Strandmarken and Dueodde

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By Brian J. R. Blench

Abstract

The development and vegetational history of the dune areas at South Bornholm characterized by a narrow beach and a tideless sea.

The island of Bornholm is the most easterly of the Danish archipelago lying approximately 120 miles from Copenhagen at 14° 43' E on latitude 55° N. Both the physical and cultural features of the island are said to be 'transitional between Sweden to the north, Central Europe to the south and Denmark to the west', (*Sommers,* 1957), though this is probably best seen in the geology of the island.

Bornholm's geology is of special interest to Danish geologists for '.. Pre-Cambrian, Cambrian, Ordovician, Gothlandian, Triassic, and Jurassic systems have been found in situ only on this island', (*Madsen,* 1928) though later oil-borings have revealed their presence now in other parts of Denmark. The fact that this is the only area of Denmark where igneous rocks appear at the surface, probably accounts for the numerous studies of this aspect of the island's geology and the relative paucity of material on the Pleistocene and Recent geology of the area. The peripheral dune areas, that of the region north of Rønne largely fixed during the eighteenth century, and the Strandmarken – Dueodde region have received little attention in geographical literature. Though the names Strandmarken and Dueodde refer strictly only to the dune areas of the extreme south and south-west of the island, this preliminary study will be concerned with the whole of the coast from Boderne to Balke.

The parish records of Pedersker and Povlsker (*Bruel,* 1908) and contemporary accounts from the seventeenth to the nineteenth centuries (e.g. *Garlieb & Rawert,* 1819) constantly record losses of agricultural land due to sand movements in the area, while various

maps after 1760 provide information on a more quantitative level of the actual extent of the dune area. The most useful of these is that of *Bugge and Wilster* (Videnskabernes Selskabs Kort). Published in 1805 on a scale of 1:60.000, it provides detailed information as to the limits of the dune area and illuminates much of the written material of the preceeding century. However, there is really insufficient material available to trace the development of the area accurately and fruitfully before 1879.

In that year, the Tegner's Lithografisk Institut published in Copenhagen, the first series of maps to cover Bornholm on the scale of 1:20.000. This increase in scale over previously published maps meant that far more information could be presented adequately. This was particularly true of the dune areas where four types of surface were differentiated: bare sand, dune (with or without grass), heather, and an area called „lystanlæg". This term was used to denote areas set aside for recreation and is therefore a land-use category rather than a term which describes vegetation type. It may be assumed, however, that in this region it was used to describe a mixed wooded vegetation area. Field boundaries are shown on this series and on the Geodætisk Institut later series which replaced them, so that comparison of the two series shows accurately the changes in vegetation throughout the area. In 1879, the region immediately east of Boderne is grassless dune which gives way to an area of mixed dunes – some fixed while others are not. From the mouth of the Henrikebæk, almost the whole coastal region is composed of duneless sand areas of varying width. There are four exceptions: Sømarken, where we find two small examples of the category „lystanlæg", Aspesgård and Krogegård, where we find small areas of fixed dune, and the wide dune belt of Balke, immediately to the south of Neksø. Elsewhere the sand area varies in width, 1,5 km at Dueodde, but no other examples of vegetation growth or dune formation. We can thus picture a large belt of shifting sand fixed only in a few places – this probably being the result of action taken by local farmers and noted by *Hauberg* (1879) when he stated that "en betydelig strækning af sandflugten ved Dueodde er tilplantet ved privat virksomhed." However comparison with the second edition of the Geodætisk Institut maps on the same scale, which appeared in 1914, reveals many startling changes.

Vegetation appears to have colonized rapidly and an even greater attempt has been made to represent in detail the resulting types of surface. By 1914 the whole of the area from Boderne to Raghammer

