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Aeolian dynamics in relation to vegetation in a blowout complex in the Meijendel dunes, The Netherlands

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Abstract. Changes in surface elevation in a former blowout in the coastal dunes of Meijendel, The Netherlands, have been monitored almost weekly during one year at 48 erosion pin sites, distributed over 12 units. The units are characterized by specific geomorphological processes. The changes in elevation are caused by wind, slope wash and mass movements. At almost each pin, periods of erosion alternate with periods of accumulation in a random way. Erosion and accumulation sequences are relatively long in areas dominated by aeolian activity, but even here they are randomly distributed. It is the balance between the effects of periods of erosion and periods of accumulation which determines the formation of blowouts or dunes.

Units with the highest degree of erosion or accumulation at the end of the year of monitoring also show the highest fluctuations in elevation during that year. In the accumulation units there is even a significant positive correlation between surface lowering by erosion and surface rise by accumulation.

Plant species in the blowout are divided into four groups on the basis of responses to aeolian dynamics: (1) *Sedum acre* is the only species associated with deflation; it might be suitable for blowout stabilization; (2) *Ammophila arenaria*, *Festuca rubra* and *Ononis repens* are associated with aeolian accumulation and can be used for the stabilization of accumulation sites; (3) *Erodium cicutarium*, *Koeleria macrantha* and *Corynephorus canescens*, occurring at lower aeolian activity; (4) *Tortula ruralis* var. *ruraliformis* and *Galium verum* are found where slope wash and mass movements (*Galium*) are active.

In the relationship between aeolian dynamics and vegetation, the former appears to be the independent variable: there is no consistent relationship between accumulation and vegetation cover. This means that the formation of blowouts and adjacent dunes is not controlled by vegetation with its present cover.

Keywords: Accumulation; Deflation; Erosion.

Nomenclature: van der Meijden (1990) for vascular plants.

Introduction

Many years of monitoring wind activity in the coastal dunes of The Netherlands have made it clear that prolonged periods of surface lowering and surface elevation are rare (Jungerius & van der Meulen 1988). In a moving dune system this is easy to envisage. Sand ripples moving past an erosion pin will clearly show the vertical movements of the surface. At a larger scale of space and time, the same applies to moving dunes. However, periods of surface lowering and surface rise alternate, also in the largely fossil dunes behind the recent foredunes. Readings of erosion pins, even in active blowouts, may indicate surface lowering for some time, but sooner or later the sequence is interrupted by surface rise. This applies also to erosion pins placed on the adjacent accumulation mounds. The formation of a blowout or an accumulation mound (and eventually a dune) depends on the balance between deflation and accumulation: the first is formed if periods of lowering are in the long run more effective than periods of rise, the latter is formed if periods of rise are more effective in the long run than periods of lowering.

Little is known about the length of deflation and accumulation sequences. It is expected that negative sequences are considerably longer in blowouts, and that positive sequences are considerably longer on dunes and other sites of accumulation. On the other hand, a random element is expected from the unpredictability of the weather (wind speed, direction, moisture). It is one of the aims of this paper to test the hypothesis that blowouts and adjacent dunes (accumulation mounds) can be formed even if the surface elevation measurements show random changes of sign (+ or –).

The variations in surface height could have important consequences for plant growth. Certain species such as *Ammophila arenaria* are characteristic of sites of sand accumulation (Doing 1985), and the response of the plant to burial has been examined by several authors (Sykes & Wilson 1990; Maun 1994), but little is known about the effect of the interruption of the accumulation process by periods of erosion. Research by Noest (1987) in the Dutch coastal dunes has raised the question whether *Ammophila arenaria* and shrubs such as *Hippophae rhamnoides* and *Salix repens* are adapted to strong accumulation as such, or that strong fluctuations in surface elevation are the decisive factor. It is the second aim of this paper to answer this question.

