Notes concerning the vegetation on deflation surfaces, Kapp Linné, Spitsbergen

JONAS ÅKERMAN

Åkerman, J. 1983: Notes concerning the vegetation on deflation surfaces, Kapp Linné, Spitsbergen. *Polar Research 1 n.s.*, 161–169.

The distribution of vascular plants within four sample areas on a deflation surface on a set of raised beach ridges near Kapp Linné, Spitsbergen, is described. The vegetation cover and distribution of the different species are related to the wind pattern and microtopography. Details of the distribution and growth characteristics of *Dryas octopetala, Saxifraga oppositifolia*, and *Silene acaulis* in relation to each other, and to the wind and microtopography are discussed.

Jonas Åkerman, Department of Physical Geography, University of Lund, Sölvegatan 13, S-22362 Lund, Sweden; January 1983 (revised May 1983).

The vegetation of Spitsbergen shows a very great regional variability which is mainly dependent upon differences in climate, soils, hydrology, and topography. The vegetation along the strandflats of western Spitsbergen is fairly uniform, however, belonging to the 'Dryas zone' (Hinz 1976). The small-scale vegetation pattern is much more complex than the regional, reflecting the extremely variable local conditions which may influence plant growth in the harsh periglacial environment.

This paper describes the vegetation pattern on exposed deflation surfaces and its relation to the environmental factors. The study is based on 'secondary' observations made during field work concerning geomorphological processes (wind action, patterned ground processes, etc.); it is a brief descriptive report without any deeper analysis or discussion.

The investigation area

General description

The investigation area is situated in central western Spitsbergen in the outer part of Isfjorden, east of Kapp Linné and Isfjord Radio Station (78°04'N, 13°38'E) (Fig. 1). To the west, the area is limited by the open sea, to the north by Isfjorden, and to the east by the Starostinaksla and Vardeborgaksla mountain ridges. The major part of the area is a wide strandflat characterized by a set of raised beach ridges up to about 60 m above sea level. The area is rich in small lakes and ponds and contains several small bogs. As far as is known the area has continuous permafrost and an active layer varying between 30 cm in the bogs to 2 m on the exposed beach ridges.

Climate

Isfjord Radio Station, which is also a meteorological station, lies in the investigation area. The area has a maritime influenced arctic climate with at least one month above ±0°C, but below +10°C. According to the Köppen classification, the station has a true tundra climate (ET). The mean annual air temperature is −4.8°C (1912–1975) and the mean annual precipitation 400.8 mm (1934–1975) (Åkerman 1980). The annual course of air temperature and precipitation is given in Table 1.

The wind climate is of great significance as regards the periglacial processes and the vegetation pattern of the area. In Fig. 2 the basic wind climatic conditions are shown. For further details about the wind climate, refer to Åkerman (1980).

Site of detail studies

The area in which the vegetation studies have been carried out is a very level set of beach ridges at a height of 20 to 40 m above sea level. It is about 500 × 300 m in extent and is dominated by two very level areas, one at a level of 22 to 24 m

