SAND DUNE VEGETATION AND MANAGEMENT DYNAMICS

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Abstract

Until recently, sand dune internal management had an essentially conservative and protective character. Gradually, however, an increasing need was felt for more naturalness and more wildness, i.e. more dynamics, especially in the almost entirely fixed Dutch dune landscape. The central question of nature management thus became: what exactly is the golden mean we have to find in our management practice to establish optimally diversified sand dune sites.

Such 'optimal' landscapes now, could be found at several places along the Flemish coast during the last two decades. It is demonstrated, however, that such landscape structures are essentially ephemeral, and occupy only a very small part in a long evolution from extremely mobile naked landscapes to a completely forested area; it is argued that the maintenance of such 'optima' ad eternum is neither desirable nor technically practicable. For the permanent availability of these intermediate stages in landscape development, here or there within the total sand dune area, far more drastic additional dynamics (in grazing pressure, in sand drift surface) will be needed temporally and locally than is suggested by the appearance of the 'optimum'. On the other hand, our reaction will have to remain largely conservative when dealing with properties which need(ed) much space and/or much time to develop.

Introduction

The Flemish coastal plain, extending from Cap Blanc Nez to the Scheldt estuary, forms the direct south-westward continuation of the Dutch lowland and is, like the latter, entirely bordered with sand dunes. As a consequence, climatic and floristic conditions in this coastal area are very similar to those, observed in the Dutch dune district; the same holds true for the primary soil conditions (sand grain diameter between 100 μm and 500 μm: lime content frequently surpassing 10%).

Contrasting with these natural similarities are the strong differences in human interference, which have developed during the last century. These cultural differences partly have their origin in the natural conditions in the hinterland. The Flemish plain almost everywhere exceeds sea level with 2-4 m: so the function of the dunes for coastal defence is felt as far less essential here than in the Netherlands, and such extensive protective measurements, resulting in a completely fixed dune landscape, have been taken nowhere. Besides, the hydrogeological constitution of inner Belgium and northern France renders the dunes redundant for drinking-water supply: dune water exploitation has been (and indeed is still) practised in several places along the Belgian coast, but modern infiltration methods have not been introduced, nor was felt the necessity for a touch policy with regard to the assessment and/or protection of the dunes as a valuable drinking-water reservoir, as was done in the Netherlands.

Coastal sand dunes thus fully conserved their former status of waste land - at
tempts to valorize them for agriculture had for long proved to be unsuccessful. So their only suitability was found in sand exploitation, afforestation and ... house building: nothing was put in the way of the exponential growth of touristic industry, and at the present time, no less than 70% of the Belgian sand dune area has been urbanized (Vermeersch, 1986).

As to nature conservancy, Belgium found a very modern thinking, competent and enthusiastic protagonist of it in the prominent person of Jean Massart (1912), who was especially concerned with coastal sand dunes, in the first decade of the 20th century (id., 1907–1908; 1908). Again however, Belgium would be separated from the Netherlands by being involved in the first World War, and the arrests - regarding both scientific background and mentality about nature conservancy - in which it gradually fell during the following decades were considerable enough to miss the opportunities offered by the magic year 1970, which made the Dutch ‘Natuurmonumenten’ to such an influential organisation. Only in the late seventies and the eighties a new elan for dune conservation originated within the Laboratory for plant ecology, State University of Ghent, and in the private ‘Belgische Natuur-en Vogelreservaten’, and only the very last events indicate that the government at last seems to recognize the urgent need for it.

It will be clear that problems met with by Flemish and Dutch nature conservationists and managers are quite different (cf. Bakker, 1979; Leten, 1986); their attitudes when solving them are sometimes merely each others counterparts. Yet, their divergence might be the most valuable aspect of the two viewpoints, their confrontation being a help in seeing the own ideas in perspective. And one of the most conspicuous controversies is exactly reflected by the - indeed very Dutch - question: to a more dynamic approach? The chaotic developments linked with the laissez-faire mentality in the Belgian landscape not only caused extreme losses, but, on the other hand, they left practically intact the major natural processes in the few unexploited areas, including active parabolic systems and large moving bare sand masses. And the disappearance of such features from the Netherlands’ mainland is increasingly felt there as a negative consequence of a policy which is regarded as too rigidly protective and conservative.

