Botany of Bouvetøya, South Atlantic Ocean. II. The terrestrial vegetation of Bouvetøya*

TORSTEIN ENGELSKJØN

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Bouvetøya (54°25′S, 3°20′E), the northernmost land in the maritime Antarctic, has a climate typical of oceanic islands south of the Antarctic convergence, and a non-vascular vegetation of maritime Antarctic composition and structure. Mean vegetation temperatures during the growing season are from +1 to +4.5°C on the low ground, whereas elevations above 200 m a.s.l. are more prone to freezing and show regular diurnal freeze/thaw cycles. Radiative heating of the ground is important in some well-drained lichen communities with a northward aspect, but generally the mean diurnal temperatures registered in the superficial part of substratum and vegetation are low because of the prevailing cloudiness and high windspeeds. Some geothermally heated communities are described.

The soil reaction ranges from slightly acid on silicic lava and leached basalt ground, to alkaline on calcite-bearing pyroclastic rocks, with a correspondingly different vegetation. The main plant communities of Bouvetøya are documented by quadrat analyses, and a classification is proposed. Local distribution patterns of 26 cryptogamic species are discussed and related to soil chemistry and elevation, as well as to the time elapsed for their establishment and the development of communities undisturbed by volcanism, landslides, glacierization, and animal influence.

Torstein Engelskjøn, Botanical Garden and Museum, University of Oslo, Trondheimsveien 23B, N-0560 Oslo 5, Norway; December 1985 (revised August 1987).

Introduction

Geographical outline of Bouvetøya

Bouvetøya is centred on 54° 25′ S, 3° 20′ E, and is one of the most remotely isolated pelagic islands in the world. It is irregularly rectangular in outline, measuring 9.5 × 7 km. The topography is that of a stratovolcanic cone, of Pliocene and Pleistocene age (Prestvik & Winsnes 1981). Large parts of it have been removed by marine abrasion, especially on the north, west, and south-west coasts. Accordingly, the main crater has an eccentric position within the present land-mass.

The base map for local plant distribution (Maps 1–20) contains place-names for the most important botanical localities, see also Table 1 and the map of Bouvetøya 1:20 000 (Norsk Polarinstitutt 1986).

The highest mountain summits, all ice-covered, are situated on the north-eastern crater margin, reaching altitudes from 755 to 780 m above sea level. The ice-filled crater bottom has an elevation of c. 500 m, whereas the evenly sloping flanks of the volcanic cone extend down to c. 60 m a.s.l. on the east coast and 100–300 m on the south coast. On the west and north coasts the slopes terminate in abrasion precipices up to 400–500 m high. The beaches are narrow and wave-exposed, making access to the island quite difficult.

The coast has some prominent capes and promontories. To the east, the cliffs at Kapp Lollo reach 80 m. On the middle part of the north coast the silicic dome of Kapp Valdivia rises to 320 m from a plateau at 90 m a.s.l. Kapp Valdivia is nearly barren because of its exposed situation with excessive wind action, and possibly also because of the soil conditions, but there are some particular species on the cape.

The north-west corner of the island and the place first sighted by Bouvet in 1739, is named Kapp Circoncision; it is snow-free up to about 200 m a.s.l. and is the site of the largest penguin colony on Bouvetøya. Between Kapp Circoncision and the new ground of Nyrøysa there are vegetated sites at some elevation, e.g. the hill 177 m a.s.l. (see Fig. 7).

Nyrøysa is a 1.5 km long, supralittoral platform with a northern elevation of 51 m a.s.l. (in 1979). This is the main place for landing and setting up camp, but the area is rapidly being consumed by breaker action (Prestvik & Winsnes 1981, Figs. 6

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and 7). The platform consists of lava boulders, scoria, and avalanched ice, which originated from an enormous landslide between the years 1955 and 1958, possibly in connection with some seismic or volcanic activity. It also received the unofficial name 'Westwind Beach', and in some circumstances the informal notions 'Nordstranda' and 'Sørstranda' are used to describe the lower shores to the north and south, respectively, of the main platform (N and S on the maps of distribution). Nordstranda also has a large penguin and seal colony, which has expanded for some years to affect the sparse vegetation establishing on Nyrøysa. A major part of the plant collections were made on Nyrøysa, because of easy access from the 1978/79 camp.

Smaller vegetated areas occur on the crest north of Aagaardbreen (Fig. 2a); at Norvegiaodden, and inside the islet of Larsøya on the southwest coast. There is also a particular, elevated vegetation at the hill 410 m a.s.l. on the west coast.

However, the most extensive vegetation occurs on the high ground (260–380 m a.s.l.) on the south coast, which is defined as the ice-free plateau of Rustadkollen (Fig. 8); the small nunatak north of Rustadkollen (up to 380 m), and the ridge of Moseryggen, which attains 287 m a.s.l.

The remaining parts of Bouvetøya are largely ice-covered (93%) or so steep and susceptible to avalanches that only a sparse crustose lichen and thallose alga vegetation exists.

The work 'Bouvetøya, South Atlantic Ocean' (*Norsk Polarinstitutt Skrifter 175* 1981) provides further information on the natural conditions of the island, including papers on the fauna, geology, and meteorology, as reported by the Norwegian Antarctic Research Expeditions (NARE) of 1976/77 and 1978/79.

Previous and present botanical investigations

A preliminary account of the vegetation of Bouvetøya was published by Engelskjøn (1981). Part I of this series — Cryptogamic taxonomy and phytogeography (*Norsk Polarinstitutt Skrifter 185* 1986) contains articles on the bryophyte flora (Bell & Blom 1986), macrolichens (Jørgensen 1986), crustose lichens (Øvstedal 1986), lichenicolous ascomycetes (Øvstedal & Hawksworth 1986), a bryophilic ascomycete (Schumacher 1986), mainly terrestrial algae (Klaveness & Rueness 1986), and a regional phytogeographical discussion (Engelskjøn & Jørgensen 1986).

During the NARE 1984/85 the present author had the opportunity to revisit Bouvetøya for a few hours on 28 February, landing on some previously unknown sites on the high ground above the south and west coasts.

The objective of the present contribution is to describe the local development and distribution of the Bouvetøya vegetation in relation to environmental conditions. The localities which were studied are enumerated in Table 1. A previous account by Engelskjøn & Jørgensen (1986) briefly discussed the floristic distribution patterns within the island, but these will be treated in greater detail here.

Table 1. Localities on Bouvetøya at which botanical investigations have been made by NARE 1976/77, 1978/79, 1984/85.

By the present author:	
Kapp Valdivia	30 Dec. 1978
Kapp Circoncision	23 Jan. 1979
Hill 177 m a.s.l.	29 Dec. 1978
Nyrøysa, northern part	27 Dec. 1978; 12, 13, 17, 20 Jan.; 3, 8, 9, 12, 25 Feb.; 3, 6 Mar. 1979
Nyrøysa, middle and southern parts	28 Dec. 1978; 11, 13, 14, 15, 16, 17, 19, 24, 28, 30, 31 Jan.; 7, 10, 22 Feb.; 5 Mar. 1979
Crest north of Aagaardbreen	28 Feb. 1985
Hill 410 m a.s.l.	28 Feb. 1985
Rustadkollen	23 Jan.; 7 Mar. 1979
Nunatak north of Rustadkollen	28 Feb. 1985
Moseryggen	31 Dec. 1978; 1 Jan. 1979
Nyknausen	23 Jan. 1979
Other investigators collectors:	

Some collections and observations submitted by: K. Bjørklund, B. Enoksen, N. Nergaard, T. Prestvik, and L. Sømme (see Engelskjøn 1986a), i.a. from Nyrøysa, Larsøya, and high ground inside Larsøya.

Table 2. Air temperatures at Nyrøysa, Bouvetøya, 35 m a.s.l. Monthly means calculated from slightly heterogeneous, manual, and automatic observations, 1977–81 (°C). Data from Vinje (1978, 1981, and pers. comm.).

Year	J	A	S	O	N	D	J	F	M	A	M	J
−0.6	−2.7	−2.5	−2.7	−1.7	−0.6	0.7	1.6	1.5	1.5	0.3	−0.5	−1.1

Highest recorded air temperature: 9.3°. Lowest recorded air temperature −9.0°.

Table 3. Climatological summaries for Bouvetøya and some other maritime Antarctic stations. Data from Müller (1982).
A. Air temperature and wind conditions.

Station	S Lat.	Long.	Altitude m a.s.l.	Mean temperatures (°C) Dec.	Jan.	Feb.	July	Year	Degree-Days, January-February	Mean windspeed m s^{-1}
Bouvetøya	54°25′	3°18′E	35	0.7	1.6	1.5	−2.7	−0.6	c. 90	c.5
Orcadas	60°44′	44°44′W	4	−0.6	0.2	0.4	−10.6	−4.4	15	5.0
Bahia Esperanza	63°24′	56°59′W	11	−0.3	0.4	−1.0	−9.9	−5.3	−15	6.4
Argentine Islands	65°15′	64°15′W	11	−0.4	0.2	−0.2	−11.2	−5.2	0	3.9

B. Wind chill (Siple & Passel 1945)/Cooling power (Vinje 1962). Average for various months.

Station	December	January	February	July
Bouvetøya	—	914/33	925/34	—
Orcadas	890/29	874/29	900/31	1220/41
Bahia Esperanza	985/36	883/33	975/34	1261/45
Argentine Islands	816/25	820/26	848/27	1184/38

Table 4. Air and vegetation temperatures at Nyrøysa, Bouvetøya, 30 m a.s.l., 1–16 January 1979, and some other meteorological parameters.

Main weather situation		Mean temperatures (°C) Air	Vegetation category and aspect: I Epilithic lichen 50°NNW	II Moss cushion 40°NNW	III Sparse growth –	Mean air humidity %	Mean windspeed m s^{-1}
Clear, sunny days (n = 4)	Diurnal	1.0	8	5	0.5	86	6
	Maximum	2.1	27	15	1		
	Minimum	−0.6	0	0.5	0		
Partly overcast days (n = 6)	Diurnal	1.1	5	3.5	0.5	91	6
	Maximum	2.0	18.5	13	1		
	Minimum	0.2	0	0.5	0		
Heavily overcast, rainy days (n = 3)	Diurnal	2.2	2.5	2	1.5	92	13
	Maximum	3.6	6	3.5	3.5		
	Minimum	0.6	0.5	0.5	0.5		
Snowy days (n = 3)	Diurnal	0.5	2.5	2	0	86	5
	Maximum	1.4	8	5.5	0.5		
	Minimum	−0.5	−0.5	0	0		
Entire period, (n = 16)	Diurnal	1.2	4.5	3.5	1	89	7
	Maximum	2.2	16	10	1.5		
	Minimum	−0.1	0	0.5	0		

Table 5. pH and elemental analysis of some soils from Bouvetøya.

Bedrock derivation	Texture and vegetation	pH	Ca-AL mg/100 g	CaO %	Mg-AL mg/100 g	K-AL mg/100 g	P-AL mg/100 g	Na mg/100 g
Tuff and breccia, summit	Gravel, with *Mastodia*	8.2	2600	3.96	325	30	7.2	24
410 m a.s.l.	Green clay/silt, barren	8.6	1525	3.71	600	46	16	40
Average		8.4	2063	3.84	465	38	11.6	32
Basalt lithosol, leached, on Rustadkollen plateau,	Cryoturbated patch, with *Pannaria/Andreaea/Usnea*	5.2	120	0.61	63	31	3.0	30
330–340 m a.s.l.	Stony slope, with *Drepanocladus/Andreaea/Usnea*	5.6	110	0.67	71	31	3.0	25
Average		5.4	115	0.64	67	31	3.0	28
Silicic lava sand, Kapp Valdivia, 80–90 m a.s.l.	Sandy detritus with ? *Ceratodon, Drepanocladus*	6.6	72	—	37	33	—	47

—: Not analysed

Climate and microthermal regimens

General

Meteorological data collecting on Bouvetøya started with setting up an automatic weather station on the southern part of Nyrøysa during the NARE 1976/77 (Vinje 1978), and this programme was expanded during the 1978/79 expedition (Vinje 1981) when a manned station was also operated, with the present author participating. New automatic stations have been installed on the northern part of Nyrøysa and on the glacierized high ground, and they are now operating continuously (Vinje pers. comm.).

The time span necessary for a valid air temperature summary in this kind of environment is about 10 years (Landsberg & Jacobs 1951, p. 979). Calculated monthly means and extremes are shown in Table 2. The figures are preliminary, but give an indication of the air temperature regimen at the station 35 m a.s.l. on Bouvetøya. The present automatic stations do not measure precipitation. Orheim (1981, p. 8) suggests a four-monthly winter precipitation of 500 mm, and Vinje (1981, p. 89) estimated 100 mm during January and February. Hence a yearly precipitation between 700 and 1000 mm appears realistic. Windspeed is well documented for January and February, but the station is only locally representative (Vinje 1981). Average windspeed and derived figures of wind chill and cooling power are seen from Table 3a and b, which also compare some other maritime Antarctic stations.

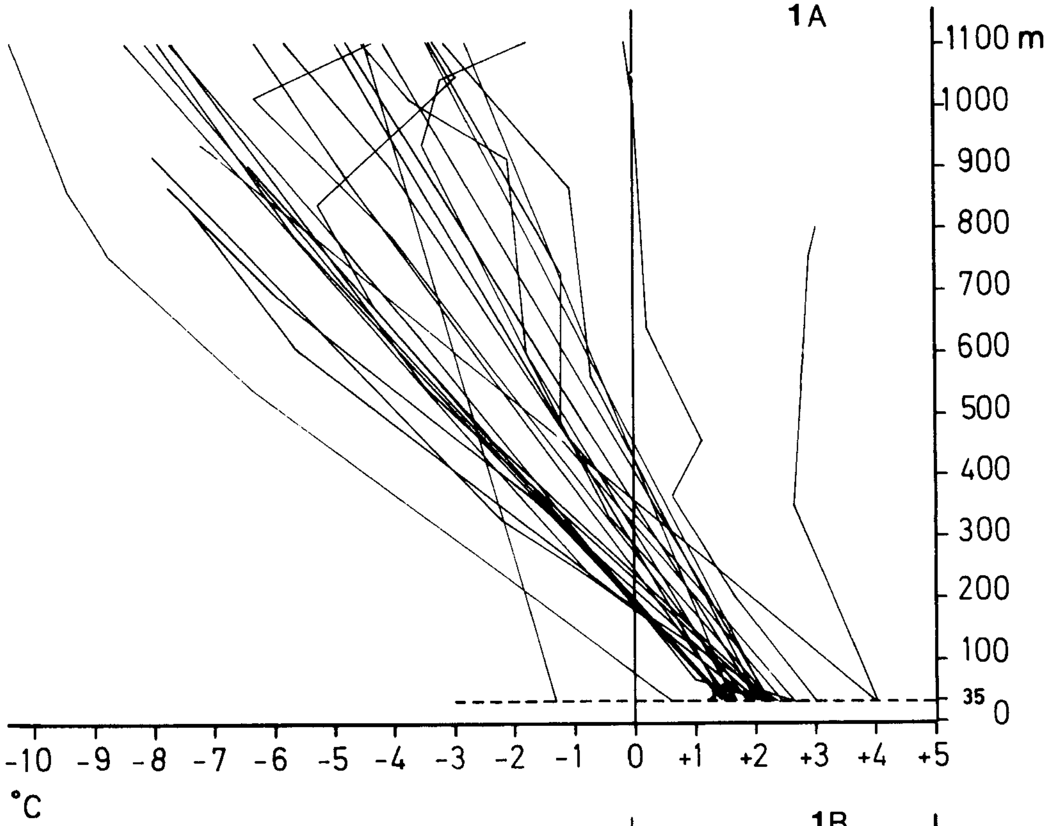
The vertical temperature gradient

Upper air soundings were made at 1200 and 2400 hrs. GMT during January and February 1979. The altitudinal decline of temperature at the lower elevations is shown graphically in Fig. 1a and b, based on a total of 60 sonde balloon ascents. The midday air temperature at the station averaged +2°. Air temperatures may remain positive even at high altitudes during special weather conditions, but on average zero temperature is reached at 320 m, and −4.5° at 1000 m a.s.l. At midnight the air temperature at the station averaged +0.5°, and the average zero level is at 200 m a.s.l. In both cases the vertical temperature gradient comes close to 0.7°/100 m, which was also calculated by Vinje (1981, p. 97) for the austral summer.

Microthermal measurements

Preliminary results of soil and vegetation temperature measurements were presented in an earlier publication (Engelskjøn 1981). Microthermal measurements have been much used during the past two decades to describe the environment near the ground (Walton 1984).

Fig. 1. Altitudinal gradients of air temperature, Bouvetøya, January-February 1979. Data from radiosonde ascents, by courtesy of Det norske meteorologiske institutt/Norsk Polarinstitutt. A. At midday, 1200 hrs. GMT (30 ascents). B. At midnight, 2400 hrs. GMT (30 ascents).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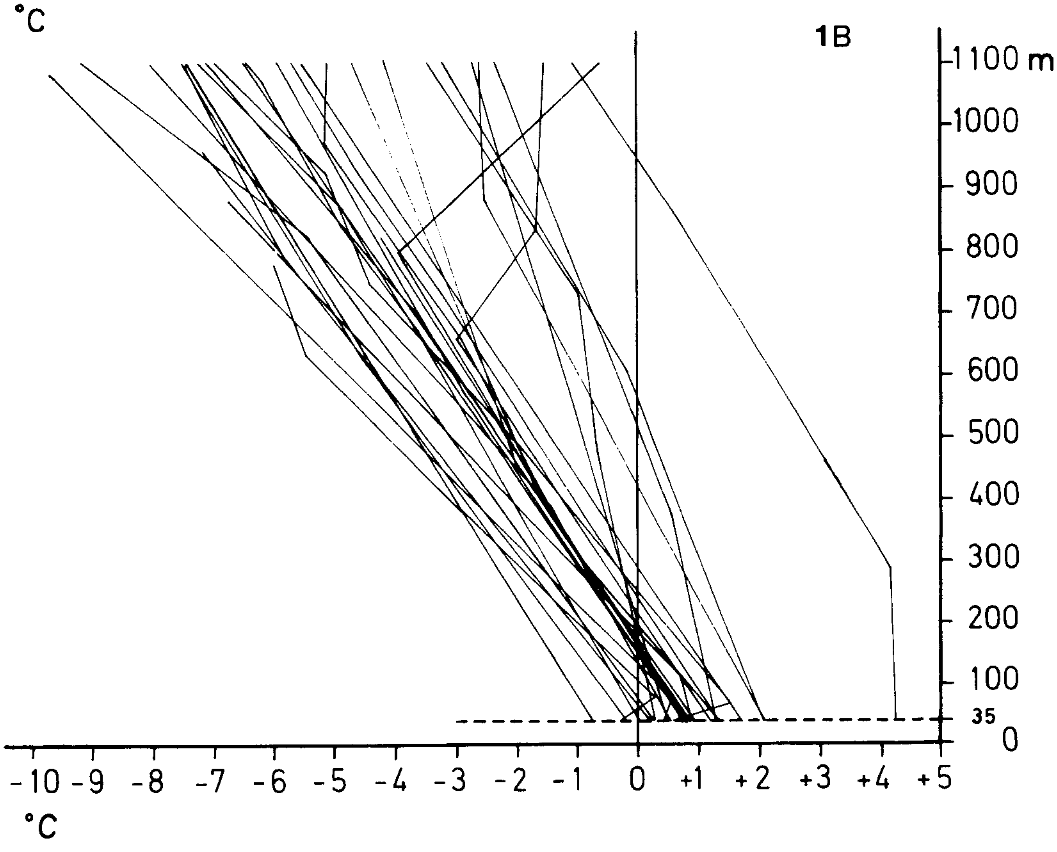
°C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°C

Such measurements were performed on Bouvetøya during 16 days in January 1979. There are no summaries for extended periods and those obtained may be inadequate for comparative purposes (cf. Walton 1984, p. 23). However, they do indicate the actual thermal conditions in the non-vascular vegetation at low levels on Bouvetøya, which lies within the maritime Antarctic as defined by Smith (1984, p. 64).

