map 13 in 1972) and Elvebakk (Fig. 30 in 1989).

Ranunculus arcticus

*Ranunculus arcticus* is dispersed in Svalbard from Edgeøya (Neilson 1970: 35, as *R. pedatifidis*) and Sorkapp (South Cape) northwards to Krossfjorden. It occupies sunny promontories to 230 m asl at Sassenfjorden (Elvebakk & Hodin 1985, TROM).

Neilson (1970) found the species co-dominant at a bird rookery on Edgeøya, but we believe most *R. arcticus* populations are small. A characteristic inhabitant of south-exposed hills with *F. rubra* ssp. *arctica*, *R. arcticus* associates with less common species such as *Draba arctica*, *D. norvegica*, *Festuca baffinensis*, *Polemonium boreale*, *Potentilla hyparctica*, *P. ×insularis*, *Silene furcata*, *Taraxacum arcticum* and *T. brachyceara*.

Simmons (1906: 101–108) and Lynge (1924: 35 and pl. XXI) discuss the nomenclature of *R. affinis*/*R. arcticus* (see Ericsson 2001: 256). The related *R. pedatifidis* Sm., to which the Svalbard plants were referred in earlier treatments, originates from the mid-latitude Altay Mountains (Hadač 1944).

See the distribution map in Elvebakk (Fig. 53 in
1989). See local map in Hadač (Fig. 50 in 1944).

**Ranunculus lapponicus**

The species extends from Bromelldalen south of Van Mijenfjorden northwards to Wijdefjord and (Nathorst 1883), from 5 m upwards to 130 m asl. A record of *R. lapponicus* from Edgeøya (Michelmore 1934) is not documented (see Dahl 1937: 25). Among 37 local populations of known size we consider only two as large (Appendix 1).

In Adventdalen, Colesdalen and Reindalen *Ranunculus lapponicus* occurs in bryophyte communities of *Aulacomnium palustre*, *A. turgidum*, *Oncothecium wahlenbergii*, *Paludella squarrosa*, *Sphagnum fimbriatum*, *S. squarrosum*, *S. teres*, *Sanionia uncinata*, *Tomentypnum nitens* or *Warnstorfia tundrae*. It associates with *Carex subspathacea*, *Dupontia fisheri*, *Equisetum arvense* ssp. *boreale*, *Petasites frigidus* (Table 20 in Lid 1967), *Ranunculus hyperboreus*, *R. ×spetsbergensis*, *R. pallasii* and *Salix polaris*. See distribution maps in Engelskjøn (Fig. 8 in 1986) and Elvebakk (Fig. 52 in 1989). See local map in Hadač (Fig. 53 in 1944).

**Ranunculus pallasii**

The species is known from Reindalen, extending 21 km inland and upwards to 70 m asl, and from a few places at Isfjorden (Hadač 1944), reaching 100 m asl at interior Colesdalen (Engelskjøn & Spjelkavik 1999). Records of *R. pallasii* prior to Nathorst (1883: 21) partly include *R. ×spetsbergensis*, and those from Hornsund (Triloff 1944: 292) and Prins Karls Forland (Brown 1908: 315) probably refer to the latter.

The rhizomes are immersed during the first half of summer. Characteristic accompanying species are *Scapania sp.*, *Sphagnum squarrosum*, *Warnstorfia exannulata*, *W. fluitans*, *W. sarmentosa*, *Ranunculus lapponicus*, *R. ×spetsbergensis* and *Carex subspathacea*. On the Reindalsletta plain, 6 August 1985, we observed the drying out of the pools harbouring *R. pallasii*.

See distribution maps in Engelskjøn (Fig. 9 in 1986) and Elvebakk (Fig. 31 in 1989).

**Ranunculus wilanderi**

Restricted to a boggy plain inside Kapp Thordsen at Isfjorden, *R. wilanderi* was first observed, but not named, by Nathorst (1871). In his original description Nathorst (1883: 23–24) recorded it “in two places” at Kapp Thordsen, whereas the population was considered as “fairly extensive” by Elven & Elvebakk (1996: 40). Plants apparently numbered not more than 20 in 1996. They were confined to runnels between a dolerite cliff with *Ranunculus arcticus* and a *Sphagnum* moor with abundant, sterile *Rubus chamaemorus*.

Described as *R. affinis* *Wilanderi*, this is a member of the *R. auricomus* complex (Ericsson 2001: 237 and his Fig. 105b), apparently close to var. *glabrat* Lyne (1924: 35–36, pl. XXII). The latter was described from Novaya Zemlya, and subsequently identified from north-eastern Greenland (Sørensen 1933: 53–54). Var. *glabrat* was ranked as a species *R. glabrat* by Fagerström & Kvist (1983).

Engelskjøn et al. 2003: *Polar Research* 22(2), 317–339
Rhodiola rosea

The species was first discovered in Svalbard by Keilhau (1831) on his pioneer visit to Bjornoya. This island has most of Rhodiola in Svalbard (Engelskjøn & Schweitzer 1970; Engelskjøn 1987). Two large populations inhabit the cliffs and promontories of the north-eastern and south-western coasts; otherwise the species is scattered with a few individuals. Occurrences on Prins Karls Forland (Brown 1908: 318), including Richardaguna (Rønning, pers. comm. 1985), need further study. Pollen of Rhodiola has been found in droppings of incubating barnacle geese at Lovénøyane islands in Kongsfjorden (Alm & Alsos, unpubl. data 1999), suggesting that the species also may occur in that area.