Geomorphological process vs. vegetation cover change is a two-way relationship (Sarre 1989). This means that plant growth is not only dependent on aeolian processes, but also may have important consequences for wind erosion and accumulation. Plants in the study area have a much more extensive surface cover in summer than in winter. The third aim of this paper is to test the hypothesis that an increase in vegetation cover at the areas surrounding the blowouts (accumulation mounds) leads to increased accumulation.

Description of the site

The experimental area is situated in the Meijendel dunes just north of The Hague, The Netherlands, ca. 3 km from the sea. The dune sand is primarily calcareous – ca. 2 - 3 % free $CaCO_3$ (van der Meulen & van der Maarel 1993). It is the site of a former blowout which is ca. 50 m long in cross section (Fig. 1). It was a saucer blowout as defined by Carter et al. (1990). Since its stabilization, three new blowouts have been formed (Fig. 1). The relief inside the former blowout is also remodelled by two other geomorphological processes: erosion and sedimentation of sand and organic material by slope wash (Jungerius & Dekker 1990), and slope failure by mass movements (Rutin 1983; Jungerius & van der Meulen 1988).

As a result of the variation in geomorphological dynamics and other conditions, the vegetation in and around the former blowout reflects different ecosystem complexes in the sense of Olson & van der Maarel (1989):
- yellow dune complex with *Ammophila arenaria*;
- dune grassland and steppe complexes with *Corynephorus canescens*, *Tortula ruralis*, *Festuca rubra*, *Koeleria macrantha*;
- dune pioneer scrub complex with *Ligustrum vulgare*.

Most of the plant species recorded in our plots show morphological features which can be interpreted as adaptations to stress conditions in and around coastal blowouts (cf. Hesp 1991), e.g. (1) leaf succulence (*Sedum acre*), (2) sclerophylly (*Ammophila arenaria*, *Corynephorus canescens*, *Festuca rubra-Ligustrum vulgare* is adapted too, but the leaves are not rolled or folded inwards like those of the three grasses) and (3) extensive root systems (*Ammophila arenaria*, *Festuca rubra*, *Ononis repens*). Figs. 2 and 3 show different aspects of the blowout system.

Methods

The surface inside and around the former blowout was divided into several units based on a visual assessment of the prevailing geomorphological processes. A total of 48 erosion pins was inserted in the dynamically most important units (Fig. 1).

The period of monitoring ran from 26 November 1986 to 24 November 1987. This period was divided into 40 measuring periods. The average length of these periods was nine days, with a standard deviation of three days. If an outlier period of 32 days in the summer of 1987 is omitted from the sequence, the lengths of the measuring periods have an approximately normal distribution, i.e. a χ^2 test carried out to compare the actual data with data generated by Monte-Carlo sampling of a population with the same mean and standard deviation, showed that the null hypothesis of no difference could not be rejected at the 0.05 level of significance.

For the purpose of the argument presented in this paper it should be emphasized that the length of time between the measurements is not important. Any distribution will do. In view of this, non-parametric statistics were used in the analysis when periods of measurements were involved (Siegel 1956). To test the hypothesis that a sequence is random, the one-sample

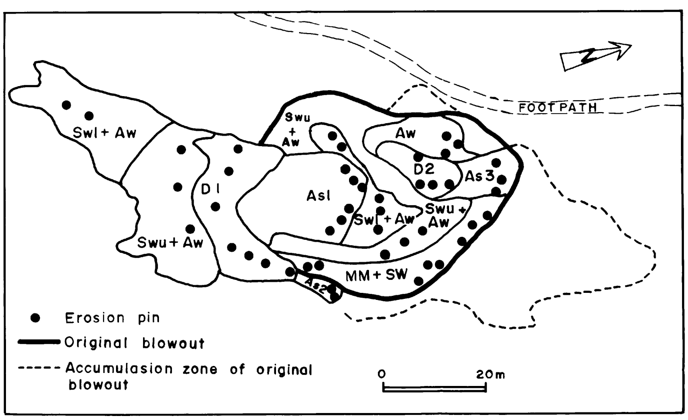

Fig. 1. Units inside the former blowout and location of the erosion pins. D = deflation; As = strong aeolian accumulation; Aw = weak aeolian accumulation; SWu = slope wash, upper slope; Swl = slope wash, lower slope; MM = mass movements.

