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ICELAND

NORWAY

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POLAND

(Chairman, Science Commission, EUCC)

DENMARK

GERMANY

NETHERLANDS

BELGIUM

GREAT BRITAIN

IRELAND

FRANCE AND THE IBERIAN PENINSULA

FRANCE

PORTUGAL

SPAIN

EASTERN MEDITERRANEAN

ITALY

YUGOSLAVIA & ALBANIA

GREECE

ROMANIA

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SAND DUNE INVENTORY OF EUROPE

ACKNOWLEDGMENTS

The European Union for Coastal Conservation (EUCC), which aims to promote coastal nature conservation across Europe, provided the driving force for the production of this inventory. Recognition of the importance of the dune environment and the devastating impact of man on its flora, fauna and physical characteristics led to sand dunes being chosen as the first of what it is hoped will be a series of similar publications for the other major coastal formations. Throughout staff of the EUCC secretariat in Leiden, the Netherlands, have provided help with the collection and collation of information. Several individuals have also prepared preliminary versions of country reports. These include Albert Salman (EUCC, Secretary General), Robert Tekke, Barbara van Agt, Veronique Loeffen and H.W.J. van Dijk. Without their help the information would be much less complete than it is.

Many people have also helped in a variety of other ways. Clearly those who have written individual country sections have played a particularly important part. Others have provided information, commented on drafts and helped identify alternative data sources and contacts. An attempt has been made throughout to acknowledge all of these, but in case any are missed out, I should like to thank everyone here.

Finance for the publication was provided by the Dutch Ministry of Agriculture, Nature Management and Fisheries, Department of Nature Conservation, Environmental Protection and Wildlife Management.

The UK Joint Nature Conservation Committee's staff have provided invaluable support, in particular Roger Bolt who handled all the administrative chores.

Finally, despite all the help which has been received, any inaccuracies in the identification of sites, particularly where they are derived from more than one information source, inexpert use of the English language, or other inconsistencies are the responsibility of the editor.

Dr Pat Doody
Peterborough, October, 1991.

INTRODUCTION

Coastlines may be split into two broad categories: those with a predominantly cliffed landform and low-lying areas where sedimentary material is moved by the action of waves or wind to create intertidal or terrestrial habitats. The erosion of the former (particularly cliffs made of soft glacial material) may provide an important source of sediment for the latter, notably saltmarshes, sand dunes and shingle beaches and structures. The type of sedimentary structure which develops depends on its physical location, the size, type and availability of sedimentary material and the way in which the material is transported.

Sand dunes develop on coastlines with an adequate supply of material within the size range 0.2-2.0mms. The critical factor is the availability of a sufficiently large beach which dries out at low tide and where sand grains can be blown onto the land by the action of the wind. In most locations in the temperate regions of the world, vegetation plays an important role in the growth of the typical dune landscape, which is so familiar to anyone visiting the "seaside", by facilitating the accumulation of sediment.

Sand dunes are built on instability and it is their natural ability to accommodate change which is one of their most important features. However man has, perhaps too frequently, viewed this instability as a threat and has sought to stop the sand movement, most notably by the planting of non-native trees. The rapid rise in tourism has put further pressure on the remaining areas of open dune landscapes both as a result of the building of hotel and other accommodation and the recreational activities themselves.

Many of these problems and others were highlighted in the first European dune conference held in Leiden, The Netherlands, in 1987. Following this conference one of the first tasks suggested by the European Union for Dune Conservation [EUDC] and Coastal Management, [now the EUCC] was to establish an inventory of coastal dunes throughout Europe.

This report, which was presented to the European Coastal Conservation Conference, held in the Netherlands in November 1991, attempts to provide an overview of the sand dune resource throughout the whole of Europe including Scandinavia, the Atlantic coast and the Mediterranean.

METHODS

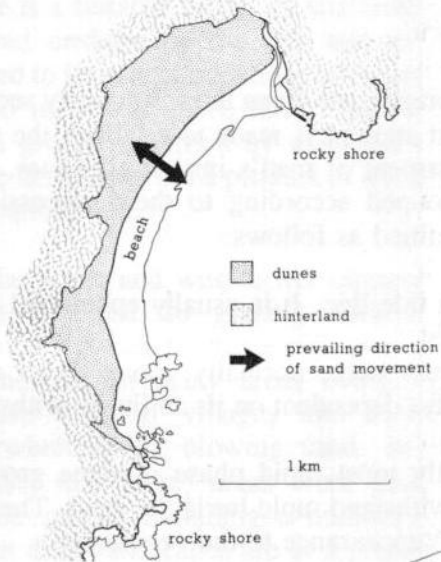
The wide ranging nature of the dune landscapes of Europe and the sometimes different perceptions within individual countries of what constituted a sand dune required a very broad definition of the type of dune encompassed within the survey. As a first stage it was decided to adopt the definitions given by Ranwell (1977). In addition in order to establish the extent of change which has taken place both in recent years and historically, it was decided to include dunes which had been modified by afforestation and the like. Wherever possible the dune distribution given for each country represents an attempt to show the maximum extent of blown sand.

The scope of the inventory required the cooperation of a wide variety of people involved in dune conservation throughout Europe. In the event it proved difficult to obtain detailed information suitable for the inventory for some countries. In these cases maps and other published information were collected and collated and used to prepare draft chapters. These were then circulated to the EUCC contact points in each country as the work was

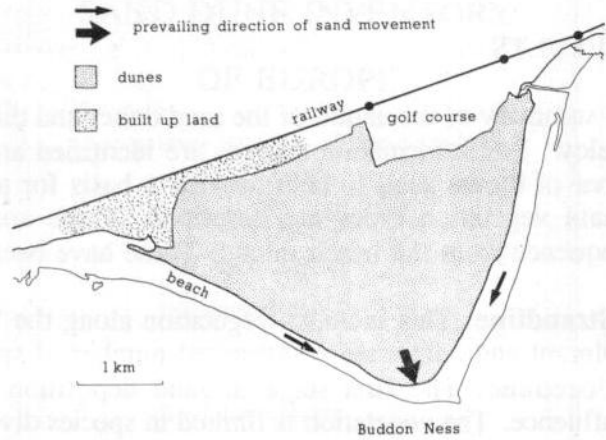
FIGURE 1 (after Ranwell, 1977)

Major types of dune systems in Great Britain [after Ranwell] 1986]

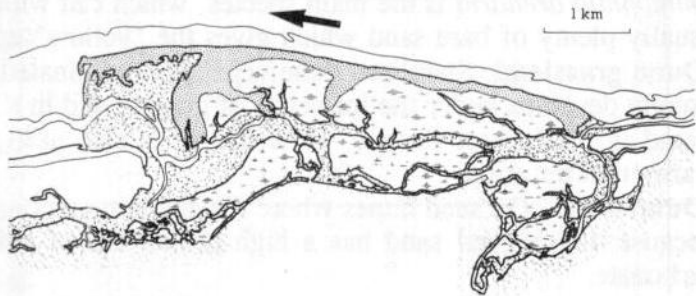
Bay Dunes : Bay of Cruden, Grampian



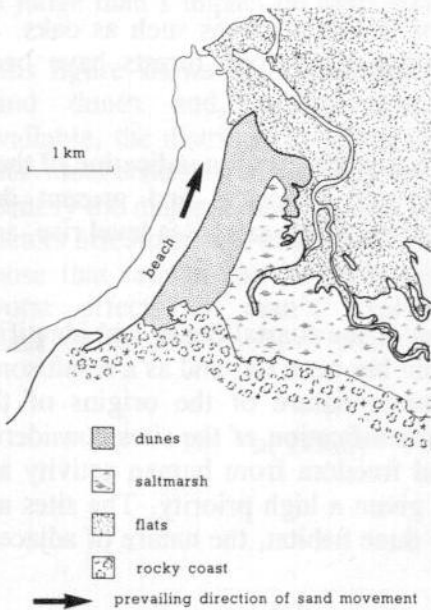
Ness / Foreland Dunes : Barry Links, Fife



Offshore Island / Barrier Dunes : Scolt Head, Norfolk

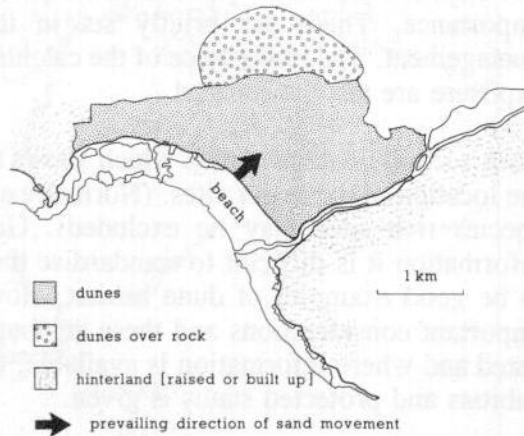


Spit Dunes : Whiteford Burrows, South Wales



- dunes
- saltmarsh
- flats
- seawall / landward transition
- ➔ prevailing direction of sand movement

Hindshore Dunes : Merthyr Mawr, South Wales



completed. Revised versions of the descriptions for each country were then produced and these are included in this report. It proved impossible to obtain comment in all cases and hence its content may be incomplete and inaccurate in some areas. Because of this it is hoped that those who read it and who have additional information will inform the editor, so that any revision can be improved.