The microthermal measurements were made with PT 100 thermistors connected to a Grant recorder giving hourly chart readings. Calibration at 0° necessitated corrections from +0.1° to −0.1°, and readings were made with an accuracy of 0.1°. Because instrument and transmission factors probably do not allow an accuracy greater than ±0.5°, the calculated mean values are given according to this.

Synoptic meteorological observations at the station operating from January to March 1979 (Vinje 1981; Engelskjøn 1981, Fig. 25) include air temperature (to the nearest 0.1°), relative humidity (%), and windspeed ($m\ s^{-1}$). Table 4 summarizes general meteorological conditions and local temperatures in three kinds of vegetation (I, II and III) showing varying aspect and hydrology, and during different weather conditions. The site was in the middle part of the Nyrøysa platform, 30 m a.s.l. (Fig. 2a and b).

I is a lichen stand on a greyish-red lava surface, sloping 50° NNW. It is nearly optimally sun-exposed and consists of *Caloplaca sublobulata*, *Lecanora* cf. *lavae*, and *Usnea antarctica*. The sensor was placed superficially below an *Usnea* tuft, at times exposed to direct sunlight, but the temperature regimen is probably representative of the surface parts of a small rock fissure into which the sensor was wedged.

II is a moss cushion on the same rocky slope as I, consisting mainly of *Brachythecium austro-salebrosum*. It measured 10 × 15 cm, was 5 cm deep and well hydrated. The sensor was placed amongst the assimilating shoots, a few mm below the surface, but not exposed to direct sun radiation.

III is an aggregation of scoria in shade below the same rocky slope as I, nearly horizontal and not exposed to direct sunlight. There were some sparse shoots of *Brachythecium austro-salebrosum*, *Bryum* sp., *Tortula filaris*, and some soil algae. The sensor was placed in the superficial gravel layer, covered by mineral fragments.

Results of the microthermal measurements compared to air temperature

During the observation period (Table 4) the air temperatures varied between −0.6 and +3.6°. The coldest air occurred during high pressure situations with calm weather, usually around 4 a.m. Cyclone passages brought in slightly warmer air and also caused gales with gusts up to 80 knots, and high air humidity. This is typical for a maritime Antarctic climate (Vinje 1978, 1981). Snowy days had the lowest mean diurnal air temperature, only +0.5°, but the snow usually remained for less than 10 hours at the observation site.

The vegetation temperatures differ considerably from the air temperature, with regard to magnitude and diurnal course. Only the shaded site (III) was in near-equilibrium with ambient air. This shows the importance of solar radiation to the vegetation also on a foggy island like Bouvetøya, lying just south of the Antarctic Convergence.

The epilithic lichen community (I) is the most sun-heated, with an average maximal temperature of 27° on sunny days, and an absolute maximum of 33° (Engelskjøn 1981, Fig. 6). It is also heated in overcast situations, and its average temperature for the entire period was 4.5° compared with 1.2° in the air.

The moss cushion (II) has a thermally intermediate position, mainly because it seldom dries out and is less influenced by heat accumulation of the cliff.

Assessment of the bioclimate of Bouvetøya

With reservations for the short observation period, Table 2 shows that Bouvetøya has a pronounced maritime Antarctic climate. The mean annual temperature is −0.6°, the mean amplitude between 4° and 5°, and the annual amplitude of temperature extremes only 18°.

The heat sum for the two warmest months is c. 90 Degree-Days, which is considerably more than at other maritime Antarctic stations (Table 3a), but the convective cooling parameters (Table 3b) are relatively high.

It may be assumed that the frequency of low stratus or fog is comparable with Orcadas (South Orkney Islands), which have a mean of only 487 hours of sunshine per annum, one of the lowest values on Earth (Müller 1982). However, clear sky may prevail during parts of the day, which

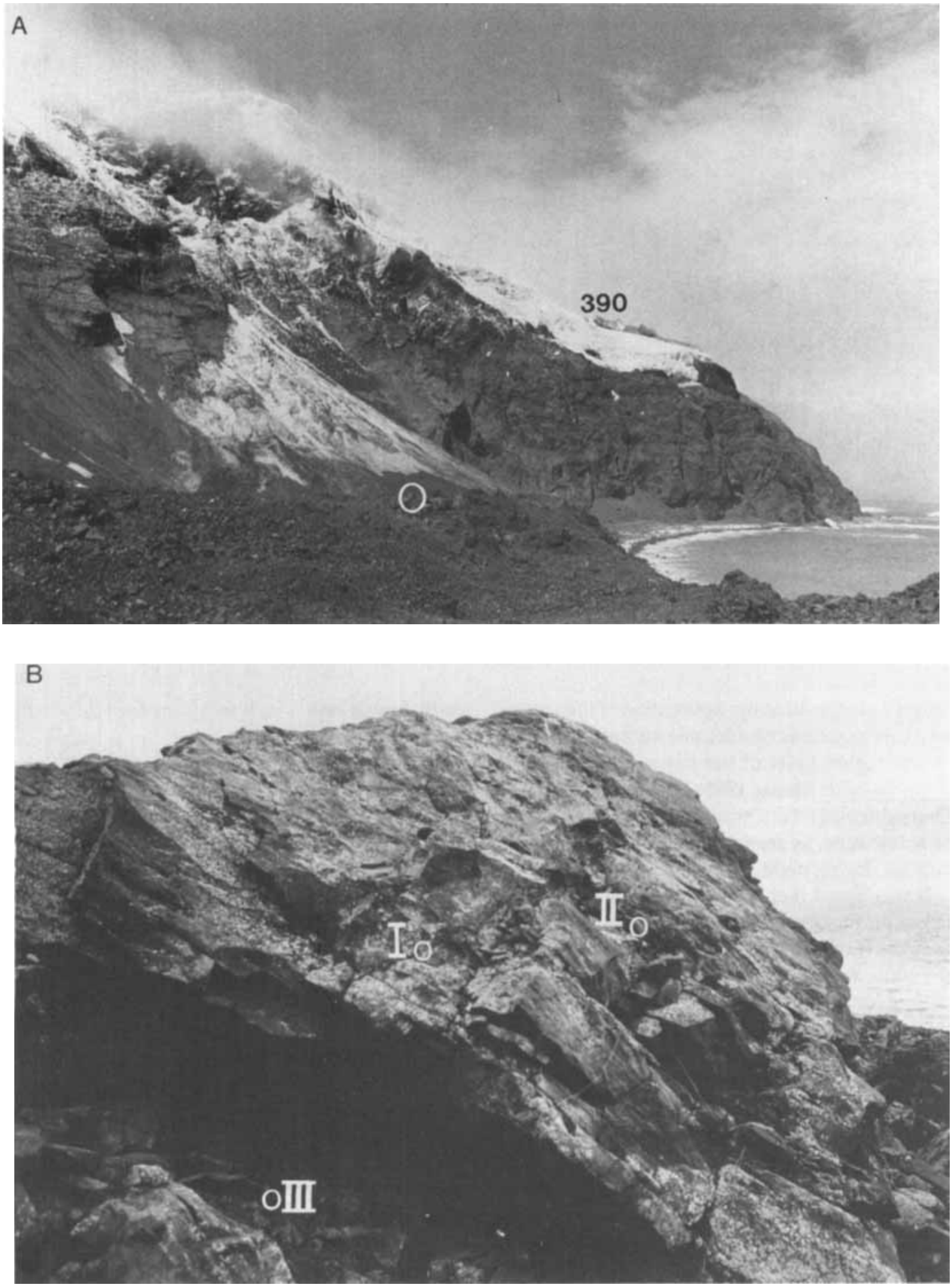


Fig. 2. The reference site for microthermal measurements at Nyrøysa, Bouvetøya. A. Location on the southern part of Nyrøysa. 30 m a.s.l. (0) viewed from the meteorological station. Summit 390 m a.s.l. (crest north of Aagaardbreen) in the background. 11 January 1979. B. Placing of temperature sensors at north facing cliff, actually an avalanched lava boulder. I: Epilithic lichen growth, II: Moss cushion, III: Scoria patch in shade. 31 December 1978.

Fig. 3. Coarse rock debris of silicic, columnar-jointed lava. Nyrøysa, southern part, approximately 20 m a.s.l. In background, right, site of trigonometrical station 35 m a.s.l. 30 January 1979.

causes radiative heating, desiccation of the porous lava surfaces, and considerable ice and snow melt on the higher parts of the island. The glacier is warm-based (Orheim 1981; Vinje pers. comm.). Diurnal temperature minima are usually close to or below zero, as are the vegetation temperature minima during night.

It was noted that the vegetation was prone to freeze during late summer nights, even on the low ground. But the temperature minimum does not last long, nor do the frequent falls of snow and sleet affect the vegetation so much at this level. Conversely, snow and hoarfrost become more persistent above 200 m a.s.l. (cf. Fig. 1b). Diurnal freeze/thaw cycles are regular on the high ground, as testified by the course of air temperature, and by direct observations of frozen vegetation. This may be prohibitive for the growth of even the most cold-resistant vascular plant species on Bouvetøya, at least at higher elevation.

Bedrock and soil chemical conditions

The volcanic structure of Bouvetøya contains two main formations – a lower sequence of easily eroded breccia and tuff, and an upper sequence of solid basalt flows, the latter building up the ice-free plateaux of Rustadkollen (Fig. 8) and Moseryggen.

The lower formation is rich in chlorite, clay minerals, and calcite (Prestvik & Winsnes 1981, p. 49). Analyses of derived soils (Table 5) indicate pH from 8.2 to 8.6 and high Ca, Mg, K, and P values.

The upper basalt is massive, weathering into coarse boulders and slabs. Analyses of derived soils (Table 5) indicate acidic conditions with pH from 5.2 to 5.6, considerably lower values of Ca, Mg, and P than the tuff soil, and comparable values of K.

The concentration of Na is high in all soil samples, because of the general influence of sea spray which is deposited even at 400 m a.s.l.

Several kinds of volcanic rocks have avalanched to form Nyrøysa on the north-west coast. Some contain abundant calcite and aragonite (Prestvik & Winsnes 1981, p. 51), while others are silicic (Fig. 3). This may contribute to a certain heterogeneity in the Nyrøysa pioneer vegetation.

The lava at Kapp Valdivia on the north coast

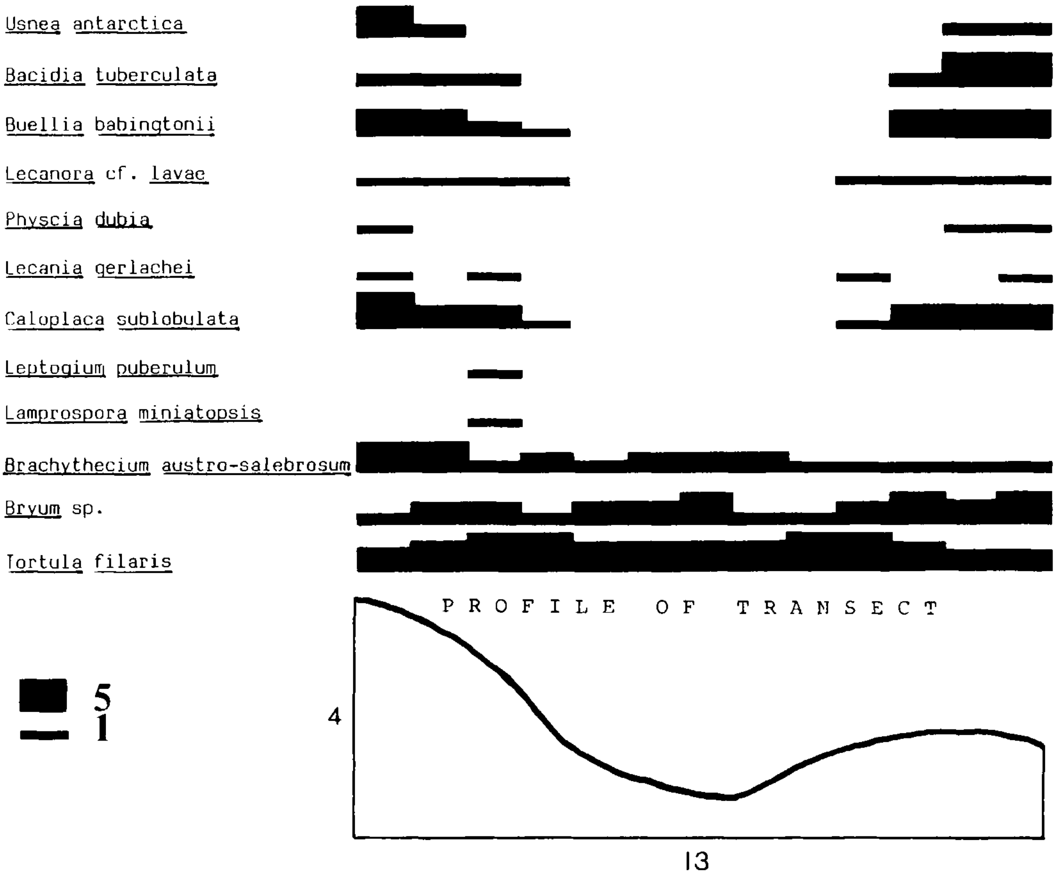


Fig. 4. Vegetation transect no. 1. Nyrøysa, northern elevation, 30–34 m a.s.l. Degree of coverage (1–5) according to Hult–Sernander. Scales in m. 9 February 1979.

is of granitic composition (Prestvik & Winsnes 1981, p. 55) and the derived soil shows rather low pH and electrolyte values (Table 5).

Plant communities

General

A preliminary classification of the Bouvetøya vegetation was provided by Engelskjøn (1981, Table 1). After taxonomic revision of the flora by co-workers mentioned in the Introduction, and comparison with current classification of maritime Antarctic (Smith 1972) and Antarctic vegetation in general (Smith 1984), a slight revision is needed. The main units (Table 6) remain unchanged, but this classification is not syn-taxonomic. It is merely a reflection of the ecology of certain indicative species and of their associations. However, because all vegetated parts of Bouvetøya were visited, the classification does reflect the local vegetation with regard to specific composition and some main ecological variables.

150 vegetation samples, usually of quadrat size 1 or 4 m^2, were analysed by the Hult–Sernander scale from 1 to 5 (Hult 1881), including an extra degree of coverage 5+ equivalent to 75%–100%. The quadrat analyses are considered as representative of certain conspicuous plant communities, but not all distinguished communities could be described in this way for reasons of time. Rock surface communities were analysed with a quadrat size of only 0.25 m^2, and epilithic cryptogams are listed in the bottom section of each table. Their degree of coverage is given as +, ++, or +++, corresponding to <20%, 20–40%, and >40% of the exposed rock surfaces, respectively.

43 of the samples were recorded as contiguous

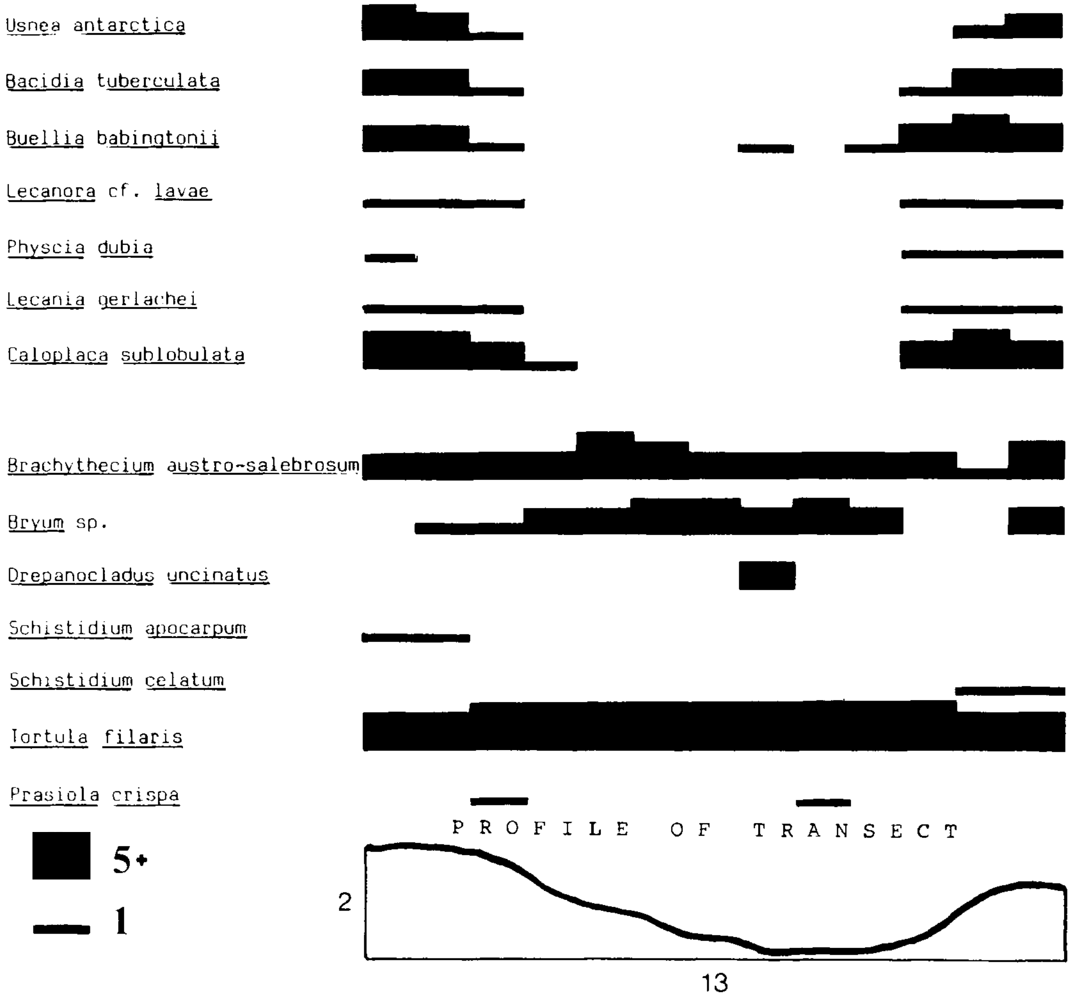


Fig. 5. Vegetation transect no. 2. Nyrøysa, northern elevation, 25–27 m a.s.l. Degree of coverage (1–5+) according to Hult–Sernander. Scales in m. 12 February 1979.

quadrats along transects, in order to show local environmental and vegetational gradients. In these transects (Figs. 4, 5 and 6) all degrees of cover were given in the Hult–Sernander scale.