Fig. 2. View from the northern rim of the former blowout towards the southwest across the units of strong accumulation (As1) and deflation (D1); *Ligustrum vulgare* in the centre.

Fig. 3. View from the northern rim of the former blowout towards the southeast across the units of weak aeolian accumulation and slope wash (Swl+Aw; Swu +Aw); *Ammophila arenaria* in the foreground, *Festuca rubra*, *Koeleria macrantha*, *Erodium cicutarium* and *Ononis repens* behind. Compare with Fig. 2.

runs test was chosen. A good approximation to the sampling distribution of r is the normal distribution. Therefore, the hypothesis of randomness has been tested by $z = (r - \text{mean})/\text{standard deviation}$. All values of z equal to or more extreme than 1.96 or – 1.96 are assumed to indicate that the order of periods of surface rise and surface lowering is not random ($p < 0.05$). This means that either the periods of one type dominate and are very long ($z \leq$ 1.96), or, at the other side of the scale, that the periods of both types are short and alternate regularly ($z > 1.96$).

A run is defined as an uninterrupted succession of measurements with an identical sign.

At the end of each period, the following data were collected:

- relative height of the surface at each pin,
- vegetation species and visual estimate of percentage cover in a plot (1 m × 1 m) around each erosion pin.

Results

After examination of the results at the erosion pins, we decided for the purpose of this paper to report only on results at pins with aeolian activity, i.e. which represent units of deflation (D1, D2) and accumulation (AS1, AS2, AS3, Aw) (Tables 1 and 2). At the other pin-sites different processes interfere and it is difficult to assess their individual contribution.

The random nature of the aeolian processes

Table 1 shows the number of measurements of surface lowering ($n1$), surface rise ($n2$) and 'no change' ($n3$) at each of the 26 erosion pins on sites where slope wash and mass movements are not important, and the number of runs (r). The frequent alternation of surface lowering and rise is evident from the large number of runs which ranges from 9 to 23.

Table 1, column 7 shows that nowhere are the runs too few in number to reject independence. The value of 1.98 for z at pin 37 (Table 1, column 7) indicates that the erosion and accumulation runs here are short and alternate regularly.

The length of the runs

The maximum lengths of the runs and their mean size are shown in Table 1, columns 8 to 11. There is no clear dominance of erosion or accumulation runs at any of the pins. The longest sequence of erosion measurements was 11 and has been recorded at pin 45 in the largest blowout. Accumulation was measured during eight consecutive periods at pin 7 in the smallest accumulation area.

The mean length of the erosion runs is above average (1.93) in the blowouts – as expected – with pins 45 and 46 showing the highest deviation, but erosion runs above average are also found in the accumulation areas (pins 4 to 7 and pin 13)!

The mean length of the accumulation runs is consistently above average (1.75) only in two of the three areas where new dunes are formed, but pin 39 in one of the blowouts also has an above-average record of accumulation sequences.

Changes in surface elevation

The vegetation cover in the former blowout is nowhere complete, leaving bare surface to be affected by the various geomorphological processes. For the sites of aeolian activity this is shown in column 3 of Table 2. Columns 4 to 6 of this table show the change effectuated by the longest erosion and accumulation runs, and the range. Elevation changes and ranges are highest in the larger units, suggesting a relationship between size of the unit and the efficiency of the wind.