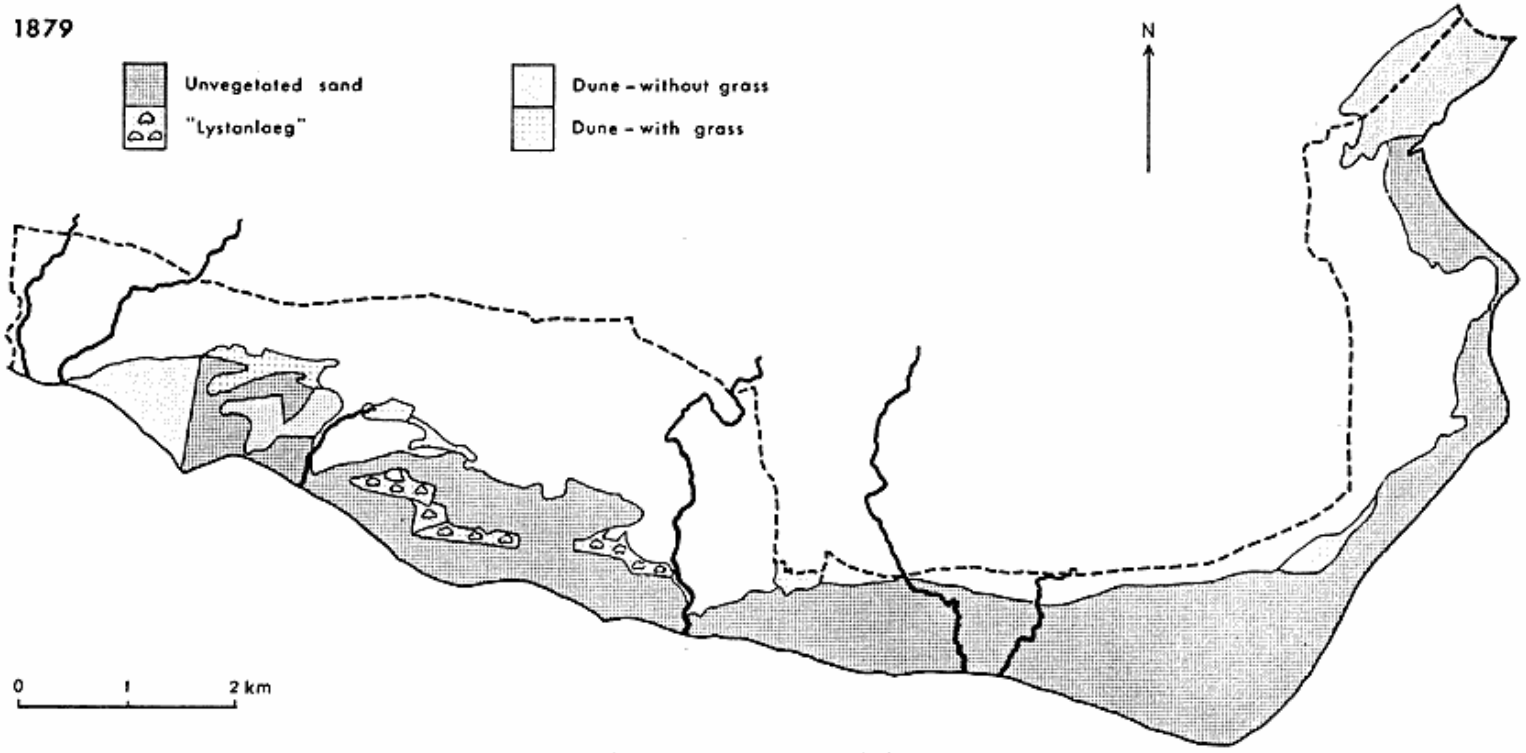

Fig. 1 a. Vegetation 1879.

The younger and older dune areas here differentiated solely on their morphological characteristics. The younger dune areas are those where the dune form is still easily recognisable while the older dune areas are those areas which are much more flat and approximate more closely to dune plateaux.

Fig. 1 a. Kortudgaven 1879 med følgende signaturindhold: sand, klit med og uden bevoksning samt arealer med benævnelsen lystanlæg.