RESULTS

A summary of the nature of the sand dunes and their origins are given in each country section below. The information sources are identified and an attempt is made to establish the total area of blown sand to help provide a basis for assessment of man's impact on dunes. The main vegetation types are described. These are grouped according to their successional sequence from the beach inland. These have been defined as follows:

Strandline. This includes vegetation along the high tide line. It is usually ephemeral, salt tolerant and composed of a limited number of species.

Foredune. The first stage in sand deposition occurs here, normally above direct tidal influence. The vegetation is limited in species diversity, dependent on its ability to withstand the influence of salt spray and trap moving sand.

Yellow dune. This represents the main and usually most rapid phase of dune growth. *Ammophila arenaria* is the main species, which can withstand rapid burial by sand. There is usually plenty of bare sand which gives the "yellow" appearance to the vegetation.

Dune grassland. Stabilised dune vegetation dominated by species of grass and herbs. This usually develops under the influence of grazing and in a moist climate. It is therefore mostly found in north west Europe. However, it is also used to describe similar communities in warmer, drier areas.

Dune heath. On sand dunes where the calcium carbonate content of the soils is low, either because the original sand has a high proportion of silica or where leaching has removed carbonate.

Scrub. Areas with low shrubs. These include woodland understorey species in the north west and the "maquis" and other similar vegetation in the Mediterranean.

Dune slacks. Vegetation which develops under the influence of high water table which may be completely flooded in winter.

Woodland. Natural forest with various pine species or deciduous trees such as oaks. In many areas natural woodland is scarce. However throughout Europe forests have been planted.

For each of these stages in dune development an attempt is made to give an indication of their importance. These are briefly set in the context of both historical and present day management. The importance of the calcium carbonate content of the sand, sea level rise, and exposure are also considered.

Each section contains a map which shows the distribution of the coastal dunes and identifies the location of the major sites. (Normally a lower size limit has been set, and as a result some species rich sites may be excluded). Given the disparate nature of the origins of the information it is difficult to standardise the criteria for identification of the sites considered to be good examples of dune habitat. However size and freedom from human activity are important considerations and these attributes have been given a high priority. The sites are listed and where information is available, the size of the dune habitat, the nature of adjacent habitats and protected status is given.

THE COASTAL DUNES OF EUROPE

Sand dunes border long stretches of the European coastline. They develop wherever there is a suitable supply of sediment which is moved onshore by the tide and then blown inland to form accumulations a few centimetres to 40 metres or more thick. Their form has been greatly modified by man and today the dune landscapes are a product of a long history of exploitation.

In the north and west a wet climate coupled with their use for grazing stock (including rabbits) has helped create rich grasslands and heathlands. In many areas overgrazing and misuse lead to villages and farms being overwhelmed by blowing sand. In order to combat this large areas were planted with exotic species including a number of pines. Open dune landscapes are at a premium.

In the Mediterranean, more recently, recreational pressures have caused the destruction of dunes with the construction of mass tourist facilities. In the process they have obliterated many of the natural landscapes which attracted the visitor in the first place.

This inventory has been produced in an attempt to provide a background against which to judge man's impact on sand dunes.

This figure shows the approximate total area sand dunes and, where information is available, the distribution of blown sand. The individual descriptions which follow attempt to identify the major sand dune sites and the main factors affecting their conservation. It is hoped those that remain can be protected from the worst effects of man's exploitation and managed for the benefit of wildlife and man.

Dr. Pat Doody



INTRODUCTION. Sand dunes in Iceland are found inland and on the coast. The inland dunes have been estimated to cover up to 200,000 ha. Inland dunes only occur in the volcanic zone which is situated across the middle of the country from south to north. Coastal dunes have been estimated to cover approximately 120,000 ha. occurring mainly on the south coast. East and west fjords are characterised by cliffs and small sand reefs.

DISTRIBUTION AND TYPE OF DUNE. Most sands in Iceland are black due to their volcanic origin. Yellow sand dunes are very scarce. Glacial rivers, retreating glaciers and volcanic eruptions constantly bring materials for the growth of new sand dunes.

VEGETATION. The flora of Iceland has only about 440 vascular plants and only a few of these are halophytic coastal species. The sand dunes of Iceland have complex associations of vegetation depending on geographical locality.

Strandline. *Cakile arctica* forms scattered colonies along the shoreline. Other species include *Honkenya peploides*, *Atriplex longipes* and *Leymus arenarius*.

Foredune. *L. arenarius* is found in association with *Mertensia maritima*, *Honkenya peploides*, *Silene maritima*, *Festuca rubra*, *Rumex acetosella* and *Potentilla anserina*.

Yellow dune. The main dune building species, *Leymus arenarius*, is usually the only plant present.

Dune grassland. Grassland develops to landward with *Festuca rubra*, *Silene maritima* and *Equisetum arvensis*. On older back dunes other grasses may also occur including *Festuca ovina* and *Poa* spp. which may occur in association with *Leymus arenarius*. Scrub including willows (*Salix* spp.) is also present in these same areas.

MAJOR SITES. Included in the list below are dune systems which are protected either by the National Conservation Council of Iceland (NCCI) or the Soil Conservation Service of Iceland (SCSI). There are many more areas protected than are listed here but only those which are important for nature conservation are given. One unprotected site is listed.

SITE NAME	SIZE(ha)	OTHER HABITAT	STATUS
1. Budir	500	Lava field	NCCI
2. Raudisandur	500	-	None
3. Saudlauks-dalur	500	-	SCSI
4. Sigridarstad-arsandur	1500	-	SCSI
5. Dimmubogir	420	Birch scrub	SCSI & NCCI
6. Heradssandur	1400	Wetland	SCSI
7. Medalland	14000	Lava field	SCSI
8. Myrdalssandur	30000	-	SCSI
9. Vik i Myrdal	532	-	SCSI
10. Landeyjar	5800	Wetland	SCSI
11. Thykkvibaer	2160	-	SCSI
12. Thorlakshofn	7550	Lava field	SCSI
13. Hlodufell-Skjaldbreidur	43100	Inland dune, glacier	SCSI
14. Haukadals-heidi	7560	Eroded soil	SCSI
15. Reykjanes-skagi	34350	Eroded, lava field	SCSI

CONSERVATION. Iceland has, and still faces, tremendous problems with soil erosion. Although some sand dunes are protected others, even those which receive a constant supply of sand, are threatened. Sand stabilisation is a constant requirement, and on the south coast has saved several successful fishing villages from being abandoned.

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INTRODUCTION. Coastal sand dunes in Norway are scattered and small. Data for the inventory has been obtained by reference to two detailed studies of the shorelines of: Finnmark (Elven & Johanson, 1983) and Troms (Fjelland, Elven & Johanson, 1983). Less information is available for the rest of the coastline, though Lundberg (EUCC contact) describes south west Norway and within this area detailed descriptions are available for the sites of Karmøy (Lundberg, 1987) and Lista (Høiland, 1978). The total area of dune is estimated at c.2,000ha. (Council of Europe, 1984).

DISTRIBUTION AND TYPE OF DUNE. The rocky nature of much of the coastline of Norway does not create favourable conditions for the development of sand dunes. However, there are a relatively large number of small sites, particularly in the north, which are associated with embayments. These "bay dunes" may develop into small "hind-shore" systems on the outer coast, though there is no information on size so far available for the inventory.

The material for the development of the dunes is largely derived from glacial moraines which have been reworked by the sea. The sand is blown on-shore, and dunes become colonised by vegetation in the normal way. Most of the dunes are prograding and only a few show erosional features. The dunes tend to have a high content of calcium carbonate and as a consequence the soil pH is relatively high.

VEGETATION. Most of the sand dunes described appear to have a sequence of vegetation types which includes all the more important successional communities from strandline (driftwalls) to yellow and grey dune, dune pasture and scrub. There appears to be an important geographical divide in species composition between north and south. In addition, in the past many were used by man as pasture for grazing animals and this had a profound influence on the type of vegetation which developed. In particular it helped to create species rich calcareous dune grassland. A brief description of each of the main successional vegetation types is given below:

Strandline. These communities are dominated by a few higher plants, prominent amongst which are several species of *Atriplex*. *Cakile maritima* is a frequent component in the south, whilst this is replaced by *Cakile arctica* and *Honkenya peploides* in the north.

Foredune. The most frequently encountered species in the south is *Elymus farctus* ssp. *boreali-atlanticus*.

Yellow dune. *Ammophila arenaria* and *Elymus arenarius* are the main dune building species. In the south west they may occur together, however *Ammophila* is absent north of Hustad.

Dune grassland. Typically under the influence of grazing by domestic stock, species rich dune grasslands develop. These include a wide variety of plants with a number of rare species. Where erosion takes place in the south *Corynephorus canescens* may become dominant, in the north *Carex maritima*.