The actual change of the surface elevation in the course of the year of monitoring is shown in Table 2, column 7. All pins in the new blowouts showed a

Table 1. Surface dynamics of the units dominated by aeolian activity ($n1$ = the number of measurements of surface lowering by deflation; $n2$ = the same for surface rise by accumulation; $n3$ = the same for 'no change'; r = number of runs; z = test statistic for randomness. For the explanation of the symbols in column 2, see Fig. 1.

Pin #	Unit/Process	$n1$	$n2$	$n3$	r	z	Longest run		Mean size runs	
							Erosion	Accumulation	Erosion	Accumulation
41		26	14	0	19	0.07	5	3	2.6	1.6
42		25	7	8	10	1.03	5	3	2.8	1.4
43		24	4	12	9	0.94	5	1	2.0	1.0
44	D1	26	10	4	15	1.86	8	2	2.9	1.4
45		24	9	7	12	0.94	11	3	3.0	1.5
46		25	10	5	16	0.30	10	2	3.1	1.3
47		18	17	5	20	0.52	3	3	1.8	1.5
36		22	11	7	20	1.73	4	2	2.0	1.1
37		23	13	4	23	1.98	4	2	1.9	1.1
38	D2	21	13	6	16	0.35	5	2	1.9	1.4
39		21	14	5	17	0.29	3	5	1.9	1.8
40		14	16	10	17	0.40	3	3	1.6	1.5
1		15	20	5	17	0.40	4	3	1.7	2.0
2		12	18	10	11	1.71	2	5	1.5	2.6
3	As1	13	21	6	13	1.50	4	6	1.9	2.3
4		17	20	3	17	0.80	5	4	2.1	2.2
5		14	18	8	14	1.00	5	4	2.0	2.3
6		17	20	3	14	1.81	4	4	2.1	2.5
7	As2	11	22	7	11	1.86	5	8	1.8	3.1
8		7	20	13	13	0.84	2	4	1.2	1.8
9		15	22	3	18	0.29	4	6	1.5	2.2
10	As3	8	18	14	15	1.38	2	3	1.1	1.6
10a		12	16	12	15	0.11	4	4	1.3	2.0
11		17	13	10	16	0.10	3	3	1.4	1.4
12	Aw	12	16	12	18	1.29	2	3	1.2	1.8
13		23	11	6	20	1.65	5	2	2.1	1.1

negative balance at the end of the year. Lowering of the surface is most pronounced in the largest blowout, with a maximum of nearly 40 cm (pin 42). All pins on sites with strong aeolian accumulation were higher at the end of the year, with 55 cm as the recorded maximum (pin 5). Also in this case the largest of the accumulation units, i.e. As1, profits most from aeolian activity. Surprisingly, two of the three pins in Aw which was considered to be a site of net accumulation, showed a negative balance at the end of the year.

The response of the vegetation to aeolian activity

The species in the former blowout can be divided into four groups on the basis of their occurrence in units with different aeolian dynamics. As is shown in Table 3, none of the species is restricted to sites with only aeolian dynamics.

1. Species associated with deflation

Sedum acre is the only species recorded in this group. It occupies the smallest of the two new deflation patches. The other occurrences are subjected to slope wash and mass movements.

2. Species associated with strong aeolian accumulation

Three species belong to this group: *Ammophila arenaria*, *Festuca rubra* and *Ononis repens*. *Ligustrum vulgare* is included although this shrub presumably existed before the blowout was reactivated by aeolian activity. The accumulation site leeward for SW winds of the largest deflation patch is bare with the exception of *Ligustrum vulgare*. *Ammophila arenaria* and *Festuca rubra* colonize the two smaller patches, *Ononis repens* only one of these.

The areas occupied by *Ammophila* receive sand deposited by SW winds. *Ononis* on the other hand is found where winds from other directions drop their sand, including units which are dominated by slope wash. *Festuca* is less selective and much more widespread, occupying most other units recognized in the former blowout.