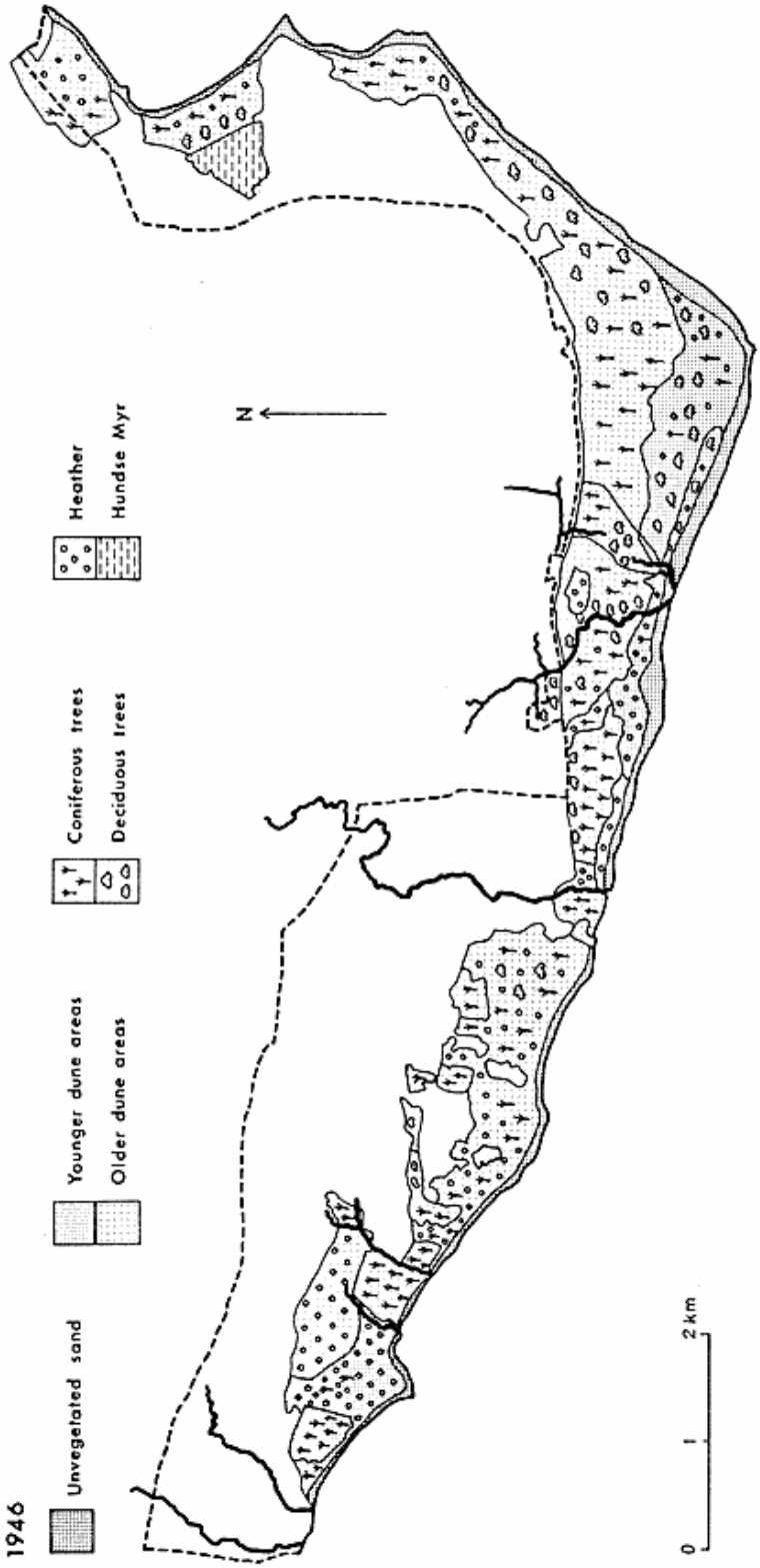

Fig. 1 b. Vegetation 1946.

Fig. 1 b. Målebordsbladets signaturindhold udg. 1946, der yderligere registrerer beplantning med nåleskov og løvtræer samt hede og mose.

Odde is shown as having passed into coniferous forest, probably again the result of judicious planting. Part of the point, classified as sand in 1879 is now dune, as is the whole of the sand belt as far as Slusegaard. The area of „lystanlæg" is no longer included in the littoral belt. The area between Slusegård and Dammebæk consists of a short stretch of dune which gives place eastwards, first to a plantation of young conifers and then to dune with a scatter of conifers, fronted by a line of deciduous trees. This gives way to grass covered dune at Dueodde. East of Dammebæk, the landward half of the dunes is also planted with conifers. On the south-east facing shore, east of Dueodde, are two small lakes, but these have disappeared by the 1946 survey, nor have they re-appeared since. The whole of the south-eastern section of the area shows signs of having been planted with conifers as far as Broens Odde.

The next edition of the 1:20.000 map was published in 1946 and again many changes are visible. The Boderne-Raghammer section is almost completely forested by young conifers, though a foredune belt, with grass, has appeared, indicating that dune formation was still active during the intervening period. A similar increase in planted forest is noticeable in the section as far as Slusegård. Here cultivation reaches to within 200 metres of the shore; the intervening section being dune-heath. Further east the belt widens to its maximum at Dueodde, as in all previous surveys. The dunes are covered partly by natural heath and scrub and partly by planted woodlands. The largest heath area is that bounded by lines joining Dueodde Pynt with the hotel and with the mouth of the Munkebæk. By 1946 we find the south-easterly section of the dune area fixed with coniferous plantation though in some few places heath is still present. Here we also have the widest stretch of beach and some indications that dune formation is still continuing as far north as Balke. (See Figure 1.).

We can see from this short historical survey that the dune area of Strandmarken – Dueodde has been of fairly constant area, at least over the last 80 years and probably for the last three centuries. The complaints mentioned above of blown sand ruining crops refer only to the marginal areas of the region where some inundation would be expected. The encroachment was rarely permanent though on some occasions the damage may have had more lasting consequences. (*Hübertz,* 1852, *Resens,* ed. *Knudsen* 1925) Before proceeding with the detailed description of the present day situation, it will be valuable to consider some of the factors governing the deve-

lopment of the dunes at the present. As there are no records of significant climatic changes in the region over the last 300 years it will be safe to assume that present conditions have been operative over this period.

It is normally regarded as axiomatic that coastal dunes will only develop where either considerable areas of sand are exposed at low tide for a time long enough to allow them to dry out, or where there is a very large supply of material. Here, in south Bornholm, we have both a narrow beach and a tideless sea, so that the exposure of the sand area is both relatively constant and small; usually only about 10 metres and only at Dueodde reaching over 100 metres. In addition nearly all writers studying the area have noted the purity of the sand in this region: "as the brackish water of the Baltic has resulted in a poverty of bivalves and snails, here we find almost pure quartz sands" (*Larsen* 1955-56) – this is in direct contrast to the Jylland sand regions and more similar to the Sandhammeren of south Sweden (*Løfstrom* 1946, and *Davidsson* 1958). This absence of shell material is an important limitation on sand supply.