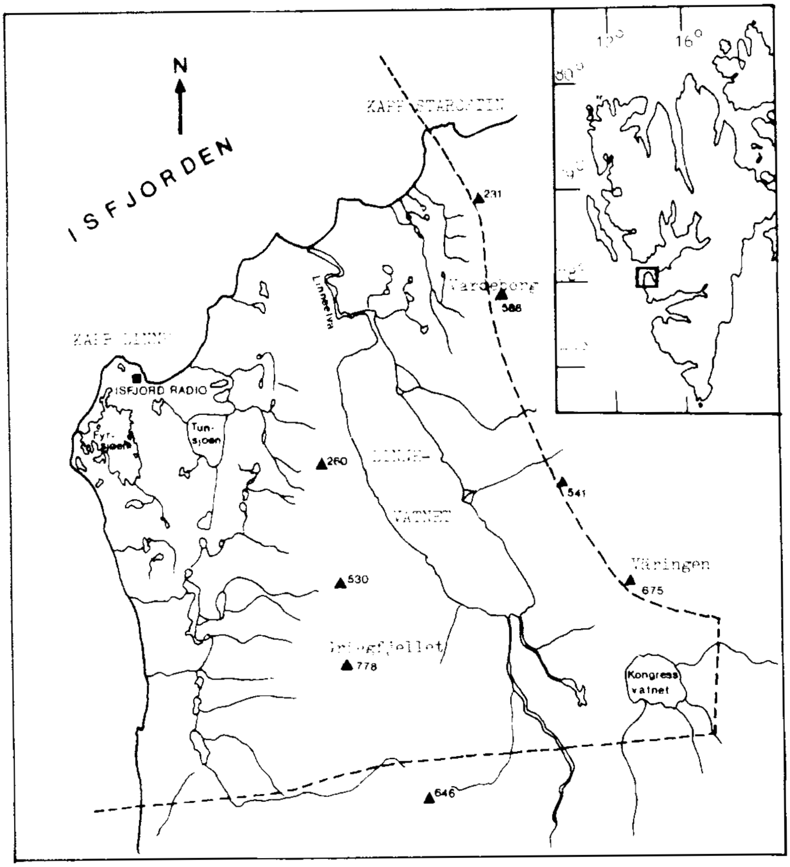

Fig. 1. Orientation map of the investigation area around Kapp Linné. Place names and heights (in m) according to Norsk Polarinstitutt Map No. B9 Blad Isfjorden, scale 1:100,000.

above sea level, and one at between 32 and 38 m above sea level (Figs. 3 and 4). These are deflation surfaces with a few blocks the majority of which are ventifacts showing well developed facets on their northeast exposed sides. The detail morphology is dominated by the smooth ridge system and by polygon furrows of two different types (Fig. 5). The large-scale polygon pattern is the result of an ice-wedge system with comparatively wide (0.5–1.5 m) and deep (0.2–0.5 m) polygon furrows.

The small-scale polygons are frost fissure polygons restricted to the active layer, which is here about 2 m deep. These furrows are generally narrower and shallower than the large-scale pattern.

The soils of the area are dominated by a fairly uniform well-washed beach gravel material in the upper 1.5–3 m. Below this there are thick glaciomarine silty deposits which can be seen from the active thermokarst processes along the shores of the Linnévatnet lake and the Linnéelva river. The beach gravel, lacking finer fractions, is well-drained and dry and lacks larger amounts of ground ice in winter.

Table 1. Mean monthly air temperature (1946–1975) and mean monthly precipitation (1934–1975) at Isfjord Radio Station, Kapp Linné, Spitsbergen.

	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	−11.2	−11.5	−12.2	−9.2	−3.5	+1.6	+4.7	+4.2	+1.1	−3.4	−7.1	−9.5
Prec. (mm)	31.5	30.5	30.9	22.3	23.6	24.8	35.8	45.0	40.6	41.3	38.8	35.6

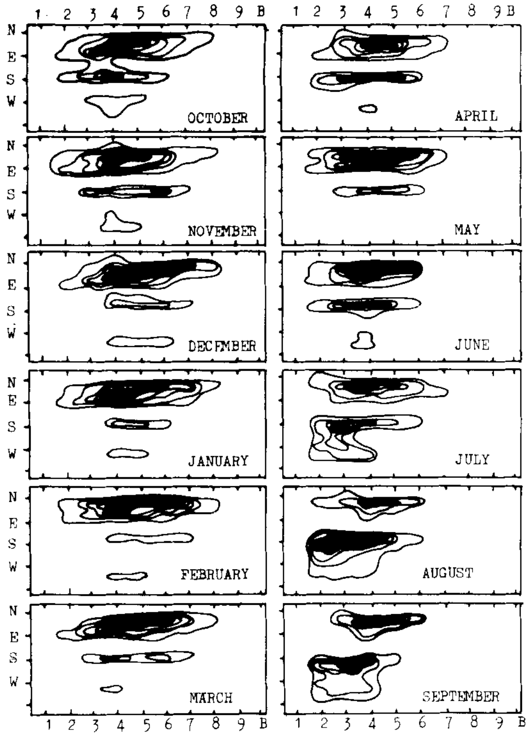

Fig. 2. Monthly percentage frequencies (frequency interval 1%, black areas represent more than 5%) of concurrent wind forces (Beaufort scale) and wind directions at Kapp Linné (Isfjord Radio) during the period 1956 to 1975.