Dune slack. Dune slacks are rare since the erosional processes that favour their development are restricted. Where they do occur, *Salix repens* is an important component. In the north *Juncus balticus* is a rare but significant species.

Dune heath. Because of the calcareous nature of most of the dunes, dune heath rarely develops. However on Lista, leaching of some of the older dunes has resulted in communities with *Empetrum nigrum* and *Calluna vulgaris*.

Scrub. There is little information but *Quercus robur* and *Corylus avellana* are recorded from Karmøy.

MAJOR SITES. The list of dune sites given below includes those which have been identified as having a "very high conservation value (++++)" in the studies for Finnmark and Troms. In south west Norway only Jærstrendene has been included, though taken together the small dunes described for Karmøy and Lista could justify inclusion.

SITE NAME	STATUS
1. Kvalnes-Komagvær	-
2. Hamningberg-Sandfjorden	-
3. Kinnarodd-Sandfjorden	-
4. Ingøya:Eidnesbukta	-
5. Sørøya:Sørsandfjorden	-
6. Torsken:Sandvika	-
7. Jærstrendene	Landscape Protection Area.

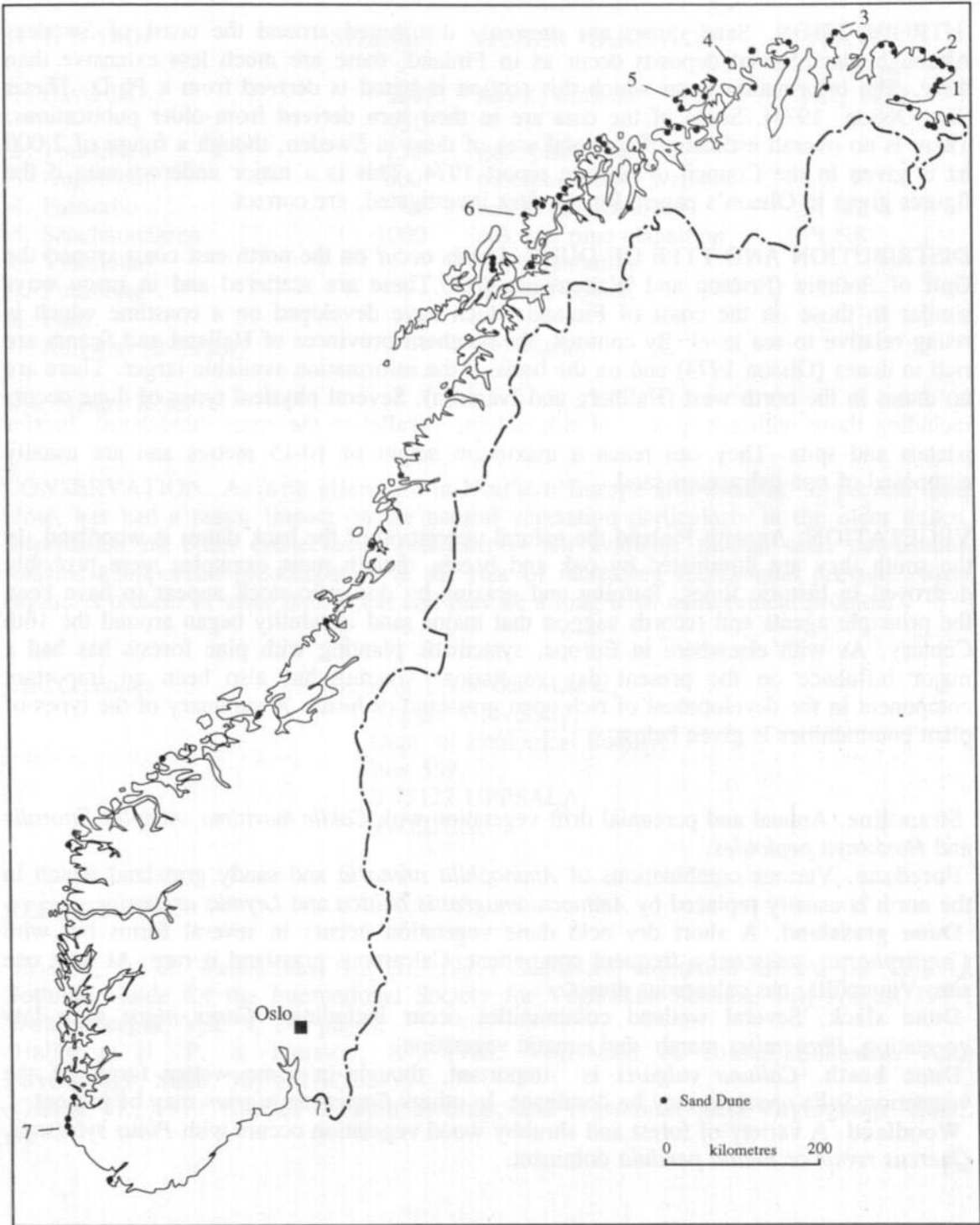
Further information on the precise significance, including size, of the sites in Norway is required before a definitive list of sites can be made. However, the seven listed above form a first assessment.

CONSERVATION. Despite the relatively low population density in Norway, sand dunes have suffered considerable destruction at man's hand. In the study of the shorelines of Troms, of 131 localities visited, over 40% were considered to have been destroyed or severely affected by human activity. Only 12% were deemed more or less undisturbed. In addition to this direct damage, the change in management practice away from pastoral uses is resulting in the growth of coarser vegetation and scrub. In Great Britain this has led to a reduction in the conservation interest of a number of sites as the species rich grassland is overgrown.

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- Jærstrendene landscape map 1977.**



INTRODUCTION. Sand dunes are unevenly distributed around the coast of Sweden. Although glaciofluvial deposits occur as in Finland, these are much less extensive than there. The information upon which this section is based is derived from a Ph.D. Thesis (See Olsson, 1974). Some of the data are in their turn derived from older publications. There is no overall estimate of the total area of dune in Sweden, though a figure of 2,000 ha is given in the Council of Europe report 1974. This is a major underestimate if the figures given in Olsson's paper, for the sites investigated, are correct.

DISTRIBUTION AND TYPE OF DUNE. Dunes occur on the north east coast around the Gulf of Bothnia (Ericson and Wallentinus, 1965). These are scattered and in many ways similar to those on the coast of Finland which have developed on a coastline which is rising relative to sea level. By contrast, the southern provinces of Halland and Scania are rich in dunes (Olsson 1974) and on the basis of the information available larger. There are no dunes in the north west (Hallberg and Ivarsson). Several physical types of dune occur, including those with a sequence of ridges lying parallel to the coast (hindshore), barrier islands and spits. They can reach a maximum height of 10-15 metres and are usually composed of non-calcareous sand.

VEGETATION. As with Finland the natural vegetation of the back dunes is woodland. In the south they are dominated by oak and beech, though most examples were probably destroyed in historic times. Burning and grazing by domestic stock appear to have been the principle agents and records suggest that major sand instability began around the 16th Century. As with elsewhere in Europe, systematic planting with pine forests has had a major influence on the present day vegetation. Grazing has also been an important component in the development of rich open grassland or heath. A summary of the types of plant communities is given below:

Strandline. Annual and perennial drift vegetation with *Cakile maritima*, *Atriplex littoralis* and *Honkenya peploides*.

Foredune. Various combinations of *Ammophila arenaria* and sandy grassland which in the north is usually replaced by *Ammocalamagrostis baltica* and *Leymus arenarius*.

Dune grassland. A short dry acid dune vegetation occurs in several forms but with *Corynephorus canescens* a frequent component. Calcareous grassland is rare. At least one site, Vittemölla, has calcareous dunes.

Dune slack. Several wetland communities occur including *Carex nigra* in a low vegetation, *Phragmites* marsh and aquatic vegetation.

Dune heath. *Calluna vulgaris* is important, though in some wetter forms of the vegetation *Salix arenaria* may be dominant. In others *Empetrum nigrum* may be present.

Woodland. A variety of forest and shrubby wood vegetation occurs with *Pinus sylvestris*, *Quercus robur* or *Betula pendula* dominant.

MAJOR SITES. The sites listed below are taken from Olsson (1974), except for Rullsand (Ericson and Wallentinus, 1979).