It is impossible at present to estimate with accuracy the amount of sand brought to the beach from the offshore zone but two facts indicate that this is probably not a major source of supply in some of the westerly areas. In many places along this coast there is little sand cover only a short distance out from the water's edge. Frequent rock outcrops were noted especially at the extreme western and eastern ends of the region. The presence of a steep submarine cliff of about two feet in height – the shore-face terrace (*Schou* 1945) – may inhibit the movement of offshore materiel onto the beach. It seems likely that most of the material which formed and is still forming the dunes is a result of longshore movement of material from two directions: one, an easterly movement along the south-west facing shore and two, a south-westerly movement along the south-east facing shore. The supply is from two different types of source.

Along the west coast, from Boderne to Dueodde, the main source of supply is the cliff region west from Boderne to Sose Odde. The cliffs here are composed mainly of soft Rhaetic and Lias deposits topped by moraine boulder clays, though in some places the boulder clay deposits themselves form cliffs and seem to produce an abundant supply of material. An indication of the amount of the drift on this section of the coast is shown by the deflection of the Grødby Å to the east. The fragments of the graptolitic shales which are

Fig. 2. Fragments of graptolitic shales on the beach east of Øle Å.
Fig. 2. Fragmenter af graptolitskifer på stranden øst for Øle Å.

brought down by the Øle Å and are moved eastwards along the coast provide another source of material and the only major impurity in the sand composition. (See Figure 2). East of the Øle Å, on the surface and below the surface in some places, we find large quantities of shale which break down easily and rapidly to form fine particles which slightly discolour the sand of this area. However this is only a relatively minor source of supply. On the eastern facing coast the supply is possibly from the Neksø sandstone which outcrops immediately north of the dune belt and underlies much of the dune area. The hardness of the rock makes this unlikely to be a major source of supply and it is more probable that it is in this section that off-shore material is more important as a source of sand. The great stretch of foreshore at Dueodde represents the meeting place of the two longshore movements of material and provides a constantly changing picture of ridges, shallows and sand-bars. It seems likely that here also large quantities of sand may be brought from the off-shore region onto the beach.

The climate of Bornholm is typical of the Baltic temperate coastal type, Cfb in Köppen's classification (*Köppen* 1923). Probably the most outstanding feature of the climate of the island is the late spring, on average eight days later than the rest of Denmark, and the "Indian summer" which leads to increased tourist traffic during the extension of warmer weather into September. The rainfall is moderate and distributed throughout the year with a late summer mini-

Fig. 3. Dune heath fronted by a narrow foredune belt at Slusegård.
Fig. 3. Klithede brømmet af et smalt forklitbælte ved Slusegård.

mum being on the whole slightly lower than the rest of Denmark: Rønne 54 cm, Almindingen 71 cm, compared with 58 cm at Copenhagen and 75 cm on the west coast of Jylland. The island is exposed to winds from all directions though there is a south-westerly maximum over most of the island.

There is a marked change in the type of coastline at Boderne, where the Læså and the Grødby Å reach the sea. West of the Læså is a low cliff coast developed in the Rhaetic, and Lias deposits and Boulder Clays. To the east is the beginning of the great dune belt of Strandmarken and Dueodde. Though the mouth of the Læså is deflected slightly to the east, the deflection of the Grødby Å is more impressive. At the time of investigation (1961/62) the amount of deflection was 25 metres, though it was possible to trace channels in the foreshore, here about 20 metres wide, indicating outlets 30 and 50 metres further to the east: these channels were occupied by small salt-water lakes. Little material larger than sand was observed in the beds of the streams as was the case with most streams which crossed the dune belt, apart from the Øle Å, though in many cases it was possible to see small areas of mud deposition along the banks.

The dune region itself begins at the Grødby Å, though for the first 350 metres it is impossible to recognize any significant foreshore features in front of the area of *Ammophila baltica* as this is the road to the military training ground at Raghammer. The road soon passes inland into the coniferous forest and immediately we can

recognise a succession which is to recur throughout the region. There is narrow beach backed by a sand cliff about 60 cm high, formed as a result of the coalescing of the foredunes. This is followed by a belt of fixed dunes up to 3 metres in height. This in turn grades into a grey dune area followed by a belt of coniferous forest which seperates the beach area from the cultivated area.

The Raghammer military training ground is a fine example of dune heath but is spoilt from the geomorphological viewpoint by its use as a tank training ground which no doubt accounts for some of the spectacular "blowouts" which were observed here. The area contains dunes up to 22 metres in height – some of the highest in the whole region. On the east side of the point we find the sea vigourously attacking the fore-dune belt and even the marram fixed dunes. The next section of the coast is a stretch about 4 km long where there is a marked similarity in development. The sea is not attacking this at all at present and the beach is backed by a degrading dune cliff, which increases in height towards Slusegård. The fixed dunes vary in height between 2.5 and 4 metres and are backed by one of the examples of planted forest to be found in the region.