3. Species associated with weak aeolian activity

This group comprises *Koeleria macrantha*, *Erodium cicutarium* and *Corynephorus canescens*. *Koeleria* shows the highest degree of adaptability as it occurs also on sites that are subject to slope wash and mass movements, in addition to being covered by aeolian sand transported by SW as well as NE winds. *Erodium* occurs mainly to the NE of the largest accumulation unit. *Corynephorus* has almost the same restricted occurrence as *Ammophila*; apart from the unit with weak aeolian activity it is found only in the zone of mass movements NE of the largest blowout.

4. Species not found on sites with only aeolian dynamics

This group lists *Galium verum* and *Tortula ruralis* var. *ruraliformis*. *Galium* is found in three of the six units with slope wash including the one with mass movements. *Tortula* is only found in two of these units.

Table 2. Vegetation cover and changes in surface elevation for the longest runs and for the whole year, of the units dominated by aeolian activity. For the explanation of the symbols in column 2, see Fig. 4.

Pin #	Unit/ Process	Maximum cover	Elevation change by longest run (cm)		Range (cm)	Elevation change after one year (cm)
			Erosion	Accumulation		
41		0	– 10.1	3.4	13.5	– 38.1
42		0	– 11.7	0.6	12.3	– 39.7
43		0	– 12.0	1.0	13.0	– 29.8
44	D1	0	– 7.7	1.0	11.5	– 20.6
45		0	– 15.2	3.8	19.1	– 21.1
46		0	– 16.7	3.9	19.4	– 23.9
47		0	– 10.5	2.7	12.5	– 8.7
36		0 - <1	– 3.5	1.6	5.1	– 9.8
37		0 - <1	– 3.1	3.0	6.1	– 10.2
38	D2	0 - <1	– 11.4	0.7	12.1	– 20.1
39		0 - <1	– 5.8	1.7	7.5	– 9.2
40		0 - <1	– 6.3	2.2	8.5	– 8.3
1		<1- 35	– 2.7	7.4	10.1	17.5
2		<1- 35	– 1.4	6.7	8.1	6.9
3	As1	<1- 35	– 1.9	19.6	21.8	23.5
4		0	– 4.9	16.9	23.4	37.5
5		0	– 5.4	18.0	14.7	55.0
6		0	– 4.1	10.6	14.7	26.3
7	As2	2 - 17.5	– 2.3	13.3	15.6	19.6
8		2 - 17.5	– 0.7	7.0	7.7	9.9
9		2 - 30	– 2.3	9.1	11.4	12.0
10	As3	2 - 30	– 0.5	2.0	2.5	5.2
10a		2 - 30	– 1.0	3.5	4.5	2.7
11		1 - 7.5	– 2.9	3.0	5.9	– 1.2
12	AW	1 - 7.5	– 1.0	3.0	4.0	2.8
13		1 - 7.5	– 2.4	0.5	2.9	– 4.3

Perhaps purely aeolian soils dry out too quickly to sustain these plants.

The plant species are listed in Table 3, along with the unit where they are found, their growing season and information on changes of surface elevation. The latter comprises the range of changes in elevation recorded within the unit at the end of the year of monitoring (column 4), and the fluctuation which is the sum of changes in elevation by the longest sequence of accumulation and the longest sequence of erosion, recorded during the growing season (column 5). Large fluctuations are associated not only with aeolian activity but also with deposits of slope wash.

Discussion

Our results show that the order of runs is practically always random in all cases. This means that the null-hypothesis that blowouts and adjacent dunes cannot be formed by random sequences of erosion and accumulation periods, is rejected. The balance between the effects of periods of surface lowering and surface rise, not their length or number, determines the formation of blowouts or accumulation features.

The variability in time is probably even more complex than is shown by the tables. During the time in-between two measurements the surface could have experienced an unknown number of up and down movements. It means that a long sequence of readings with the same sign should be conceived as the statistical expression of dominance of moments of erosion over moments of accumulation, or vice versa, during that time. The spatial variability of the aeolian activity is also complex, as is exemplified by the measurements of different sign, even in the same units.