Vegetation characteristics

General distribution

The study area lacks a continuous vegetation cover and the vegetation and occurrence of isolated plants are dictated by the microtopography. The regulating factors are the wind and the soil moisture content. The general distribution of the vegetation is shown in Fig. 6. In this figure three classes are distinguished: (1) the thermokarst surfaces, (2) the deflation surfaces, and (3) the shallow depressions.

The thermokarst surfaces are generally very poor in vegetation as they are subject to intensive disturbances like earth flows, slumps and rill erosion. Some areas which are temporarily more stable have mosses, lichens, and some vascular plants – Saxifraga sp., Ranunculus sp., Draba sp., etc.

The deflation surfaces constitute the flattest in the area and the crests of the raised beach ridges. These surfaces appear very poor in vegetation, but the number of lichens and mosses is great and the area studied has a fairly large number of wind eroded tufts of *Dryas octopetala* and *Silene acaulis. Saxifraga oppositifolia, Draba nivalis,* and

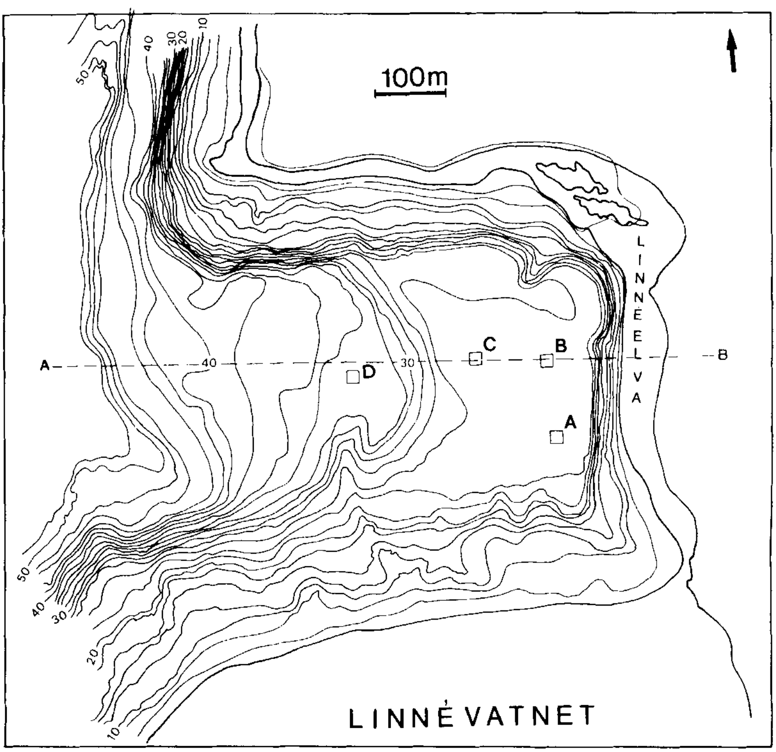

Fig. 3. Topographic map of the investigation area. The test surfaces are shown by squares (A–D). Contour interval 2 m.

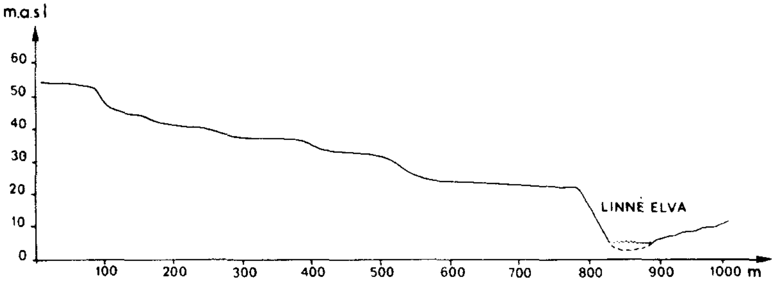

Fig. 4. Profile across the investigation area.