The only important break in the dune area is round Slusegård (Figure 3). This farm is marked on most of the old maps as being the one where farming comes closest to the beach – a result of soils derived from the graptolitic shales rather than from the Jurassic sands to the east and west. This is still the case today, the nearest fields being only about 400 metres from the water's edge. The beach rises to a degrading cliff which is fronted by a narrow foredune belt and succeeded by a „dune plateau" rising gently to the oldest dunes with elder bush. The beach is somewhat wider than the average possibly due to augmentation by shale fragments and sand brought down by the Øle Å. These fragments break down rapidly and they soon die out as a surface feature though their effect on the vegetation of the section is important. Though not particularly interesting from the scenic viewpoint, this part of the coast illustrates the major principles of dune development.

Isolated "embryo dunes" form due to irregularities in the surface or as the result of obstacles such as seaweed and driftwood. These are the asperitogenic and umbratogenic "lens" or "cushion dunes" of *Kuhlman* (1960). These grow and move inland fairly rapidly. By uprooting the marram and measuring the distance between the nodes it is possible to gain an approximate idea of the rate of growth

of the plant and thus indirectly of the rate of growth of the dunes.

The orientation of the dunes is interesting and provides a problem when viewed in the light of "classic theory". Frequently emphasis is laid on wind direction as the dominant factor in orientation: "the orientation of coastal dunes depends upon the direction of the most effective wind" (*Guilcher* 1958), "the growth or otherwise of sand accumulation is intimately connected with the relative strength, duration, and direction of alternating periods of strong and gentle winds" (*Bagnold* 1941). This is an oversimplification of the situation and *Landsberg* (1956) in stating that "the orientation of dunes is a result of the interaction of all environmental factors", underlines the complexity of the problem. We have already noted the narrowness of the beach, which, coupled with the tideless nature of the Baltic, makes conditions in this area unusual. A statistically significant sample of foredune orientations was obtained and found to group round a figure of N 95° E – that is parallel or sub-parellel to the trend of the coast. This would seem to indicate that the most important winds for foredune formation in this area were not the prevailing and dominant westerlies and south-westerlies but those blowing along the beach and having the greatest "fetch" over sand. (cf. Figure 4). This is however only true in the early stages of dune development. It is easily seen in the field that the dunes, in addition to extending in this direction parallel to the coast, move inland as they increase in size and take up an alignment closer to that of the prevailing winds, and that therefore the older and larger dunes show a greater influence by the south-westerly winds than do the foredunes. The general development of the system would appear to be the following: the foredune belt develops in response to the minor maximum of the west winds but they present a greater area to the south-westerlies as they grow in height and mass. The westerlies and south-westerlies being both the strongest and prevailing winds, push the dunes inland at the same time as they impart a closer alignment to the NE-SW orientation which could be expected under normal circumstances. The increased area of beach at Dueodde augments the supply of material along this alignment and so the dunes are able to increase in height also.

In many places the sea is able to attack the foredune belt, washing away the sand from the primary plant colonizers and in many places dead plants can be seen which have probably died as a result of this process but which may, in time, begin to form new dunes as a result of their new role as an obstacle to sand movement.

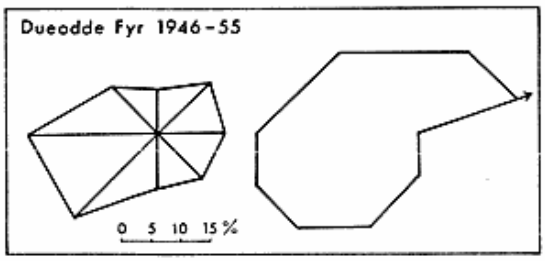

Fig. 4. Wind rose and modified resultant for Dueodde Fyr. Constructed from *Maanedsoversigt over Vejrforholdene*, Det Danske Meteorologiske Institut, 1946-1955. As no detailed breakdown of wind forces was available, the wind resultant diagram has been constructed from all winds rather than from only those above force 4 as suggested by Schou. (op. cit.).

Fig. 4. Vindrose og vindvirkeresultant for Dueodde Fyr. Konstrueret efter samtlige oplysninger fra Maanedsoversigt over Vejrforholdene, Det Danske Meteorologiske Institut, 1946-1955.

Beyond the outlet of the Munkebæk, the dunes begin to increase in height and some spectacular blowouts are present. The dunes are about 5 metres in height, in some places slightly more, and where they are highest there is usually no dune cliff and a slightly wider beach than normal. Frequently we find a series of slacks and low dunes, all thickly vegetated, behind the first line of high dunes.

Dueodde itself is a complex dune area, half forested and half heath covered. The forest appears to be largely natural though some is obviously planted. The dunes reach their maximum elevation at this point – in some places over 20 metres. The direction of the dune ridges is well represented on the Geodætisk Institut 1:20.000 maps (see Figure 5) and we have already noted the interesting change in the orientation of the dunes.

The final stretch of coast in the dune area, from Dueodde to Snogebæk and Neksø, is almost the same throughout its length, though it does present some interesting problems and contrasts to the west facing coast. Again we find that the orientation of the foredunes is parallel to the coast but in general the beach is much narrower and active dune formation occurs in only a few places. These two effects may well be the result of a shortage of material. The dune cliff, about 1 metre high, is continuous throughout the area. There is no great width of dune heath and in many places the dune forest tops the dune cliff suggesting that, at present, erosion is a more potent force than construction along this section of the coast. (see Figure 6).