In this paper some considerations are given with respect to this question, based on experiences mainly gained in the Belgian situation. It will be preceded by a brief description of the vegetation itself (for more details see De Raeeve et al., 1983), where special attention will be given to the more typically Flemish aspects and to management-relevant features, and by an evaluation of the pursued internal management.

**Flemish sand dune vegetation: general characteristics**

The general configuration of the Belgian coastline - with exception of the Zwin estuary - has remained practically unchanged since at least 150 years. At any point however, it is constantly on the move in either landward or seaward direction, erosion and accretion apparently alternating in cycles of some 30 years. As a consequence, embryonic *Elymus farctus* dunes have a limited and discontinuous distribution, alternated both in time and in space with cliff dunes: the omnipresent sand drift vegetation with halonitrophic (mainly *Cakile maritima* and *Salvia kali*) does not seem to play any significant role in further dune formation.

Fore-dunes are up to 25 m high, and mainly covered by *Ammophila arenaria* and

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*Festuc a junceifolia*. Other *Scabiosa maritimum*, *Calystegia soldanella* and *Hordelymus maritimus* are more typical ruderal dune species from the Yzdonal phase.

As sand accumulation and number of species increases around *Festuca junceifolia*, it is now replaced by a growth of more common inland arable species in the absence of severe drought in summer, and succession hardly exceeds the first stage.

Only a small part of the dunes however. Nearly the entire area has been converted into a system of beach and parabolic dunes, running in the direction of the prevailing winds, NWO.

The damp bare sand of the hinterland and algae, followed up by bacterial activity, led to a characteristic vegetation of alkali marsh and coastal dune systems (cf. e.g. Nieuwenhuijse et al., 1979; Willis et al., 1959; Wattez, 1986). This, more than in the surrounding region, has caused a relatively unstable vegetation through erosion, shrinkage and decay due to the geological conditions of the site (De Ceuninck, 1980), caused by the frequent exposure to the brackish marsh and by the conditions to swamp vegetation.

All this makes this slack dunes and their intertidal beach increasingly become restricted, as the deterioration of their fauna is extremely vulnerable. Its maritime aspect seems to be a natural succession to swamp vegetation.

A much more important part of the Belgian dune landscape, however, has been transformed into the establishment of *Salix rubra* and *Salix viminalis* in sand. This process is not predictable in extent, being dependent on the coastal supply of sand. In fact, in the absence of active vegetation, the evolution of a primary succession. But if there are a series of special *Salix* dunes.
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Festuca juncifolia. Other species, said typical for the Ammophiletum (Eryngium maritimum, Calystegia soldanella, Leymus arenarius) are mostly absent from this extremely mobile landscape, and occupy presently or formerly more stable and mostly also more typical ruderal sites. Only Euphorbia paralias becomes a rather constant dune species from the Yzer estuary southwards.

As sand accumulation and shift decrease, and relief is more or less fixed, the number of species increases and Ammophiletum is replaced by moss dunes, dominated by Tortula ruralis. The group of sturdy geophytes with strictly coastal distribution is now replaced by a group of tiny winter therophytes, most of them close relatives of common inland arable weeds with a very large geographic distribution: the risk of severe drought in summer becomes the determining ecological factor, and further succession hardly exceeds low scrubs of Hippophae rhamnoides.

Only a small part of the vegetation cover is to be explained by this primary succession however. Nearly the whole Flemish dune landscape is secundarized, and converted into a system of both extensive and much smaller slacks with intermittent parabolic dunes, running subparallel to the coastline (the latter being oriented, like the prevailing winds, NWW - SEE).

The damp bare sand of the fresh blow-outs is, here too, colonized by grassy species and algae, followed up by bryophytes, and gradually enriched with herbs. The species composition of this slack vegetation closely reflects the characteristics of the groundwater table, in the first place its average depth. It is very comparable to the well-known vegetation of alkaline marshes found in the other north temperate European, calcareous dune systems (cf. e.g. Van der Maarel and Westhoff, 1964; Westhoff et al., 1970; Willis et al., 1959; Witter, 1971), though it has always been less well-developed here than in the surrounding regions and it is always closely interwoven here with the essentially unstable vegetation of the Nanocyperion (Duvegneaud, 1947). This is probably due to the geological constitution of the Flemish plain (cf. Lebbe, 1978; Lebbe and De Ceuninck, 1980), causing larger seasonal groundwater fluctuations than are observed in e.g. the dunes of Voorne, while this instability factor cannot be compensated here by a constant support of seapage water coming from adjacent hills, as in e.g. Picardy dunes, nor by a more constant wet and cool climate, as e.g. in Wales. And as the coast does not accrete, we furthermore lack almost completely both the transitions to the brackish marshes of the 'green beaches' and primary slacks, and the transitions to swamp vegetation of secundarily permanently submerged slacks.

