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A STUDY OF THE INFLUENCE OF DESALINATION ON THE JUNCETUM GERARDII.

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SUMMARY

The effect of desalination on the *Juncetum gerardii* was studied by means of permanent quadrats from 1933 up to and including 1966. One of the quadrats has been safeguarded against grazing and mowing, while in the other one this management was continued. In the first quadrat all species of the *Asteretea tripolii* disappeared within ten years whereas in the latter in 1966 this class was still represented by two species.

In the exclosure species of the *Angelicion litoralis*, the *Convolvuletalia sepium* and the *Filipendulion* took an increasing share in the stand of vegetation. Both quadrats showed a period of rapid change during the first few years. Since in the exclosure this period persisted seven years longer than that in the grazed and mown quadrat, its plant cover deviated appreciably more from the original one.

1. INTRODUCTION

In 1932, after the construction of an enclosing dam, the Zuiderzee became separated from the North Sea and desalination of its water and its surrounding coasts started. Before and shortly after the enclosure the coastal area was occupied by vegetation types characteristics of muddy North Sea marshes. Apart from a few fragments, these halophytic communities gradually disappeared (CHAPMAN 1974).

In order to study the vegetational changes two permanent quadrats were established in 1933 on a slightly brackish salt marsh situated in IJdoorn near Amsterdam. Since then, one of the quadrats has been safeguarded against grazing and mowing practised in the whole marsh before, while in the other one this management was continued. The original stand of vegetation belonged to the association *Juncetum gerardii* and resembled the subassociation with *Leontodon autumnalis*, characterized by the presence of *Armeria maritima*, *Juncus gerardii*, *Leontodon autumnalis* and *Trifolium repens (table 1)*. This subassociation occurs in the alphamesohalinicum and in places with a high salt content but influenced by fresh or brackish water (WESTHOFF & DEN HELD 1969). In 1969 WESTHOFF gave a first account of the results. In this paper the data have been worked out mathematically and the relevant tables are published.

2. METHODS

The two permanent quadrat plots (of 100 m^2 each) were established in 1933 and studied by means of the Braun-Blanquet-method from 1933 up to and

Table 1.

		A	B
As	Plantago maritima	311	3232222211
	Triglochin maritima	11	1331 221221 11
	Aster tripolium	11	1
Ar	Armeria maritima	311	32233112 1
	Juncus gerardii	222	22144334145 643344
	Alopecurus bulbosus	2 1	21 322 232 1
	Agrostis stolonifera	33332331 1	33434432343 333233
Cs	Solanum dulcamara	1111121 111111111	
	Sonchus palustris	11 1112223344443	
	Calystegia sepium	2134411331233	
	Eupatorium cannabinum	1 2111223434	
	Glechoma hederacea	111 11	
	Galeopsis bifida	111	
	Symphytum officinale	1	
Al	Apium graveolens	11	
	Sonchus arvensis	121212211 11 2 1	1 311211
	Cirsium arvense	1111221122332221111	1 1
	Galium aparine	1123333131 111	
	Atriplex hastata	11	
	Oenanthe lachenalii	1	
	Urtica dioica	1133332333235	
	Elytrigia pungens	1 2	
F	Angelica sylvestris	1111 12111332222	
	Epilobium hirsutum	11112422222343	1 1
	Stachys palustris	1112123231	
	Valeriana officinalis	2234345433	
Ph	Phragmites australis	223524656665644464345423322222235 133344	
	Lycopus europaeus	2111232112	1
	Iris pseudacorus	1111111121	
	Scutellaria galericulata	111121	1
	Phalaris arundinacea	1	
	Glyceria fluitans		22
ARo	Poa trivialis	1 1123221242666636441	1 221 222
	Elytrigia repens	212222 1311134233	
	Ranunculus repens	1 12232212	111332 133212
	Leontodon autumnalis	1 1	11221321132 122111
	Trifolium repens	111 111	1 11131443 133333
	Rumex crispus	1 11 1111 1	111 111
	Rumex conglomeratus	111 1	
	Carex otrubae	1	
	Hyosotis cespitosa		1 1
	Lysimachia nummularia		1
	Festuca arundinacea		1
	Juncus articulatus		11
	Alopecurus geniculatus		1
MA	Holcus lanatus	11111232111 32343333	1 11132321 145333
	Cerastium holosteoides	1 1	1 1 111 1
	Rumex acetosa	11 13	11121 21212
	Trifolium pratense	1	1 11 212 121121
	Anthoxanthum odoratum		3 33
	Cirsium palustre	1 1145323133	1 111 111111
	Lychnis flos-cuculi	111 1 1	1 2 111
	Caltha palustris	11 1	
	Senecio aquaticus		1111 2 1
	Cardamine pratensis	12	2 11 11
	Galium mollugo	11	
	Ranunculus acris	1 1 1	1111
	Alopecurus pratensis	1113	
	Scirpus maritimus		11 1
RS	Aegopodium podagraria	1	
	Dactylis glomerata	1	1
	Trifolium dubium		111122
	Bellis perennis		1
	Matricaria maritima ssp inodora	1 1	1 1
	Eriophorum angustifolium		1 11
	Epilobium palustre	111 11	1
	Chenopodium album	1	
	Stellaria media	1 11	
	Sonchus oleraceus		1
	Senecio congestus		1
	Festuca rubra	6666555432 1111122221	652344345 3 344555
	Taraxacum officinale	1 1 1 1	111 11 21 11 1
	Epilobium parviflorum	212111 111 1 11	
	Mentha aquatica	111212221	
	Brachythecium rutabulum	44544252	
	Eurhynchium stokesii	2211112	
	Amblystegium serpens var. juratzkanum	1	
	Deschampsia cespitosa	11	
	Plagiothecium sp	11	
	Galeopsis tetrahit	1	
	Lolium perenne	1	1 1
	Cirsium arvense		1
	Leontodon nudicaulis		1
	Sagina procumbens		2 2 1
	Brachythecium mildeanum		2 3 1
	Acroladium cuspidatum		222 2
	Galium palustre		11111