North of Snogebæk, young dunes were seen to be forming in some places and were rapidly colonized, though here planting of the dunes

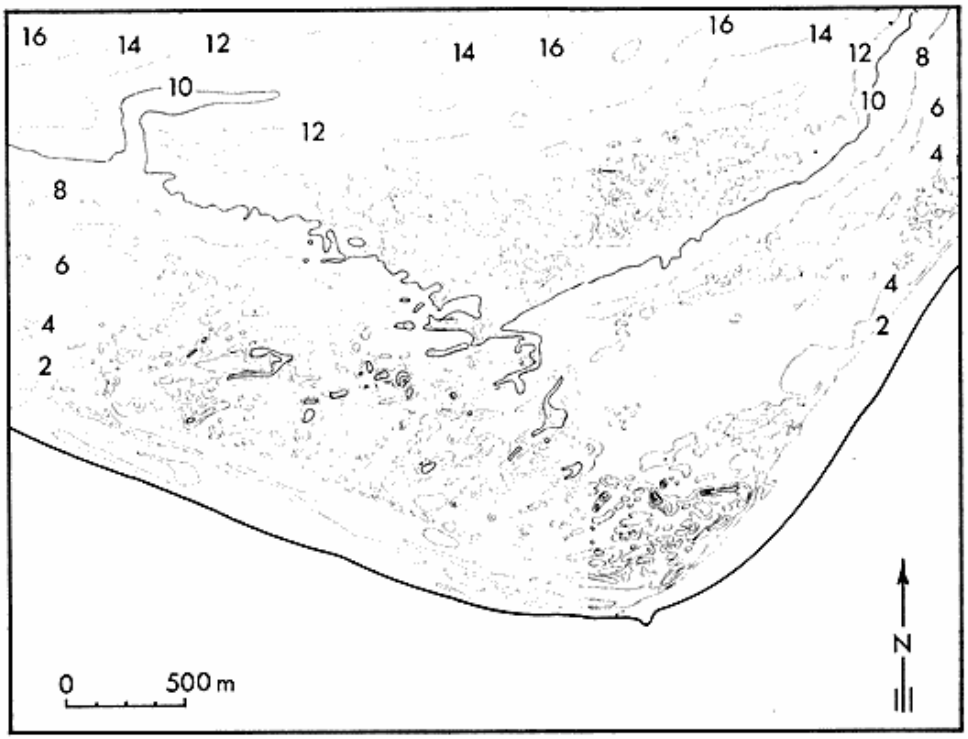

Fig. 5. Contour map of the Dueodde dune complex. Reproduced from the Geodætisk Institut map (1:20.000).

Fig. 5. Gengivelse af målebordsbladets kurveplan for Dueodde-komplekset.

has been practised and it is probable that apart from the foreshore communities, little natural vegetation is present. The dunes die out at Balke, which, though an admirable site for dune formation with a wide stretch of beach and an ample supply of sand, is a tourist centre so that traffic and general human interference destroy the natural balance and dunes are no longer forming.

Vegetation is always an important factor in the development of a littoral dune belt and several features have combined to make the flora of the Bornholm dunes of special interest (*Larsen* 1955-56). Its Baltic position serves to differentiate it from the dune regions of the British Isles and even from those of the rest of Denmark for some plants, for example *Ammophila baltica* and *Calamogrostis epigea,* are only found in the Baltic region *(Warming 1914)*. Despite the differences in detail the general outline of the floral succession is similar to that found in most coastal dune areas except that frequently the succession continues right through to woodland – a feature of exceptional rarity in the British Isles. Two further factors are important in Bornholm. There is a very low intensity of inter-

ference with the dune succession from animals – rabbits, for example, are rare on Bornholm – so that those areas rarely visited by man are allowed to develop the dune series largely uninterrupted. The second factor – human influence – is noticeable both in the few small areas where man has planted as a means of stabilization and in those areas where the morphology and flora are being influenced by tourist and military activities such as Balke and Raghammer. Unrecorded seeding of the dunes may have occurred but the appearance of most of the dune forest makes this unlikely.

The edaphic factors are similar to those found on any stretch of dune coast. Pure quartz sand is sterile, and as humus formation is difficult due to the rapid decomposition and oxidization of plant material, suitable only for a limited range of plants. The loose soil has little water capacity and is on the whole slow to absorb substances nutritious to plants. The supply of salts usually obtained from the sea is limited in this case due to the low salinity of the Baltic, all of which factors tend to increase transpiration from plants other than those peculiarly adapted to this environment. The great temperature variations in this type of soil are also important but the dry surface layer hinders evaporation from the normally cool, moist subjacent sand (*Warming* 1909).

The vegetation of the area can be divided into four main sections:

1) strandline and foreshore communities,
2) foredune, white and grey dune communities,
3) dune heath communities, and
4) slack communities.

