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A NOTE ON THE RELATION BETWEEN VEGETATION AND ELEVATION IN THE DUNE AREAS OF THE NETHERLANDS' WADDEN ISLAND VLIELAND

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SUMMARY

Detailed vegetation maps, showing the distribution of five associations (*Violo-Corynephoretum, Polypodio-Empetretum, Festuco-Galietum maritimi, Polypodio-Salicetum, Empetro-Ericetum*) in four study areas, together covering 64.6 ha of the sand dunes of Vlieland, were compared with contour-maps, giving the elevation (above Amsterdam ordnance datum) in 2.5 m intervals.

A quantitative picture is presented of the associations over the four elevation classes: < 5.0 m, 5.0–7.5 m, 7.5–10.0 m, and > 10.0 m and the results are briefly discussed. The preference of each association for a particular elevation range is clearly demonstrated.

1. INTRODUCTION

As part of a long-term study on the relations between vegetation, the breeding of some selected bird species (waders) and recreational use in a sand-dune area, detailed vegetation maps of four study areas in the sand-dunes of the Netherlands' Wadden island Vlieland (53° N 5° E) were prepared.

For the same areas 2.5 m contour maps were available which allowed a quantitative area comparison between vegetation and elevation.

In their descriptions of the vegetation of the Wadden island several authors have incorporated the aspects of slope and relief, but a systematic comparison of dune vegetation types at association- and elevation level has not yet been published (VAN DIEREN 1934, BRAUN BLANQUET & DE LEEUW 1936, WESTHOFF 1947, BOERBOOM 1960, DOING & DOING-HUIS IN 'T VELD 1971, BAKKER et al. 1979, and others). In addition to this comparison in this note some observations on the five associations that could be distinguished are presented.

2. METHODS

The four study areas selected are 10, 10, 26.2 and 18.4 ha, respectively. Their location is shown in *fig. 1.* Using the contour maps (scale 1:2000) as a base, homogeneous vegetation units were delineated. Within these units the vegetation was described with the standard Braun-Blanquet relevé method. The size of the relevés was 10 m^2 and in general in each delineated, relatively homogeneous unit at least one, but usually two or more relevés were recorded (*fig. 2.*). A total number of 44 relevés was recorded, which could be grouped conveniently to

* Communication nr. 208.

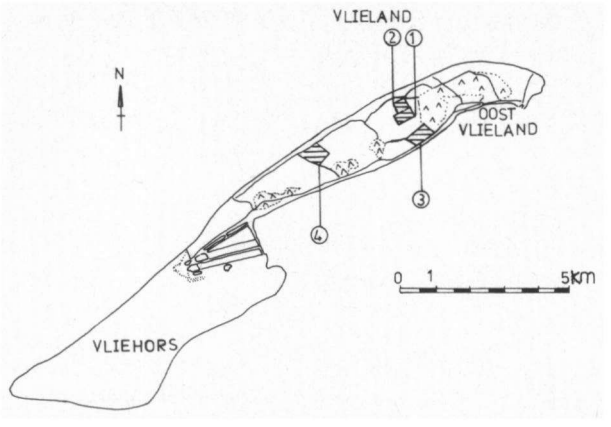

Fig. 1. Location of the four study areas on the island Vlieland.

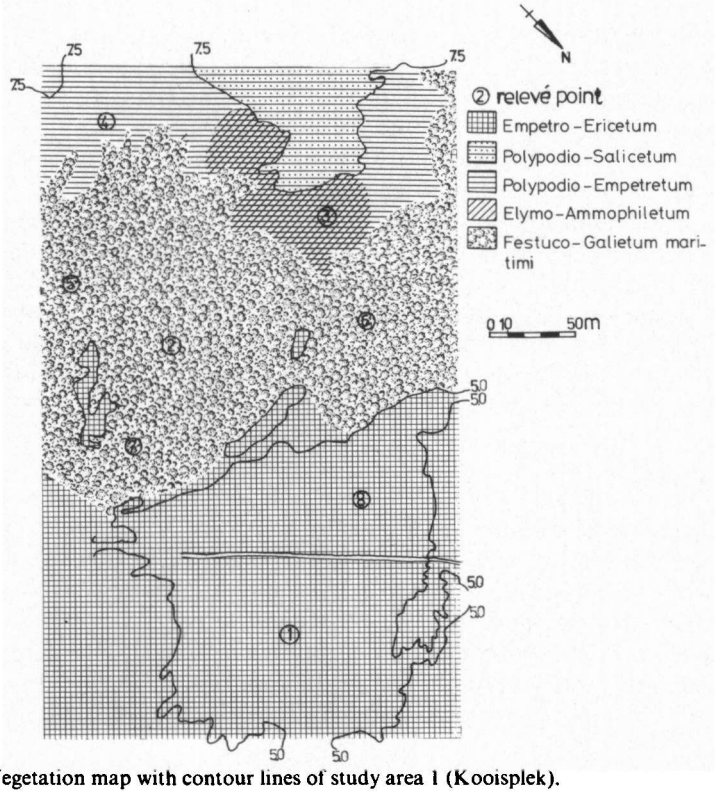

Fig. 2. Vegetation map with contour lines of study area 1 (Kooisplek).