Growing near the coastal brink of Bjornoya, Rhodiola prefers bedrock of Kulm sandstone and associates with Cochlearia groenlandica, Draba norvegica, Festuca rubra ssp. arctica, F. vivipara and Poa pratensis ssp. alpigena. There is also a Rhodiola–Luzula arcuata community.

The broad-leaved, dwarfed Svalbard strain (Fig. 9 in Engelskjøn & Schweitzer 1970) is referable to ssp. arctica (A. Boriss.) A. & D. Löve (Borisssova 1939: 30–31, 171–172).

See the distribution map in Elvebakk (Fig. 33 in 1989). See local map in Alsos, Lund et al. (2002).

Rubs chamaemorus

Rubs chamaemorus is restricted to moors near Isfjorden. One stand at Kapp Thordsen measures at least 50 × 50 m and is rated as medium-sized. Due to lack of flowers in 1996, the local proportion of pistillate/staminate plants is unknown. At Rusanovodden, near Coleshukta, south of the Rusanov hut, there were (in 1998) four stands (with staminate flowers), measuring 6 × 9 m; 4 × 8 m; 2 × 4 m, and 6 × 7 m, as well as (in 2002) two stands (with pistillate flowers), measuring 5 × 20 m and 20 × 20 m. One stand north of the Rusanov hut, not flowering in 2002, covered approximately 100 m². At Colesdal, near the cemetery south-east of the former mining settlement, two patches of staminate plants were found, each 6 × 6 m (Alsos, Lund et al. 2002).

Two pistillate stands below Ekmanfjellet were both approximately 10 × 3 m, and a staminate one at the river Hemsil was 9 × 11.5 m in 1998. At Sveasletta, west of Ekmanfjorden, one stand exceeded 10 × 10 m (Wirén 1922; Hauge, pers. comm. 1998). Flowering has been observed at most localities, but seed set is weak because of the prevailing unisexual clones. Ripe fruits were recorded at Sveasletta in the warm season of 1998 (Hauge, pers. comm. 1998).

The stands at Kapp Thordsen are on peat, mainly of Sphagnum fimbriatum. At Rusanovoden Rubus chamaemorus associates with Aulacomnium turgidum, Dicranum laevidens, Polytrichum strictum, Sphagnum aongstroemii or S. squarrosum, Betula nana and Luzula arcuata ssp. confusa. At Colesdal Rubus occurs in mesotrophic bryophyte carpets. The stands west of Ekmanfjorden support Cassiope tetragona and a number of lichen species, e.g. Pilophorus robustus, suggesting rather dry conditions.

See the distribution map in Elvebakk (Fig. 22 in 1989). See local map in Alsos, Lund et al. (2002).

Salix lanata

One Spitsbergen occurrence of a disputed Salix sp. is located on the northern brink of Adventelva, WSW of the Helvetia pingo (Innerhytta). It was discovered by Schweitzer in 1963 (see Hultén 1964; Schweitzer 1966). The juvenile, sparse material was first identified by Hultén as S. glauca L. ssp. callicarpaea (Trautv.) Böcher (see Hultén 1958, 1964). We have studied this occurrence in 1986, 1998 and 2001. Four small clones were permanently established over an area of 10 × 30 m. Only staminate catkins developed in the field and in cultivation at Tromsø Botanic Gardens (Fig. 4a).

The Adventdalen Salix grows in bryophyte carpets, mainly of Tomentypnum nitens, together with Alopecurus borealis, Calamagrostis stricta, Equisetum arvense ssp. boreale, Poa pratensis ssp. alpigena, Bistorta vivipara and Salix polaris. Patches of Dryas octopetala occurred on drier parts of the moist, sloping terrace, which is subjected to river undercutting and may become destroyed in the course of a few decades.

Elven & Elvebakk (1996: 41) reported another medium-sized Salix (as S. arctica) from Ny-Ålesund. That individual was extirpated in 1990/1991 according to a note on the herbarium label by O. I. Rønning. We have studied material collected in 1974 and (as a dead twig) in 1991 (TRH), and a colour photograph from 1976 (Elvebakk, pers. comm. 2002), to compare it with the Adventdalen plants. In Elvebakk’s photograph
the sterile Salix sp. is seen with Bistorta vivipara, Salix polaris and Saxifraga oppositifolia.

Propagation of a twig transplanted from the Adventdalen Salix in 1998 (Fig. 4b) did not confirm Hultén's original identification of it as S. glauca ssp. callicarpaea, nor as S. arctica proposed by Elven (1994), Elven & Elvebakk (1996), Ronning (1996) and Elven & Karlsson (2000: 141). Its identification as S. lanata was suggested by George Argus, leading salicologist of North America, who has examined photographs and herbarium specimens from Adventdalen (pers. comm. 2002). This is corroborated by leaf morphology and venation, well-developed stipules (Fig. 4b), pale yellowish indumentum of short-pedunculate catkins, yellow anthers and glabrous anther filaments (Fig. 4a).

Carrying obovate, reticulate leaves, the sparse material from Ny-Ålesund is also referable to Salix lanata.

Both populations resemble low-growing strains of ssp. richardsonii (Hook.) A. Skvortzov, a view advanced by Elven (pers. comm. 2002). Further investigation is needed to assess the local distribution and phytogeographical connections of Salix lanata in Spitsbergen.

Vaccinium uliginosum

The species was discovered in 1908 at Mimerdalen (Lid 1925) and subsequently collected at what was then known as Coles Bay by G. Holmisen in 1912. The Vaccinium habitat at Kreklingpasset, north of Adventdalen, approximately 200 m asl, was exposed to natural erosion in 1981 (J. Nilsen, pers. comm. 1999). The species was not seen there in 1998 and may have been locally extirpated.