All this makes this slack flora, which originally is not typically maritime, but has increasingly become restricted to the dune landscape because of the almost complete deterioration of its former sites in inner Belgium by drainage and fertilization, extremely vulnerable. Its more recent impoverishment due to water catchment besides natural succession to scrubland, is dramatic indeed (De Raeve and Lebbe, 1984).

A much more important feature with relation to the further development of the dune landscape, however, is another difference with the primary succession, namely the establishment of Salix repens, especially when it is followed by secondary blowing in of sand. This process is not exceptional today, but occurs to very variable and unpredictable extent, being determined mainly by often very short-lived storms. If sand supply is sudden and massive, dune slack is rapidly converted in an Ammophila vegetation, the evolution of which more or less runs parallel to that, observed in primary succession. But if smaller quantities of sand are more constantly blown on, a series of special Salix dwarf scrub vegetations develops, characterized by a large
quantity of Agraric species (mainly Cortinariaceae) and herbs indicating strong mycorrhizal activity, such as Pyrola rotundifolia, Monotropa hypopitys, some orchid species, and by the strange combination of the minerotrophic and calcicolous species Carlina vulgaris and Inula conyza with the acidophilous Viola canina. Suddenly then, succession which hitherto had proceeded very fast, both in xerophilic and hygrosere, slows down considerably: the Salix hummocks show a remarkable resistance against overgrowing by Hippophae for several years; on the other hand, these are the only places where colonisation of birch is noticed. The up to now very badly understood soil ecology of the systems Salix/Agaricales/semiparasitic herbs and Hippophae/lower fungi and bacteria/nematodes is certainly one of the major gaps in our understanding - both theoretically and in practice - of dune landscapes.

These hygrosere-bound Salix vegetations, variants of which dominate in a striking way some Welsh and mid-west English dune systems entirely have become extremely rare in Picardy and seem to lack completely in the Netherlands. On the Flemish coast, their distribution is rather irregular today, and more or less linked with the broad transition zones in between predominantly mobile and completely fixed dune landscapes.

Both by its apparent stability and by its physiognomic characters, the Pyrola-Salix complex strongly resembles the mosaic landscape of dry dune grassland and taller scrub, which is found in much older parts of the slacks. Tall scrub occupies most of the larger slacks area today, and is dominated by Ligustrum vulgare, Sambucus nigra, Crataegus monogyna and Rosa species, in the wet hollows by tall Salix species. Dune grassland, which must be considered as the plagioclimax all over this dune region, still dominates in some of the inner dune landscapes. It is mostly very rich in species, the concentration of chalk grassland taxa being the most conspicuous aspect of this Flemish sand dune flora. Finer internal variation in these vegetation is nearly infinite and, just like finer differences in species distribution, it can only partly be explained in relation to the variation in the ecological complex relief/microclimate/grazing regime/soil development. Historical factors involved are very badly understood until now however, and a well differentiated 'Old dune village landscape', as described from the Dutch coast (Doing, 1974), is far less obvious here. In further contrast to the younger slack vegetations, the response of dune grassland to environmental changes is slow and rather unpredictable.

As a final stage, some acidic grasslands and grass heaths, and lichen formations are observed on the leached soils of the oldest dune landscapes, of which only a small part has escaped from the subsequent medieval transgressions. Natural woodland does not exist in Flemish sand dunes, but some wood fragments have originated here and there from planted trees and the spontaneous distribution of several woody species is in clear extension.

Finally, the richest and ecologically most particular vegetations and species (although their floristic component is even less typically maritime) are known from the transition zone between dunes and polders, especially nearby the estuaries. Nothing in the lowland however has been degenerated so dramatically as this area, formerly characterized by very special edaphic and hydrological conditions, and it has become impossible now even to imagine how the vegetations, in which formerly species like Eriophorum angustifolium, Drosera anglica, Dianthus superbus have been collected, may have looked like.

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Dune vegetation and management

A mobile landscape
Young soils

HIGH

Small biomass
Low structural organization

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Fig 1 The major ecological facts

So the general appearance of a dune landscape with all sorts of vegetation and ecological strategy classes is fairly rare - at least within the study area.