Stellaria crassipes are also fairly common at protected 'microsites' on these surfaces. The polygon furrows on the deflation surfaces are also rich in mosses and *Salix polaris* (Fig. 7).

The depressions between the smooth ridges (incl. the polygon furrows) have a protective snow cover during winter, also providing moisture to the soil in the early summer, and have a discontinuous vegetation cover dominated by lichens and mosses; the surfaces are comparatively rich in plants. The dominating vascular plants are *Salix polaris, Saxifraga oppositifolia, Stellaria crassipes, Silene acaulis, Draba alpina,* and *Poa alpina.*

The deflation surfaces

The deflation surfaces are characterized by the sandy-gravelly material and by a pavement of small stones and pebbles 1–3 cm in diameter (Fig. 8); vegetation coverage is not great. Including the lichens and mosses the percentage of vegetation cover is larger than the general impression may indicate, however. In order to obtain a more representative picture of the vegetation distribution, the deflation surfaces were studied in detail within four test surfaces 7 × 4 m large (Fig. 3). These surfaces were photographed from a

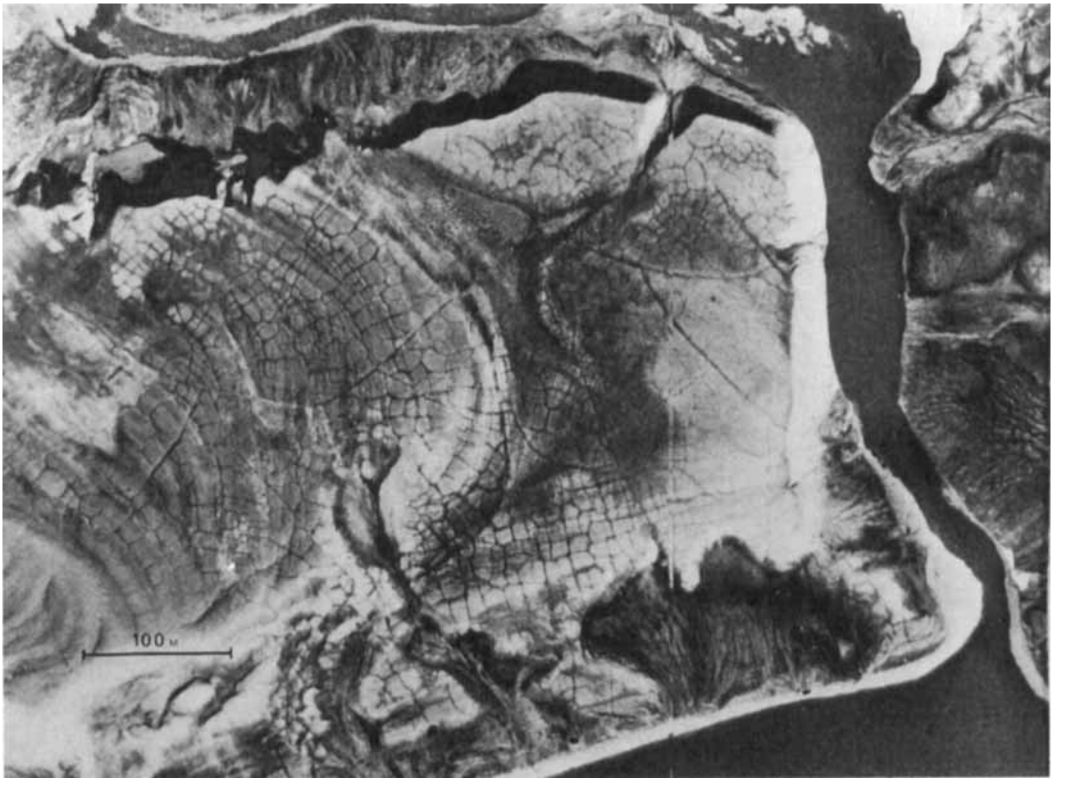

Fig. 5. Air photograph of the investigation area. Detail from Norsk Polarinstitutt airphoto No. S69 2436.