The Colesdalen population is medium-sized, covering more than half of an area of 1360 m² (consisting of one genotype), with two satellites (a closely related genotype) extending over 3.2 m² and 16 m², located 32 m and 40 m uphill, respectively (Alsos, Brochman et al. 2002). The Colesdalen habitat is a south-facing slope with prostrate Vaccinium mixed with Cassiope tetragona and Dryas octopetala. At Rusanovodden, 40 m asl, another medium-sized population, not flowering, was discovered in 2002. It occurred with Betula nana and Empetrum nigrum ssp. hermaphroditum (Alsos, Lund et al. 2002).

No germinable seeds or seed bank have been found in the Colesdalen population, the only place where flowers or fruits have been observed in Svalbard (Alsos et al. 2003; Cooper et al. in press).

One Vaccinium stand at Mimerdalen extending over a few square metres, probably on the hill Estheriahaugen (O. A. Hoeg, 1928, TRH), was accompanied by Dryas octopetala, Carex rupestris, Bistorta vivipara, Luzula arcuata ssp. confusa, Salix polaris, Dicranum laevigens, Tomenypnum nitens and several fruticose lichens, e.g. Thamnolia vermicularis (Möller & Thannheiser 1997).

Idodalen harbours stands of two partly overlapping V. uliginosum genotypes measuring 120 m² and 60 m², only 3 m apart (Alsos, Brochman et al. 2002). Co-dominant were Cassiope tetragona, Saxifraga oppositifolia and Tomentypnum nitens associating with some restricted, calciphilous species, e.g. Tofieldia pusilla.

Material from Colesbukta was found to be diploid with 2n=24 (Flolvik 1940). All the Svalbard populations are referred to the circumpolar ssp. microphyllum (Lge.) Tolm. (Alsos et al. 2003).

See the distribution map in Elvebakk (Fig. 32 in 1989). See local map in Alsos, Lund et al. (2002.)

Discussion

The Spitsbergen ranges of the thermophilous species broadly coincide with the Inner Arctic Fjord Zone (Elvebakk 1989), where the Longyearbyen meteorological station enjoys the highest summer warmth, 365 degree-days for July–August. However, we consider this local climate as marginal for the following 12 target species which require more than 400 degree-days for July–August (data from Engelskjøn 1994): Alchemilla glomerulans, Betula nana, Calamagrostis stricta, Campanula rotundifolia, Euphrasia frigida, Hippuris vulgaris, Juncus castaneus, J. triglumis, Ranunculus lapponicus, Rubus chamaemorus, Salix lanata and Vaccinium uliginosum. Lack of viable seeds or seed bank in three of these species, i.e. B. nana, C. rotundifolia and V. uliginosum, suggests that thermal requirements for seed production have not been met during recent decades (Misund 1997; Alsos et al. 2003).

Among the 20 thermophilous species treated here, 13 attain their northernmost limits in Svalbard. The remaining seven have their polar limits
in northern Greenland, from 81°55' to 83°N (Fredskild 1966; Bay 1992, 1997). A farthest
north station of “Empetrum nigrum” (Edlund & Alt 1989) indicates that Ellesmere Island also
possesses world northern limits of flora.

Other boreal or arctic species have been
recorded in the fossil or subfossil state north of
their present ranges. Instances are Angelica cf.
archangelica ( Bjørnøya, Wohlfahrt et al. 1995);
Armeria scabra (Edgeøya, Bennike & Hedenäs
1995); Parnassia palustris (Spitsbergen, van der
Knaap 1988); Saussurea alpina (Spitsbergen, van
der Knaap 1988) and Selaginella selaginoides
(Jan Mayen, van der Knaap 1987). Possible relict
occurrences of these or other warmth-demanding
species should be searched for in the Inner Arctic
Fjord Zone of Svalbard.

Eutrophic, mesotrophic and oligotrophic spe-
cies are represented in the group of thermophi-
lous species. There is no over-representation of
species with particular edaphical demands (see
Elvebakk 1982).

The following three species have most popu-
lations: Calamagrostis stricta (108), Empetrum
nigrum ssp. hermaphroditum (approximately 80),
and Ranunculus lapponicus (70). In these cases,
medium-sized or large populations prevail and
the species may be locally copious. Accordingly,
they were rated as at lower risk in Svalbard.

Less frequent, with 22 to 39 populations, are
Betula nana, Hippuris vulgaris (found only on
Bjørnøya), Juncus triglumis, Rhodiola rosea
(mainly on Bjørnøya) and Ranunculus arcticus.
They are rated as vulnerable or at lower risk.

Species with 1-16 populations are Alchemil-
la glomerulans (only on Bjørnøya), Campanula
rotundifolia, Carex marina ssp. pseudolagopina,
Euphrasia frigida, Juncus castaneus, Kobresia
simplicicula, Luzula wahlenbergii, Ranunculus
pallasii, R. wilanderi, Rubus chamaemorus,
Salix lanata and Vaccinium uliginosum. Depend-
ing on local conditions, they are rated as vulnera-
ble, endangered or critically endangered.

The latter category—critically endangered
at the regional level—comprises Alchemil-
la glomerulans (confined to Bjørnøya), Ranuncu-
lus wilanderi (confined to Kapp Thordsen),
Salix lanata (extirpated at Ny-Ålesund, persist-
ing at Adventdalen) and Vaccinium uliginosum
(critically endangered at Colesdalen because of
a mining scheme).