It is also clear that strong surface fluctuations and a high rate of accumulation go together on the accumulation sites. Surprisingly, the value of the Spearman rank correlation coefficient (r) between the figures in the columns 4 and 5 for pins 1 to 10a is 0.74 which means that there is a significant correlation between surface lowering by longest erosion and surface rise by accumulation runs in the accumulation units ($p < 0.01$). The value of the correlation coefficient between range and total elevation change after one year, for the same pins, is even higher ($r = 0.87$). It means that surfaces with a large increase in altitude at the end of the year of monitoring also show a high rate of surface elevation fluctuations during that year so that the second hypothesis cannot be tested: it is not possible to differentiate between the response of plants to these two processes.

Table 3. Plant species and surface dynamics of the units where they are found. The year in column 3 is the year of monitoring: 26.11.1986 to 24.11.1987. For the explanation of the symbols in column 2, see Fig. 1.

Plant species	Unit / Process	Growing season	Elevation changes in growing season (cm)	Fluctuation (cm)
Sedum acre	D	all year	– 20.0 - – 8.3	5.1 - 12.1
	Aw		– 4.3 - 2.8	2.9 - 5.9
	SWu+Aw		3.8 - 6.2	2.8 - 3.7
	SW +AW		– 4.4 - 6.2	1.4 - 5.4
	MM+SW		0.0 - 8.6	4.4 - 6.9
Ligustrum vulgare	As	all year	2.7 - 19.6	2.9 - 5.9
Ammophila arenaria	As	all year	2.7 - 19.6	2.5 - 15.6
	MM + SW	all year	0.0 - 8.6	4.4 - 6.9
Festuca rubra	As	7/5 - 24/11	0.9 - 14.2	1.0 - 9.6
	Aw	1/5 - 24/11	– 2.3 - 4.0	2.9 - 5.9
	SWu+Aw	17/4 - 24/11	4.1 - 15.1	2.4 - 14.6
	SW1+Aw	17/4 - 24/11	0.2 - 2.2	1.6 - 5.4
	MM+SW	1/5 - 24/11	– 0.2 - 6.5	1.7 - 6.9
Ononis repens	As	4/6 - >24/11	– 1.9 - 1.3	1.5 - 1.8
	Aw	4/6 - >24/11	0.5 - 4.0	2.9 - 5.9
	SWu+Aw	all year	– 5.1 - 14.9	5.4 - 15.3
	SW1+Aw	4/6 - >24/11	2/0 - 3.4	1.4 - 2.6
Koeleria macrantha	Aw	26/11- 5/2	– 0.3 - – 0.7	1.3 - 1.6
	SWu+Aw	26/11- 5/2	– 0.1 - 1.2	0.8 - 2.8
	SW1+Aw	all year	– 4.4 - 0.5	1.5 - 5.4
	MM+SW	6/7 - >24/11	– 0.3 - 9.2	1.7 - 4.4
Erodium cicutarium	Aw	26/11- 5/2	– 0.3 - 0.7	1.3 - 1.6
	SWu+Aw	not 5/2-6/7	3.9 - 4.2	0.8 - 3.7
	SW1+Aw	not 5/2-18/8	1.4 - 2.1	1.0 - 2.1
Corynephorus canescens	Aw	4/6 - >24/11	0.5 - 4.0	2.9 - 5.9
	MM+SW	all year	0.0 - 8.6	4.4 - 6.9
Galium verum	SWu+Aw	1/5 - >24/11	3.8 - 6.1	2.4 - 3.7
	Sw1+Aw	18/8 - >24/11	1.5 - 1.8	1.0 - 1.8
	MM;SW	1/5 - >24/11	– 0.2 - 6.5	1.7 - 6.9
Tortula ruraliformis	SWu+Aw	26/11- 5/2	– 0.1 - 1.2	0.8 - 2.8
	SW1+Aw	all year	3.5 - 6.2	1.4 - 2.7