Furthermore, both land use and management rather: apparently still well balanced as to their relative importance, and according to the recommendations (Herbaux, 1971; see map) parallel with increasing staff size and organization, while wind and open vegetation types.

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Internal sand dune management

An extraordinary small-scale management has been applied in the French part of the area. Therefore - but rather also by local tradition - the management has always been done by nature management traditionally, by local people, particularly to volunteers; and prior to the Second World War, management has always been applied. Its main objectives were conservation of the natural vegetation types, and the recuperation of the local vegetation types. Today, agricultural and agropastoral principles of temporal constancy, species diversity and the species of the mentioned values, are common. So it can be applied for example for agricultural land, meadows, or other vegetation types, sods, like it was done in inland...
Dune vegetation and management dynamics

![Diagram of dune vegetation and management dynamics](image)

Fig. 1. The major ecological factors in a concept of cyclic succession.

So the general appearance of sand dunes is that of an extremely diversified landscape with all sorts of vegetation types of contrasting structure, floristic composition and ecological strategy closely intermingled, very rich in species, of which many are fairly rare - at least within the general context of the north-west European lowland.

Furthermore, both landscape elements and major ecological parameters are (or rather: apparently still were in the beginning of the seventies) remarkably well-balanced as to their relative spatial and functional importance, and the system as a whole suggests (or: suggested) a high degree of stability, due to internal cyclic succession (Herbauts, 1971; see also Ranwell, 1960). Figure 1 summarizes this concept: parallel with increasing stabilisation and age runs increasing biomass and structural organization, while wind and rabbits assure continuous regeneration of young and open vegetation types.

Internal sand dune management: concepts and practice

An extraordinary small-scaled diversity; internal stability: the sand dune landscape was the almost perfect embodiment of nature conservancy ideals of the late sixties. Therefore - but rather also because of more prosaic circumstances (there was no such nature management tradition as in the Netherlands; management had been left largely to volunteers; and priority had to be given to external threats), active internal management has always been very limited in the Belgian, and even completely absent from the French part of the Flemish dune area. Like inland ecosystem management, its main objectives were conservation and restoration of the landscape that embraced the aforementioned values. As a consequence, it was mainly copied from the old agricultural and agropastoral practices, and hence 1. based on the two main principles of temporal constancy and spatial diversity (cf. van Leeuwen, 1966); 2. essentially species-centered; and 3. concentrated on the removal of nutrients. So, like inland meadows, moist slacks were mown, while bare soils were created by cutting sods, like it was done in inland heaths; on dry dunes extensive grazing was left to the...
rabbis, eventually with some extra mowing, except for the old pastures on the inner dunes, the former commons, where extensive cattle grazing was accepted as the best management continuation (cf. Rijksinstituut voor Natuurbeheer, 1979). And, as to species and population conservation, these practices proved to be quite successful indeed.

More and more, however, one began to realize: 1. that these time-consuming measures were very expensive; 2. that they brought about structural leveling with sharpening of boundaries; 3. that they were simply completely inadequate for certain vegetation types, e.g. Salix dwarf scrubs; and 4. that, anyway, they didn’t stop such features as soil leaching and acidification.

In addition to these particular difficulties, the more general and fundamental objection arose that management was too conservative and too meddlesome and an increasing need was heard for more naturalness (e.g. grazing instead of mowing; undisturbed development of woodland) and for larger landscape properties, which were associated with more wilderness (e.g. large moving dunes).

Parallel to these changes in management concepts, shifts had taken place in scientific interests (e.g. from vegetation classification to population dynamics and the effects of disturbance — cf. White, 1979; Pickett et al., 1987; Schmidt, 1987) and new scientific explanation models were developed (especially the theory of Grime (1979) influencing radically the thinking of many management researchers).

All this can be situated in an epoch, which is quite remote from the self-satisfied golden sixties. The economic crisis had deeply shocked our belief in unlimited control over the surrounding world. Rather than an intensified care for the former attainments in the old rationalistic tradition, it brought about a strongly subjectivist craving for escape out of degenerating reality (cf. Stoetzel, 1983; Kerkhofs and Rezsohazy, 1984).

I would like to check these two contrasting approaches by examining the evolution of the Belgian sand dune landscape has undergone in recent times.