including 1946 by G. Kruseman and J. Vlieger. From 1950–1966 relevés of these plots were made by them again and also by V. Westhoff, L. Bergman and P. Bakker. The relevés have been tabulated chronologically with the species arranged in phytosociological groups (*table 1*). The cover values +, 1, 2, 3, 4 and 5 were transformed into 1, 2, 3, 4, 5 and 6. The percentage of the various phytosociological groups in each relevé was calculated by dividing the sum of the cover values for all species forming part of a group by the sum of the cover values of all species in a relevé (*figs. 1* and *2*). The difference in time was determined by means of the change quotient:

$$Dt = \frac{dt}{a_1 + a_2}$$

in which dt is the sum of the absolute values of the differences between the cover values of the species of a new relevé compared with the relevé made in 1933, a_1 the sum of the cover values of all species found in the quadrat in 1933, and a_2 the sum of the cover values of all species found in the same quadrat in one of the successive years (LONDO 1971, fig. 3).

3. RESULTS

In the exclosure all species of the *Asteretea tripolii* disappeared within ten years after the desalination commenced, whereas in the other quadrat at the end of the experiment this class was still represented by *Juncus gerardii* and *Triglochin maritima*. After three years the first species of the *Angelicion litoralis* appeared in the exclosure, three years later followed by species belonging to the *Convulvuletalia sepium*. *Urtica dioica* was encountered for the first time in 1944 and increased considerably from then onward.

Under grazing conditions these species were totally absent excepted *Epilobium hirsutum*, which appeared twice with a very low coverage. In contrast, *Cerastium holosteoides*, *Trifolium pratense* and *Anthoxanthum odoratum* covered the greater part of the grazed quadrat. Although the differences in the total cover of species of the *Agropyro-Rumicion crispi* were only slight, there were differences in the species composition. While *Poa trivialis*, *Elytrigia repens* and *Rumex conglomeratus* prevailed in the ungrazed quadrat, *Leontodon autumnalis* and *Trifolium repens* were more frequent in the grazed and mown quadrat (*figs. 1* and *2*).

The rate of vegetational change was about the same in both quadrats during the first four years of the experiment. After 1937 it slowed down in the grazed and mown quadrat, whereas in the exclosure the rapid change continued until 1944.