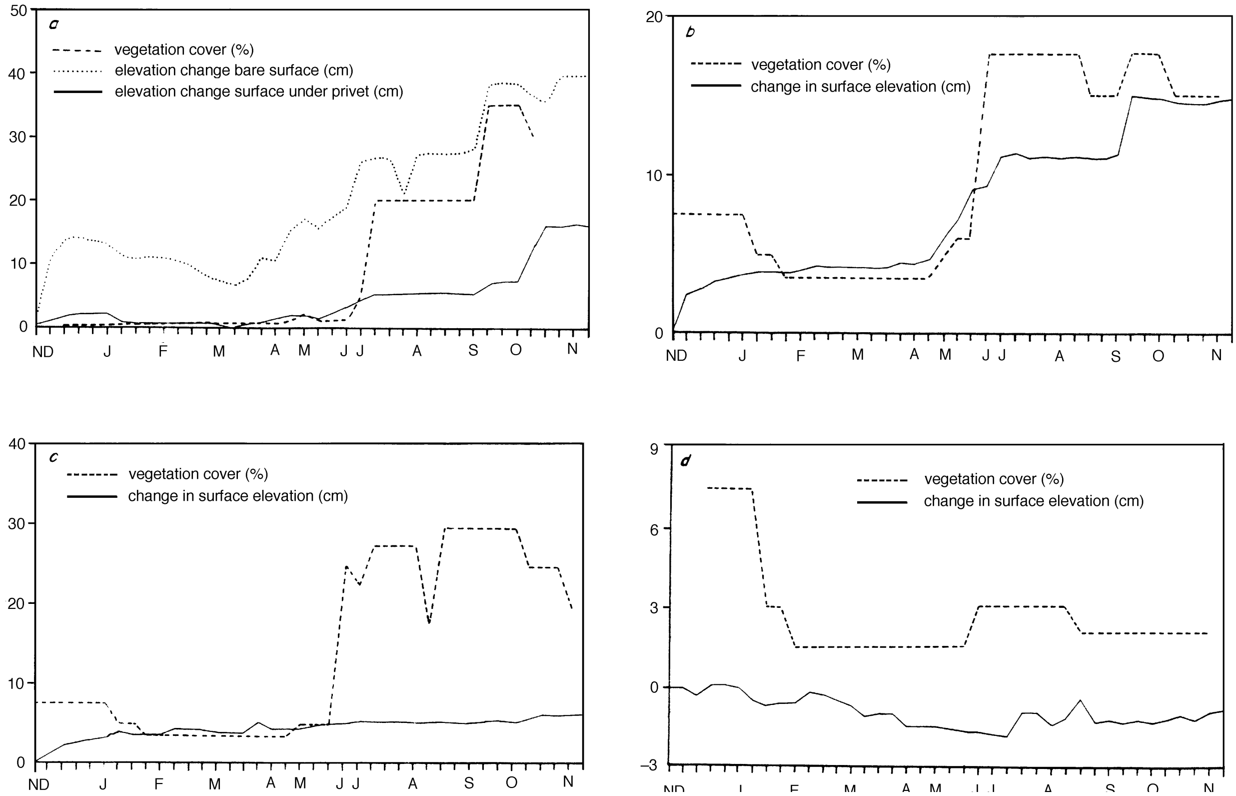

Fig. 4. Vegetation cover and surface elevation change throughout the year of monitoring (N for November 1986 to N for November 1987). **a.** Unit of strong aeolian accumulation As1 (pins 1 - 6); **b.** Unit of strong aeolian accumulation As2 (pins 7 - 8); **c.** Unit of strong aeolian accumulation As3 (pins 9 - 10a); **d.** Unit of weak aeolian activity (pins 11 - 13).