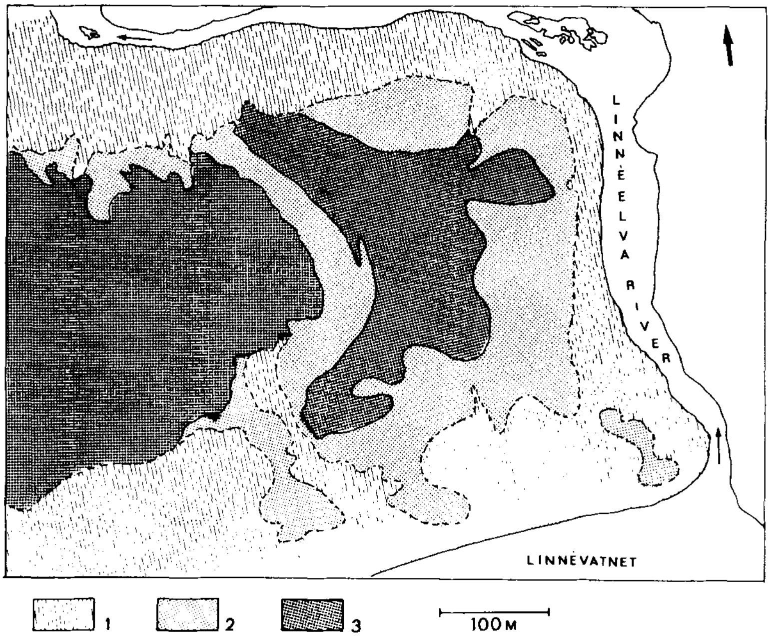

Fig. 6. Vegetation characteristics of the investigation area. 1. 'the thermokarst surfaces', 2. 'the deflation surfaces', and 3. 'the depressions'.

height of 6 m, affording the possibility of obtaining the percentage coverage of the vegetation within each 7 × 4 m sample area. Within these surfaces a 1 × 1 m frame subdivided into an 0.1 × 0.1 m grid (Fig. 7) was used for evaluating the detailed distribution of the vegetation and the number of plants per unit area.

The most characteristic plant of these surfaces is the *Dryas octopetala*, which grows in wind eroded tufts evenly distributed over the area. The tufts are very characteristically parabolic in shape (Figs. 9 and 11), indicating the active wind direction from the northeast (Åkerman 1980).

The percentage coverage of Dryas on the deflation surfaces is 19.4% (Table 2); the distribution arrangement within the sample areas is shown in Fig. 10A–D. The parabolic-shaped Dryas tufts have a very characteristic form which

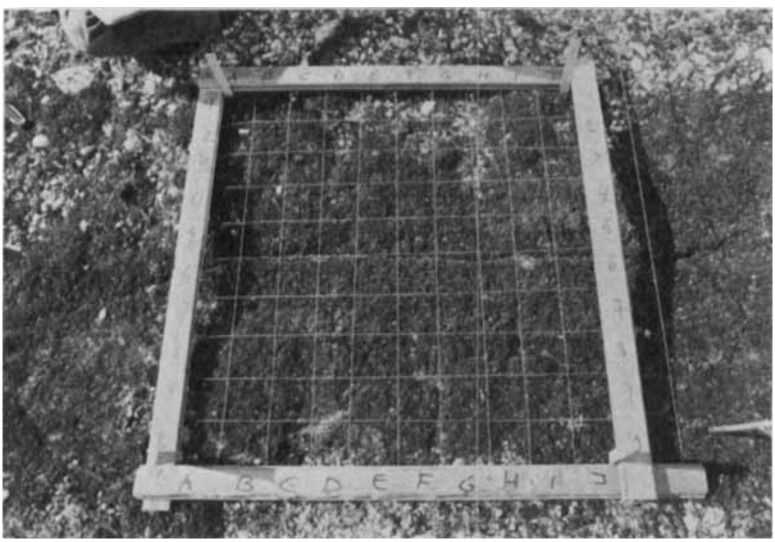

Fig. 7. The characteristic vegetation pattern in the polygon furrows. The frame is 1 × 1 m.