◄ Table 1. Allogenic succession caused by desalination (for explanation of figures see text). A: exclosure; B: grazed and mown annually. As = Asteretea tripolii, Ar = Armerion martitimae, Cs = Convolvuletalia sepium, Al = Angelicion litoralis, F = Filipendulion, Ph = Phragmitetea, ARc = Agropyro-Rumicion crispi, Ma = Molinio-Arrhenatheretea, RS = Remaining Species. The relevés of A were made in 1933, 1934, 1935, 1937, 1938, 1939, 1940, 1941, 1942, 1943, 1944, 1946, 1950, 1953, 1956, 1957, 1958, 1959, 1960, 1962, 1964 and 1966. The relevés of B were made in 1933, 1935, 1937, 1938, 1939, 1941, 1942, 1943, 1946, 1950, 1953, 1957, 1958, 1959, 1962, 1964 and 1966.

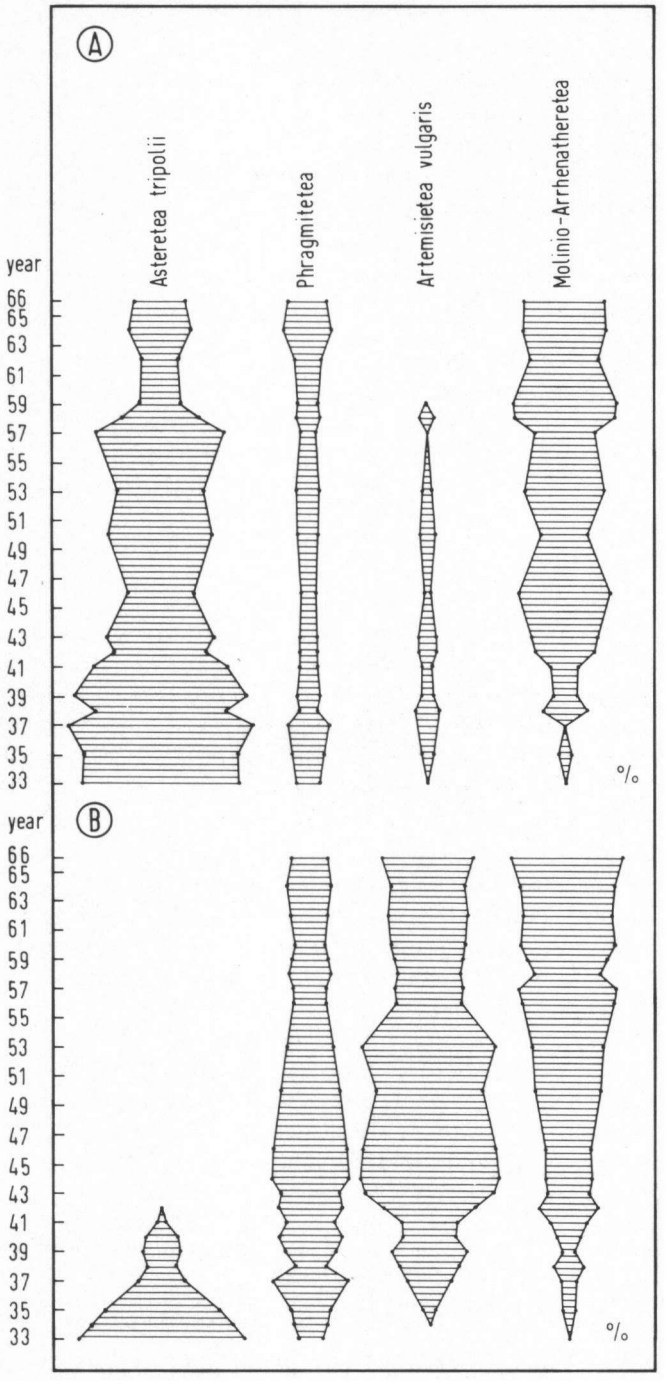

Fig. 1. The relative shares of the total vegetation cover of the various classes encountered in the permanent quadrats during the period of study. A: grazed and mown; B: exclosure.