Among the target species, Betula nana, Cam-
panula rotundifolia and Salix lanata are entire-
ly unprotected by the present area-based conser-
vation plan (Fig. 2). One Svalbard population of
Salix lanata has probably become extirpated, the
remaining one, consisting of only male plants, is
threatened by natural erosion. Ex situ conserva-
tion is now being implemented at the Phytotron
of the University of Tromsø and Tromsø Botani-
ic Gardens.

There are strong Norwegian and Russian min-
ing interests within several of the proposed
nature reserves in Svalbard. As a result, the Nor-
wegian conservation authorities have signalled
that mining and conservation interests should
be combined to some extent within the protected
areas (Miljøverndepartementet 2003). The pro-
posed protected area at Colesdalen (Governor of
Svalbard 1999; Alsos, Lund et al. 2002) has been
disputed due to Russian mining interests and has
so far not been protected by the Norwegian gov-
ernment (Miljøverndepartementet 2003), con-
trary to botanical recommendations. This area
includes populations of Betula nana, Campanu-
la rotundifolia, Empetrum nigrum ssp. hermaph-
roditum, Euphrasia frigida, Ranunculus lapponi-
cus and Vaccinium uliginosum.

The climate-correlated, northward decline of
vascular plant species (Murray 1997) shows a
local anomaly in the Inner Arctic Fjord Zone of
Spitsbergen, especially in Dickson Land, Sabine
Land and Nordenskiöld Land, which altoget-
her harbour more than 15 thermophilous species
(Fig. 3). Due to its small and fragmented popu-
lations, this phytogeographical element needs fur-
ther investigation as to its Holocene past. It is
clearly in need of conservation.

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Twenty thermophilous vascular plant species in Svalbard
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Engelskjøn et al. 2003: Polar Research 22(2), 317–339.
Appendix 1

The table below lists the locations and population sizes of 20 thermophilous vascular plant species in Svalbard. Localities within established protected areas (Fig. 2) are in boldface. Names of field-workers are abbreviated as follows: Inger Greve Alsos–IA; Mari Aasen–MA; Geir Arnesen–GA; Liv Borgen–LB; Christian Brochmann–CB; Torstein Engelskjøn–TE; Arve Elvebakk–AE; Reidar Elven–RE; Ivar Hauge–IH; Kjell Tor Hansen–KH; Leidulf Lund–LL; Arne Pedersen–AP; Olaf I. Rønning–OR; Hanna Resvoll-Dieset/Resvoll-Holmsen–HR; Sigmund Spjelkavik–SS; Bjørn Erik Sandbakk–BS; Hans-Joachim Schweitzer–HS; Jan Thomas Schwenke–JS; Ola Skifte–OS; Kristine Westergaard–KW. Years following fieldworkers’ names indicate when plant populations were located. Names followed by years in parentheses refer to sources in the reference list. See Table 5 for abbreviations of herbaria. Population sizes (see Table 1) are large–L; medium–M; small–S. Nd stands for no data and Σ is sum.