Vegetation developments in the Flemish dunes in recent times

The changes observed in Flemish sand dune vegetation during the last 10-15 years were far more extensive than foreseen in the early seventies. They can be summarized as follows:

1. Concerning the older, mesic landscapes the consecutive dry years in the seventies have coincided with an increase in rabbit grazing pressure. This has led to overgrazing and undermiring of the dune pastures, and, followed up by a period of wet years, we see now:
   - where soils were not damaged, mesic grassland has survived, but its species richness has seriously diminished: especially the sociological and spatial amplitude of the Bromion group has been reduced seriously by that time, and this was not recuperated in the subsequent wet period.
   - where soils were damaged, mesic grassland has been converted into xeric and distinctly ruderalized moss dunes, and into Rosa pimpinellifolia heath.
   - on the other hand, no mesic scrub has been converted into grassland, nor any indication was found for moss dunes succeeding progressively to mesic grassland; only in the borders of the young slacks, the Pyrola-Salix vegetation range, many mesic

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In addition, the grassland species occasionally has difficulty if it will result:

2. Especially in the younger parts of the slacks (cutting, mowing, uprooting; changes in extension rate could not be related to differences in the water table or hygroseres and xeroseres, the latter parts of the slacks, and 3.
   - Ranwell, 1972b)
   - Tortula-Peltigera-Sclerophylla, was always covered with dense, now, well-developed species
   - rarities.

As to the changes in dune mobility which characterize a sand dune (Londo (1971)), Van der Laan, 1971).
3. The species enrichment in the younger parts is irregular too: evolution is more rapid here, in new grazed situations, and not very well studied, largely dependent on chance.
4. Finally, even in the extreme south, which for more than 1/3 of the year is subject to a fairly high rainfall, grazing is decreasing rapidly, and even the parabolic dunes, are dying back.

So, the events of the last decades show a genuine succession, resulting in general high potential, characterized more observing studies on the Voornapijp comparable results (see also: Massart, 1976).

These observations are less easy to back in the past. First, dunes were not observed and photographed in detail before the 1970s. Second, dry open, dry dunes almost very much like grasslands. Scrubs. This landscape was also grazed, even in the forested, and the upper NNW burning. The nice, extremelly, which turns out to be only a sand dune, Massart landscape to a land grassland. A stage which seems to have been left, which is changing now any

And if we look even further...
Dune vegetation and management dynamics

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Dune vegetation and management

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from the relatively dry years in the seventies
more than to overgrazing. This was followed up by a period of wet years,
vegetation was not destroyed, but its species richness reduced and its structure and spatial amplitude of the vegetation thinned, and this was not recuperating
converted into xeric and disturbed
"Calluna vulgaris" heath

into grassland, nor any indicators of mesic grassland; only much greater vegetation range, many mesic

growth of grassland species occasionally established from seeds, but this process is slow and it is
doubtful if it will result in a real closed turf.

2. Especially in the younger slacks namely, extension rate of Hippophae has suddenly
increased, while that of the progressing slacks has largely fallen behind, and has even stopped for years. The complete disappearance of short slack vegetation from
the entire Belgian coast would even have been the result, if no artificial measurements
(cutting, mowing, uprooting of seedlings) had been taken. The starting times of these
changes in extension rate differed from place to place, and this irregularity often
could not be related to differences in local environmental factors. First considered as a
merely incidental feature linked with local disturbance factors (rabbit activities;
fall of the groundwater table), later a generality in the transition zone between
hygroseres and xerosere, the explosive spread of Hippophae was extended to the wetter
parts of the slacks, and now even to the old pastures and the fixed dry dunes (cf.
Ranwell, 1972b). Tortulo-Phleum, very abundant and still in expansion in the early
seventies, was always considered as completely unproblematical as to management;
now, well-developed specimens of some size of this vegetation type have become
rarities.

As to the changes in dune slack vegetation, and the different degrees of unpredict-
ability which characterize the factors affecting them, compare e.g. the studies of

3. The species enrichment in the scrub formations which are in extension everywhere
is irregular too: evolution in formerly grazed situations differs distinctively from that
in never grazed situations, and apart from this, establishment of woody species is
largely dependent on chance arrival of seeds.

4. Finally, even in the extremely mobile landscape of the ‘Westhoek’ nature reserve,
which for more than 1/3 (about 140 ha) was covered by bare sand, and which is
subject to a fairly high recreation pressure, this bare sand area quite spontaneously
is decreasing rapidly, and especially the smaller parts of it, among which the mobile
parabolic dunes, are dying out completely.