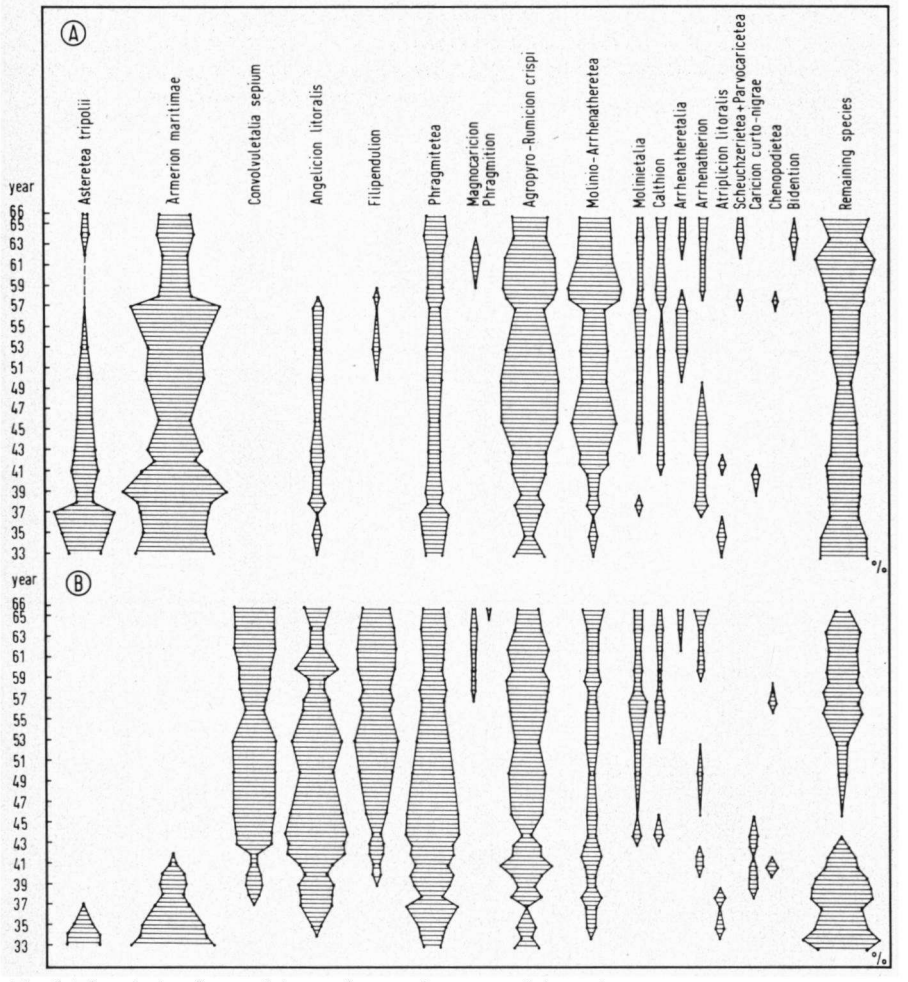

Fig. 2. The relative shares of the total vegetation cover of the various classes, orders and alliances encounted in the permanent quadrats during the period of study. A: grazed and mown; B: exclosure.

In 1966 the stand of vegetation in the latter differed more from the original situation than that in the grazed and mown quadrat (*fig.* 3). In both quadrat the total number of species increased; from 11 to 35 species in the exclosure and from 11 to 28 in the grazed and mown quadrat respectively.

4. DISCUSSION

After the Zuider Zee was separated from the North Sea, desalination induced an allogenic succession. According to DRURY & NISBET (1973) most of the phenomena of succession can be understood as consequences of differential growth and differential survival of species adapted to growth at different points on