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
1. Haverdal	900? 350	forest, wetland	NR, 1937
2. Tonnersa	1150*	pine plantation	-
3. Angelholm	800*	pine plantation, wetland	-
4. Falsterbo	-	relict oak woodland	Pt NR
5. Sandhammaren	1000	oak and pine plantation	Pt NR
6. Vitemölla	-	pine plantation	-
7. Furuboda	-	drained lagoon	-
8. Fårö	-	-	-
9. Rullsand (Billuden)	-	<i>Hippophae</i>	-

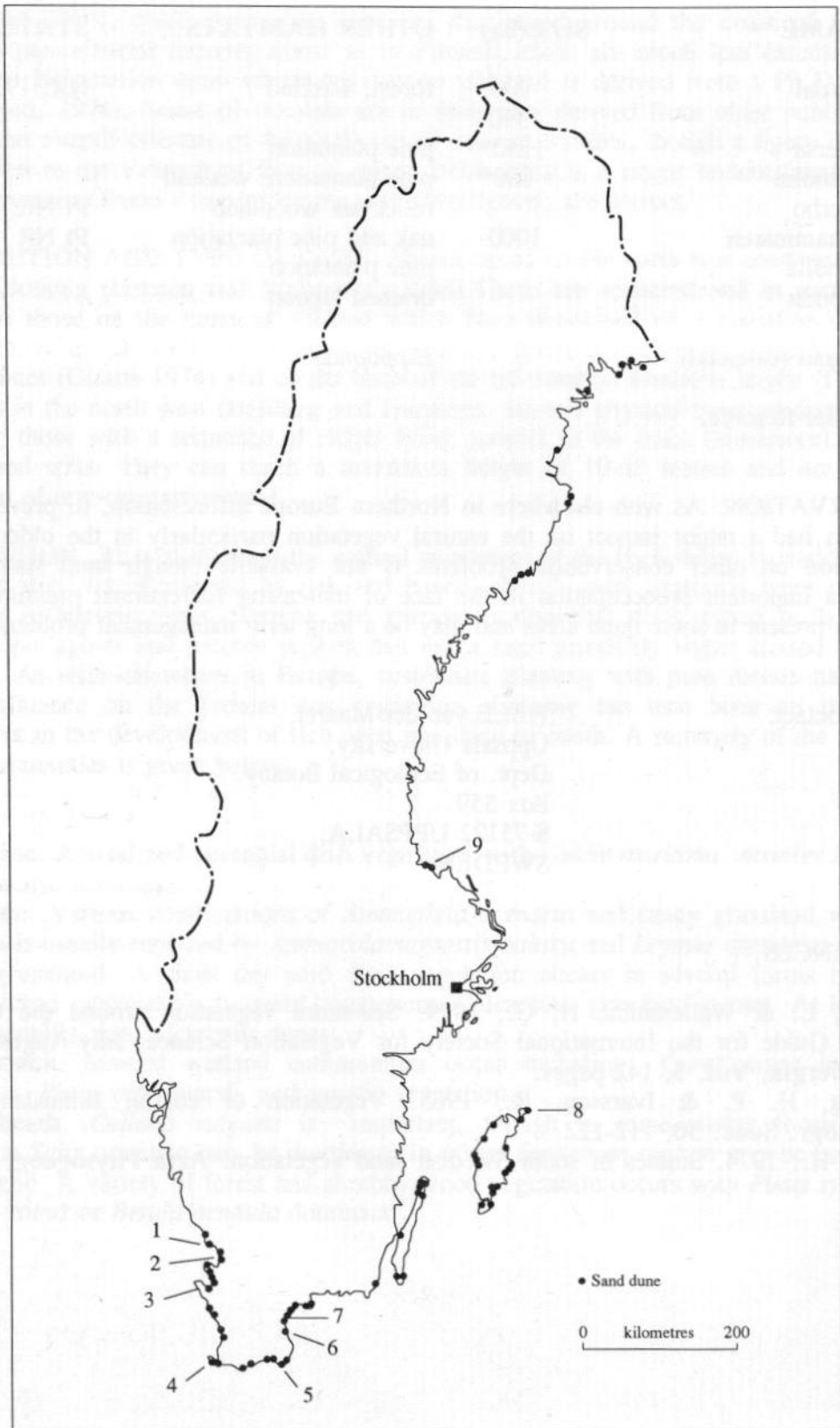
NR, Nature Reserve.

CONSERVATION. As with elsewhere in Northern Europe afforestation, to prevent sand blow, has had a major impact on the natural vegetation particularly in the older dunes. Information on other conservation problems is not available though sand stabilisation remains a important preoccupation in the face of increasing recreational pressure. *Rosa rugosa* is present in some dune areas and may be a long term management problem.

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INTRODUCTION. There are large areas of dune landscapes in Finland, mainly formed from eskers. A high proportion of these are not directly associated with the coast. These are derived from three basic situations: peri-glacial dunes; post glacial beaches, developed on a rapidly rising coastline and modern coastal dunes. All three may show aeolian activity producing typical dune forms. However, for the purpose of this inventory only those dunes of recent coastal origin have been included. There are estimated to be 1300 ha of coastal dune in Finland.

DISTRIBUTION AND TYPE OF DUNE. The modern sand dunes of Finland have formed on a coastline which is rising at a maximum rate of 9 mm. per year relative to sea level. Typically modern coastal dunes have formed only over the last 1,000 years. Prior to this, though sandy beaches developed the climate was too wet for aeolian dunes to become established. The main dune areas are situated in the Gulf of Bothnia with a few scattered and smaller sites in the south west of the country.

Because of their development on a rising coastline the dunes are generally prograding. The ridges become established as a sequence lying 'parallel' to the coast and are sometimes interspersed with damp hollows. They are never high, usually up to 8 metres, though in the south, where the rate of uplift is slower, dunes may reach 20 metres. The type of vegetation which develops is dominated by acid loving species; the calcium carbonate content of the sand is low because of the acidic nature of the bedrock.

VEGETATION. Historically, though the natural vegetation is forest, grazing helped create open dune grassland and heath. Today the absence of grazing at all sites has allowed a reversion to reed bed and woodland, with pine, birch and alder. In some areas human trampling, tourism and military activity keep beaches open, though intensive use can impoverish the flora. Where a full sequence of vegetation is present the most usual succession is outlined below:

Strandline. The upper shoreline is dominated by *Honkenya peploides* which often occurs as a carpet. *Cakile maritima* and *Lathyrus japonicus* are also frequently present.

Foredune. The main dune building species is *Leymus arenarius*, though *Ammophila arenaria* does occur in the south at one small site (Lappvik).

Dune grassland. Usually this is represented by an acid dune grassland dominated by *Deschampsia flexuosa*. *Festuca rubra* and *F. ovina* are also frequent, though in the south they are replaced by *F. polesica* and *Carex arenaria*. *Hieracium umbellatum*, *Rumex acetosella*, mosses and lichens are always present in a sparse grass cover.

Dune slack. A continuous carpet of mosses covers the sand when the ground-water table is near the surface. *Carex* spp., *Juncus* spp. and *Salix* spp. together with *Phragmites* marsh in the wetter areas.

Dune heath. *Empetrum nigrum* is the most important species though *Salix repens* can form small dunes. *Juniperus communis*, *Salix phylicifolia*, *Arctostaphylos uva-ursi*, *Juncus balticus* and sometimes *Myrica gale* may also be present.

Scrub. *Salix*, *Betula* and *Alnus* bushes are usual in dune valleys.

Woodland. Invasion by pine forest (*Pinus sylvestris*) is usual in Finland today. Prior to this, open vegetation was maintained by the grazing of domestic animals. Other species include *Prunus padus*, *Betula* spp. and *Alnus* spp. and (*Salix caprea* and *Picea abies* at Yyteri).

MAJOR SITES. The list of important sites given below includes all those coastal dunes above 50 ha. On a European scale all the sites except Vattaja are small. However Vattaja, Cape Tauvo and Yyteri can be considered to be important at least in a national context.

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
1. Vattaja	500	Woodland	MA (*)
2. Cape Tauvo	(n)180 (w) 30	Reedbeds, saltmarsh -	Pt NR -
3. Yyteri	135	Woodland	-
4. Hailuoto	120	Woodland, reedbed	(*)
5. Kalajoki	120	Woodland, scrub	-
6. Monäs	50	Woodland	(*)
7. Tulliniemi	35	-	Pt NR

NR, Nature Reserve; MA, Military Area; (*) Esker protection area, building is regulated.

The actual area of sand dune given here only includes the open beach. Each of the systems is much larger than given here, for example Kalajoki is 10,000 ha. Most of this area is covered in forest and has no connection with the present coast, because of the rapid rate of isostatic uplift.

CONSERVATION. There are two major influences on the sand dunes of Finland, firstly the direct destruction by tourist development and secondly the reduction in grazing pressure. The building of Summer cottages which is one of the major manifestations of recreational activity has adversely affected many sites.