It should be remembered that the terms white and grey dunes introduced by *Warming* (1907-09), refer only to "the plant communities and not unambiguously to the geomorphology." *(Kuhlman,* op. cit.).

The foreshore communities on Bornholm are, as in most dune areas, small areas of open vegetation which frequently change position. Here however they are limited to areas where there are fragments of material other than sand, such as the shales at Slusegård. The most common plants are *Honckenya peploides, Salsola kali, Atriplex hastata, Cakile maritima,* and *Lathyrus maritimus.* In some places where the beach widens the same association is found, but at Dueodde, in addition to a layer of seaweed, largely *Fucus,* there are some more sheltered places where the flora becomes much richer

Fig. 6. Dune cliff topped by dune forest between Dueodde and Snogebæk.
Fig. 6. Klitklinter bevokset med nåleskov mellem Dueodde og Snogebæk.

and includes *Rumex crispus, Stellaria media, Ranunculus repens* and *scleratus,* and *Lycopus europaeus.* All these contribute little to the development of the dune system as they are frequently covered by water and consequently change position.

Where some of the foreshore species become more important for the process of dune formation is in the foredune associations. In some places *Cakile maritima,* and *Lathyrus maritimus* are joined by *Agropyrum junceum, Elymus maritimus, Ammophila arenaria* and *Festuca rubra.* This foredune belt is not everywhere distinct and is absent in those parts of the coast where the aspect favours erosion. The hybrid *Ammophila baltica (Ammophila arenaria* x *Calamogrostis epigeios)* is especially characteristic of this situation particularly where the dune formation occurs near a "slack" area. The community is not stable or permanent, and further accumulation of sand sees the loss of the foreshore species and the growth of the dune formers till they join and the area becomes representative of a mobile dune community. This community with some differences of a minor type also occurs where dunes are forming behind slacks.

The white dune belt is notable in having a sand surface which is still mobile while the main body of the dune is stable. The most frequent stabilizing plant is *Ammophila arenaria,* though commonly the dunes nearest the sea have less of this and more of the purely foredune vegetation. Where an older dune belt has been rejuvenated *Elymus* and *Agropyron junceum x repens* are more likely to be the commonest species. *Ammophila* depends for vigourous growth on frequent covering by sand and so in areas where the sand supply

is reduced, other species are able to establish themselves, depending mainly on the degree of shelter from the wind. On the steep, sheltered back slopes of the dunes *Calluna* is often found, with occasional *Pinus sylvestris*. On the front of these more sheltered dunes *Carex arenaria* is a common addition to the dune flora.

The transition to the fixed "grey dune" areas is often fairly abrupt and a very different association can be seen. The commonest species are *Thymus serpyllum, Hieracium umbellatum,* and *Carex arenaria* with a varied mixture of the following: – *Rhacomittrium canescens, Barbula fallas, Cladonia sylvatica, Cetraria aculeata,* and *Cladonia squamosa.* The most widespread of the truly "grey" dune is that characterized by *Cladonia sylvatica* and *Hypogamia physodes.* This type typifies the lichen grey-dune whereas the mossy grey-dune is more commonly found to have a cover of a close community dominated by *Rhacomittrium canescens.* Another type of grey dune association is the herbaceous type dominated by *Thymus serpyllum* with *Artemisia campestris* and *Carex arenaria* both frequent.

At the foot of many of the grey dune slopes facing north and northwest we find a transitional zone before the dune heath. On these *Calluna vulgaris* is dominant though open patches may occur on the grey dunes. Below and between the *Calluna* canopy are large moss cushions and carpets with *Hypnum comp. tectorum* and *Mylocamium slendens* as two of the commonest species.

Along most of the coastline there is little development of the "slack" and "dune hollow" types of vegetation, though there is evidence that they existed in the past. Only on the region near Dueodde are there active wet and wet-dry slacks. The wet slack at the point itself contained 16 species which included *Ammophila arenaria, Atriplex hastata, Carex arenaria, Juncus bufonius,* and *Rumex crispus.* Further east are some damp slacks between the parallel dune ridges though the seaward ends have been eroded away and these are being filled with sand, in the form of secondary dunes and lateral migration of existing dunes. In the remaining portions of the slack the most common species are *Polytrichum formosum, Salex repens, Betula verrucosa* and *Ammophila arenaria.* Inland from this belt are slacks which are damp and have their own flora though *Polytrichum* and *Bryum* are still common. These slacks were one of the main phases in the establishment of the alder woodland which is frequently found. The coniferous woodlands would seem to have seeded into the *Calluna* and to have developed from there. The best example of this is to be found west of Dueodde.

The Strandmarken - Dueodde area would seem to have remained fairly constant in area since the first reports of it in the late sixteenth and early seventeenth centuries though the marginal areas frequently suffered inundation by sand. For two hundred years complaints were forthcoming yet no official aid was granted for defence. By the end of the nineteenth century private farmers were forming small groups to combat the menace. About this time and probably not unconnected with it the dune area seems to have begun to vegetate rapidly in some parts. Stray seeds from the planted areas probably helped to stabilize and colonise adjacent areas. Once the process had started the vegetation of the area proceeded quickly. Further support for this, apart from that provided by the Geodætisk Institut maps, is the fact that few of the trees in the region appear to be more than 100 years old. Most of the dune area is now stable, the active dune forming belt small, and the danger to farming slight unless drastic deforestation takes place. The region still provides problems for the geomorphologist especially with respect to the orientation of the actively forming foredune belt and the precise explanation of the development of the complex at Dueodde.