Local gradients of vegetation

Within areas of similar mineral substratum the cryptogamic plant communities were differentiated according to local differences in hydrology, snow cover, wind exposure, and biogenic influence.

These gradients were studied mainly on the new ground of Nyrøysa, close to the camp site. Logistic conditions precluded such time-consuming work in more distant and elevated areas, such as the south coast high ground.

The vegetation of Nyrøysa is very uneven – many sectors are barren because of instability of the ground – and the following transects cover sub-climax stages, which were barely more than 20 years old at the time of investigation (1979).

Transect no. 1 (Fig. 4) crosses a depression between two moderately wind-exposed hillocks. The stony community on the left flank is dominated by *Usnea antarctica*, *Buellia babingtonii*, *Caloplaca sublobulata*, and with interstitial turfs of *Brachythecium austro-salebrosum* and *Tortula filaris*. All lichens disappear towards the depression, which is covered by carpets of the same

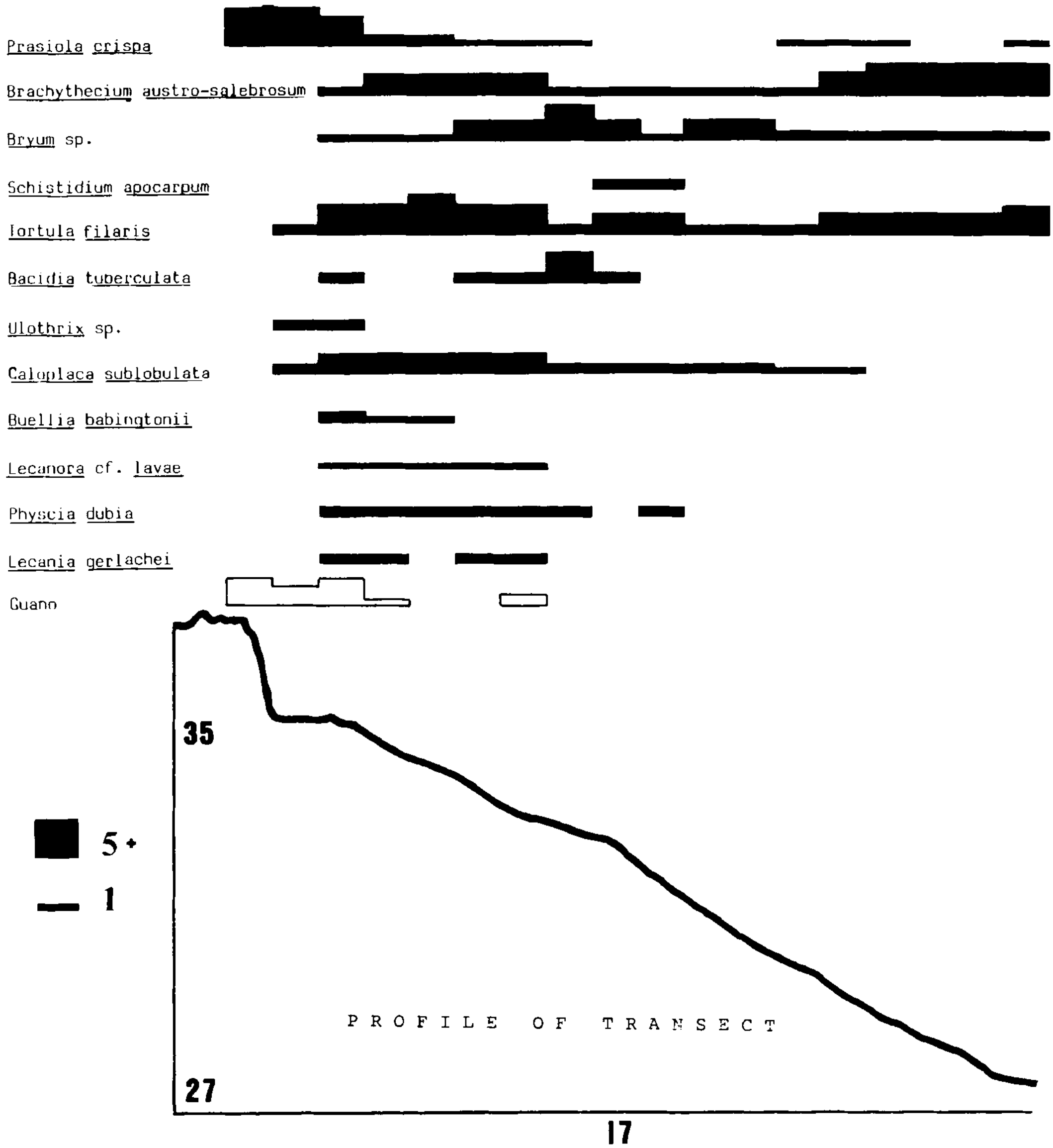


Fig. 6. Vegetation transect no. 3. Nyrøysa, station area, 27–35 m a.s.l. Degree of coverage (1–5+) according to Hult–Sernander. Scales in m. 18 February 1979.

bryophyte species, and a species of *Bryum*. The hillock to the right is lower and covered by fine scoria with dominance of *Bacidia tuberculata* encrusting *Bryum* and *Tortula*.

Transect no. 2 (Fig. 5) shows a similar situation. *Tortula filaris* dominates the sheltered depression, where there is also a patch of *Drepanocladus uncinatus* at the bottom, and lichens occupy only the more exposed hillocks on each flank.

Transect no. 3 (Fig. 6) is a section of a downward slope from a Cape petrel nesting site. The foliose green alga, *Prasiola crispa*, and some *Ulothrix*, dominate around the nest between guano patches. The bryophytes and lichens appear distally and farther down the slope, but *Usnea antarctica* remains absent, mainly because of the loose and unstable substratum. Transect no. 3 illustrates the complementary relationship between manured algal vegetation and the bryophyte communities. Moreover, the penguin colonies are nearly devoid of macrovegetation owing to trampling.

The climax vegetation on the north-western part of Bouvetøya, with prevailing alkaline substrata, is *Brachythecium* and *Tortula* carpets with *Lecania gerlachei*, *Physcia dubia*, *Usnea antarctica*, and crustose lichens covering the protruding stones. Such communities are extensive, e.g. on the hill 177 m a.s.l. above Nyrøysa (Fig. 7).

The basalt plateaux on the south coast, Rustadkollen (Fig. 8) and Moseryggen, support a quite different climax vegetation characterized by *Andreaea gainii*, *Polytrichum alpinum*, *Stereocaulon glabrum*, and *Usnea aurantiaco-atra*.

Main vegetational units

Table 6 shows the attempted classification of the principal vegetation units encountered on Bouvetøya, and the following enumeration corresponds to units given in that Table.

1. *Nearly abiotic, barren ground.* – Ice-free places may be nearly devoid of macroscopic vegetation, such as in the avalanched slopes above Nyrøysa and within the volcanic crater.

The snow and ice areas support some cryoseston communities, e.g. with *Chlamydomonas ballenyana*, *Hormidium* sp., *Koeliella* cf. *tatrae* (Klaveness & Rueness 1986), and extensive fields of 'red snow' were seen from the air on the glacier Slakhallet at 200 m a.s.l. These communities belong to the snow algae sub-formation described by Gimingham & Smith (1970) and Smith (1972).

2. *Cliff vegetation from above sea spray zone to c. 400 m a.s.l.* – A crustose lichen sub-formation is widespread in steep cliffs along the coast, but the lichens are often overgrown by *Prasiola* in manured situations. Largely inaccessible, these cliff communities had to be studied on avalanched boulders.

Table 7 lists species recorded in stands representative of cliff communities dominated by species of *Caloplaca* (2.1). Table 8 shows dominance of *Prasiola crispa* (2.2), which may form pure stands on bird-cliffs with some seepage. Table 9 shows a lichen community dominated by *Caloplaca* spp. and the squamulose, large species, *Lecania gerlachei* (2.3). These cliffs are dry and moderately bird-influenced.

3. *Seashore vegetation.* – This comprises the littoral zone up to the reach of breaking waves, whereas the zone of windborne sea spray extends much higher on Bouvetøya, judging from the Na content of soils (Table 5). Difficult to investigate for reasons of safety, these communities may prove richer in species than described here. The sandy shores on the east coast are barren owing to wave disturbance.

In the littoral zone proper are epilithic algal communities (3.1) with prominent *Leptosomia alcicornis*, *Rhodymenia palmatiformis*, a colony-forming *Navicula*, and other diatoms (determinations quoted from Klaveness & Rueness 1986). Above this, from 1 to 3 m a.s.l. they are succeeded by boulder and cliff communities with *Porphyra columbina* (3.2). Higher up or in protected situations greyish *Verrucaria* spp. and *Ulothrix* sp. predominate (Table 10). The described vertical zonation is visible from the distance on shore cliffs and stacks outside Nordstranda, at Kapp Circoncision, and at Kapp Valdivia. Confluent growths of *Verrucaria tesselatula* ascend to about 200 m a.s.l. in many places on the exposed west coast, e.g. at Aagaardbreen and Kapp Norvegia, and to 100 m a.s.l. on Kapp Valdivia on the north coast (Table 11).

4. *North and west coast climax vegetation, up to 400 m a.s.l.* – These communities are dominated by a few lichen and bryophyte species. Table 11 summarizes assemblages of ?*Ceratodon* sp., *Drepanocladus uncinatus*, and *Verrucaria* spp., which are confined to silicic lava ground on Kapp Valdivia (4.1). Table 12 shows the extensive *Brachythecium austro-salebrosum* and *Tortula filaris* communities (4.2) which are visible from the distance as green patches (Engelskjøn 1981, Figs. 2 and 4). Exposed crests in the same area to the north of Nyrøysa show local dominance of *Usnea antarctica* as large and obviously several decades old specimens, and encrustations of *Lecania gerlachei* (4.3), see Table 13.

A peculiar *Mastodia tesselata-Tortula princeps* community was seen at the hill 410 m a.s.l. on the west coast. It also contained some *Usnea antarctica*, and is entered in the classification (Table 6) as unit (4.4). Communities with *Mastodia*, which is a lichenized, thallose green alga, are also described by Smith (1972) from the western part of the maritime Antarctic.

5. *South coast high ground climax vegetation,*

Table 6. Classification of Bouvetøya vegetation.

1.	Nearly abiotic, barren ground.
	(1.1) Glaciers and snowfields, locally with cryoseston.
	(1.2) Impediment without macrovegetation.
2.	Cliff vegetation from above sea spray zone to 400 m a.s.l.
	(2.1) *Caloplaca* cliff communities.
	(2.2) *Prasiola* cliff communities.
	(2.3) *Caloplaca-Lecania gerlachei* cliff communities.
3.	Seashore vegetation, in ascending order.
	(3.1) *Rhodymenia-Leptosomia* zone.
	(3.2) *Porphyra columbina* zone.
	(3.3) *Verrucaria-Ulothrix* zone.
	(3.4) Bird and seal influenced communities – eroded and polluted versions of (2.1), (2.3), and (3.3).
4.	North and west coast climax vegetation, up to 400 m a.s.l.
	(4.1) ? *Ceratodon* sp.-*Drepanocladus uncinatus-Verrucaria* communities on silicic lava, Kapp Valdivia.
	(4.2) *Brachythecium austro-salebrosum-Tortula filaris* moss hummock communities.
	(4.3) *Usnea antarctica-Tortula* communities.
	(4.4) *Mastodia tesselata-Tortula princeps* community.
5.	South coast high ground climax vegetation, 250 to 380 m a.s.l.
	(5.1) *Drepanocladus-Brachythecium-Pachyglossa* carpets.
	(5.2) *Drepanocladus-Usnea* carpets.
	(5.3) High ground lichen and moss cushion communities.
	(5.1.1) *Andreaea gainii-Stereocaulon-Usnea aurantiaco-atra* communities.
	(5.3.2) *Andreaea gainii-Schistidium* cf. *antarcticum-Polytrichum-Usnea* communities.
6.	Nyrøysa pioneer vegetation, 10 to 51 m a.s.l.
	(6.1) *Tortula-Brachythecium-Bryum* communities on scoria.
	(6.2) *Brachythecium-Schistidium-Caloplaca-Usnea antarctica* communities on dense lava.
	(6.3) Fumarole heated communities.

250 to 380 m a.s.l. – On the basalt plateaux of Rustadkollen and Moseryggen, the aspect and species content of the vegetation becomes distinctly different from the communities described above. Dominant are species of *Andreaea, Pachyglossa dissitifolia, Polytrichum alpinum, Stereocaulon glabrum, Usnea aurantiaco-atra*, and many others which are absent or rare on the north and west coasts.

Table 14 includes a community (5.1) dominated by *Brachythecium austro-salebrosum, Drepanocladus uncinatus*, and *Pachyglossa dissitifolia*, which grow as carpets in moist and protected depressions. This green-coloured vegetation intergrades with the *Andreaea-Usnea* community (5.3.1), cf. Table 15, whereas *U. aurantiaco-atra* is generally dispersed, affixed to stones protruding from the moss carpets. The only other lichen species of some importance is *Psoroma hypnorum*.

Table 7. Caloplaca cliff communities (2.1).

Quadrat no. (0.25 m^2)	1	2	3
Altitude, m above sea level	30	40	6
Arthonia subantarctica	1	—	—
Buellia babingtonii	3	—	—
Caloplaca cirrochrooides	—	5	4
C. sublobulata	5	1	—
Lecania gerlachei	1	—	—
Lecanora cf. *lavae*	1	1	—
Mastodia tesselata	—	—	2
Bare rock surface	3	3	5

1. Nyrøysa, NW part, large boulders. 2. Cliffs above Sørstranda. 3. Between Sørstranda and Aagaardbreen, steep cliff.

Table 14 also shows more stony moss carpet and fruticose lichen stands (5.2) on areas with basalt cobbles which are better drained than community (5.1). A similar vegetation was observed on ground disrupted by periglacial features on recently exposed nunataks to the north of Rustadkollen, ascending to at least 380 m a.s.l. in 1985.

Various other lichen and moss cushion communities (5.3) are given in Table 15. Constant species in (5.3.1) are *Andreaea gainii, Stereocaulon glabrum* and *Usnea aurantiaco-atra*, but other species may attain some local coverage, e.g. *Pannaria hookeri, Placopsis contortuplicata, Rinodina turfacea*, and several liverworts.

The stands entered as (5.3.2) have a more closed bryophyte layer and less exposed mineral soil. Peat up to 15 cm thick may be formed by

Table 8. Prasiola cliff communities (2.2).

Quadrat no. (1 m²)	1	2	3	4	5	6
Altitude, m above sea level	47	47	35	35	35	47
Brachythecium austro-salebrosum	–	–	–	–	1	1
Bryum sp.	–	–	–	–	1	–
Tortula filaris	–	1	–	1	1	2
Prasiola crispa	5	5	5	4	3	5
Ulothrix sp.	–	–	–	1	1	–
Bacidia tuberculata	–	–	–	–	1	–
Gravel	2	2	3	3	3	2
Guano	2	2	3	2	3	2
Stones	4	4	3	5	5	4
Buellia babingtonii	–	–	–	+	+	+
Caloplaca sublobulata	+	++	–	–	+	++
Lecania gerlachei	–	+	–	–	+	–
Lecanora cf. *lavae*	–	+	–	–	+	+
Physcia dubia	–	–	–	–	+	–

1,2,6. Nyrøysa, hill 51 m a.s.l. 3,4. Nyrøysa, camp area, small Cape petrel hillock, close to nest. 5. Same, 2 m from nest.

Andreaea gainii, *Polytrichum alpinum*, *Schistidium* spp., and the less prominent liverworts.

All communities described here form complex mosaics corresponding to micro-gradients of cryoturbation, meltwater soaking, and wind exposure. *Andreaea, Stereocaulon* and *Usnea* spp. occur as rusty, grey, or yellowish patches, interspersed by a network of yellowish-green bryophyte carpets.

6. Nyrøysa pioneer vegetation, 10 to 51 m a.s.l. – As described previously, Nyrøysa (Figs. 2, 3 and 7) is being colonized by early stages of bryophyte and lichen vegetation, with less developed, juvenile individual plants as compared with other specimens collected on Bouvetøya.

The communities contain few species compared to the south coast high ground, their main constituents being *Brachythecium austro-salebrosum*, several *Bryum* spp. which have not yet been identified to species (Bell & Blom 1986), *Tortula filaris, Usnea antarctica*, and several crustose lichens, notably *Caloplaca sublobulata*. This vegetation may be subdivided according to the structure and composition of the substratum.

Parts of the platform, especially to the south, are covered by dark scoria and tuff material which breaks down to gravel and silt. Table 16 lists 20

Table 9. Caloplaca – Lecania gerlachei cliff communities (2.3).

Quadrat no. (1 m²)	1	2	3	4	5	6	7
Altitude, m above sea level	10	10	10	10	10	10	175
Brachythecium austro-salebrosum	1	1	1	1	–	1	1
Prasiola crispa	–	–	–	–	–	1	–
Bacidia tuberculata	–	1	–	1	–	1	–
Buellia babingtonii	1	–	1	–	1	–	–
B. bouvetii	–	–	–	–	–	–	1
Caloplaca cirrochrooides & *sublobulata*	3	3	3	4	5	5	3
Lecania gerlachei	3	3	4	3	2	2	2
Lecanora cf. *lavae*	1	1	1	1	1	1	1
Physcia dubia	–	–	–	–	–	–	2
Verrucaria dispartita	–	–	1	1	1	1	1
V. tesselatula	–	–	–	–	–	–	3
Bare rock surface	4	4	2	2	1	1	4

1–6. Nyrøysa inside Selbadet, valley with fur seal colony. Steep cliffs above, W or S exposed, extending for 100 m horizontally, up to 200 m vertically. 7. Summit 177 m a.s.l. N of Nyrøysa, exposed cliff on summit buttress.