| Species                  | Part of Svalbard | Location                           | Source, herbaria with voucher specimens | Population sizes |
|--------------------------|------------------|------------------------------------|-----------------------------------------|------------------|
| Alchemilla glomerulans   | Bjørnøya         | SE of Herwighamma                  | TE 1983, TROM; TE (1987)                | L M S Nd Σ       |
|                          |                  |                                    | Total                                    | 1 1              |
| Betula nana              | Nordenskiöld Land| Rusanovodden towards Colesbukta    | Nathorst 1882, Q; IA & LL 1998; IA, LL et al. (2002) | 1 1 2 |
|                          |                  | Colesbukta, W, S sides             | Strandwitz 1930, TROM; TE & SS (1999)   | 1 2 5 1 9       |
|                          |                  | Colesbukta, E, N sides             | Fries (1869); TE & SS 1986; TROM; IA, TE, LL, BS & MA 1998; IA & BS 1999 | 1 2 3 |
|                          |                  | Colesdalen, N side                 | TE & SS 1986, TROM; IA & LL 1998; IA & BS 1999, IA, LL et al. (2002) | 1 3 3 7 |
|                          |                  | Colesdalen, interior               | TE & SS 1986, TROM                        | 1 1               |
|                          |                  | Fardalen                           | LL 1997                                  | 1 1 2 |
|                          |                  | Gronfjorddalen                     | AE (1990)                                | 1 1               |
|                          |                  | Hotellineset                       | Vogt 1928, Q                             | 1 1               |
|                          |                  | Endalen                            | OS 1988, TROM; IA, TE, LL, BS & MA 1998 | 1 1               |
|                          |                  | Todalen                            | TE & AP 1970, TROM                       | 1 1               |
|                          |                  | Janssonhaugen                      | TE 1970, TROM                            | 1 1               |
|                          |                  | Adventdalen, N side                | Høgbom (1913); Hadač (1944); Sunding (1966); Lid (1967); TE & SS 1986, TROM; IA & LL 1998 | 1 3 6 3 10 |
|                          |                  |                                    | Total                                    | 5 13 18 3 39    |
| Species                          | Part of Svalbard         | Location          | Source, herbaria with voucher specimens | Population sizes |
|----------------------------------|--------------------------|-------------------|-----------------------------------------|------------------|
| *Calamagrostis stricta*          | Bjørnøya                  | Dispersed on plain | TE (1987)                                | 26               |
|                                  | Sørkapp Land, N side     | Døbel (1985)      | TROM                                    | 1                |
|                                  | Wedel Jarlsberg Land     | Triloft (1944)    | TROM                                    | 2                |
|                                  | Nathorst Land            | Mølterhøken       | TROM                                    | 1                |
|                                  | Nordenskiöld Land        | Bellsund, Berzeliusdalen | Dahl & Hadač (1946); TE & AP 1970; TE & JS 1987, TROM | 6               |
|                                  |                          | Reindalen         | TE & AP 1970; CB & TE 1985; TE & SS 1986, TROM | 7               |
|                                  |                          | De Geerdalen      | Hadač (1944); TE 1970                   | 6               |
|                                  |                          | Adventfjorden, Adventdalen, tributaries | Hadač (1944); TE & AP 1970; TE & SS 1986; TE 1995, TROM | 26              |
|                                  |                          | Bjørndalen        | Asplund (1919); IA, BS 2003, O          | 1                |
|                                  |                          | Colesbukta, Colesdalen | TE & SS 1986, TROM; IA, LL et al. (2002) | 13              |
|                                  |                          | Russekeila, Kapp Linné | Dahl & Hadač (1946) | 2               |
|                                  | Sabine Land              | Sassendalen, N side | RE & JS 1986, TROM                       | 1                |
|                                  | Bünsow Land              | Bjonadalen        | Asplund (1919)                          | 1                |
|                                  | Dickson Land             | Kapp Thordsen     | Dahl & Hadač (1946)                     | 2                |
|                                  | James I Land             | Hugindalen        | Lid (1967)                              | 1                |
|                                  | Oscar II Land            | Ovaasfjellet      | Ronning (1972)                          | 1                |
|                                  | Haakon VII Land          | Kapp Wårn         | Nathorst (1883)                         | 1                |
|                                  |                          | Kongsfjorden, E side | AE (1989); IA 1993                      | 3                |
|                                  |                          | Liefdefjorden, S, W | AE (1989); Möller (2000)                | 2                |
|                                  | Total                    |                   |                                         | 108              |
| *Campanula rotundifolia*         | Nordenskiöld Land        | Colesdalen, NE side | Asplund 1915, O, Asplund (1919); IA, TE, LL, MA & BS 1998, 1999, TROM | 1               |
|                                  |                          | Colesdalen, N side | TE & SS 1986; LL 1997; IA, LL & BS 1998, TROM; IA & BS 1999; IA, LL et al. (2002) | 2               |
|                                  |                          | Colesbukta towards Rusanovodden | IA, LL et al. (2002) | 1               |
|                                  | Total                    |                   |                                         | 4               |
| *Carex marina* ssp. pseudolagopina* | Nordenskiöld Land       | Sassendalen, S side | AE & Eriksen 1988, TROM                  | 1                |
|                                  | Sabine Land              | Sassendalen, N side | Nathorst 1882, O; HS (1966); RE et al. 1986–89, O, TROM | 6               |
|                                  | Bünsow Land              | Gipsdalen         | CB, TE, AE & RE 1985; Eriksen 1987, O, TROM | 7               |
|                                  | Dickson Land             | Kapp Thordsen     | Dahl 1981, pers. comm. 1984              | 1                |
|                                  | Haakon VII Land          | Liefdefjorden     | Thannheiser (1972)                      | 1                |
|                                  | Total                    |                   |                                         | 16               |
| *Empetrum nigrum* ssp. hermaphroditum | Wedel Jarlsberg Land  | Recherchefjorden | Lynge 1926, O                           | 1                |
|                                  | Nathorst Land            | Van Keulenfjorden, Annahamna | Lynge 1926, O                           | 1                |
|                                  | Van Keulenfjorden, Louisefjellet | Lind 1920, O        |                                         | 1                |
|                                  | Nordenskiöld Land        | Bellsund          | OR & OS 1958, TROM                       | 3                |
|                                  | Berzeliusdalen           |                   | TE, AP & HS 1970, TROM                   | 1                |