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Denne historiske undersøgelse viser, at klitarealet har været nogenlunde konstant de sidste 80 år, sandsynligvis de sidste 300 år, og det ligger nær at antage, at det er de samme kræfter, der har virket i hele perioden.

Strandbredden er smal og ikke udsat for skiftende vandstande som følge af tidevand, og sandet er bemærkelsesværdigt rent, uden skaller. Den ringe tykkelse af sandlaget på den kystnære havbund og tilstedeværelsen af en stejl, submarin skråning begrænser mulighederne for tilførsel af sand herfra, det må altså fortrinsvis stamme fra materialevandringen langs kysten, i østlig retning på den sydvestlige del og i sydvestlig retning på østkysten.

Materialet bliver herved af helt forskellig karakter. Fra vest blødc aflejringer fra Rhät-Lias overlejret af moræneler, som danner kysten fra Sose Odde til Boderne, og hvis vandring understreges af Grødby Å's bøjning mod øst og af forekomsten af flager af graptolitskifer ført ud af Øle Å (fig. 2). Fra nord Neksø sandsten, som på grund af sin hårdhed næppe er nogen stor leverandør, her er tilførslen udefra vigtigere. De to retninger mødes ved Dueodde, som viser et stadigt skiftende billede af marine aflejringsformer.

Selve klitregionen begynder ved Grødby Å og bliver kun afbrudt af Slusegårdens jorder, der på grund af de underliggende graptolitskifre når næsten ud til kysten. Denne kyststrækning illustrerer de vigtigste principper for klitudvikling: isolerede embryo-klitter vokser og bevæger sig ind i land med en hastighed, der indirekte kan anslås ud fra jordstænglers skudlængde.

Et statistisk forsvarligt udvalg af forklitter viste retningen N 95° E, d.v.s. nærmest parallelt med kysten, det er altså ikke de dominerende sydvestlige vinde, men dem, der blæser langs kysten, der får „tag" i sandet. Længere inde, hvor klitterne vokser i størrelse, viser sydvest-vinden større indflydelse på deres orientering. Selve Dueodde er et komplekst klitområde bevokset dels med skov og dels med hedevegetation. Klitterne når her deres største højde, ca. 20 m, og viser samme variation i orientering (fig. 5).

På strækningen fra Dueodde til Snogebæk er aktiv klitdannelse sjælden og bevoksning helt ud til klitkanten vidner om, at erosion dominerer over opbygning. Ved Balke ser det ud som om menneskets (turisternes) indflydelse har forstyrret den naturlige balance, nye klitter bliver ikke dannet trods rigelige sandforekomster.

Den florale succession adskiller sig ikke fra andre klitområders, men den baltiske beliggenhed begunstiger arter, som ikke findes i det øvrige Danmark, f. eks. *Ammophila baltica* og *Calamagrostis epigea*. Vegetationen deles i 4 bælter: strandvegetation, forklit, klithede og mose. Denne inddeling refererer ikke til geomorfologiske forhold.

Strandmarken – Dueoddeområdet synes at have haft næsten konstant areal de sidste 300 år, selvom tilstødende landbrugsjorder ofte har lidt under sandflugt. I slutningen af det 19. århundrede begyndte bønder at udplante for at dæmpe denne trusel, siden den tid og sandsynligvis som følge heraf, har der fundet en stærk bevoksning sted af det øvrige klitområde. Det meste af arealet er nu stabilt, det aktive klitbælte er smalt, og kun fældning af skoven eller måske en voldsom turistmæssig eller militær aktivitet vil kunne medføre fare for sandflugt.

For geomorfologer er regionen af stor interesse, da både forklitternes orientering og udviklingen af det komplekse mønster ved Dueodde venter på en forklaring.

R. H. J.

The Strandmarken - Dueodde area would seem to have remained fairly constant in area since the first reports of it in the late sixteenth and early seventeenth centuries though the marginal areas frequently suffered inundation by sand. For two hundred years complaints were forthcoming yet no official aid was granted for defence. By the end of the nineteenth century private farmers were forming small groups to combat the menace. About this time and probably not unconnected with it the dune area seems to have begun to vegetate rapidly in some parts. Stray seeds from the planted areas probably helped to stabilize and colonise adjacent areas. Once the process had started the vegetation of the area proceeded quickly. Further support for this, apart from that provided by the Geodætisk Institut maps, is the fact that few of the trees in the region appear to be more than 100 years old. Most of the dune area is now stable, the active dune forming belt small, and the danger to farming slight unless drastic deforestation takes place. The region still provides problems for the geomorphologist especially with respect to the orientation of the actively forming foredune belt and the precise explanation of the development of the complex at Dueodde.

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