Table 10. Verrucaria – Ulothrix communities (3.3).*

Quadrat no. (0.25 m²)	1	2	3	4
Altitude, m above sea level**	10	1	9	4
Porphyra columbina	–	1	–	–
Prasiola crispa	1	–	–	–
Ulothrix sp.	2	2	–	–
Caloplaca cirrochrooides	–	–	1	–
Verrucaria dispartita	–	–	2	–
V. mucosa	5	–	–	–
V. tesselatula	–	5	5	5
Bare rock surface	4	4	4	4

1. Kapp Circoncision, top of exposed shore cliff. 2. Shore cliffs on Nordstranda. 3. Cliffs inside Nordstranda. 4. Cliffs S of Sørstranda, towards Aagaardbreen.

* Vegetation units (3.1) *Rhodymenia-Leptosomia* zone and (3.2) *Porphyra columbina* zone were not documented by quadrat analyses.

** The difference between high and low water mark is negligible in the waters at Bouvetøya.

quadrats on this substratum. *Tortula filaris* is co-dominant with *Brachythecium austro-salebrosum* and *Bryum* spp. Lichens are few and sparse, presumably due to the loose soil. Particular species of these stands (6.1) are the soil-inhabiting lichen, *Bouvetiella pallida* (Øvstedal 1986), and the bryophilic, crimson ascomycete, *Lamprospora miniatopsis* (Schumacher 1986).

Other sectors of Nyrøysa contain accumulations of hard silicic lava (Fig. 3; cf. also Prestvik & Winsnes 1981, Fig. 8). These break down into smooth and angular fragments and thus provide substrata which attract several lichens. The quadrats listed in Table 17 indicate the most important species of (6.2) to be *Brachythecium austro-salebrosum*, *Bryum* spp., and *Usnea antarctica*. *Schistidium* spp. are also quite frequent, as are *Buellia babingtonii* and *Caloplaca sublobulata*.

Table 11. ?Ceratodon sp. – *Drepanocladus uncinatus* – *Verrucaria* communities on silicic lava, Kapp Valdivia (4.1).

Quadrat no. (1 m²)	1	2	3	4	5	6	7	8	9	10	11
Altitude, m above sea level	80	80	85	85	85	80	80	80	80	80	90
?Ceratodon sp.	–	–	2	1	1	2	1	–	–	2	2
Drepanocladus uncinatus	–	–	–	–	–	–	1	2	2	4	–
Prasiola crispa	1	1	1	1	1	1	1	–	–	1	–
Guano	–	1	1	1	–	1	–	–	–	–	–
Silt	5	5	4	3	4	4	2	3	2	2	4
Stones	4	3	5	5	5	5	5	5	5	4	5
Buellia bouvetii	++	++	–	++	++	++	–	–	–	–	–
Caloplaca cirrochrooides	–	–	+	–	–	–	–	–	–	–	–
Verrucaria dispartita	++	++	++	++	++	++	–	–	–	–	++
V. tesselatula	++	++	–	++	++	–	–	–	–	–	+

1,2. Kapp Valdivia, close to precipice at Cape petrel nest. 3–6. Kapp Valdivia, slopes of promontory. 7–10. Kapp Valdivia, ravines facing NNE. 11. Kapp Valdivia, pass-point.

Table 12. Brachythecium austro-salebrosum – Tortula filaris moss hummock communities (4.2).

Quadrat no. (1 m²)	1	2	3	4	5	6	7	8	9	10	11
Altitude, m above sea level	170	170	170	170	20	20	20	20	5	5	200
Brachythecium austro-salebrosum	5	5	5	5	5	5	5+	5+	5+	5+	4
Tortula filaris	3	4	4	5	–	1	1	1	1	1	4
Prasiola crispa	–	–	–	–	–	–	1	1	1	–	2
Gravel and organic debris	–	1	1	1	1	1	1	1	–	–	3
Stones	3	–	–	–	4	4	2	1	–	1	3
Buellia babingtonii & B. bouvetii	++	–	–	–	++	++	–	–	–	–	–
Caloplaca sublobulata	++	–	–	–	++	++	–	–	–	–	–
Lecania gerlachei	++	–	–	–	–	–	–	–	–	–	–
Physcia dubia	++	–	–	–	–	–	–	–	–	–	–

1–4. Summit 177 m a.s.l. N of Nyrøysa, SW-facing, extensive moss carpets. 5–8. Fumarole area in middle part of Nyrøysa, vegetation temperature 9.6°–11.9°, subsoil temperature 12.4°–19.0°. 9–10. N of Nyrøysa, valley inside Selbadet, clayey slope in fur seal area. 11. Slope above summit 177 m, NW-facing moss patches on scoria.

Table 13. Usnea antarctica – Tortula communities (4.3).

Quadrat no. (1 m²)	1	2	3	4	5	6
Altitude, m above sea level	180	180	180	180	190	190
Brachythecium austro-salebrosum	1	1	1	2	4	5
Bryum sp.	1	2	1	–	–	–
Tortula filaris	3	3	4	5	3	3
Prasiola crispa	1	1	1	–	2	1
Lecania gerlachei	3	4	3	1	–	–
Physcia dubia	1	1	1	–	–	–
Usnea antarctica	4	3	5	4	1	1
Gravel	2	2	2	1	4	4
Stones	3	3	3	3	2	3
Buellia babingtonii & B. bouvetii	++	++	++	++	+	+
Caloplaca cirrochrooides & C. sublobulata	++	++	++	+	+	+

1–4. Summit 177 m a.s.l. N of Nyrøysa, slope to the E, wind-exposed scoria. 5–6. Same, more protected moss cushions facing N and overlooking Kapp Circoncision.

Tortula spp. are less frequent on silicic lava than on easily disintegrating tuff.

Fumarole-heated sites on Nyrøysa support luxuriant cushions of *Brachythecium* and *Tortula* (Engelskjøn 1981, pp. 26–27). The surroundings of some steam vents also contained bryophyte species which were not found elsewhere, e.g. a *Bryum* sp., *Ceratodon validus*, and *Dicranella* cf. *hookeri* (Bell & Blom 1986). The classification of vegetation (Table 6) unites these special habitats as fumarole heated communities (6.3). For convenience, they are subsumed in Table 12 as stands 5–8 and in Table 17 as stands 12–13.

Species distributions within the island

The local distribution of 26 cryptogamic species occurring on Bouvetøya are presented on Maps 1–20. The selected taxa are considered as representative of various local environments; they

Table 14. High ground moss carpet communities (5.1) and (5.2). (5.1): *Drepanocladus – Brachythecium – Pachyglossa* carpets. (5.2): *Drepanocladus – Usnea* carpets.

	(5.1)				(5.2)			
Quadrat no. (1 m²)	1	2	3	4	1	2	3	4
Altitude, m above sea level	270	270	270	310	310	310	280	280
Andreaea gainii	–	1	1	–	–	–	–	–
Brachythecium austro-salebrosum	3	3	4	3	–	–	–	–
Dicranoweisia grimmiacea	–	1	1	2	–	1	–	–
Drepanocladus uncinatus	4	4	4	4	3	4	1	1
Herzogobryum atrocapillum	1	–	–	–	–	–	–	–
Pachyglossa dissitifolia	2	1	2	2	–	–	–	–
Bacidia tuberculata	–	–	–	–	–	1	–	–
Caloplaca sublobulata	–	–	–	–	–	–	–	1
Lecanora sp.	–	–	–	–	1	–	–	–
Psoroma hypnorum	1	1	–	–	–	–	–	–
Rhizoplaca melanophthalma	–	–	–	–	–	–	–	1
Stereocaulon glabrum	–	–	1	–	–	–	–	–
Usnea antarctica	–	–	–	–	4	3	–	1
U. aurantiaco-atra	3	2	2	–	–	–	4	3
Basalt lithosol	2	3	1	1	4	4	5	5

(5.1): 1–3. Moseryggen, moist and protected depression. 4. Rustadkollen, SW plateau, water-logged and partly frozen bryophyte carpet.
(5.2): 1–2. Rustadkollen, SW plateau, intermittently flushed area with basalt pebbles. 3–4. Moseryggen, N slope facing Christensenbreen, basalt lithosol of relatively recent exposure from glacial cover.

Table 15. High ground lichen and moss cushion communities (5.3). (5.3.1): *Andreaea gainii – Stereocaulon – Usnea aurantiaco-atra* communities. (5.3.2): *Andreaea gainii – Schistidium* cf. *antarcticum – Polytrichum – Usnea* communities.

	(5.3.1)						(5.3.2)			
Quadrat no. (1 or 4 m^2, see below)	1	2	3	4	5	6	1	2	3	4
Altitude, m above sea level	340	285	285	285	280	330	330	330	286	286
Andreaea gainii	4	3	4	3	1	1	2	4	1	2
Brachythecium austro-salebrosum	1	1	1	1	–	–	2	–	–	2
Dicranoweisia antarctica	–	–	1	–	–	–	1	–	–	–
D. grimmiacea	1	2	–	1	1	–	3	–	1	1
Drepanocladus uncinatus	1	–	1	–	1	–	2	1	–	–
Polytrichum alpinum	–	–	–	–	–	–	3	–	3	2
Schistidium cf. *antarcticum*	–	–	–	–	–	–	1	4	–	–
Cephaloziella exiliflora	–	–	1	–	–	–	1	1	1	1
Herzogobryum atrocapillum	–	–	1	1	1	1	1	–	1	1
Pachyglossa dissitifolia	1	1	1	1	–	1	2	–	1	1
Prasiola crispa	1	–	–	–	–	–	–	–	1	1
Cladonia pyxidata	–	–	1	–	–	–	–	–	–	–
Massalongia carnosa	–	–	1	–	–	–	–	–	–	–
Microglaena cf. *mawsonii*	–	–	–	–	–	1	–	–	–	–
Pannaria hookeri	–	–	1	–	–	4	–	–	–	–
Placopsis contortuplicata	2	–	–	–	–	2	–	–	–	–
Psoroma hypnorum	–	–	1	–	–	–	1	–	–	–
Rinodina turfacea	1	–	–	–	–	2	–	–	–	–
Stereocaulon glabrum	2	3	2	2	1	1	–	–	3	2
Usnea antarctica	–	–	–	1	–	–	1	1	–	1
U. aurantiaco-atra	4	5	5	5	4	2	–	–	5	5
Basalt lithosol	3	1	1	–	4	4	1	1	1	1

(5.3.1): 1 (4 m^2). Rustadkollen, summit plateau with cryoturbation patches. 2–4. Moseryggen, S slope of summit. 5. Moseryggen, NW-facing slope close to Christensenbreen. 6 (4 m^2). Rustadkollen, slope of summit plateau.
(5.3.2): 1 (4 m^2). Rustadkollen, SW part of summit plateau with a local *Polytrichum* peat bank. 2. Same place, water-logged and partly frozen *Andreaea – Schistidium* cushions. 3–4. Moseryggen, peat bank just S of summit.

are easily recognizable, and their local geographic distribution appears as well documented. They comprise 16 of the 44 lichen species hitherto identified (Jørgensen 1986; Øvstedal 1986), 2 of the 4 liverworts, and 7 of the 25 mosses (Bell & Blom 1986), and, finally, the most important terrestrial thallose alga, *Prasiola* (Klaveness & Rueness 1986). Short comments are made on the local occurrence and performance of each species, with reference to the distribution maps. The principal communities in which each species occurs are given in parentheses, with reference to Table 6, Tables 7–17, and the vegetation transects illustrated in Figs. 4, 5 and 6.

Bryophyta

1a. *Herzogobryum teres* (Carrington & Pears.) Grolle

This liverwort, like the more common *H. atrocapillum*, *Cephaloziella exiliflora* and *Pachyglossa dissitifolia* (Bell & Blom 1986), is confined to the climax vegetation of the south coast high ground. It is apparently rare, but collections may be insufficient. (5.1), (5.2) and (5.3) are typical plant communities containing the microhepatics mentioned.

1b. *Pachyglossa dissitifolia* Herzog & Grolle

A common constituent of wet bryophyte carpets on the south coast high ground, but not encountered outside this area (5.1), (5.3).

2. *Andreaea gainii* Card.

A most important species of the bryophyte carpet and cushion vegetation of the south coast high ground (5.1), (5.3). Not found on the alkaline scoria and tuff areas on the west coast, nor on the new ground of Nyrøysa.

3. *Brachythecium austro-salebrosum* (C. Müll.) Kindb.

This is undoubtedly the most common bryophyte of Bouvetøya, occurring also on Nyrøysa (6.1), (6.2), Transect nos. 1, 2 and 3. It is predominant in the coherent *Brachythecium–Tortula* com-

Table 16. Nyrøysa pioneer vegetation. *Tortula – Brachythecium – Bryum* communities on scoria (6.1).

Quadrat no. (1 m²)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Altitude, m above sea level	20	20	20	30	25	25	35	35	35	35	30	30	30	30	25	25	25	25	25	25
Brachythecium austro-salebrosum	2	3	2	1	2	2	3	3	2	2	1	2	1	1	1	1	2	1	1	1
Bryum sp. (taxon 3)	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	1	–	–	–	–
Bryum sp. (taxon 4)	3	3	3	–	1	1	–	–	–	–	2	1	2	3	3	3	–	3	2	1
Bryum sp. (not defined)	–	–	–	2	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–
Tortula filaris	2	1	1	4	4	4	4	4	3	1	4	4	4	3	3	3	3	3	2	1
Bouvetiella pallida	1	1	3	–	–	–	–	–	–	–	–	–	–	1	2	3	2	2	2	–
Leptogium puberulum	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Lamprospora miniatopsis	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	1	–	–	1	–
Gravel and silt	5	4	3	2	3	2	2	3	4	5	3	3	3	3	3	3	4	4	5	5
Stones	–	–	2	2	4	5	2	3	3	3	4	5	4	3	4	3	4	4	4	4
Buellia babingtonii	–	–	+	–	–	–	+	+	+	–	+	+	–	++	–	+	+	+	+	+
Caloplaca sublobulata	–	–	+	++	–	–	+	+	+	+	++	+	+	++	+	+	++	++	++	+
Lecania gerlachei	–	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–	–	–	–	–
Lecanora cf. *lavae*	–	–	–	+	–	–	–	–	–	–	+	+	+	+	–	–	+	+	+	–
Physcia dubia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–

1–3. Nyrøysa, fumarole area, silty lakelet bottom. 4. Middle elevation, grey scoria and tuff debris. 5–6. SE extension of middle elevation, depression with red tuff debris. 7–10. SE of fumarole area, slightly heated black gravel (9.4°–9.9°). 11–14. Northern elevation below a small skua hillock, loose greyish tuff. 15–16. Southern part in columnar lava area, on peaty, coarse lithosol. 17–19. Southern elevation on black gravel. 20. Nyrøysa camp area, black gravel.

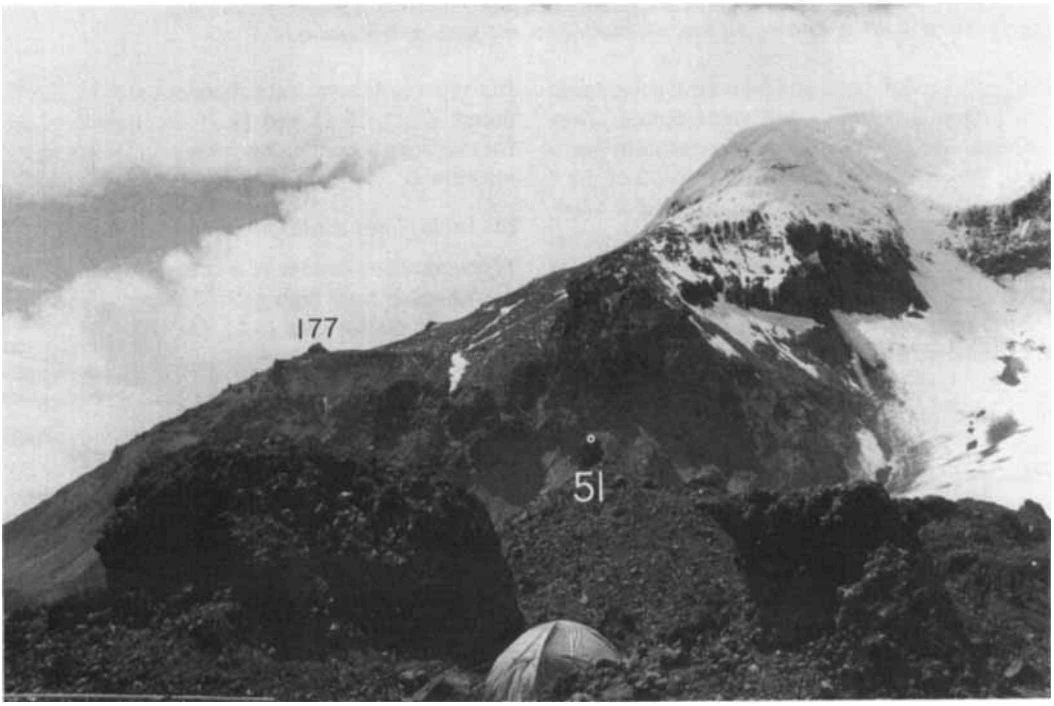


Fig. 7. View from the northern part of Nyrøysa to the hill 177 m a.s.l. In the centre, the highest elevation of the Nyrøysa lava platform in 1979; an agglomerate tower 51 m a.s.l. In the foreground, typical terrain of blackish scoria and agglomerate. 11 January 1979.

Table 17. Nyrøysa pioneer vegetation. *Brachythecium – Schistidium – Caloplaca – Usnea antarctica* communities on dense lava (6.2).

Quadrat no. (1 m^2) Altitude, m above sea level	1 30	2 30	3 20	4 20	5 35	6 35	7 30	8 30	9 25	10 25	11 25	12 25	13 25	14 30	15 30	16 30	17 30	18 30
Brachythecium austro-salebrosum	–	–	1	2	1	2	1	1	4	4	5	4	4	2	2	2	3	3
Bryum spp. (not defined)	–	–	–	–	1	1	1	–	1	1	2	2	2	–	1	–	1	2
Drepanocladus uncinatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
Schistidium apocarpum	–	–	1	1	1	2	1	–	–	–	–	1	–	–	1	1	1	–
S. celatum	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tortula princeps	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
T. filaris	–	–	2	1	1	1	1	1	–	1	–	–	–	2	2	2	3	3
Prasiola crispa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–
Bacidia tuberculata	–	1	1	–	1	1	–	–	1	1	–	–	–	1	1	1	1	1
Leptogium puberulum	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Usnea antarctica	2	1	2	1	3	1	1	1	2	1	1	2	2	1	3	2	3	1
Gravel and organic debris	–	–	–	–	4	2	4	2	–	–	–	–	–	1	2	1	1	2
Rock surface, stones	5	5	5	5	5	5	5	5	4	5	4	4	4	5	5	5	5	5
Buellia babingtonii	+++	++	++	++	++	++	+	++	++	++	++	++	++	++	++	++	++	++
Caloplaca sublobulata	++	+++	+++	++	++	++	+	++	++	++	++	++	++	++	++	++	++	++
Lecania gerlachei	+	+	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	–
Lecanora cf. *lavae*	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
Physcia dubia	+	+	+	+	+	–	–	+	++	++	++	++	++	–	–	–	+	–
Xanthoria candelaria	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

1–2. Nyrøysa, northern elevation, W-facing, massive lava boulder. 3–4. Nyrøysa, middle part at seismometer and fixed point site. Horizontal rock surface. 5–6. Middle elevation, top ridges of columnar lava. 7–8. Southern part, on heaps of fractured columnar lava. 9–11. Around fumarole area on medium-sized boulders. 12–13. Fumarole area, by steam vent, surface temperature 10°–15°. 14–18. Northern elevation, boulder area near small skua hillock.