Fig. 8. The parabolic shaped wind-eroded tufts of *Dryas octopetala* on the deflation surfaces. The active wind direction is indicated by the gun.

has been mapped by stereographic methods based on vertical photographs taken from a height of 2 m. An example is given in Fig. 11.

Saxifraga oppositifolia, which is one of the most common and characteristic plants of Spitsbergen, is also found on these deflation surfaces, but here this plant is apparently growing at the very limit of existence. Elsewhere *S. oppositifolia* is found evenly distributed over almost all suitable surfaces, but here almost exclusively in association with the *Dryas* tufts. On these exposed surfaces *S. oppositifolia* is obviously entirely dependent upon the protection that the *Dryas* tufts are providing.

The position of the *S. oppositifolia* plants within the four test surfaces in association with the *Dryas* tufts was investigated (Fig. 12 and Table 3). In this investigation six 'classes' were distinguished (A = not in direct contact with the Dryas tufts, B = central lee position, C = marginal lee position, D = central windward position, E = marginal windward position, and F = 'inside' the Dryas tufts. The distrbution frequence is given in Table 3.

It is clearly indicated in this table that *S. oppositifolia* is dependent upon the Dryas for its existence – 92.3% of all plants on the deflation surfaces are found in contact with the Dryas tufts. The Dryas tufts may provide a higher soil moisture content, a higher content of fines, and above

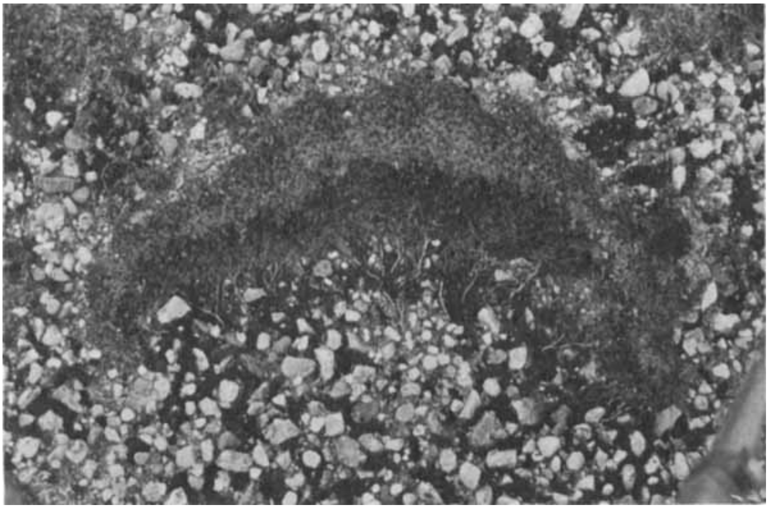

Fig. 9. Detail of one perfectly developed parabolic *Dryas* tuft on the deflation surface.

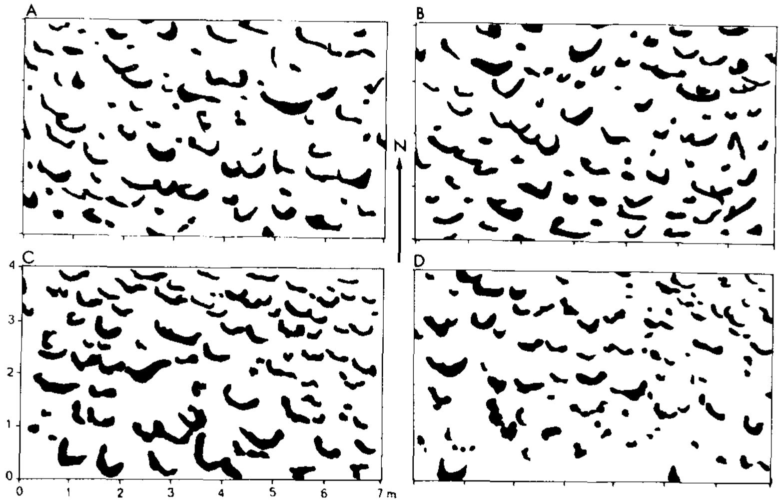

Fig. 10. The distribution of *Dryas octopetala* within the four test surfaces based on photographs taken from a height of 6 m above each surface.