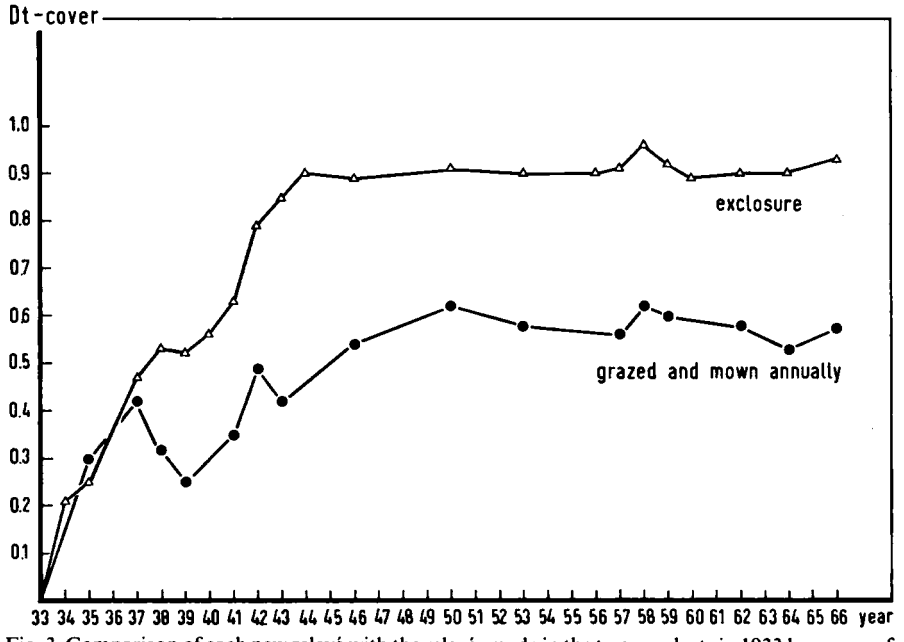

Fig. 3. Comparison of each new relevé with the relevés made in the two quadrats in 1933 by means of the change-quotient (Dt-cover).

environmental gradients. Interspecific competition permits one group of plants temporarily to suppress more slowly growing successors. It is generally accepted that glycophytes do not occur on saline soils because they are not able to endure the salt content and the water stress, whereas halophytes are restricted to this habitat because they are unable to survive competition with glycophytes (WAISEL 1972, CHAPMAN 1954, CHAPMAN 1974, CHAPMAN 1975). The great majority of halophytes produce their most opulent growth under slightly brackish or freshwater conditions, but even then their growth is sufficiently slow to enable glycophytes to eliminate them through competition. This may explain the decrease of the species characteristic of the *Asteretea tripolii* in the grazed and mown quadrat. Since the characteristic species combination of the *Juncetum gerardii* develops under continuous grazing pressure (SCHMEISKY 1974) and as halophytes require high light intensities (ELLENBERG 1978), their total disappearance in the exclosure may be attributed to overgrowth of the assimilatory organs by rapidly growing, high forms.

Although this conclusion seems very plausible it can not be drawn without some restriction. During the period of study the soils of the plots differentiated. The soil of the grazed quadrat remained compact, poorly aerated and watersaturated. In the exclosure this situation changed and the soil became loose, well aerated and humusrich. Owing to a better drainage the salt content decreased to about one third of the content in the areas adjoining the exclosure. In 1934 one litre of soil water contained 5 gr NaCl, an amount often found in the *Armerion*. In

1937 the concentration decreased to 0.5 gr per litre in the grazed quadrat remaining almost constant till 1963. In the exclosure it diminished to about 0.15 gr per litre, however. A complete explanation of the vegetational changes is impossible without any consideration of the alterations in the soil. The exclusion of cattle allowed the appearance of species sensitive to grazing. Hence species characteristic of the *Angelicion litoralis*, the *Convulvuletalia sepium* and the *Filipendulion* took an increasing share in the stand of vegetation of the exclosure (*table 1, figs. 1* and *2*). These communities are characteristic of nutrient-rich soils where organic material is deposited along rivers, rivulets, ditches, lakes and, as far as the *Angelicion* is concerned, also along the sea shore (WESTHOFF & DEN HELD 1969).

Apart from the species characteristic of these communities taxa occur for which the exclusion of cattle appeared to be profitable: *Scutellaria galericulata*, *Poa trivialis*, *Elytrigia repens*, *Cirsium palustre*, *Alopecurus pratensis*, *Epilobium parviflorum*, and *Mentha aquatica*. Grazing and mowing on the contrary appear to be favourable to *Leontodon autumnalis*, *Trifolium repens*, *Trifolium pratense*, *Anthoxanthum odoratum*, *Senecio aquaticus* and *Trifolium dubium*.
According to ODUM (1969) rate-of-change curves are usually convex, with changes occurring most rapidly at the beginning. This is in concurrence with our data (*fig. 3*). The rapid-change period in the exclosure was seven years longer than in the grazed and mown quadrat, which resulted in a plant cover deviating considerably more from the original stand of vegetation. The explanation for this is that besides desalination the vegetation of the exclosure had to endure the disturbance shock effect caused by the sudden termination of grazing and mowing, whereas this management was continued in the other quadrat.

Unfortunately in 1956, 1965 and 1966 cattle broke through the fence occasionally. However, in our opinion these brief intrusions are of but little significance, as the relevés made during these years do not deviate noticeably from the general direction and tendency.

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