1–4 are characterized as boulder surfaces, 5–8 as blockfields with scarce moss, and 9–18 as blockfields with well-developed moss growth.

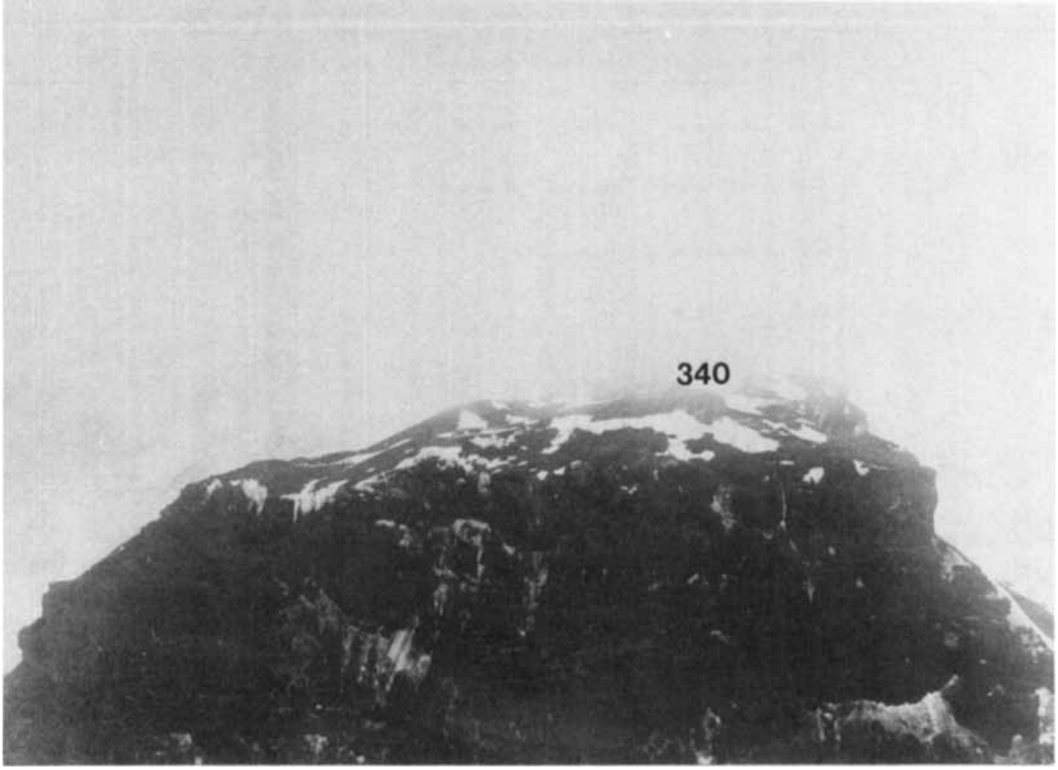


Fig. 8. Part of the south coast high ground: Rustadkollen, 340 m a.s.l. and its southern precipice. Nunataks to the north of Rustadkollen hidden in fog. 23 January 1979.

munities on the hill 177 m a.s.l. (Fig. 7), above Kapp Circoncision, and on the crest north of Aagaardbreen (Fig. 2a). Although common, it becomes less prominent on the south coast high ground apart from the *Drepanocladus uncinatus – Brachythecium – Pachyglossa* carpets (5.1).

Bryophyte vegetation, at least partly containing *Brachythecium*, was observed in several inaccessible places and indicated as open circles on Map 3. *B. austro-salebrosum* is absent from the silicic substrata of Kapp Valdivia.

4. *Dicranoweisia grimmiacea* (C. Müll.) Broth.

A prominent member of moss carpet and cushion communities on the south coast, up to 380 m a.s.l. (5.1), (5.2), (5.3), it has also colonized one site on Nyrøysa, where a single cushion was seen on a large boulder, 25 m a.s.l.

5. *Drepanocladus uncinatus* (Hedw.) Brid.

Frequent on the south coast high ground up to 380 m a.s.l. (5.1), (5.2), and locally on Kapp Valdivia (4.1). It occurred sparsely on the new ground of Nyrøysa (Transect no. 2), and is a colonizer which tends to avoid alkaline or manured ground.

6. *Polytrichum alpinum* Hedw.

Restricted to Rustadkollen and Moseryggen on the south coast (5.3.2), where the species is locally frequent and builds up a turf, usually 10–15 cm thick.

7. *Schistidium apocarpum* (Hedw.) B. S. G.

This variable species comprises two substrate-specific growth-forms on Bouvetøya (Bell & Blom 1986). Their field performance is strikingly different. Xeromorphic, small cushions were seen on dry boulders in parts of Nyrøysa (6.2), whereas a carpet form occurs at 320–340 m a.s.l. in the climax vegetation on the Rustadkollen plateau.

8. *Tortula filaris* (C. Müll.) Broth. (syn. *T. excelsa* Card.)

A common and widespread species on Nyrøysa (6.1) and the slopes of the hill 177 m a.s.l. (4.2), (4.3). It is less common on the south coast high ground, 320–340 m a.s.l.

Lichenes

9a. *Buellia anisomera* Vain.

Restricted to boulders and scree slabs on Moseryggen on the south coast, 270 m a.s.l., together with other crustose lichens which are rare on Bouvetøya.

9b. *Buellia babingtonii* Vain.

This is the most common species of its genus on Bouvetøya, being particularly common on lava slabs of Nyrøysa (2.1), (2.2), (2.3), (4.2), but also occurring elsewhere, up to 270 m a.s.l.

10. *Caloplaca sublobulata* (Nyl.) Zahlbr.

This is the most common crustose lichen on Bouvetøya. Yellow lichen vegetation which probably includes this species was also observed from a distance in the cliffs above Kapp Lollo on the east coast (ring signature on Map 10). It ascends to 380 m a.s.l., but is most frequent on Nyrøysa (2.1), (2.2), (2.3), Transect nos. 1, 2 and 3.

11a. *Huea grisea* (Vain.) Darb.

Possibly overlooked, but seems confined to the south coast high ground between 270 and 310 m a.s.l., usually in stable, stony or turfy communities.

11b. *Lecania gerlachei* (Vain.) Darb.

A large and conspicuous lichen, this species seems restricted to the cliffs around Nyrøysa, up to 200 m a.s.l. (2.3), (4.3), from where it has colonized the new ground on the lava platform, (6.1), (6.2), Transect nos. 1, 2 and 3.

12a. *Lecanora* cf. *lavae* Darb.

Generally distributed on Nyrøysa and surrounding cliffs, and collected once on Moseryggen, 270 m a.s.l. (2.1), (2.2), (2.3), Transect nos. 1, 2 and 3, but may be more widespread.

12b. *Placopsis contortuplicata* Lamb

A most conspicuous species of basalt lithosol and cliffs (5.3.1), both on Moseryggen and Rustadkollen on the south coast, but absent elsewhere.

13a. *Leptogium puberulum* Hue

In sheltered sites, often amongst cobbles and in rock cavities. Dispersed on Nyrøysa (6.1), (6.2), Transect no. 1. It probably has more stations on the high ground than the one marked on Rustadkollen, where the species grows rather densely in a carpet of *Drepanocladus uncinatus*.

13b. *Mastodia tesselata* (Hook.f. & Harvey) Hook.f. & Harvey

Apparently widespread in parts of the west coast and ranging from 5 to 400 m a.s.l. The species grows as foliose thalli on rock walls and fragmented lava. The habitats are moderately bird-influenced.

14. *Usnea antarctica* Du Rietz

Growing on projecting stones of various sizes at elevations between 20 and 400 m (4.3), (5.2), Transects nos. 1 and 2. It is more widespread than the following species, *U. aurantiaco-atra*, having colonized parts of the lava platform at Nyrøysa as juvenile specimens (6.2). The species is usually found away from seaspray or excessive manuring.

15. *Usnea aurantiaco-atra* (Jacq.) Bory

This is the most important fruticose lichen species on the south coast high ground, growing attached to pebbles, stones, or rock walls and forming more or less continuous stands, with individual plants up to 15 cm tall. It is also dispersed amongst *Andreaea* cushions, and may attain a considerable degree of coverage in communities entered here as high ground lichen and moss cushion communities (5.3).

Being definitely absent from the new ground of Nyrøysa at the time of investigation, it has invaded recently exposed, periglacial ground on the nunataks to the north of Rustadkollen, up to 380 m a.s.l.

16. *Physcia dubia* (Hoffm.) Lett.

Confined to the north-western corner of the island and extending from 15 to 190 m a.s.l., including the new ground of Nyrøysa (2.2), (4.2), (4.3), Transect nos. 1, 2 and 3. It is moderately tolerant of manuring and often associates with *Lecania gerlachei* on boulders and rock walls.

17a. *Rhizocarpon geographicum* (L.) DC.

Restricted to one solitary, large boulder on the ridge of Moseryggen, 270 m a.s.l. Here it occurs as sparse crusts, associating with several other uncommon species (see note on *Buellia anisomera*, 9a).

17b. *Rhizoplaca melanophthalma* (Ram.) Leuckert & Poelt

A frequent crustose lichen on the south-west and south coasts, confined to elevated stony ground between 270 and 400 m a.s.l. Yet it has not been encountered on the low ground of Nyrøysa.

18. *Verrucaria dispartita* Vain.

Principally a shore cliff species (2.3), (3.3), which also ascends to 320 m a.s.l. It is one of the few conspicuous species on the plateau of Kapp Valdivia, growing on silicic slabs (4.1).

19. *Xanthoria candelaria* (L.) Th. Fr.

Dispersed, but seldom abundant, in various rocky communities, as well as dispersed in moss cushions. The species appears as moderately dependent on manuring and was observed up to at least 270 m a.s.l.

Chlorophyta

20. *Prasiola crispa* (Lightf.) Menegh.

Definitely the most common terrestrial cryptogam on Bouvetøya and a prevalent species in communities such as (2.2). It occurs in all sectors of the coast except at sites disturbed by ice avalanches, and is tolerant of excessive penguin or petrel manuring (Transect no. 3). *Prasiola* was the only macroscopic plant seen in 1979 on the small rock of Nyknausen on the south-east coast, which is encircled by the glacier ice sheet.

As to altitude, it still forms continuous growths on the peak 390 m a.s.l. between Aagaardbreen and the Nyrøysa area (Fig. 2a).

Discussion

A phytogeographical assessment was given by Engelskjøn & Jørgensen (1986) with emphasis on the history of Bouvetøya and the chorology of its flora, including its affinities to other South Atlantic and maritime Antarctic land areas. One conclusion is that the flora, of necessity, has reached Bouvetøya by trans-oceanic migration.

The present discussion considers the development and spatial distribution of flora and vegetation on the island. A considerable number of vegetation units (Table 6–17) were recognized, based on physiognomic and floristic criteria as perceived during the field work.

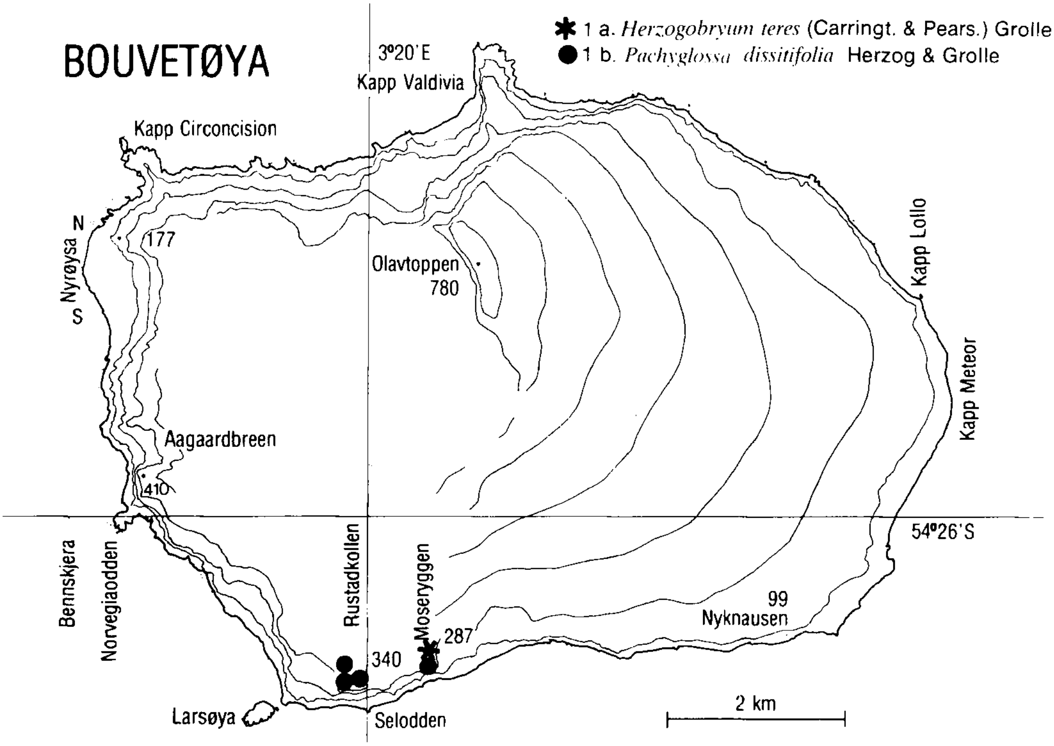
Small-scaled patterns of vegetation are difficult to discern during hurried work on windy mountains, while the helicopter is waiting. Consequently, the vegetation of the south coast high ground may contain more definable sociations of restricted local distribution. For instance, there were patches with dominance of *Pannaria hookeri* or *Placopsis contortuplicata* within the more ubiquitous bryophyte and lichen communities, cf. Tables 14 and 15.

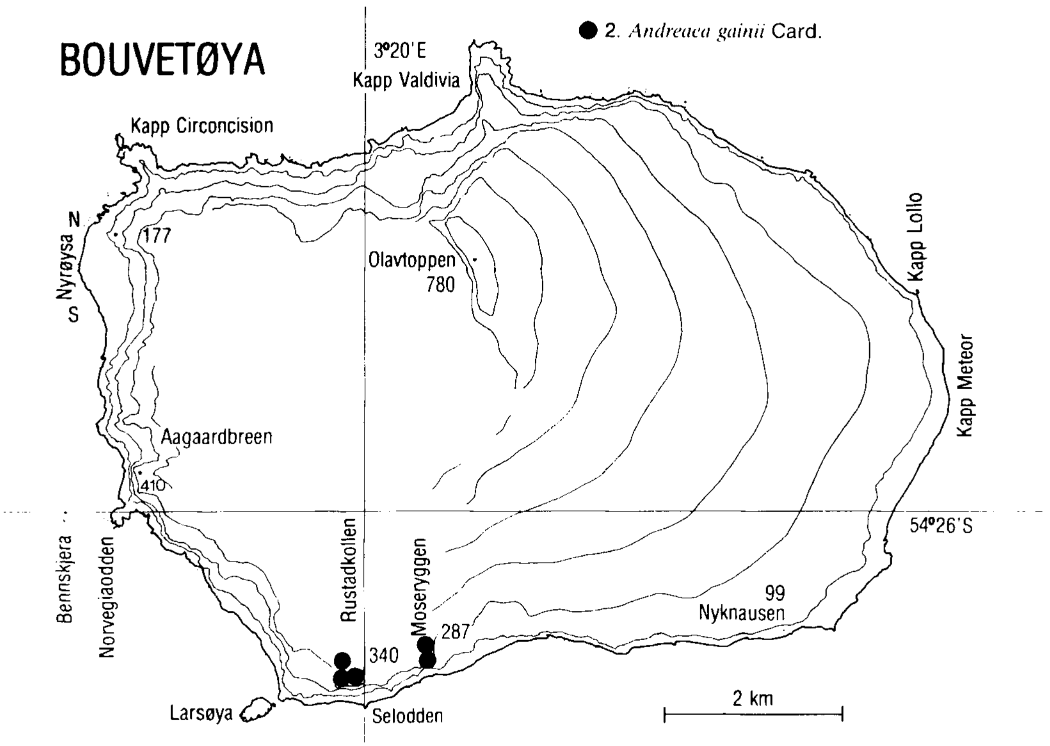
The range of growth-forms on Bouvetøya is comparable with that in other parts of the maritime Antarctic, but the relative and absolute areas with plant cover are small, and there is a more restricted range of communities within each subformation (Gimingham & Smith 1970; Smith 1984, pp. 82–83) than in e.g. the South Shetland Islands (Lindsay 1971), the South Orkney Islands (Smith 1972), and the South Sandwich Islands (Longton & Holdgate 1979).

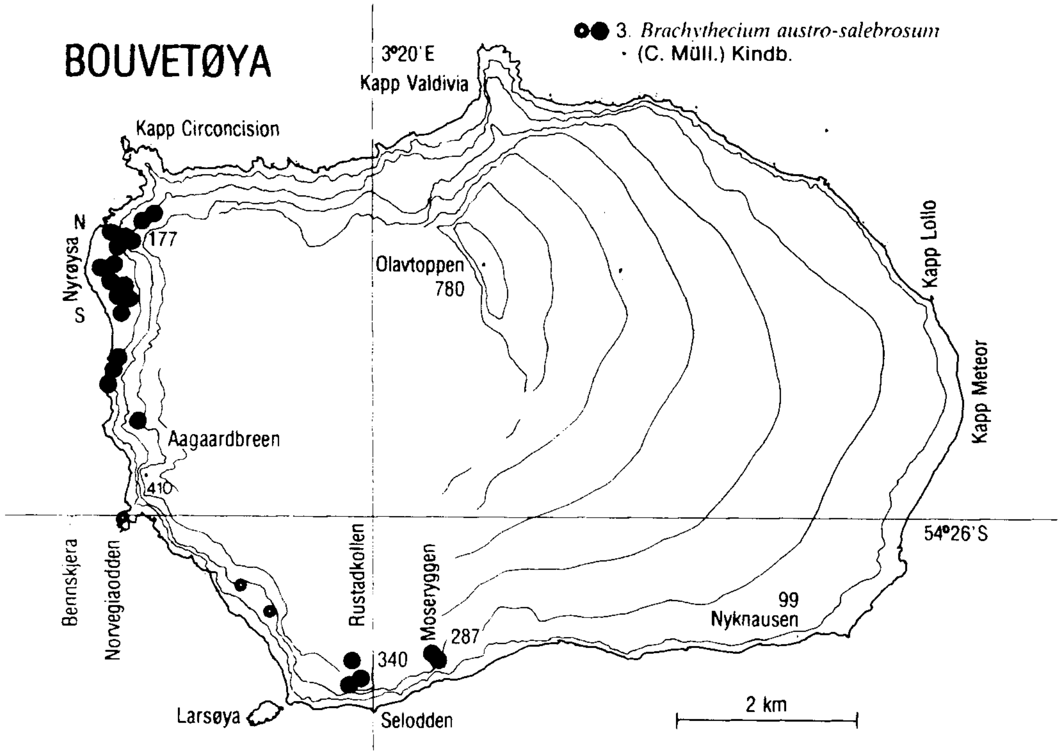
Bouvetøya, on approximately 54.5°S, and the South Sandwich Group, which ranges from approximately 56.3° to 59.5°S, represent the most northerly lands within the Antarctic botanical zone as defined by Skottsberg (1960), Greene (1964), Holdgate (1970), and Smith (1984). It is a distinctive feature of maritime Antarctic vegetation that the same, or closely related species recur at remotely distant sites (Smith 1972, p. 108). Gams (1932) held this as characteristic of closed bryophyte communities. There is, for instance, a considerable structural resemblance between the non-vascular cryptogamic communities on Bouvetøya, e.g. those with *Andreaea gainii*, and *Andreaea* sociations of the high-alpine belt in North Scandinavia (Engelskjøn unpublished), or on Spitsbergen (Elvebakk 1984). Other instances of bipolarity of cryophilic plant communities in Arctic and Antarctic zones could be vegetation containing *Usnea* subg. *Neuropogon* (Lynge 1941; Walker 1985; Engelskjøn 1986b), and the prevalence of *Brachythecium* and *Tortula* moss carpet vegetation both in the maritime Arctic and the maritime Antarctic (Engelskjøn 1987).