So, the events of the last decades are difficult to be reconciled with the model of cyclic
succession, resulting in general stability. It is rather a matter of unidirectional evolu-
tion, characterized moreover by essentially saltatory mutations and the very extensive
studies on the Voorne dunes by Van der Maarel et al. (1984) have lead to very
comparable results (see also Ranwell, 1972).

These observations are less strange and inexplicable if one looks somewhat further
back in the past. First, dune landscape in the beginning of the century, as described
and photographed in detail by Massart, was completely different from ours: extremely
open, dry dunes almost without vegetation, the slacks practically only with dwarf
scrubs. This landscape was clearly not controlled by extensive, but by quite intensive
grazing, even in the foredunes, proceeded moreover, locally at least, by periodical
burning. The nice, extremely diversified, park-like landscape of some 10-20 years ago
thus turns out to be only a short stage in a long evolution. An evolution from a naked
Massart landscape to a landscape probably almost completely covered with wood-
land. A stage which seemed to be quite consolidated during a certain period, but
which is changing now anyway.

And if we look even further back in history, we can not have but the strong impres-
sion that in fact, landscape history was a series of catastrophes, followed up by periods of relative stabilization. An evolution in which were involved irregular fluctuations not only of human interference but also of much deeper lying factors, such as land/sea interaction, coastline modifications, and even climate (cf. Boerboom, 1958; Gimingham, 1964; Jelgersma et al. 1970; Granados Corona et al. 1988).

**Attempt for a better interpretation diagram for general dune landscape dynamics**

It will be clear that the diagram in Figure 1 needs some adjustments. Figure 2 may meet its major objections.

1. To a very large extent, progressive vegetation succession (CD) did not and still does not run parallel with increasing age of landscape and soils (AB) (and neither it spatially runs parallel with the line beach-polder!); grazing is an appropriate tool to maintain a short turf with a lot of small herbs we erroneously call pioneer species, but this deflexion does not make the landscape younger; you simply cannot stop time.

2. At every moment in the evolution from A to B, a different balance between progressive and regressive forces on CD is established, and vice versa: the observations on processes, their rate, intensity and spacial impact, in a certain stage of landscape development X, can not simply be extrapolated to other phases X' in that evolution. (E.g. if a low grazing intensity was apparently sufficient to maintain the highly diversified landscape of some 20 years ago, this does not necessarily mean that this low intensity will keep on being appropriate to control Hippophae today, and if you would want it to be strong enough in its destructing capacity to restore the total surface of bare sand of this former landscape, maintaining comparable sanddrift

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processes, this much higher intensity in the development of such structures.

3. Balances between progressive and regressive forces are not situations, so the resulting landscapes will be unstable and CD (e.g. small-scaled landscape) or sand-drift can add diversity to the landscape. Interventions, in a landscape with a more or less stabilized vegetation, will be ineffective and even cause an increase in productivity (a feature observed in many cases in the Netherlands today). This difference will rapidly change continuously but abruptly.

4. The situation is complicated by the fact that interactions can be influenced by chance factors, and the possible hierarchy of species and higher hierarchic position, species that can cause irreversible changes in the vegetation in one or a few decades; coastline regression or, for example, equally irrevocable overgrowth or stabilization.

5. On account of all this, it is clear that property (invasion, establishment and distribution of stress and disturbance) is not property (whatever that might be) of the vegetation. On the contrary it will only be found if the vegetation covers only part of the floristical unit, of entire landscape unit ABCD, and, thus, in a part of one property.

**Conclusions**

The question was: towards a better interpretation of the dune landscape.

If one means by this: do we have to face the reality of the situation. For some properties, like sand drift, it is probably true that these will be less likely to be yes, at least some of the time. If we talk about a groundwater regime, the argument is perhaps more correct and applicable than in the case of sand drift: 1. It is important to realize that some properties of the landscape have always been subject to control by man. 2. The dynamics of these properties follow the natural parameters.
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3. Balances between progressive and regressive processes are rearranged in every new situation, so the resulting landscape will be different in every point X between AB and CD (e.g. small-scaled vegetation disturbances, followed up by small-scaled sand-drift can add diversity in a landscape mainly covered by herbs; but the same interventions, in a landscape where *Hippophae* was latently omnipresent, can remain ineffective and even cause an opposite effect, simply by activating *Hippophae* growth - a feature observed in many sand dune areas in both Flanders and the Netherlands today). This difference will remain fairly unpredictable, as balances very often do not change continuously but abruptly, with irregular pulses, and then often very rapidly. This situation is complicated by the fact, that these processes moreover are influenced by chance factors, which may have their origin in landscape parameters of higher hierarchic position, such as climate, or land/sea interactions (e.g. a few dry years can cause irrevocable rabbit 'damage' in grasslands which had been stable for decades; coastline regression can cause a water table fall, sufficient for sudden, and equally irrevocable overgrowth by *Hippophae*).