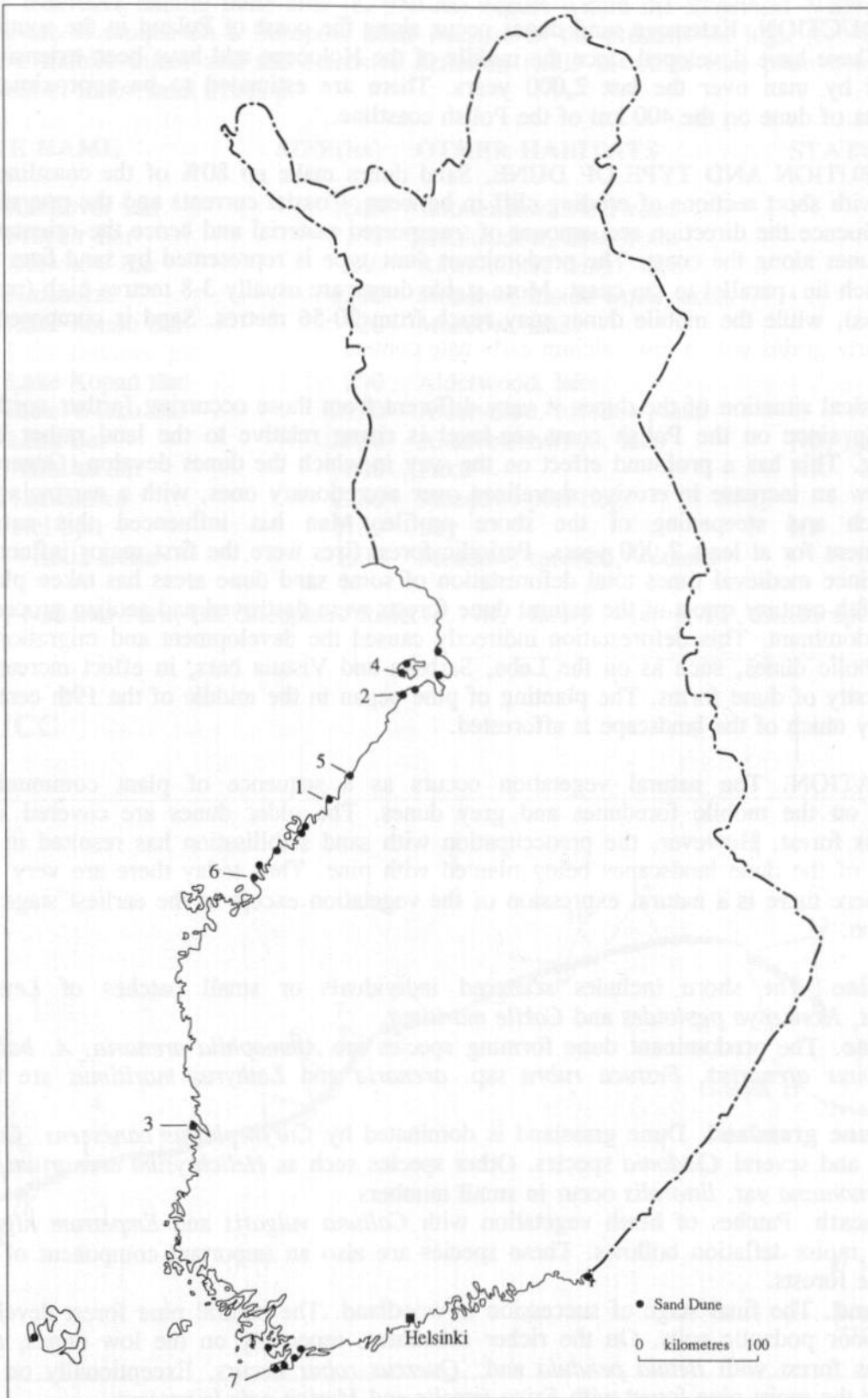
It is not clear how the re-invasion of pine is viewed, as it could be argued that it is simply taking the dunes back to a natural stage in their development, before man introduced grazing animals. However, if the experience of other countries is any guide, pine invasion is often detrimental to nature conservation as the open and richer dune vegetation is lost. *Rosa rugosa*, which can become dominant in the absence of grazing and has done so in other countries, is only considered to be a weed at one site.

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Heikkinen, O. & Tikkanen, M., 1987. The Kalajoki dune field on the west coast of Finland. *Fennia*, 165, 241-267.



INTRODUCTION. Extensive sand dunes occur along the coast of Poland in the southern Baltic. These have developed since the middle of the Holocene and have been extensively modified by man over the last 2,000 years. There are estimated to be approximately 35,000 ha of dune on the 400 km of the Polish coastline.

DISTRIBUTION AND TYPE OF DUNE. Sand dunes make up 80% of the coastline of Poland with short sections of eroding cliff in between. Coastal currents and the prevailing wind influence the direction and amount of transported material and hence the orientation of the dunes along the coast. The predominant dune type is represented by sand bars and spits which lie parallel to the coast. More stable dunes are usually 3-8 metres high (rarely 10 metres), while the mobile dunes may reach from 20-56 metres. Sand is composed of 95% quartz grains with a low calcium carbonate content.

The physical situation of the dunes is very different from those occurring further north in the Baltic since on the Polish coast sea-level is rising relative to the land rather than subsiding. This has a profound effect on the way in which the dunes develop. Generally they show an increase in erosive shorelines over accretionary ones, with a narrowing of the beach and steepening of the shore profile. Man has influenced this natural development for at least 2,000 years. Periodic forest fires were the first major influence, though since medieval times total deforestation of some sand dune areas has taken place. By the 18th century most of the natural dune forests were destroyed and aeolian processes became dominant. This deforestation indirectly caused the development and migration of the parabolic dunes, such as on the Leba, Sarbska and Vistula bars, in effect increasing the diversity of dune forms. The planting of pine began in the middle of the 19th century and today much of the landscape is afforested.

VEGETATION. The natural vegetation occurs as a sequence of plant communities growing on the mobile foredunes and grey dunes. The older dunes are covered with deciduous forest. However, the preoccupation with sand stabilisation has resulted in the majority of the dune landscapes being planted with pine. Thus today there are very few areas where there is a natural expression of the vegetation except in the earliest stages of succession.

Strandline. The shore includes scattered individuals or small patches of *Leymus arenarius*, *Honkenya peploides* and *Cakile maritima*.

Foredune. The predominant dune forming species are *Ammophila arenaria*, *A. baltica* and *Leymus arenarius*. *Festuca rubra* ssp. *arenaria* and *Lathyrus maritimus* are also common.

Acid dune grassland. Dune grassland is dominated by *Corynephorus canescens*, *Carex arenaria* and several *Cladonia* species. Other species such as *Helichrysum arenarium* and *Jasione montana* var. *littoralis* occur in small numbers.

Dune heath. Patches of heath vegetation with *Calluna vulgaris* and *Empetrum nigrum* occur in moist deflation hollows. These species are also an important component of the open pine forests.

Woodland. The final stage of succession is woodland. The natural pine forest develops on the poor podzolic soils. On the richer substrates, especially on the low dunes, acid deciduous forest with *Betula pendula* and *Quercus robur* occurs. Exceptionally on the Leba Bar the moist pine forest with *Erica tetralix* and *Myrica gale* is present.

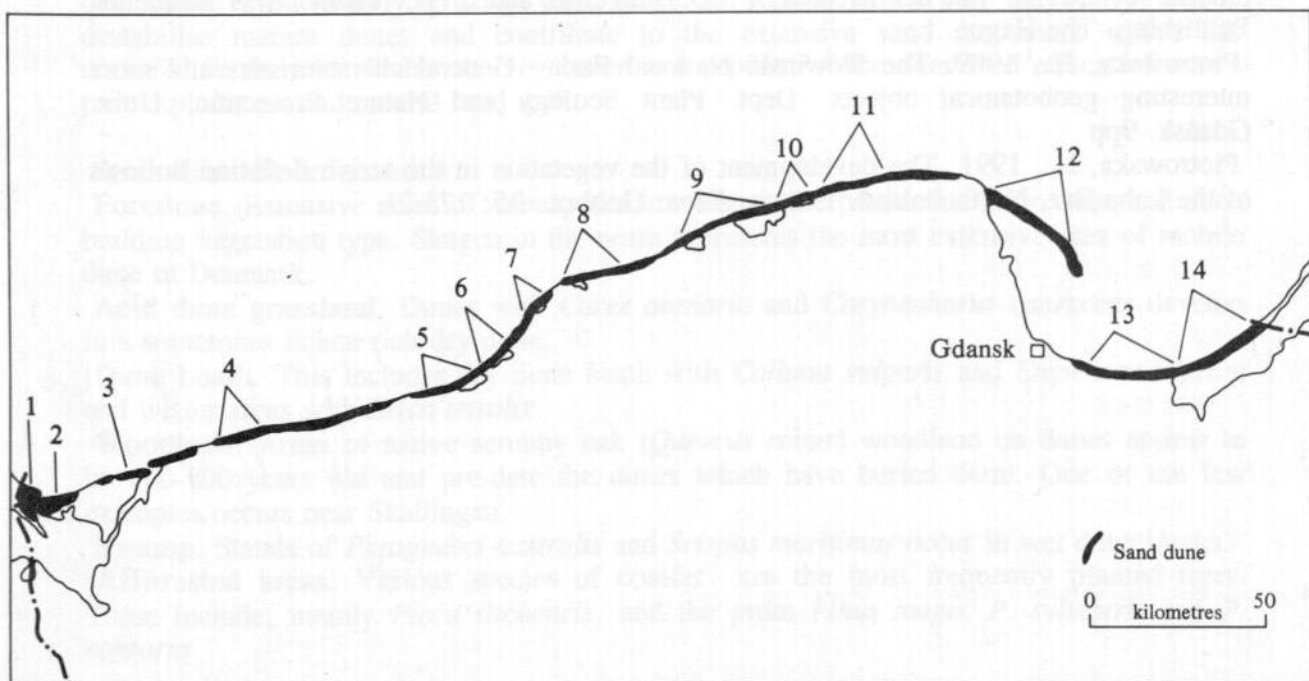
MAJOR SITES. The extent of planted pine forest has severely reduced the natural dune landscape so that today this is virtually restricted to the early stages of succession. The only extensive natural dune area (c. 950 ha) occurs within the Slowiński National Park. This site is unique on a European scale because of the presence of high (to 40 metres) active mobile dunes and the extensive deflation fields in which rare plant communities typical of moist sand develop.