(Text cont. p. 161)

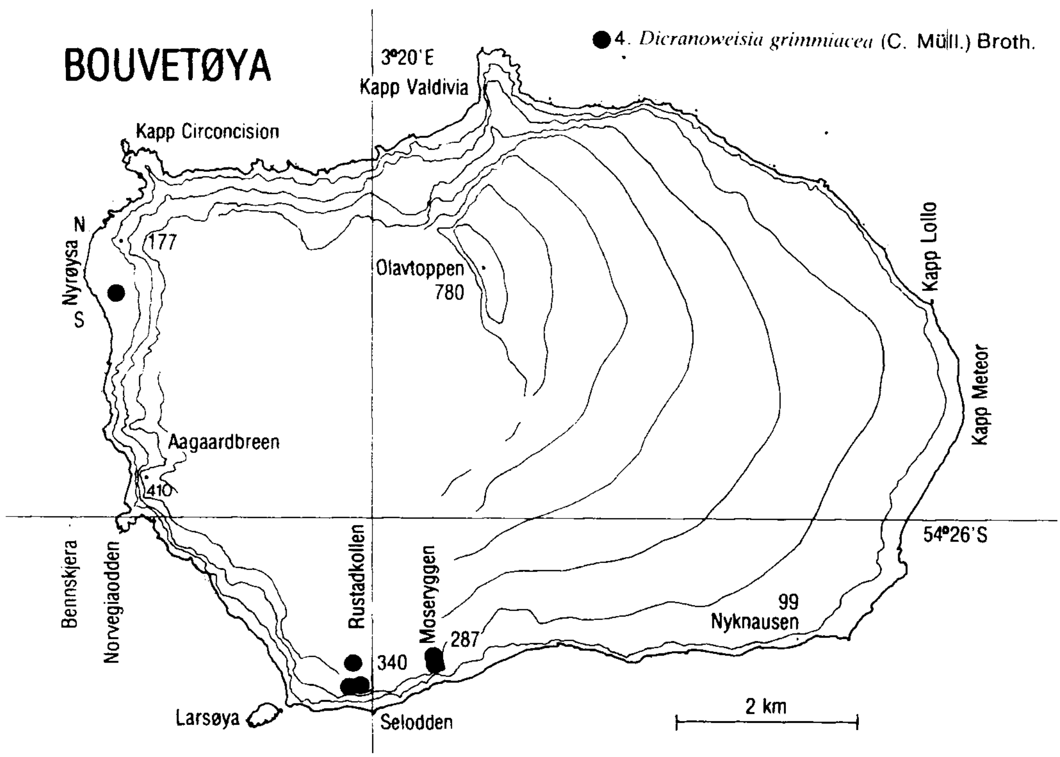
Distribution maps 1–20



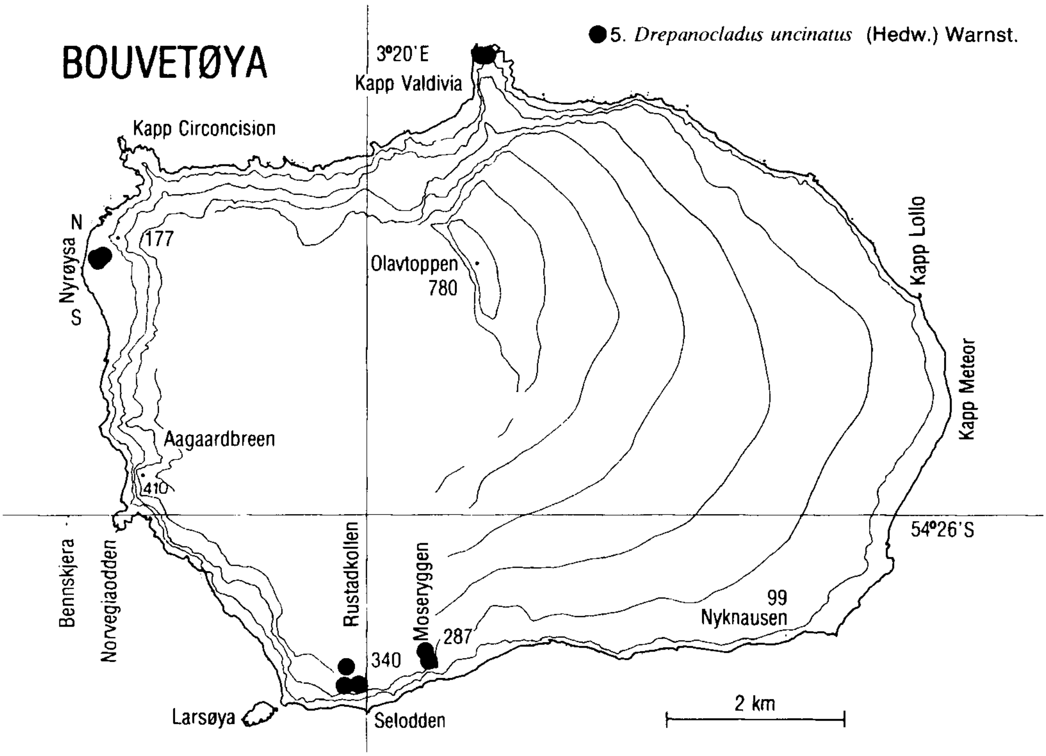


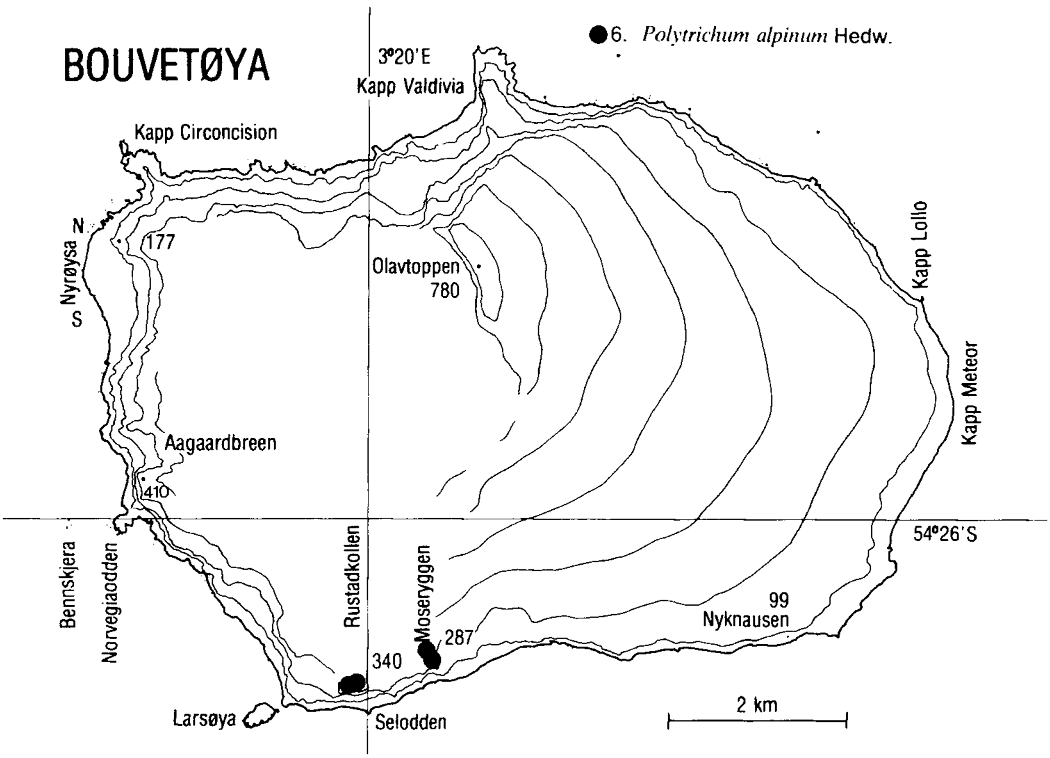


3. *Brachythecium austro-salebrosum* (C. Müll.) Kindb.

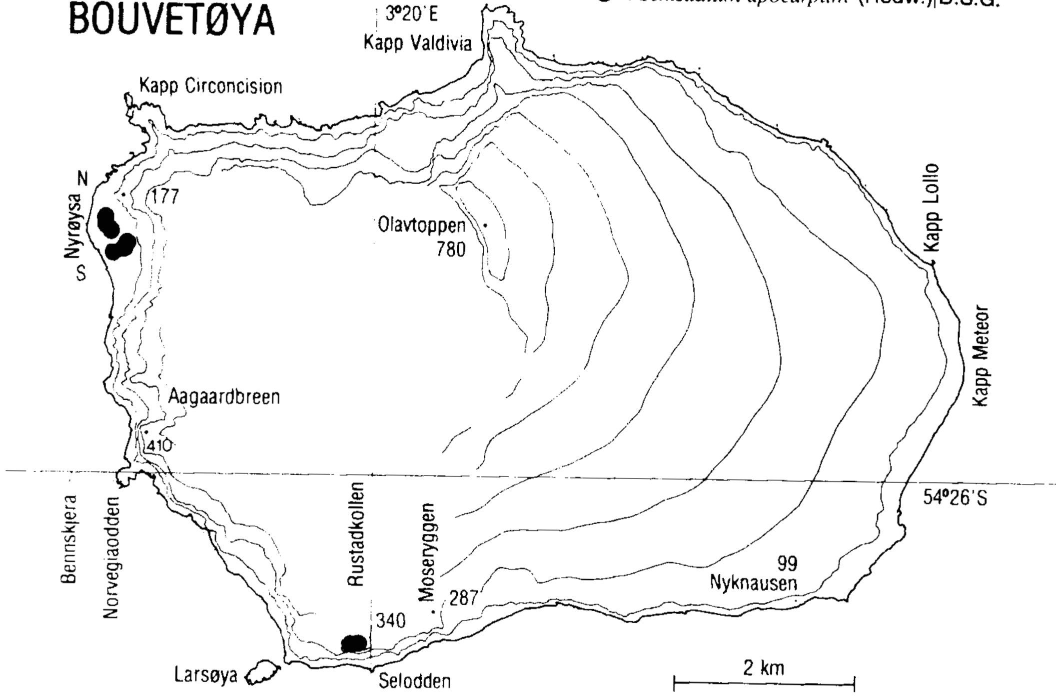


4. *Dicranoweisia grimmiacea* (C. Müll.) Broth.

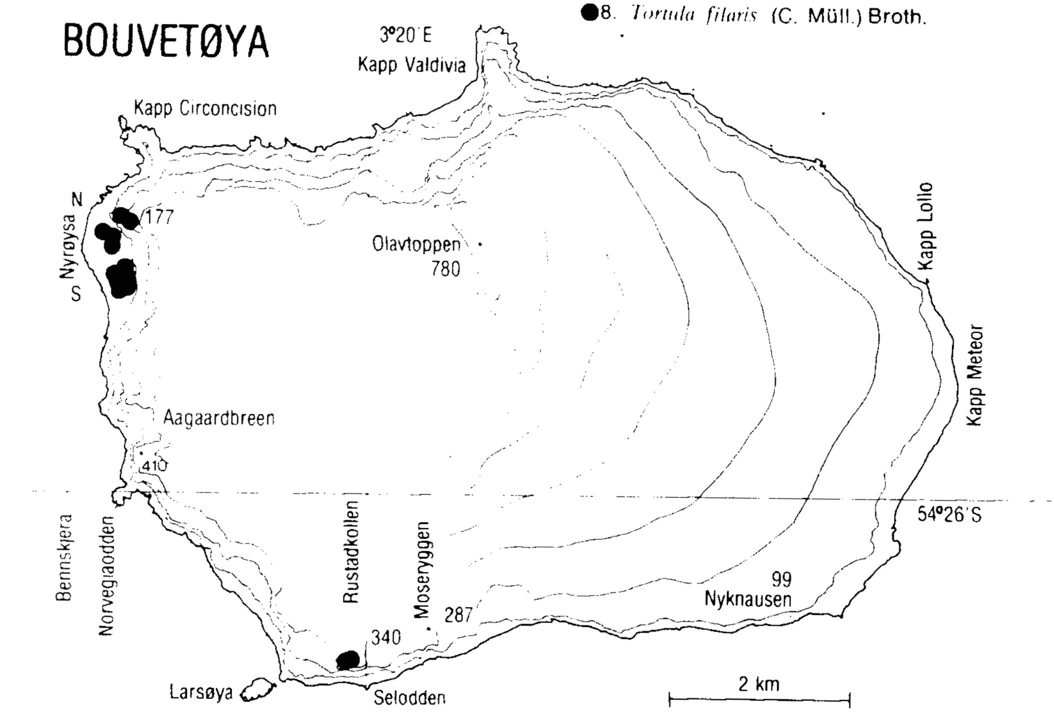

●5. *Drepanocladus uncinatus* (Hedw.) Warnst.
BOUVETØYA
3°20'E
Kapp Valdivia
Kapp Circoncision
N
Nyrøysa
S
177
Olavtoppen
780
Kapp Lollo
Kapp Meteor
Aagaardbreen
410
54°26'S
Bennskjera
Norvegiaodden
Rustadkollen
Moseryggen
99
Nyknausen
287
340
2 km
Larsøya
Selodden

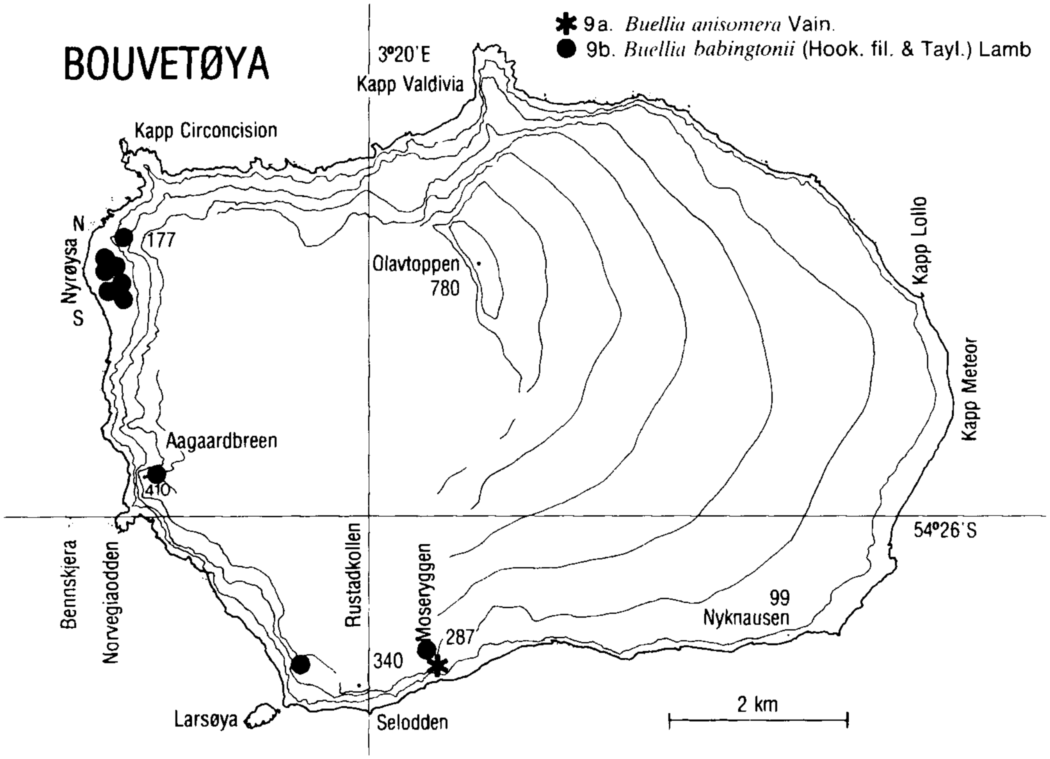

●6. *Polytrichum alpinum* Hedw.
BOUVETØYA
3°20'E
Kapp Valdivia
Kapp Circoncision
N
Nyrøysa
S
177
Olavtoppen
780
Kapp Lollo
Kapp Meteor
Aagaardbreen
410
54°26'S
Bennskjera
Norvegiaodden
Rustadkollen
Moseryggen
99
Nyknausen
287
340
2 km
Larsøya
Selodden

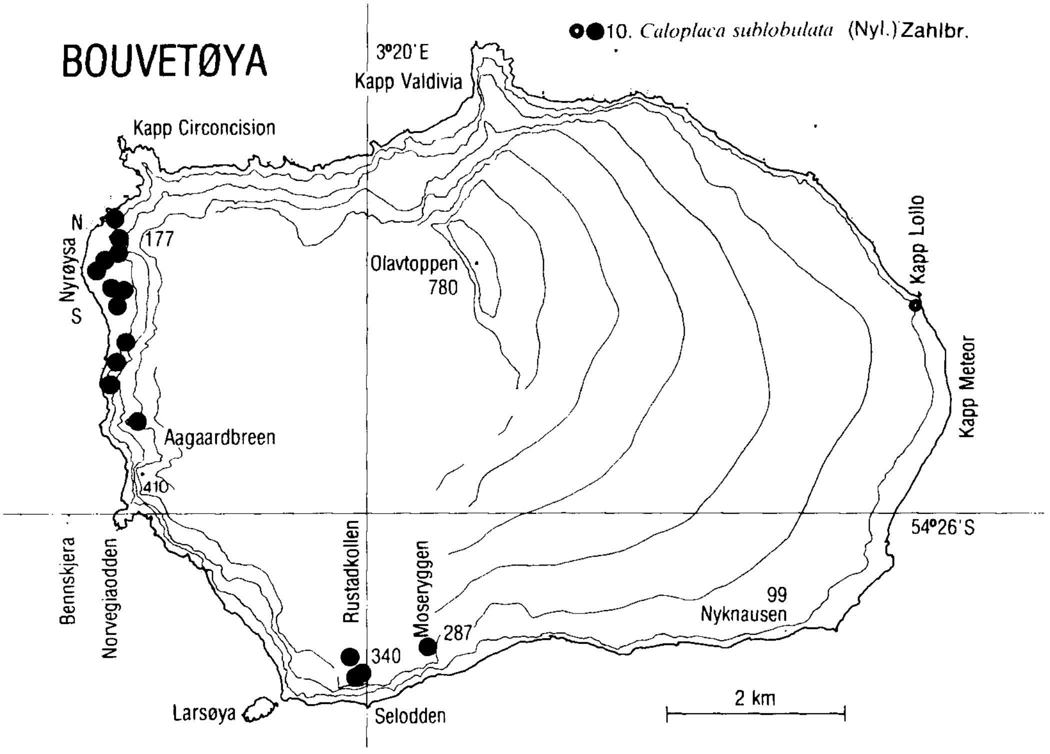
●7. *Schistidium apocarpum* (Hedw.) B.S.G.