Table 1. Synoptical table of the five associations distinguished, showing the occurrence of spermatophytes, pteridophytes, mosses,* and lichens.

Plant community	Violo-Corynephoretum	Polypodio-Empetretum	Festuco-Galietum maritimi	Polypodio-Salicetum	Empetro-Ericetum
Number of relevés;	7	10	9	8	10
% Cover dwarf shrub layer:	–	62 (10–90)	–	57 (30–80)	76 (10–95)
% Cover herb layer:	31 (25–40)	56 (25–90)	36 (15–80)	60 (35–90)	31 (5–90)
% Cover moss layer:	3 (1–15)	65 (40–90)	38 (5–90)	9 (1–30)	46 (35–90)
% Cover lichen layer:	10 (1–35)	5 (<1–20)	25 (10–50)	–	5 (1–15
Corynephorus canescens	1 (1–2)	–	–	–	–
Festuca rubra	+	–	–	–	–
Viola canina	r	r (r–+)	r	(+–r)	–
Ammophila arenaria	1 (1–2)	+ (r–+)	1 (1–3)	+ (r–1)	r
Carex arenaria	+ (r–+)	1 (+–1)	1 1–2)	1 (r–4)	+ (r–1)
Festuca ovina	(+–1)	+ (+–2)	1 (1–2)	+	+
Hieracium umbellatum	–	+ (r–+)	–	–	–
Luzula campestris	–	+ (r–+)	+	+	r
Salix repens	–	3 (+–4)	–	3 (2–4)	+ (+–5)
Empetrum nigrum	–	3 (1–4)	–	1	4 (4–5)
Polypodium vulgare	–	+ (r–+)	–	r	–
Rumex acetosella	–	r	+	–	–
Veronica officinalis	–	r (r–+)	–	+	–
Agrostis tenuis	–	+	–	r	–
Hypochaeris radicata	–	r	–	+	–
Holcus lanatus	–	r	–	+	–
Cerastium arvense	–	–	+	r	–
Aira praecox	–	–	+ (+–2)	–	–
Calamagrostis epigeios	–	–	–	1 (1–3)	+ (r–2)
Poa pratensis	–	[	]	+	r
Potentilla erecta	–	–	–	–	+
Oxycoccus macrocarpos	–	–	–	–	(+–3)
Hydrocotyle vulgaris	–	–	–	–	1
Carex trinervis	–	–	–	–	1
Erica tetralix	–	–	–	–	1 (+–2)
Dicranum scoparium	r	3 (+–4)	1 (+–4)	+ (r–1)	1 (+–3)
Hypnum cupressiforme	–	1 (+–2)	1	+	2 (1–4)
Pseudoscleropodium purum	–	(+–2)	–	+ (+–1)	(+–1)
Eurhynchium praelongum	–	+	–	r	–
Dicranoweisia cirrhata	–	–	r	–	–
Polytrichum piliferum	–	–	–	–	2
Cornicularia aculeata	+	–	+ (r–+)	–	–
Cladonia destricta	r	–	(+–3)	–	–
Cladonia coccifera	r	–	r	–	–
Cladonia foliaceae	(r–+)	–	+ (+–1)	r	–
Cladonia pyxidata	+	+ (r–+)	+ (r–+)	r	+ (r–+)
Cladonia furcata	–	+ (r–+)	(r–+)	r	+
Cladonia impexa	–	1 (+–2)	+ (+–3)	–	+
Parmelia physodes	–	+	+	–	+
Cladonia sylvatica var. mitis	–	r	–	r	+
Cladonia glauca	–	–	–	–	+

* Incidental species: Ranunculus flammula, Juncus alpino-articulatus, Juncus subuliflorus, Carex panicea, Potentilla anserina, Lotus corniculatus, Jasione montana, Galium verum; Ceratodon purpureus.

Table 2. Distribution (relative percentage per plant community per elevation class) of the five plant communities over the four elevation classes. In brackets the absolute percentages are shown.

Association	Elevation class (m + NAP)			
	>10	10–7.5	7.5–5	< 5
Violo-Corynephoretum	73.9 (33.5)	20.8 (9.4)	5.3 (2.4)	0.0 (0.0)
Polypodio-Empetretum	39.3 (21.0)	60.7 (32.5)	0.0 (0.0)	0.0 (0.0)
Festuco-Galietum maritimi	0.9 (1.0)	13.2 (14.9)	84.3 (95.0)	1.6 (1.8)
Polypodio-Salicetum	3.0 (2.3)	7.7 (5.8)	40.7 (30.7)	48.6 (36.7)
Empetro-Erictum	0.1 (0.1)	0.3 (0.3)	22.7 (25.7)	76.9 (86.9)

determine five associations as distinguished by WESTHOFF & DEN HELD (1975). The results are shown in the synoptical *table 1*. In this table the first figure indicates the average value of the Braun-Blanquet cover-abundance scale in the relevés of the community; The second and third (between brackets) the lowest and highest value, respectively.