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
1. Karsibvór Bar	1600	Saltmeadow, alderwood	-
2. Przytor Bar	2190	Saltmeadow, alderwood	-
3. Dziwnów Bar	380	Alder/mixed wood, lakes	-
4. Niechorze	1290	Meadow, mixed wood, lakes	-
5. Lake Jamno Bar	720	Meadow, lakes	-
6. Lake Bukowo Bar	110	Lake	-
7. Lake Kopań Bar	290	Alderwood, lake	-
8. Lake Wicko Bar	2150	Alderwood, meadow, lake	-
9. Leba Bar	3980	Alder/birchwood, lake	NP, BR
10. Sarbska Bar	640	Lake	NR
11. Lubiatowo	2580	Meadow, peat bog	-
12. Hel Spit	3130	Bay	LP
13. Vistula Delta	3500	Meadow, reedbed, wetland	-

NP, National Park; BR, Biosphere Reserve; NR, Nature Reserve; LP, Landscape Park.

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Poland



CONSERVATION. Man's activities over the last 2,000 years have had a profound effect on the dune landscapes of Poland. The erosion, which the planting of pine forests was set to overcome, has reduced the natural wooded dunes to such an extent that they represent a much impoverished nature conservation resource. Despite the massive and long term commitment to stabilisation the dunes continue to erode, suggesting that the natural erosive forces may be of overwhelming importance. In addition to the natural processes, large scale recreational pressures, especially in the foredunes, have an adverse impact on the nature conservation interest of the dunes.

Protection of the coastline is the responsibility of the Maritime Boards whose technical and biological methods of stabilisation are not always successful. Slowiński National Park is the only area in Poland where natural dune dynamics are allowed to develop without attempts to stabilise them. This area includes the Leba Bar reserve (3,532ha). Natural dunes are also partly protected on the Hel Spit and Vistula Bar Landscape Parks and on the Sarbska Bar Nature Reserve.

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- Piotrowska, H., 1989. The Slowiński National Park - General characteristics and more interesting geobotanical objects. Dept. Plant Ecology and Nature Protection, Univ. Gdańsk. 9pp
- Piotrowska, H., 1991. The development of the vegetation in the active deflation hollows of the Leba Bar, North Poland. *Fragm. Flor. Geobot.* 35: 173-21

INTRODUCTION. The western shores of Denmark are bordered by extensive dune landscapes. Dunes also occur inland and on the east coast mainland and the islands, although here they are much smaller and more widely scattered. This report only considers the coastal dunes, of which there are estimated to be 80,000 ha. Some 30,000 ha have been afforested. The data presented below are derived from a variety of published sources. The map shows the estimated total area of dune, based on Kuhlman (1969).

DISTRIBUTION AND TYPE OF DUNE. The sand dunes of Denmark are not only extensive, but also include some of the most active dune landscapes in Europe. The last big period of sand drift began about 500 years ago and in places they have moved inland by some 8-10 km. It is as a consequence of this movement and the overwhelming of villages, that a large area has been planted with pine. The dunes on the north-west coast are up to 30 metres high with a seaward facing, eroding dune front backed by extensive parabolic dunes. In the south the dunes are lower, less than 20 metres, have more stable forms, with transitions to saltmarsh.

Although large areas of dune have been artificially stabilised as a deliberate and long established policy designed to prevent the shifting sands from destroying farmland and villages a few important areas of mobile dune still survive. The dunes have developed on a coastline which is rising relative to sea-level in the north, whilst sinking in the southern part of the country by 1-2 mm per year, as a result of isostatic adjustment (Sparks and West, 1972). The calcium carbonate content of the sand is generally low and this is reflected in the predominantly acid vegetation which dominates the unafforested dune.

VEGETATION. Much of the vegetation in the unafforested dune is composed either of mobile, *Ammophila* dominated yellow dune or dune heath, with only a few areas with oak scrub. Undoubtedly grazing took place in former times and may have helped destabilise mature dunes and contribute to the extensive sand movement which has occurred in the past. Today the vegetation is a product of the combined effects of man's past exploitation and natural sand drift.

Strandline. No information.

Foredune. Extensive areas of *Ammophila arenaria* is the predominant foredune and dune building vegetation type. Skagen in the north represents the most extensive area of mobile dune in Denmark.

Acid dune grassland. Dunes with *Carex arenaria* and *Corynephorus canescens* develop in a sometimes lichen rich dry dune.

Dune heath. This includes dry dune heath with *Calluna vulgaris* and *Empetrum nigrum* and wetter areas with *Erica tetralix*.

Woodland. Areas of native scrubby oak (*Quercus robur*) woodland on dunes appear to be 400-800 years old and pre-date the dunes which have buried them. One of the few examples occurs near Skallingen.

Swamp. Stands of *Phragmites australis* and *Scirpus maritimus* occur in wet dune slacks.

Afforested areas. Various species of conifer are the most frequently planted trees. These include, mainly *Picea sitchensis*, and the pines *Pinus mugo*, *P. sylvestris* and *P. contorta*.

MAJOR SITES. The dune landscapes along the western shores of Denmark are unbroken from Skagen (Site 1) to Skallingen (Site 3), a distance of about 300 km. The dunes range from 100 m to 8-10 km wide. Four sites have been identified as being important examples of natural and semi-natural dune habitat. In the north the untamed landscape of the Skagen is obviously important. In the south, in the northern part of the Wadden Sea, Rømø has extensive dry and wet dune heath with transitions to saltmarsh. The extensive area of dunes point to the fact that there are numerous sites of importance on a European scale though not identified here.

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
1. Skagen	4000	-	NR
2. Hanstholm	6500	Cal. oligotrophic lake	NR
3. Skallingen	2300	Saltmarsh	NR
4. Rømø	8000	Saltmarsh	NR

NR, Nature Reserve. NB The areas given in the table represent the total for the whole site including saltmarshes, mud flats, lakes and other adjacent habitats.

CONSERVATION. Given the preoccupation with prevention of sand drift it is not clear if full recognition is given to the conservation importance of the more natural dune forms, other than at Skagen and Hanstholm. Past management and over-exploitation of the dune may be partly responsible for the major instability, which combined with a natural tendency for landward movement under the influence of the prevailing westerly winds, has led to considerable effort being expended on sand stabilisation. Today the use of the dunes is regulated through a special law of protection. There is no grazing and from 1935 no new summer cottages are allowed in the protected dunes. Seven state forest districts, under the National Forest and Nature Agency of the Ministry of Environment, are responsible for sand dune management. Today it is also recognised that dune areas have an intrinsic value which is often hidden by pines. Therefore regeneration projects are underway which aim to convert pine plantations into natural dune landscapes.