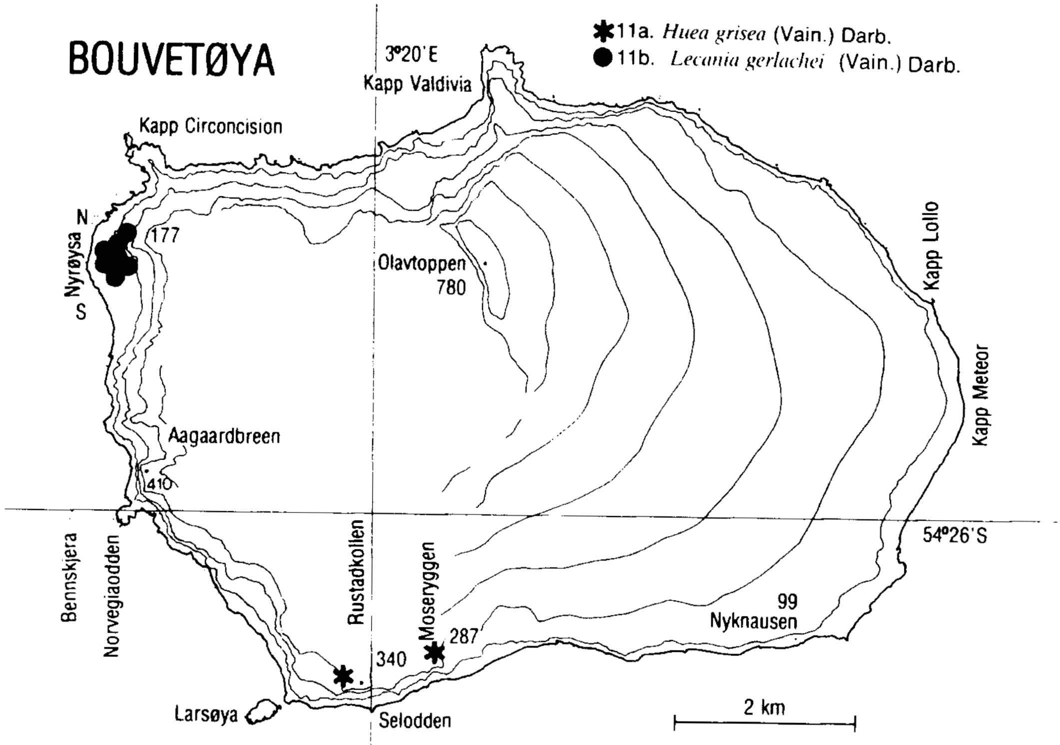


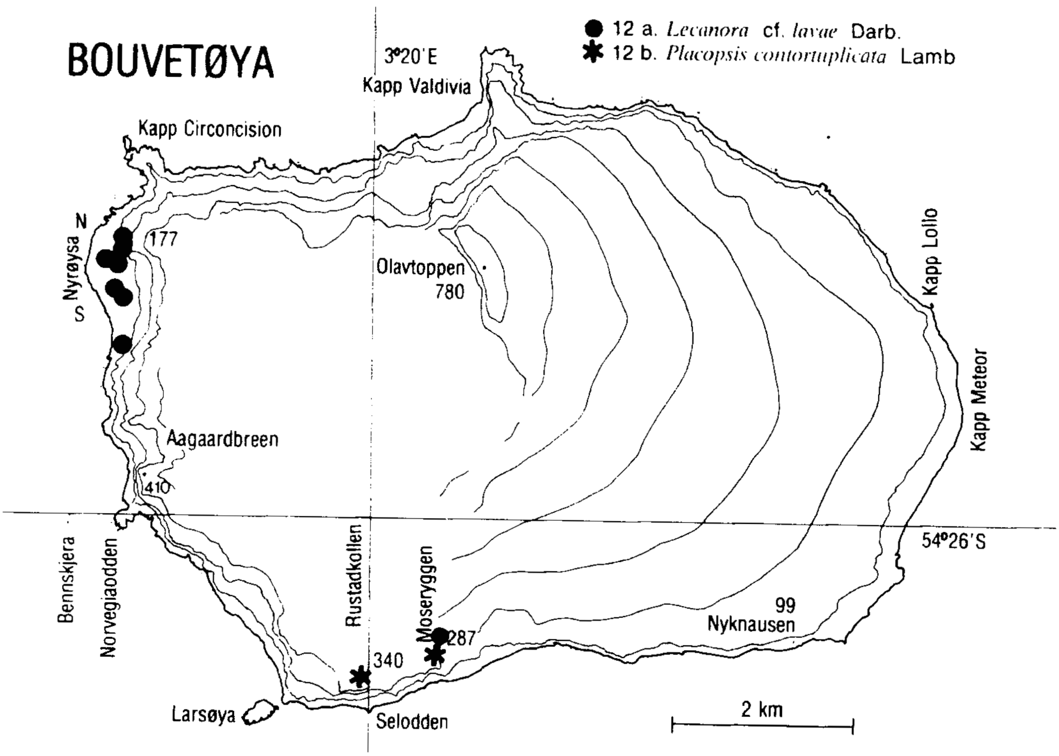
●8. *Tortula filaris* (C. Müll.) Broth.



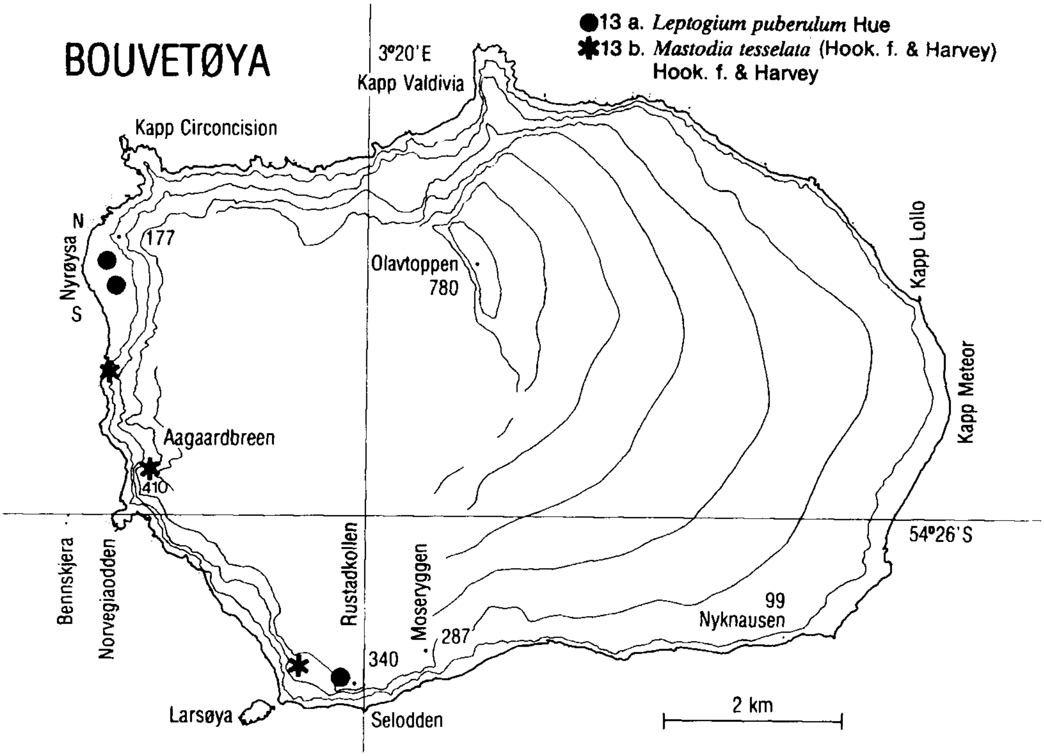

✱ 9a. *Buellia anisomera* Vain.
● 9b. *Buellia babingtonii* (Hook. fil. & Tayl.) Lamb
BOUVETØYA
3°20'E
Kapp Valdivia
Kapp Circoncision
N
Nyrøysa
S
177
Olavtoppen
780
Kapp Lollo
Kapp Meteor
Aagaardbreen
410
54°26'S
Bennskjera
Norvegiaodden
Rustadkollen
Moseryggen
287
340
99
Nyknausen
Larsøya
Selodden
2 km


○● 10. *Caloplaca sublobulata* (Nyl.) Zahlbr.
BOUVETØYA
3°20'E
Kapp Valdivia
Kapp Circoncision
N
Nyrøysa
S
177
Olavtoppen
780
Kapp Lollo
Kapp Meteor
Aagaardbreen
410
54°26'S
Bennskjera
Norvegiaodden
Rustadkollen
Moseryggen
287
340
99
Nyknausen
Larsøya
Selodden
2 km

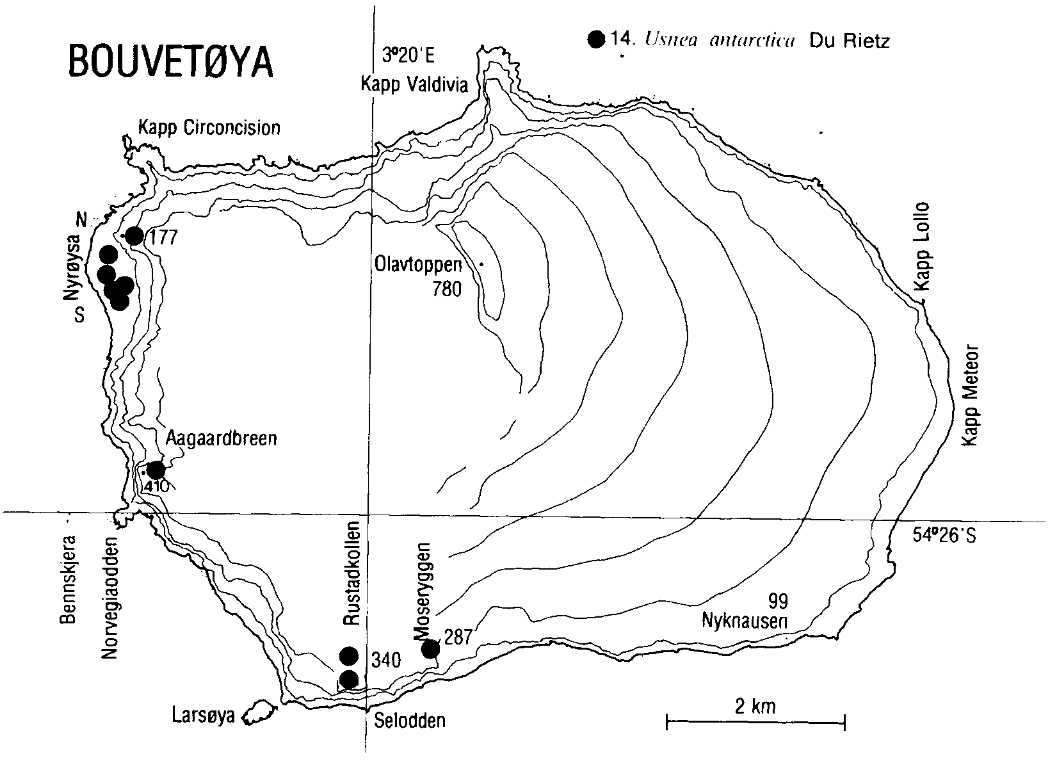

BOUVETØYA
✱11a. *Huea grisea* (Vain.) Darb.
●11b. *Lecania gerlachei* (Vain.) Darb.
3°20'E
Kapp Valdivia
Kapp Circoncision
N
Nyrøysa
S
177
Olavtoppen
780
Kapp Lollo
Kapp Meteor
Aagaardbreen
410
54°26'S
Bennskjera
Norvegiaodden
Rustadkollen
Moseryggen
287
340
99
Nyknausen
Larsøya
Selodden
2 km


BOUVETØYA
● 12 a. *Lecanora* cf. *lavae* Darb.
✱ 12 b. *Placopsis contortuplicata* Lamb
3°20'E
Kapp Valdivia
Kapp Circoncision
N
Nyrøysa
S
177
Olavtoppen
780
Kapp Lollo
Kapp Meteor
Aagaardbreen
410
54°26'S
Bennskjera
Norvegiaodden
Rustadkollen
Moseryggen
287
340
99
Nyknausen
Larsøya
Selodden
2 km

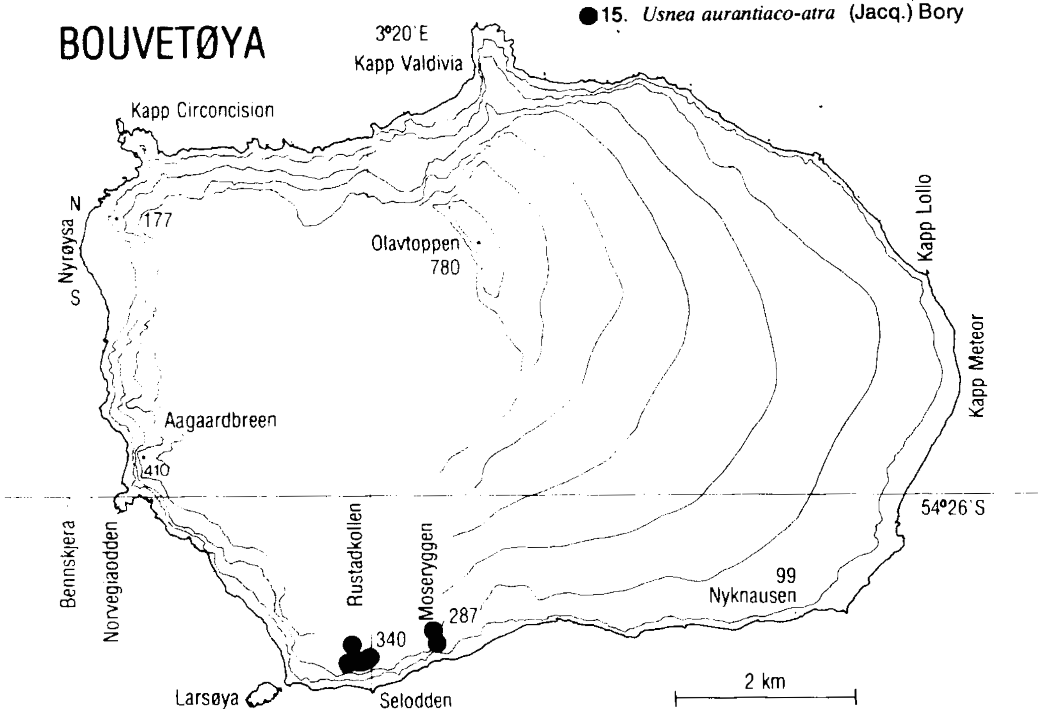
● 13 a. *Leptogium puberulum* Hue
✱ 13 b. *Mastodia tesselata* (Hook. f. & Harvey) Hook. f. & Harvey