Nomenclature follows HEUKELS & VAN OOOSTSTROOM (1977) for seed-plants and ferns, LANDWEHR (1966) for mosses, and HENNIPMAN (1969) for lichens.

The areas of the associations in the elevation classes on the 1:2000 coastal contour maps were determined with a digital planimeter. The average of three readings was taken. Four elevation classes were applied to the areas: <5.0 m, 5.0–7.5 m, 7.5–10 m and >10.0 m (above Amsterdam ordnance datum, comparable with A.S.L., further indicated as: + NAP).

3. RESULTS AND DISCUSSION

The five associations occurring in the four study areas are the *Violo-Corynephoretum*, *Polypodio-Empetretum*, *Festuco-Galietum maritimi*, *Polypodio-Salicetum*, and *Empetro-Ericetum*. Their distribution over the four elevation classes is shown in *table 2*.

The *Violo-Corynephoretum* generally develops from the *Elymo-Ammophiletum* or the *Tortulo-Phleetum arenarii* and forms a climax vegetation of the xero-series in dunes with a low lime content (WESTHOFF & DEN HELD). It is an open to a more or less closed, rather stable association in the dry dune area. All characteristic lichen species appear in the initial stage of the association and the higher plants remain to the final stage. *Cornicularia aculeata* and *Cladonia* species will dominate, but wherever on the southern slopes the phanerogams disappear, strong wind may destroy the vegetation and a phase with *Carex arenaria* follows, intermingled with *Ammophila arenaria*. The *Violo-Corynephoretum* association mostly occurs in the area of elevation class > 10 m + NAP on the dune tops and faint southern slopes which are very much exposed.

The *Polypodio-Empetretum* dwarf-shrub association is found on steep slopes (N.W.N. and N.E. exposition) in particular on isolated dunes. The steeper the slope, the more complete the association. The association develops from a stage

of *Hippophaë rhamnoides* with *Polypodium vulgare* and is a climax vegetation. The top soil-layer never dries up totally and the air humidity is high by exposition, inclination, and the production of humus. The soil has an A-C profile. The association was only found in two higher elevation classes, above 7.5 m + NAP. The species combination of *Salix repens*, *Empetrum nigrum* and *Polypodium vulgare* is determining here. The occurrence of the last-mentioned species can be explained by the micro-climatic conditions, especially the air humidity. GOETHART et al. (1924) mention the occurrence of *Salix repens* where the ground water level is not higher than 0–10 cm below surface. DE VRIES (1961) states that this species occurs in the polders with dikes of drift-sand at Vlieland independent of the elevation. From *table 1* it can be seen that *Salix repens* also occurs in the lower elevation classes and in the *Polypodio-Salicetum* association. *Salix repens* thus occurs in all elevation classes with exception of the highest class (above 10 m) where the *Violo-Corynephoretum* is predominant. According to DOING (1974) *Salix repens* is restricted to open and moist sand related to its establishment and germination. Its presence is primarily determined by the occurrence of areas which at least for some time in the past have been wet. Its continued occurrence is determined by the capacity to withstand temporal sand-covering and its ability to extend in a horizontal direction by a strong vegetative reproduction.

The *Festuco-Galietum maritimi* forms rather closed, grassy vegetations on somewhat nitrogen containing and humous, weakly acid, stabilized sands. The community may originate from the process of older stabilized dunes being continually grazed by rabbits (WESTHOFF & DEN HELD 1975). This community occurs principally in the elevation class 5–7.50 m + NAP, where the area is slightly sloping. According to DE VRIES (1961) *Festuca ovina*, which is typical for this vegetation-type, never occurs lower than 1.25 m + NAP and prefers an acid and dry environment. GOETHART (1924) mentions that this perennial species is independant from the ground water level.

The *Polypodio-Salicetum* is a low shrub association, developed optimally on northern slopes and in valleys. It is a stage in the xero-series in the dunes on dry, somewhat decalcified sands or sandy soils not too deficient in lime (WESTHOFF & DEN HELD 1975). The association is floristically poor. It was found throughout the elevation classes, but predominantly in the lower ranges and very limited above 10 m elevation.

When the ground water level comes near the surface, a wet heathland with *Empetrum nigrum*, *Erica tetralix*, *Carex nigra*, etc. (the *Empetro-Ericetum*) may develop from a *Schoenetum* association. It occurs in acid primary or secondary valleys in dunes which are deficient in lime (WESTHOFF & DEN HELD 1975). On the sand a 2–5 cm layer of humus is found, while the soil has an A-G profile. During winter the ground water level rises above the surface.

From the data presented a clear relationship between elevation and plant associations can be seen. Within the elevation classes exposition (northern or southern slope) is a key factor. Elevation seems for the lower ranges mainly related to soil moisture conditions and distance to ground water, in the higher

ranges macro and micro climatic conditions, especially exposure to wind and sun, seem to be determining. Factors related to the substratum (lime content, organic matter, etc.) must be further differentiating. A quantitative analysis including other environmental factors and a larger number of sample areas, including also other coastal areas, could reveal a far more differentiated picture.

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