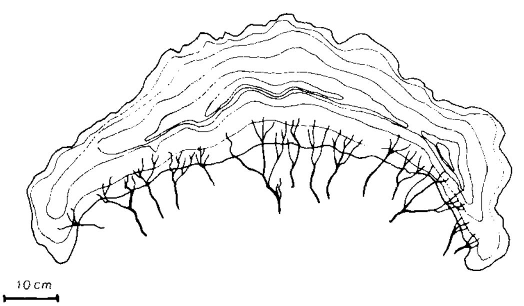

Fig. 11. The 'topography' of one of the parabolic-shaped *Dryas* tufts on the deflation surface (test surface B) based on stereographic measurements in vertical photographs taken from a height of 2 m. Contour interval 2 cm.

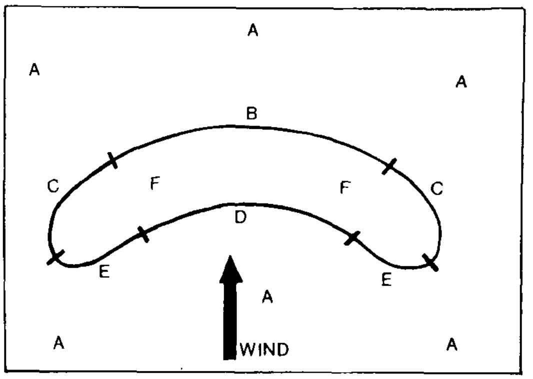

Fig. 12. The division used in the investigation of the position of *Saxifraga oppositifolia* in relation to the *Dryas octopetala* tufts. A. Not in contact with the *Dryas* tufts, B. central lee position, C. marginal lee position, D. central windward position, E. marginal windward position, and F. inside the *Dryas* tufts.

all protection from the desiccating and abrasive effects of the strong winds, as the high percentage of observations within the 'lee position class' (73%) indicates.

Another plant which is interesting in relation to wind activity within the area is *Silene acaulis*. This plant is not very common on the deflation surfaces but occurs in sufficiently large numbers to be used for a simple analysis (Table 4).

Many of the *Silene* tufts have wind scars on their northeast exposed side (43.6% of the observations) and a clear correlation between the size of the tufts and the wind erosion was observed early. The tufts with a diameter below 10 cm

Table 2. Percentage vegetation cover on the four sample areas based on the total area 7 × 4 m (Dryas) and five 1 × 1 m test squares (Mosses and lichens).

	A	B	C	D	Mean
Dryas octopetala	17.9%	20.4%	22.5%	16.7%	19.4%
Mosses and lichens	26.6%	19.2%	20.2%	28.2%	23.5%
Total	44.5%	39.6%	22.7%	44.9%	37.9%

Table 3. The distribution frequence of *Saxifraga oppositifolia* in relation to tufts of *Dryas octopetala* within four test surfaces on a deflation surface east of Kapp Linné, Spitsbergen.

	A	B	C	D	Mean
A. Not in contact with Dryas	8.4	8.1	7.9	6.3	7.7%
B. Central lee position	47.4	44.2	50.3	42.9	46.2%
C. Marginal lee position	29.5	28.8	22.7	26.1	26.8%
D. Central windward position	4.2	7.2	5.6	9.3	6.6%
E. Marginal windward position	2.1	4.5	1.9	3.9	2.7%
F. Inside the Dryas tufts	8.4	7.2	17.2	11.5	11.0%
Number of plants (7 × 4 m)	95	111	87	105	99.5

Table 4. Observations on the relation between wind erosion and the size of tufts of *Silene acaulis* within the four test surfaces on deflation surfaces east of Kapp Linné, Spitsbergen.