4. On account of all this, it is clear that maximal internal variation in vegetation properties (invasion, establishment, competition, symbiosis - in all possible situations of stress and disturbance) cannot be achieved simply by 'optimizing' (whatever that might be) of ecological conditions in a certain 'ideal' point X. On the contrary it will only be found in the presence, within every large climatological and floristical unit, of entire landscapes in as many situations X as possible, in the whole field ABCD, and, thus, in all stages of differentiation on the whole evolutionary line AB, time.

5. This need now for differentiation in both structural organization, and in age, in time, has important implications for the needs concerning space. Indeed, we know that when using large herbivores much space is needed to obtain all intermediates between overgrazed and ungrazed vegetation. Even larger areas of both bare sand masses and stabilized landscape of all ages will be needed to obtain all possible intermediates in sand drift influence. It is clear that the more combinations between both one desires the more the amount of space available will become determinant.

Conclusions

The question was: towards a more dynamic approach?

If one means by this: do we need more instability, the answer cannot be unequivocal. For some properties, like grazing pressure or geomorphological dynamics, it is likely to be yes, at least sometimes, and in some places. For others, like natural groundwater regime, the answer will probably remain: no. Concerning dynamics, it is perhaps more correct and more significant to state:

1. It is important to realize that dune vegetation as a part of the whole dune landscape has always been subject to, and is even completely formed by, the dynamics of several natural parameters.

2. The dynamics of these parameters, especially groundwater, moving sand, growing plants and grazing animals will probably also remain the very best tools for future
landscapes. And when applying them, the diagram of Bakker et al., 1979) will largely remain useful as a general guiding principle.

3. This however, does not imply that these dynamics will have to be used in exactly the same way as has been done in the nearby past or under other previous human occupation regimes. On the contrary, they can be used (and, to be technically successful, will have to be used) in quite a lot more different combinations. And according to the differences in scale by which their components will be applied, a much greater variation in landscapes can and will be obtained, than can be observed today or even has ever existed.

So, the problem of dynamics is rather a problem of scale, both of time and of space. This consciousness of the importance of scale has two major implications for vegetation management and general nature management:

1. We shall have to learn to realize that many small-scaled processes cannot be separated from very large-scaled evolutions, of which they are just an ephemeral component; and we shall have to learn to realize that many highly diversified small-scaled patterns are dependant on - present or preceeding - much larger undifferentiated landscape structures. In other words: we shall have to re-examine the concepts of both constancy and spatial variation as the major principles in nature management.

2. On the other hand, the importance of scale gives an indication of the limits we shall have to regard when adopting a more dynamic approach. An essentially conservative, protective attitude will probably remain the wisest solution, when dealing a. with properties, which have needed a very long time to establish even if they are situated on a low hierarchic level in the 'Bakker diagram' (e.g. the flora), or which would need a very long time to re-establish if destroyed by unwise human intervention (e.g. we have to avoid accumulation of nutrients in the subsoil as a consequence of infiltration) and b. with properties which need very much space: it is essential to conserve the dune landscape as one large undivided unit where it is still present as such (e.g. in most parts of the Netherlands), or to attempt, where ever possible, to restore it by removing fractioning elements (e.g. in Belgium).

References


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The diagram of Bakker et al., 1984, principle.
will have to be used in exactly the same way as under other previous human orders and, (and to be technologically successful) combinations. And according to this combination, a much greater variety of vegetation can be observed today or even created in the future, both of time and of space. But we cannot expect that the major implications for vegetation of these processes cannot be separated as an independent one from the highly diversified small-scale processes with much larger undifferentiated regional processes to re-examine the concepts and principles in nature management. The condition of the limits we shall not be able. An essentially conservative management requires a solution, when dealing with land (e.g. the flora), or which would never be possible as a consequence of infiltration into a dune face; it is essential to conserve water. It is still present as much as (e.g. the flora), therefore ever possible, to restore it.