Engelskjon et al. 2003: *Polar Research* 22(2), 317–339
| Species            | Population sizes | Part of Svalbard | Location | Source, herbaria with voucher specimens |
|--------------------|------------------|------------------|----------|----------------------------------------|
|                     | L    | M    | S    | Nd  | ∑    |                                |                        |
| Van Mijenfjorden, N, W, Camp Morton area, 30-40 m asl | 3   | 3   | 3   |     | 3    | Holmboe (1910); AE & Hodin 1986, TROM |
| Reindalen, tributaries | 1   | 3   | 3   | 1   | 8    | TE et al. (1972); CB, TE 1985, TROM; SS (1991) |
| Lundstrømdalen | 1   |     | 1   |     | 1    | SS (1991) |
| Van Mijenfjorden, N | 1   |     | 1   |     | 1    | TE et al. (1972) |
| Gronsfjorden area | 1   |     | 1   |     | 1    | Fries (1869), Asplund (1919), Wirén (1922) |
| Hollendardalen | 1   |     | 1   |     | 1    | Sunding (1966) |
| Colesbukta, both sides | 3   | 2   | 2   | 7   | 7    | TE & SS 1986, TROM; TE & SS (1999); IA, TE, LL, BS & MA 1998; IA & KW 2002 |
| Colesdalen, N side | 1   | 4   | 5   |     | 6    | TE & SS 1986, TROM; TE & SS (1999); IA & SS 1999; IA, LL et al. (2002) |
| Adventfjorden, Adventdal, tributaries | 4   | 1   | 1   | 6   | 6    | Nathorst (1883); Hadač (1944); Sunding (1966), TE & AP 1970; GA & TE 1996, TROM; IA & LL 1998 |
| Mimerdal and Pyramiden | 1   |     | 1   |     | 1    | Nathorst (1883); Högbovm (1913); Möller, Thannheiser (1997); IA & LL 1998 |
| Odindalen | 1   |     | 1   |     | 1    | RE 1990, TROM |
| Kapp Wijk | 1   |     | 1   |     | 1    | Ballye 1896, CGE |
| Kapp Thorsden 75 m asl | 1   |     | 1   |     | 1    | RE 1992, TROM |
| James I Land | 3   | 3   |     |     | 3    | Fries (1869); Asplund (1919) |
| Ekmåfjorden, Kapp Wann | 2   | 1   | 1   | 8   | 8    | Hofmann & Thannheiser (1972); Möller (2000); AE & SS (1995) |
| Oscar II Land | 1   |     | 1   |     | 1    | Andersson & Hesselman (1900) |
| Bohemansset | 1   |     | 1   |     | 1    | Iversen & Koefoed 1923, BG, O |
| St. Jonsfjorden area | 1   |     | 1   |     | 1    | Nathorst (1883) |
| Ymerbukta | 1   |     | 1   |     | 1    | Asplund (1919) |
| Bertiffjellet | 1   |     | 1   |     | 1    | |
| Kongsfjorden area | 4   | 2   | 1   | 8   | 8    | Hofmann & Thannheiser (1972); Möller (2000); AE & SS (1995) |
| Haakon VII Land | 2   | 10  | –12 |     | –12  | Thannheiser (1972); AE & SS (1995); Möller (2000) |
| Liefdefjorden, Lernersøyane | 1   |     | 1   |     | 1    | Iversen & Koefoed 1923, O |
| Raudfjorden | 1   |     | 1   |     | 1    | Solheim et al. 1936, O |
| Smeerenburgfjorden | 1   |     | 1   |     | 1    | Hjelle 1964, O |
| Krossfjorden, W side | 1   |     | 1   |     | 1    | Hofmann & Thannheiser (1972); AE & S (1995) |
| Krossfjorden, E side | 2   | 2   |     |     | 2    | Summerhayes & Elton (1928) |
| Ny-Friesland | 1   |     | 1   |     | 1    | |
| Wijdefjorden, E side | 1   |     | 1   |     | 1    | |
| Mosselbukta | 1   |     | 1   |     | 1    | |
| Gustav V Land | 1   |     | 1   |     | 1    | Bratbakk (1981, cited in AE & SS 1995) |
| Nordaustlandet, Depotodden | 8   | 14  | 30  | 28  | –80  | Thannheiser (1972); AE & SS (1995); Möller (2000) |
| Nordenskiöld Land | 3   | 3   |     |     | 3    | IA & LL 1998, TROM; IA & LL (1999); IA & BS 1999 |
| Colesbukta, E side | 2   | 2   |     |     | 2    | IA, LL et al. (2002) |
| Haakon VII Land | 1   |     | 1   |     | 1    | OS 1960, TROM, OR (1961) |
| Beckfjorden, Trollkjeldene | 1   |     | 1   |     | 1    | |
| Oissian Sarsfjellet | 1   |     | 1   |     | 1    | KH, IA, BS 2003, TROM |
| Total | 8   | 14  | 30  | 28  | –80  | |
| Euphrasia frigida | 15  |     |     |     | 15   | |
| Hippuris vulgaris | 7    |     |     |     | 7    | |
| Bjørnøya | 15  |     |     |     | 15   | |
| Total | 22  |     |     |     | 22   | |
| Juncus castaneus | 1  |     |     |     | 1    | |
| Nordenskiöld Land | 2   | 10  | 10  | 22  | 22   | |
| Longyeardalen | 1   |     | 1   |     | 1    | Líd 1924, O |
| De Geerdalen | 1   |     | 1   |     | 1    | Håkanson (1966) |
| Sabine Land | 1   |     | 1   |     | 1    | Nathorst (1883) |