	A	B	C	D	Mean
Number of tufts (4 × 7 m)	39	45	22	41	35.7
Intact	53.8%	51.1%	59.3%	61.2%	56.4%
Wind eroded	46.2%	48.9%	40.7%	38.8%	43.6%
Intact < 10 cm	48.7%	44.4%	49.2%	51.7%	48.5%
Intact > 10 cm	5.2%	6.7%	10.1%	9.5%	7.9%
Wind eroded < 10 cm	7.7%	13.3%	9.3%	8.6%	9.7%
Wind eroded > 10 cm	38.5%	35.6%	31.4%	30.2%	33.9%

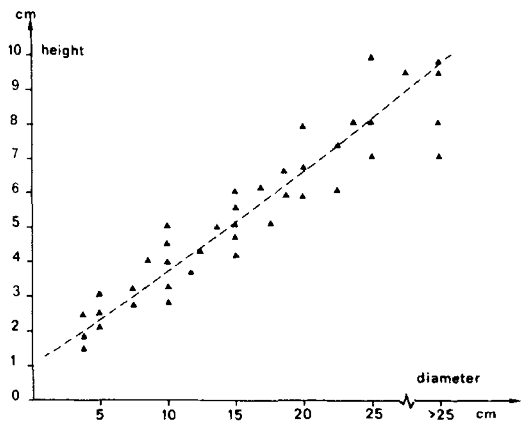

Fig. 13. The relation between tuft height and tuft diameter of *Silene acaulis* L. at the deflation surfaces, Kapp Linné, Spitsbergen.

showed erosion in only 7.7% of the observed cases, while tufts with a diameter above 10 cm were wind eroded in 38.5% of the observed cases (Table 4). As there is a clear correlation between the tuft diameter and the height of the tufts (Fig. 13), it is indicated that 3–4 cm height is the critical tuft height for *Silene acaulis* in this environment.

Conclusions

The distribution of vegetation on the exposed parts of the deflation surfaces shows a characteristic pattern governed by the direct or indirect action of the wind. The microtopography down to the centimetre scale is one of the most important factors. The dominating vascular plant on the most exposed surfaces is the *Dryas octopetala* L., which may cover up to 22.5% of the surface. On these surfaces the growth pattern is characterized by wind-eroded parabolic-shaped tufts fairly evenly distributed over the surface.

Saxifraga oppositifolia L. is the second plant occurring in any quantity and in this environment is apparently entirely dependent upon the protection provided by the Dryas tufts. The majority of the *S. oppositifolia* L. plants found are located in the lee and with direct contact with these tufts.

Silene acaulis, which grows in more or less circular tufts, is commonly subject to wind erosion. Of all observed tufts, 43.6% showed scars of wind erosion. The critical tuft height is about 3–4 cm and of tufts higher than 3–4 cm, only 7.9% was not eroded by the wind.

References

Åkerman, H. J. 1980: Studies on periglacial geomorphology in West Spitsbergen. *Meddelande från Lunds Univeristets Geografiska Institution Ser. Avh. LXXXIX.* 297p.

Gill, D. 1972: The point bar environment in the Mackenzie River Delta. *Can. J. Earth Sci. 9 (11)*, 1382–1393.

Hinz, W. 1976: Zur Ökologie der Tundra Zentralspitzbergens. *Norsk Polarinstitutt Skrifter Nr. 163.*

Peterson, K. M. & Billings, W. D. 1980: Tundra vegetational patterns and succession in relation to microtopography near Atkasook, Alaska. *Arctic and Alpine Research 12 (4)*, 473–482.

Raup, H. M. 1971: The vegetation of the Mesters Wig District, Northeast Greenland. *Meddelelser om Grönland. 194 (3).*

Rönning, O. I. 1979: Svalbards flora. *Norsk Polarinstitutt Polarhåndbok Nr. 1.*

Scholander, P. F. 1934: Vascular plants from Northern Svalbard. *Skrifter om Svalbard og Ishavet Nr. 62.*

Theakstone, W. H. & Knighton, A. D. 1979: The moss *Aongstroemia longipes*, an environmentally sensitive colonizer of sediments at Austerdalisen, Norway. *Arctic and Alpine Res. 11 (3)*, 353–356.