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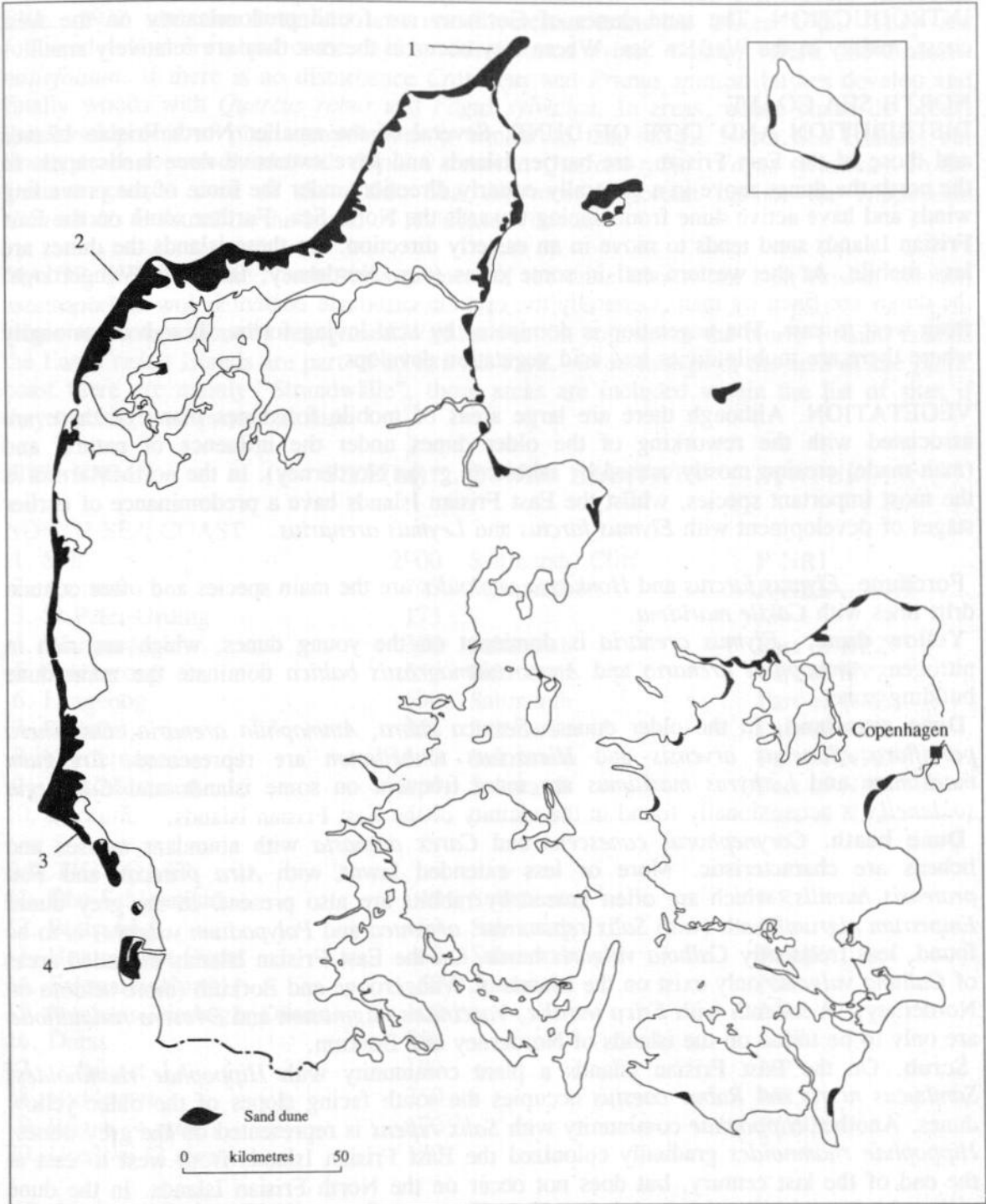
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INTRODUCTION. The sand dunes of Germany are found predominantly on the west coast, mainly in the Wadden Sea. Where they occur in the east they are relatively small.

NORTH SEA COAST

DISTRIBUTION AND TYPE OF DUNE. Several of the smaller North Frisian Islands and those of the East Frisian, are barrier islands and have extensive dune landscapes. In the north the dunes move in a generally easterly direction under the force of the prevailing winds and have active dune fronts facing towards the North Sea. Further south on the East Frisian Islands sand tends to move in an easterly direction. On these islands the dunes are less mobile. At the western end in some cases (e.g. Norderney, Baltrum, Wangerooge) the dunes are fixed by man. Generally the calcium carbonate content is low and decreases from west to east. The vegetation is dominated by acid loving forms, though occasionally where there are mobile dunes less acid vegetation develops.

VEGETATION. Although there are large areas of mobile foredunes many of these are associated with the reworking of the older dunes under the influence of natural and (man-made) erosion mostly caused by rabbits (e.g. on Norderney). In the north Marram is the most important species, whilst the East Frisian Islands have a predominance of earlier stages of development with *Elymus farctus* and *Leymus arenarius*.

Foredune. *Elymus farctus* and *Honkenya peploides* are the main species and often contain drift lines with *Cakile maritima*.

Yellow dune. *Elymus arenaria* is dominant on the young dunes, which are rich in nitrogen. *Ammophila arenaria* and *Ammocalamagrostis baltica* dominate the main dune building zone.

Dune grassland. In the older dunes *Festuca rubra*, *Ammophila arenaria*, *Oenothera parviflora*, *Sonchus arvensis* and *Hieracium umbellatum* are represented. *Eryngium maritimum* and *Lathyrus maritimus* are more frequent on some islands and *Calystegia soldanella* is occasionally found in the vicinity of the East Frisian Islands.

Dune heath. *Corynephorus canescens* and *Carex arenaria* with abundant mosses and lichens are characteristic. More or less extended lawns with *Aira praecox* and *Poa pratensis humilis*, which are often grazed by rabbits are also present. In the grey dunes *Empetrum nigrum* heath (with *Salix repens* var. *argentea* and *Polypodium vulgare*) is to be found, less frequently *Calluna vulgaris* heath. On the East Frisian Islands extended areas of *Calluna vulgaris* only exist on the islands of Wangerooge and Borkum (more seldom on Norderney). Wet heath with *Erica tetralix*, *Vaccinium uliginosum* and *Drosera rotundifolia* are only to be found on the islands of Norderney and Borkum.

Scrub. On the East Frisian Islands a plant community with *Hippophae rhamnoides*, *Sambucus nigra* and *Rubus caesius* occupies the south facing slopes of the older yellow dunes. Another *Hippophae* community with *Salix repens* is represented on the grey dunes. *Hippophae rhamnoides* gradually colonized the East Frisian Islands from west to east at the end of the last century, but does not occur on the North Frisian Islands. In the dune valleys bushes with *Betula pendula* and *B. pubescens* develop.

Afforested areas. Afforestation in general represents a much smaller proportion of the dune landscape than elsewhere in the northern part of Europe. On the different East Frisian Islands afforestation only occurs to a limited extent and can be traced back to the end of the last century. In contrast on the North Frisian Island of Amrum there is a large afforested area on dune heath east of an extended grey dune area.

BALTIC SEA COAST

Real dunes are rare on the German coast of the Baltic Sea. The sand beaches are "Strandwälle" with two more northern plant communities: the rare *Crambetum maritimae* EKL. 1932 and the *Potentillo anserinae-Elymetum arenariae* Tüxen 1966. They are followed inland by plant communities with *Festuca ovina*, *Galium verum* and *Achillea millefolium*. If there is no disturbance *Crataegus* and *Prunus spinosa* bushes develop and finally woods with *Quercus robur* and *Fagus sylvatica*. In areas, where dunes do occur, the development of plant communities is similar to that on the North Sea Islands, but finally leads to woodland (with *Populus tremula*, *Quercus robur*, *Fagus sylvatica*). In the German coastal area of the Baltic Sea the most important habitat for *Hippophae rhamnoides* is found on the island of Hiddensee (Bessin).

MAJOR SITES. In the North Sea area most of the dune islands (all East Frisian Islands) are important and lie within two National Parks which themselves form part of the much larger and internationally recognised Wadden Sea. In contrast to the North Frisian Islands the East Frisian Islands are part of a National Park. Even though in the area of the Baltic coast there are mainly "Strandwälle", those areas are included within the list of sites if they are larger or protected sites.