Twenty thermophilous vascular plant species in Svalbard
| Species                      | Part of Svalbard | Location            | Source, herbaria with voucher specimens | Population sizes |  |
|-----------------------------|------------------|---------------------|----------------------------------------|------------------|---|
|                            |                  |                     |                                        | L    | M | S  | Nd | Σ  |
| Gjelhallet                  |                  | Dahl 1981, Q        |                                        | 1    | 1 | 1  |    | 1  |
| Bünsow Land                 |                  | Eriksen 1987, Q, TROM; RE et al. (1990) |                                        | 1    | 1 |    |    | 1  |
| Total                       |                  |                     |                                        | 1    | 4 | 5  |    | 5  |
| Juncus triglumis            |                  |                     |                                        |  |
| Wedel Jarlsberg Land        | Recherchefjorden  | Turnbull (1900)     |                                        | 1    | 1 |    |    | 1  |
| Nordenskiöld Land           | Sassenfjorden, S side | Hadaał (1944)       |                                        | 1    | 1 |    |    | 1  |
| Adventdalen                 |                  | Hadaał (1944); TE, SS 1986, TROM |                                        | 2    | 1 | 6  | 9  | 9  |
| Bjørndalen                  |                  | HR (1913)           |                                        | 1    | 1 |    |    | 1  |
| Sabine Land                 | Sassendalen      | Nathorst (1883); RE et al. 1986, TROM |                                        | 1    | 5 | 6  |    | 6  |
| Bünsow Land                 | Gipsdalen        | CB, TE, AE, RE 1985, TROM |                                        | 2    | 1 | 1  | 4  | 4  |
| Dickson Land                | Mimerdalen to    | Lid 1924; Lid (1925); RE 1990, Q, TROM |                                        | 1    | 5 | 6  |    | 6  |
| Haakon VII Land             | Ossian Sarsfjellet | AE 1988, TROM       |                                        | 2    | 1 | 1  | 2  | 2  |
|                            | Blomstrandhalvøya | AE 1988, TROM       |                                        | 1    | 1 |    |    | 1  |
| Andrée Land                 | Purpardalen      | Dahl, Hadaał (1946) |                                        | 1    | 1 |    |    | 1  |
| Ny-Friesland                | Austfjordnes     | Spicer 1964, TROM   |                                        | 1    | 1 |    |    | 1  |
|                            | Wijdefjorden, E side | AE 2002, pers. comm. 2002 |                                        | 6    | 6 |    |    | 6  |
| Total                       |                  |                     |                                        | 4    | 5 | 30 | 39 |     |
| Kobresia simpliciuscula     |                  |                     |                                        |  |
| Bünsow Land                 | Gipsdalen        | TE 1985, TROM; TE (1986b) |                                        | 1    | 1 |    |    | 1  |
| Dickson Land                | Mimerdalen       | Isachsen 1925, Q; Hoeg 1928, TRH |                                        | 1    | 1 |    |    | 1  |
|                            | Adolfbukta       | AE 2001, pers. comm. 2001 |                                        | 1    | 1 |    |    | 1  |
| Haakon VII Land             | Kongsfjorden     | AE 1988, TROM (1993) |                                        | 1    | 1 | 2  |    | 2  |
| Ny-Friesland                | Wijdefjorden, E side | AE 2002, pers. comm. 2002 |                                        | 3    | 3 |    |    | 3  |
| Total                       |                  |                     |                                        | 1    | 3 | 4  | 8  |    |
| Luzula wahlenbergii         |                  |                     |                                        |  |
| Nathorst Land               | Bromelldalen     | Lyne 1926, Q        |                                        | 1    | 1 |    |    | 1  |
| Nordenskiöld Land           | Berzeliusdalen   | TE & AP 1970; TE & IS 1987, TROM |                                        | 2    | 2 |    |    | 2  |
|                            | Reindalen, tributaries | Harper & Spicer 1965, Q, TROM; TE et al. (1972) |                                        | 3    | 2 | 5  |    | 8  |
|                            | Adventfjorden, Bjørndalen, Revneset, Longyearbyen | Nathorst (1883); TE & IS 1970, TROM; Spicer 1965, TROM; Bross 1996, TROM |                                        | 1    | 2 | 2  | 5  | 5  |
|                            | Colesdalen       | TE & SS 1986, TROM  |                                        | 1    | 1 |    |    | 1  |
| Total                       |                  |                     |                                        | 1    | 8 | 5  | 14 |     |
| Ranunculus arcticus         |                  |                     |                                        |  |
| Edgeøya                     | Western coast    | Neilson (1970)      |                                        | 1    | 1 |    |    | 1  |
| Sørkapp Land                | Sørkapp          | Kristoffersen 1930, TROM |                                        | 1    | 1 |    |    | 1  |
| Nathorst Land               | Midterhuken to Bellsund | Malmgren 1864, Q; TE et al. (1972) |                                        | 1    | 1 | 2  |    | 2  |
| Nordenskiöld Land           | Kolsfjellet      | TE et al. (1972); AE et al. (1987) |                                        | 1    | 1 |    |    | 1  |
|                            | De Geerdalen, outlet | Hadaał (1944) |                                        | 2    | 2 |    |    | 2  |
| Sabine Land                 | Sassendalen, outlet, N | RE 1986, TROM |                                        | 2    | 2 |    |    | 2  |
| Bünsow Land                 | Gipsdalen, Tempelfjorden | TE, CB, AE, RE & Hodin 1985, TROM |                                        | 1    | 8 | 9  |    | 14 |
| Dickson Land                | Kapp Thorsden, surroundings | HR 1908, Q; RE, AE (1996) |                                        | 4    | 4 |    |    | 4  |
| Oscar II Land               | Alkhornet        | HR 1908, Q; OR, OS 1958, TROM |                                        | 1    | 1 |    |    | 1  |
| Haakon VII Land             | Krossfjorden     | Malmgren (1862)     |                                        | 1    | 1 |    |    | 1  |
|                            | Ossian Sarsfjellet | AE 1999, TROM; IA, KH, BS 2003, TROM |                                        | 1    | 1 |    |    | 1  |
| Total                       |                  |                     |                                        | 3    | 10| 12 | 25 |     |
| Ranunculus lapponicus       |                  |                     |                                        |  |
| Nathorst Land               | Bromelldalen     | TE et al. 1970, TROM; TE et al. (1972) |                                        | 1    | 1 |    |    | 1  |