Regarding the association of plant species with surface dynamics, two things are clear from Table 3.

- Species growing in the deflation units (*Sedum*) and the accumulation units (*Ammophila*, *Festuca* and *Ononis*) are adapted to larger differences in elevation than species limited to sites with weak aeolian influence.
- Species that are adapted to strong sedimentation by surface wash, such as *Festuca rubra* and *Ononis repens*, are also adapted to strong accumulation by windblown material. The type of geomorphological process does not appear to be of much importance.

To test the third hypothesis, i.e. that the vegetation controls aeolian accumulation by catching sand, percentage vegetation cover is compared with the amount of surface change in the year of monitoring (Fig. 4). The comparison is carried out only for the sites of aeolian accumulation to avoid interference by slope wash and mass movements. In this hypothesis it is expected that elevation surface increases with the expansion of the vegetation cover.

In the largest accumulation unit (pins 1-6) it appears that accumulation increases with vegetation cover at pins 1-3 which are placed near a *Ligustrum* shrub. This shrub protects the surface with its leaves after June (Fig. 2a). The value of the correlation coefficient is high (0.90). However, a closer look at Fig. 4a reveals that the line indicating the surface elevation begins to rise before the increase in vegetation cover, and continues rising long after the privet has shed its leaves. Moreover, accumulation at pins 4 - 6 which are placed far away from the shrub, in an area devoid of any vegetation, is much stronger. It must be assumed that the correlations are accidental, because it is difficult to assume a causal relationship between cover and accumulation in this unit.

In contrast, the second accumulation unit with pins 7 - 8 (Fig. 4b) suggests a direct response of accumulation to vegetation cover which comprises *Ammophila arenaria* and *Festuca rubra* (Spearman r = 0.86), but the line indicating surface elevation in the third accumulation unit with pins 9 - 10a (Fig. 4c) shows no reaction to the increase of vegetation cover which here consists of *Ononis repens* in addition to *Ammophila arenaria* and *Festuca rubra*, although the correlation coefficient is high (r = 0.75).

Finally, the unit with weak and undetermined aeolian activity, Aw, with pins 11 - 13, again suggests an association between accumulation and vegetation cover of *Sedum acre*, *Festuca rubra*, *Ononis repens*, *Koeleria macrantha*, *Erodium cicutarium* and *Corynephorus canescens* (Fig. 4d), but the increase in height lags two months behind and continues even after the decline of the vegetation cover in autumn. The value of the correlation coefficient is relatively low ($r = 0.53$).

Summarizing, there is no consistent relationship between accumulation of sand and vegetation cover, and it must be assumed that the aeolian activity in the area is not controlled by vegetation at the present cover percentages. In spite of this, it cannot be denied that many of the above plant species are adapted to the harsh conditions of aeolian activity and should be effective stabilizers as soon as they succeed in covering a sufficient surface. *Ammophila* is often used in the Dutch coastal dunes to stabilize blowouts, but the rate of success is low because this species is not adapted to deflation. *Sedum acre* is apparently more suitable. If the stabilization of dunes is the aim of the management, *Festuca rubra* and *Ononis repens* can serve as substitutes for *Ammophila* in situations where surface dynamics are not extreme. The occurrence of *Corynephorus* on unstable calcareous substrates with weak aeolian activity does not agree with the findings of Dutch ecologists (e.g. Doing 1995) that the grass is indicative of stable (superficially) decalcified substrates. It appears that the species has a wider ecological range.

As was stated under Methods, the units inside and around the former blowout were delineated on the basis of what appeared to be the prevailing geomorphological processes (Fig. 1). A final question to be answered is: were these units well chosen in the light of the results of the one-year monitoring? For wind-dominated units the answer is positive, with the possible exception of the unit with weak aeolian activity which was mapped as an accumulation site. This is only partly true. An obvious explanation is that the area is in the process of being transformed from an accumulation site to a blowout.

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