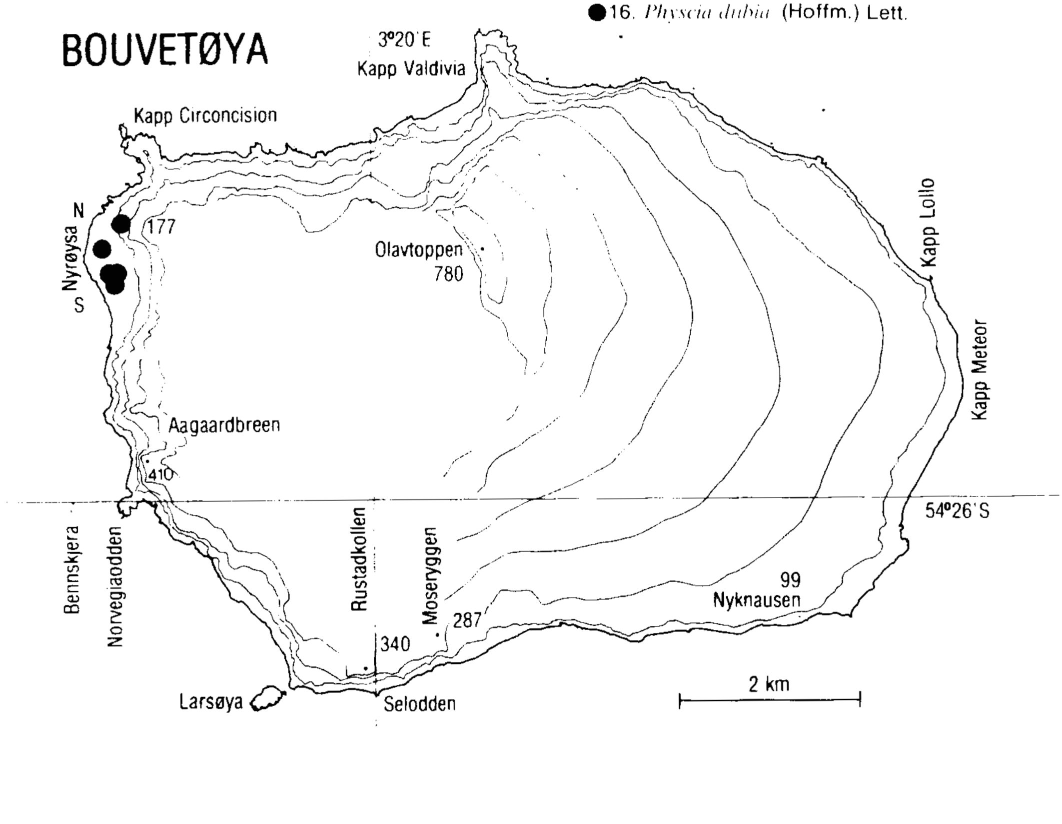
● 14. *Usnea antarctica* Du Rietz

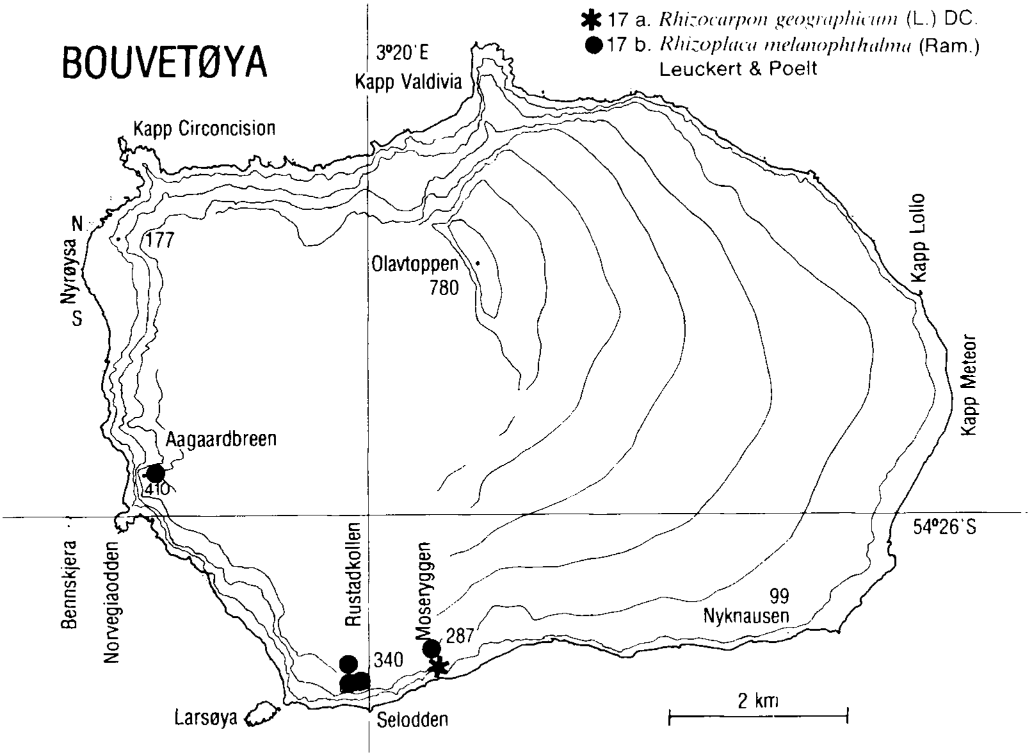


●15. *Usnea aurantiaco-atra* (Jacq.) Bory

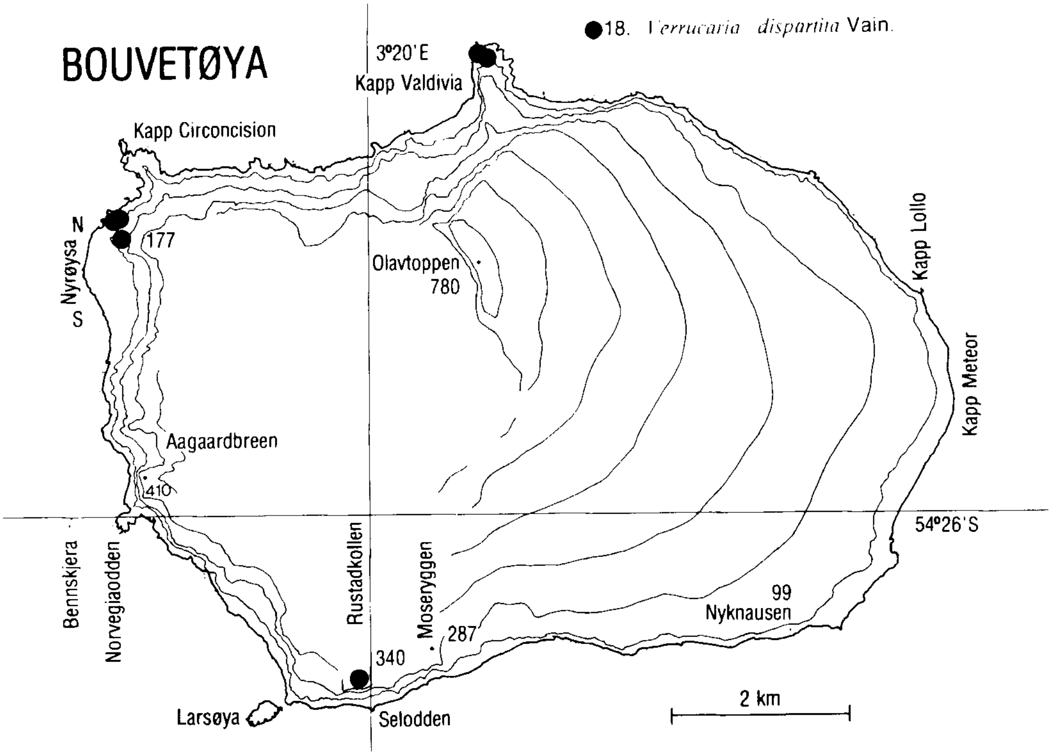


●16. *Physcia dubia* (Hoffm.) Lett.

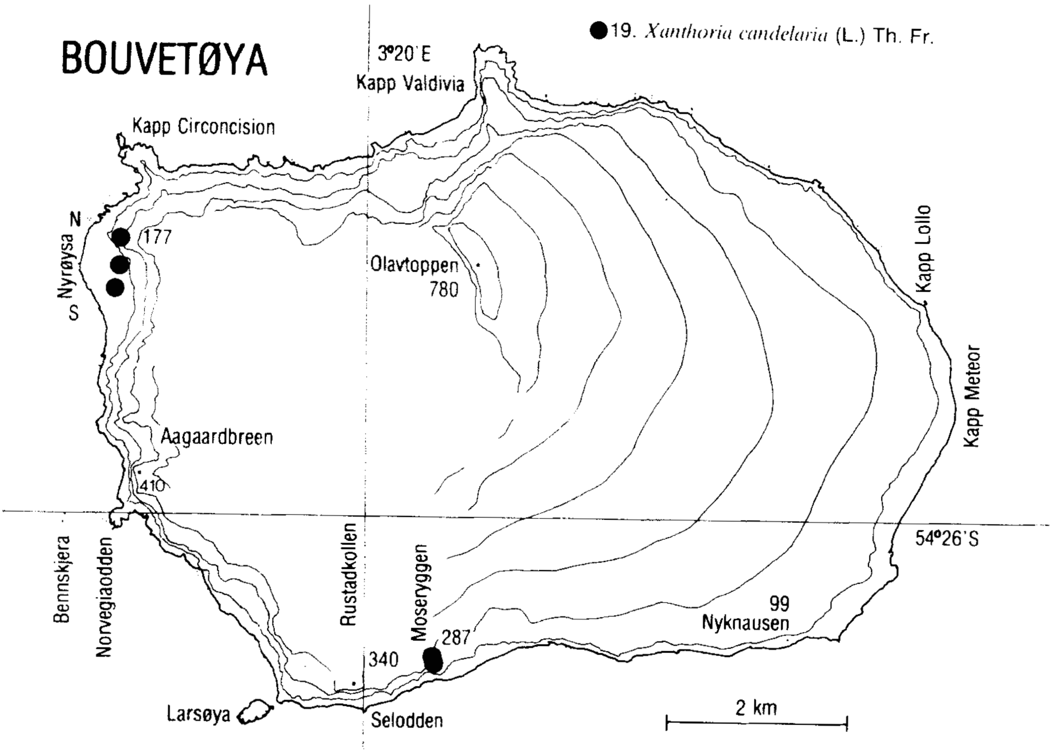




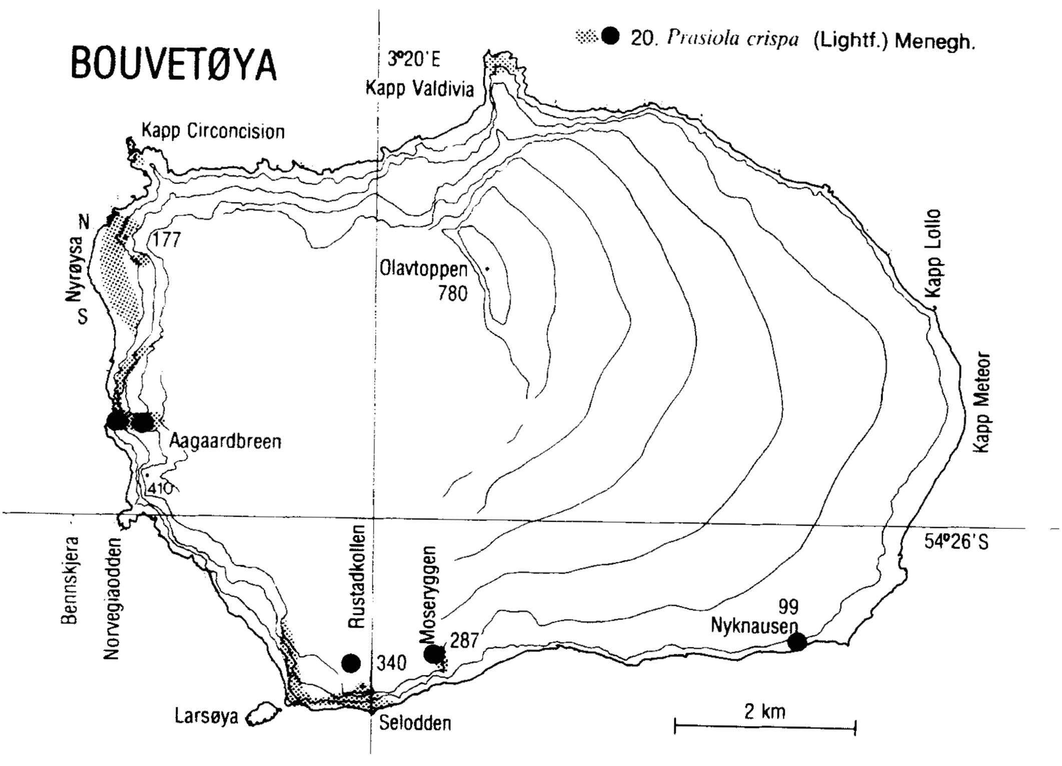
✱17 a. *Rhizocarpon geographicum* (L.) DC.
●17 b. *Rhizoplaca melanophthalma* (Ram.) Leuckert & Poelt



●18. *Verrucaria dispartita* Vain.



19. *Xanthoria candelaria* (L.) Th. Fr.



20. *Prasiola crispa* (Lightf.) Menegh.

This is a geobotanical feature which may depend on climatic similarity, and it is presumably of great geological age.

The ecological conditions and geographical isolation contribute to the floristic and vegetational poverty of Bouvetøya. The ambient meteorological observations (Tables 2 and 3) suggest an inclement climate. This may, to some extent, be compensated by an aspect towards the north, wind shelter, less disturbance from birds and seals, and an adequate water supply. Habitats supporting a more developed and diversified vegetation were mainly seen in some cliffs at the hill 177 m a.s.l. to the north of Nyrøysa, in cliffs of Moseryggen facing Christensenbreen, and in sheltered parts of Rustadkollen. These sites, however, are exposed to diurnal freeze/thaw cycles because they are all located close to, or above, the night frost level of 200 m a.s.l. Moreover, all low ground on Bouvetøya is strongly exposed to breaking waves and marine abrasion. The new ground of Nyrøysa will probably be washed into the sea within a century or less, considering the abrasion observed from 1979 to 1985.

These conditions may explain the absence of vascular plant species from Bouvetøya, even if diaspores have successfully reached the island on occasions. There is no evidence that the climatic conditions near sea level are too severe for the growth and survival of e.g. *Deschampsia antarctica*. This species grows on Candlemas Island, South Sandwich Islands, 1910 km to the west (Longton & Holdgate 1979, pp. 23–24), several places in the South Orkney Islands (Smith 1972, p. 61), and southwards to 68°42′ in Marguerite Bay on the west coast of the Antarctic Peninsula (Komarkova, Poncet & Poncet 1985; cf. also Greene & Holtom 1971; Smith 1982).

Both the South Orkney Islands and the Antarctic Peninsula experience colder climates than Bouvetøya (Table 3), but this may be compensated by more radiation and less wind.

The vegetation of fumaroles on Bouvetøya shows luxuriantly developed moss hummocks consisting of a few species (Engelskjøn 1981, pp. 26–27; Bell & Blom 1986), and some rare bryophytes of the genera *Bryum, Ceratodon,* and *Dicranella* were not found outside the vicinity of steam vents. However, these heated sites are of recent origin and hardly comparable with fumarole vegetation on the South Sandwich Islands which includes several exclusive liverworts and species of the temperate moss genus *Campylopus* (Longton & Holdgate 1979, p. 46). Local geothermal heat may have been important on Bouvetøya in the past because it counteracts snow and ice deposition and creates extrazonal conditions for plants and animals.

Composition and establishment of the vegetation

The present climax vegetation of Bouvetøya may be divided in two main groups containing different dominant and characteristic species.

The south coast high ground vegetation is confined to the non-glaciated parts of Moseryggen and Rustadkollen, 3 km away from the central crater of the volcano. These basalt outcrops are stable, the soil substratum for vegetation appears slightly leached and has an acidic reaction (Table 5). There are no fumaroles or measureable heating of the ground in this area.

Referring to the distribution maps (1–20), the following species are quoted as restricted to the south coast high ground vegetation: *Herzogobryum teres* (1a), *Pachyglossa dissitifolia* (1b) as well as two more liverworts, *Cephaloziella exiliflora* and *Herzogobryum atrocapillum*; *Andreaea gainii* (2) and *A. regularis*; *Pohlia nutans*, *Polytrichum alpinum* (6), and *Schistidium* cf. *antarcticum*.

Several lichens are confined to the same area and plant communities, i.a. *Acarospora macrocyclos*, *Buellia anisomera* (9a), *B. melanostola*, *Cladonia pyxidata*, *Cystocoleus ebeneus*, *Huea grisea* (11a), *Lecidella bullata*, *Massalongia carnosa*, *Pannaria hookeri*, *Placopsis contortuplicata* (12b), *Psoroma hypnorum*, *Rhizocarpon geographicum* (17a), *Rhizoplaca melanophthalma* (17b), *Rinodina turfacea*, *Stereocaulon glabrum*, and *Usnea aurantiaco-atra* (15).

A few species, which are practically exclusive to the same vegetation, were found in small quantities as invaders on the new ground of Nyrøysa, e.g. *Dicranoweisia antarctica*, *D. grimmiacea* (4), and *Leptogium puberulum* (13a).

The north and west coast high ground vegetation is located closer to the central crater (1–2 km) or secondary centra of volcanic activity. The substratum is usually alkaline (Table 5). Fumaroles which are generally short-lived and not producing much hot water and steam were observed in several places (Prestvik & Winsnes 1981, pp. 58–60). A considerable geothermal heat gradient, about $1° m^{-1}$ on average, was recorded in a borehole in the cliff north of Nyrøysa (Prestvik & Winsnes 1981, pp. 60–61).

The north-western corner of Bouvetøya is also the part most affected by birds and seals (Haftorn, Sømme & Gray 1981), and by mechanical disturbance such as avalanches. Hence the vegetation of Nyrøysa is considered as a pioneer phase reflecting the floristic composition of the surrounding hills under altered topographical, mechanical, and competitive conditions. Confined to this sector of Bouvetøya are the following species: *Ceratodon validus*, *Dicranella* cf. *hookeri*, some species of *Schistidium*, *Buellia falklandica*, *Lecania gerlachei* (11b), *Ochrolechia parella*, and *Physcia dubia* (16). More common in this sector than elsewhere on Bouvetøya are *Tortula filaris* (8), *T. princeps*, and most of the defined taxa of *Bryum*.

The vegetation on the northward projecting Kapp Valdivia is peculiar and seems influenced by the local outcrop of granitic lava. Confined to this cape is a species of ?*Ceratodon* occurring in some quantity, and *Rinodina deceptionis*.

The more abundant plant species of Bouvetøya occur in several sectors and at various elevations. Examples of such ubiquitous species are: *Brachythecium austro-salebrosum* (3), *Drepanocladus uncinatus* (5), *Buellia babingtonii* (9b), *Caloplaca sublobulata* (10), *Usnea antarctica* (14), and *Prasiola crispa* (20).

The local diversity of the Bouvetøya flora and vegetation is thus evident, and causal factors could be discussed. A primary feature seems to be differing substratum preferences, chemically as well as mechanically. However, also the volcanic, glacial, and erosional history of the island is worthy of consideration in relation to its present flora and vegetation.

The vegetation on the south coast high ground appears as old and stable. Basalts from this area have ages of about 1 million years (Prestvik & Winsnes 1981, Table 2). Among the 44 lichen species presently known on Bouvetøya, 30 are growing there, as do at least 16 of the 29 bryophyte species.

The plateaux on the south coast end abruptly in a 300 m high cliff (Fig. 8), which could not easily become buried in glacier ice from the central parts of the island (Orheim 1981, Fig. 2, pp. 81–82), although glacial striae were observed on parts of Moseryggen and Rustadkollen (Prestvik & Winsnes 1981, p. 54). From the point of vegetational history, the south coast high ground, including its southern precipice, may have remained the main vegetated site on Bouvetøya during periods of more extensive glaciation than at present.

The coast line of Bouvetøya is known to change due to marine undercutting of the cliffs and ensuing landslides, especially on the west coast (Prestvik & Winsnes 1981, p. 47). However, the basalts of the south coast appear as relatively resistant, and this sector may have been stable throughout millenia, extending farther to the south and south-west in the distant past.

Conversely, the vegetated areas on the north and west coasts are of quite limited extent and partly situated on unstable slopes. Prevalent are communities dominated by a few, rapidly growing species such as *Brachythecium austro-salebrosum* and *Tortula filaris*, but there are also patches with well-developed and presumably old specimens of *Usnea antarctica*. The hill 177 m a.s.l. supports stable lichen and moss cushion vegetation of these species, but the ridge is subject to erosional degradation (Engelskjøn 1981, Fig. 2; see also the present Fig. 7). Nearly all important species from the south coast are absent from this area, which suggests that its vegetation is relatively young.

There is no evidence of a continental seafloor around Bouvetøya (sources quoted in Engelskjøn & Jørgensen 1986). During the last 60 000 years, the volcanism has been on the decline (Prestvik & Winsnes 1981), but at that time the island extended somewhat beyond Kapp Valdivia, judging from the eruption age of the silicic lava dome on this cape. However, the diameter of the island hardly exceeded some 20 km.

In this time perspective, it is reasonable to conclude that abrasion and landslides have consumed considerable parts of Bouvetøya, including gently sloping sectors of the former volcanic cone which may have supported vegetation.

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