Engelskjon et al. 2003: *Polar Research* 22(2), 317–339
| Species               | Part of Svalbard | Location             | Source, herbaria with voucher specimens | Population sizes |
|-----------------------|------------------|----------------------|-----------------------------------------|------------------|
|                       |                  |                      |                                         | Population sizes |
|                       |                  |                      |                                         | L   | M   | S   | Nd  | Σ   |
| Ranunculus pallasii   | Nordenskjöld Land| Van Mijenfjorden, N  | Lygne 1926; Harper 1964, Q; TE et al. (1972); CB & TE 1985; TROM; AE 1986 | 1    | 5   | 8   | 14  |
|                       |                  | Reindalens, Gangdalen| Hadač (1944); TE 1970; RE 1987, TROM | 2    | 6   | 8   |     |
|                       |                  | De Geerdalen, E, W sides | TROM | 1    | 1   |      |     |
|                       |                  | Eskerdalen           | Hadač (1944) | 1    | 1   |      |     |
|                       |                  | Broentskaredet       | Hadač (1944) | 1    | 1   |      |     |
|                       |                  | Revneset to Adventdalen, tributaries | N 1988, Q; Hadač (1944); Lid (1967); TE & AP 1970; TE & SS 1986; TE 1987, TROM | 6    | 1   | 5   | 12  |
|                       |                  | Bjørndalen           | TROM | 1    | 1   |      |     |
|                       |                  | Colesbukta, Colesdalen | RH 1908, Q; E & S 1986; TROM; AE 1986, IA & LL et al. (2002) | 1    | 2   | 1   | 11  |
|                       | Sabine Land      | Sassendalen, N side | Asplund 1915, Q; RE & JS 1986; TROM; AE & Øvstedal 1987, TROM | 4    | 4   |     |     |
|                       | Dickson Land     | Kapp Thordsen, Kapp Wijk | Jørgensen 1896, Q; Foged 1958, TROM; RE 1990, Q; TROM | 5    | 4   | 1   | 10  |
|                       | Oscar II Land    | Bohemanneset | Wirén (1922); Lid 1924, Q | 1    | 1   |      |     |
|                       | Haakon VII Land  | Feiringfjell 5 m asl | Lid, Bratthalk 1974, TRH | 1    | 1   |      |     |
|                       | Ny-Friesland     | At Wijdefjorden      | Nathorst (1883) | 1    | 1   |      |     |
|                       |                  | Total                |                                        | 2    | 21  | 14  | 33  | 70  |
| Ranunculus wilanderi  | Nordenskjöld Land| Stormyra, below Hagsynta | TE, AP 1970, TROM; TE et al. (1972) | 1    | 1   |      |     |
|                       |                  | Reindalsletta       | TROM | 3    | 3   |      |     |
|                       |                  | Adventfjorden, Adventdalen | Lid 1924, Q; OR 1959, TROM; HS (1966) | 1    | 3   | 4   |     |
|                       | Oscar II Land    | Kapp Laila          | TE 1986, TROM | 1    | 1   |      |     |
|                       |                  | Colesdalen, interior | TE & SS (1999) | 1    | 1   |      |     |
|                       |                  | Total                |                                        | 1    | 5   | 2   | 3   | 11  |
| Rhodiola rosea        | Bjørnøya         | Mainly N and E coast | TE (1987) | 2    | 4   | 20  | 28  |
|                       | Prias Karls Forland | Central, south Rudmose Brown (1908) | 1    | 1   |      |     |
|                       |                  | Richardlaguna       | Rønning, pers. comm. 1985 | 1    | 1   |      |     |
|                       |                  | Total                |                                        | 2    | 4   | 21  | 3   | 30  |
| Rubus chamaemorus     | Nordenskjöld Land| Rusanovodden        | Nathorst (1883); IA & LL 1998 | 1    | 1   |      |     |
|                       |                  | SE of Rusanovodden  | TROM; IA, LL et al. (2002) | 1    | 1   |      |     |
|                       |                  | Colesdalen, Tenndammen | Asplund 1915; Q; Asplund (1919); Nilsen 1979, TROM; IA & LL 1998 | 1    | 1   |      |     |
|                       | Sabine Land      | Sassendalen         | HR (1913) | 1    | 1   |      |     |
|                       | Dickson Land     | Kapp Thordsen       | RE, LB 1992, TROM; GA, TE & RE 1996 | 1    | 1   | 2   |     |
|                       | James I Land     | Ekmanfjorden, W side: below Ekmanfjellet, Hemsil river | Nathorst (1883); Wirén (1922); Nilsen 1979, TROM; IA & LL 1998 | 2    | 2   |      |     |
|                       |                  | Sveaneset           | Wirén (1922); IH 1998, pers. comm. 1998 | 1    | 1   |      |     |
|                       |                  | Total                |                                        | 4    | 3   | 2   | 9   |
| Salix lanata          | Nordenskjöld Land| Adventdalen N, WSW of Innerhylta, ca. 70 m asl | HS 1963, Q, SS; HS 1964, TROM; HS (1966); Hultén (1964); TE & SS 1986; IA & LL 1998, TROM; LL 2001 | 1    | 1   |      |     |
|                       | Oscar II Land    | Ny-Ålesund, at Storvatn, 40 m asl (extirpated 1990–91) | Aasgaard & OR 1974; OR 1991; TRH; AE 1976, pers. comm. 2002 | 1    | 1   |      |     |

Twenty thermophilous vascular plant species in Svalbard
| Species          | Part of Svalbard | Location          | Source, herbaria with voucher specimens | Population sizes |
|------------------|------------------|-------------------|------------------------------------------|------------------|
|                  |                  |                   |                                          | L    | M    | S    | Nd   | Σ    |
|                  |                  |                   | Total                                    | 2    | 2    |      |      |      |
| *Vaccinium uliginosum* |                  |                   |                                          | 1    | 1    |      |      |      |
|                  | Nordenskiöld Land| Colesdalen        | Holmsen 1912, Ø; Finnseth 1936, TROM; LL 1997 (photo); IA, LL, BS, MA 1998, TROM; IA, BS 1999 | 1    |      |      |      |      |
|                  |                  | Colesbukta towards Rusanovodden | IA; LL et al. (2002) | 1    |      |      |      |      |
|                  |                  | Kreklingpasset    | Egge 1940, 1941, Ø; Nilsen 1981, TROM | 1    |      |      |      |      |
|                  | Dickson Land     | Mimerdalen        | Høgbom (1913); Høeg 1928, TRH; Möller & Thannheiser (1997) | 1    |      |      |      |      |
|                  |                  | Idodalen          | IA & LL 1998, TROM                       | 1    |      |      |      |      |
|                  |                  |                   | Total                                    | 2    | 3    | 5    |      |      |