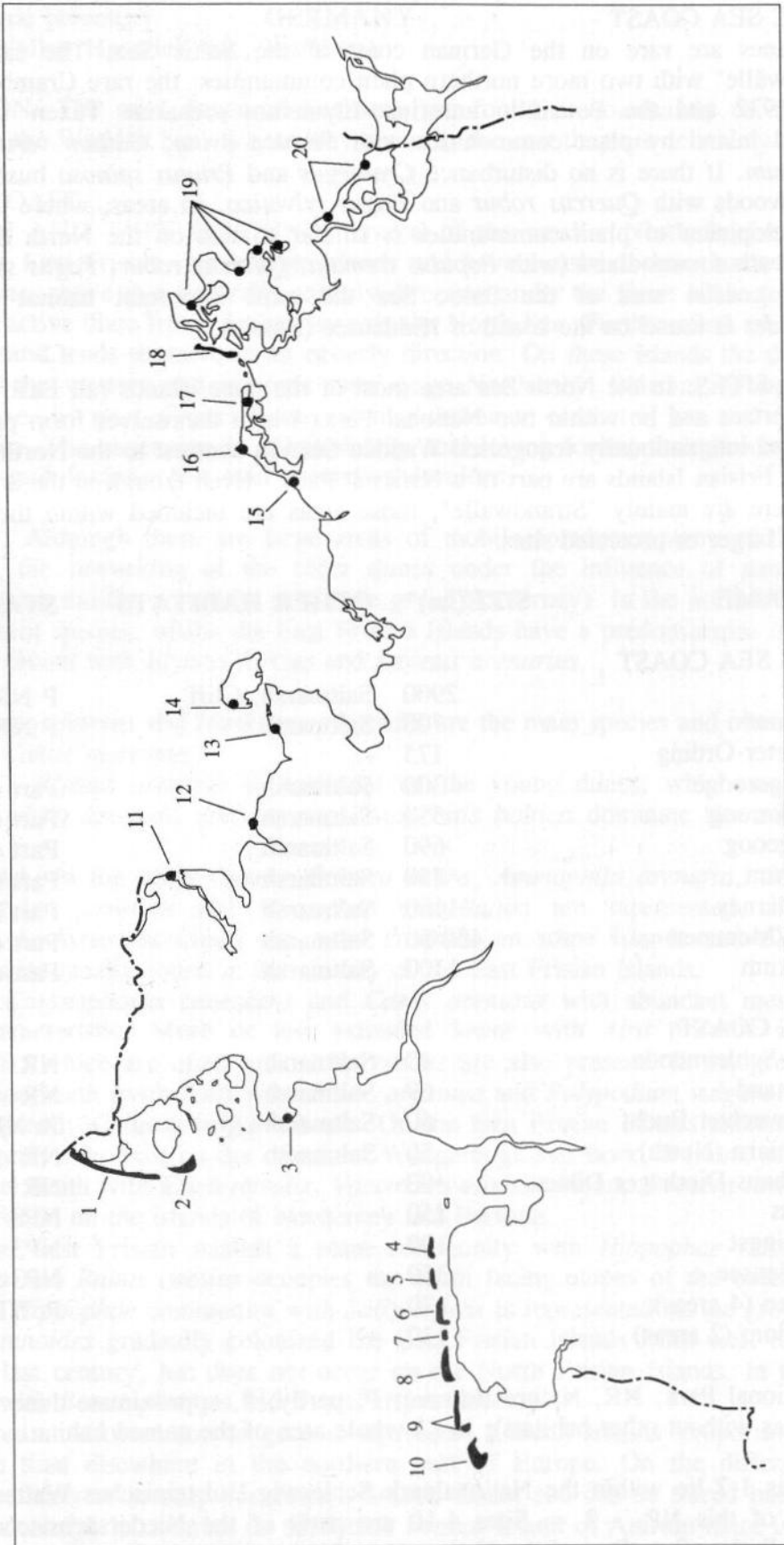
SITE NAME	SIZE(ha)*	OTHER HABITATS	STATUS
NORTH SEA COAST			
1. Sylt	2900	Saltmarsh, Cliff	P NR1
2. Amrum	700	Saltmarsh	P NR1
3. St. Peter-Ording	175	-	-
4. Wangerooge	300	Saltmarsh	Part of NP2
5. Spiekeroog	550	Saltmarsh	Part of NP2
6. Langeoog	690	Saltmarsh	Part of NP2
7. Baltrum	250	Saltmarsh	Part of NP2
8. Norderney	1130	Saltmarsh	Part of NP2
9. Juist/Memmert	450/50	Saltmarsh	Part of NP2
10. Borkum	1100	Saltmarsh	Part of NP2
BALTIC COAST			
11. Öhe-Schleimünde	40	Saltmarsh	NR
12. Bottsand	69	Saltmarsh	NR
13. Hohwachter Bucht	60	Saltmarsh	Pt NR
14. Fehmarn (North)	50	Saltmarsh	NR
15. Neuhaus-Dierhäger Dünen	100	-	NR
16. Darss	250	-	NP3
17. Ostzingst	100	-	NP3
18. Hiddensee	350	-	NP3
19. Rügen (4 areas)	170	-	Pt NR
20. Usedom (2 areas)	130	-	-

NP, National Park; NR, Nature Reserve; P, partly; *, approximate dune area (as a rule dune areas without other habitats); In () whole area of the named habitat

1 = Sites 1,2 lie within the Nationalpark Schleswig-Holsteinisches Wattenmeer; but are not part of this NP. - 2 = Sites 4-10 are parts of the Niedersächsisches Wattenmeer National Park. - 3 = Part of the Nationalpark Vorpommersche Boddenlandschaft.

Germany

EUCC



Further small dune areas exist on about 10 small North Sea islands (e.g. the islands of Trischen, Scharhörn, Mellum, Lütje Hörn, Helgoland Düne).

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INTRODUCTION. Over 250 km of the 350 km coastline of the Netherlands is composed of sand dunes. The first dune systems (now called the Older Dunes) were formed between 5000 and 3000 B.P., on a vast and broad series of sandbanks lying parallel to the coast, broken only by beach plains and river mouths. This barrier system has been partly eroded by the sea and partly covered with the much higher but narrower Younger Dunes, during the period from 1100 to 1600 A.D. Much of the Older Dunes have been excavated and levelled on their landward side since 1600, and only 8,000 ha remain. The Younger Dunes amount to approximately 40,000 ha in total. There are in addition major sandbanks, both in the north and in the southwest.

DISTRIBUTION AND TYPE OF DUNE. Because of the geological and geomorphological processes, a Wadden coast, a mainland coast and an estuarine coast can be distinguished with their specific dune types and forms. Both the Wadden coast in the north and the estuarine coast in the southwest are characterized by the highly dynamic nature of the coastal processes in the nearshore zone, which results in rapid erosion and accretion. On the seaward side of the estuarine coast there are extensive systems of sandbanks (now known as the Voordelta), and several large sandbanks can also be found in the Wadden Sea area. The mainland coast is more stable, although erosion prevails on most places.

Many different geomorphological processes can be seen in the Younger Dune areas, resulting in dune forms such as partly and fully enclosed beach plains, tidal inlets ("sluifers"), blowouts, dune slacks and lakes, parabolic dunes, comb dunes, dune fields, secondary barchans and "kopjesdunes". In some places artificial sand-drift dykes were built to enhance coastal protection. The calcium carbonate content of the primary sand varies from 0.1 up to 10%. Originally, more than 30% of the dune area was composed of wet dune slacks and lakes, though this is much less now. In most of the areas, dunes reach between 15 and 25 m, the maximum height being 43 m.

VEGETATION. The Younger Dunes have been artificially stabilised since the 19th century because of their important coastal defence function. While blowouts have become rare, the variety of plant life has increased and now includes 900 plant species. In many of the areas a complex zonation can be seen, which can be summarised as follows for the dune systems south of Bergen (province of North Holland):

Strandline. Vegetation is scarce here. *Elymus farctus* and *Honkenya peploides* occur as pioneers, followed by *Ammophila arenaria* and *Cakile maritima*.

Foredune. Almost everywhere the foredunes have become artificially moulded, and the high ridges include *Ammophila*, *Cakile*, *Leymus arenarius*, *Festuca rubra (arenaria)*, *Sonchus arvensis (maritimus)* and *Calystegia soldanella*.

Dune grassland. This zone is very complex and the vegetation differs according to the degree of exposure to the sun. South facing slopes include many therophytes such as *Saxifraga tridactylites*, *Myosotis ramosissima* and biennial species, including *Senecio jacobaea*, *Echium vulgare*, *Cynoglossum vulgare*, *Anchusa officinalis*, *Verbascum phlomoides* and *V. thapsus*. *Hippophae* often occurs here. The north facing slopes include low shrubs of *Salix repens* and *Ligustrum vulgare* and species such as *Polypodium vulgare*, *Botrychium lunaria*, *Silene nutans* and *Anthyllis vulneraria*. In several areas the vegetation is dominated by *Rosa pimpinellifolia*.

Dune slack. These include both former beach plains and blowout valleys. These are extremely rich in species, including *Gentianella amarella*, *G. campestris*, *Gymnadenia conopsea*, *Epipactis palustris*, *Liparis loeselii*, *Anagallis tenella*, *Parnassia palustris* and *Sagina nodosa*. *Salix repens* has invaded most of the slack vegetation, in some places resulting in high scrub and woodland with *Salix cinerea*, *Alnus glutinosa* and *Betula alba*. Deeper slacks have been invaded by *Phragmites*, *Typha latifolia*, *T. angustifolia* and several *Carex* spp.

Dune heath. These zones show the oldest of the dune soils with lower pH-values and may have transition zones to older dune systems. The vegetation includes *Teesdalia nudicaulis*, *Corynephorus canescens* and *Calluna vulgaris* and many lichens.

Scrub. Nitrophilous areas include *Sambucus nigra* which often borders the landward side of the first dune ridges, sometimes with *Claytonia perfoliata*. A mixed scrub and grassland zone also exists which consists of a complex mixture of patches of low scrub with *Ligustrum vulgare* and *Hippophae rhamnoides* and grasslands with *Calamagrostis epigejos*, *Festuca rubra* and *Carex arenaria*. *Rubus caesius* often occurs in abundance.

Tidal inlets and recent former beach plains. Tidal inlets only occur in four places, the main one being the Slufter on the island of Texel. Vegetation on former beach plains is similar to salt marsh vegetation and includes halophytes like *Glaux maritima*.

Woodland. The vegetation of this zone is mostly dominated by *Crataegus monogyna* and *Quercus robur*, and bordered by high scrubs such as *Euonymus europaeus* and *Rosa canina*. Several *Populus* spp. have been introduced as well as extensive pine plantations. The woodland zone also includes the remaining and mostly afforested older dune systems, where many estates can be found with planted forests.

The dune systems north of Bergen (N.H.) are relatively poor in calcium carbonate and climatic circumstances are less favourable to tall scrub and trees. This results in a number of differences in the vegetation. *Hippophae* and many other species of calcareous soils are less frequent and are replaced by extensive heath vegetation dominated by *Calluna vulgaris*, *Empetrum nigrum* and *Erica tetralix*. Species such as *Corynephorus canescens*, *Drosera rotundifolia* and *Eriophorum angustifolium* are more frequent here.

MAJOR SITES. The sites listed below are those of over 100 ha, summarized from information collected by Stichting Duinbehoud in 1990:

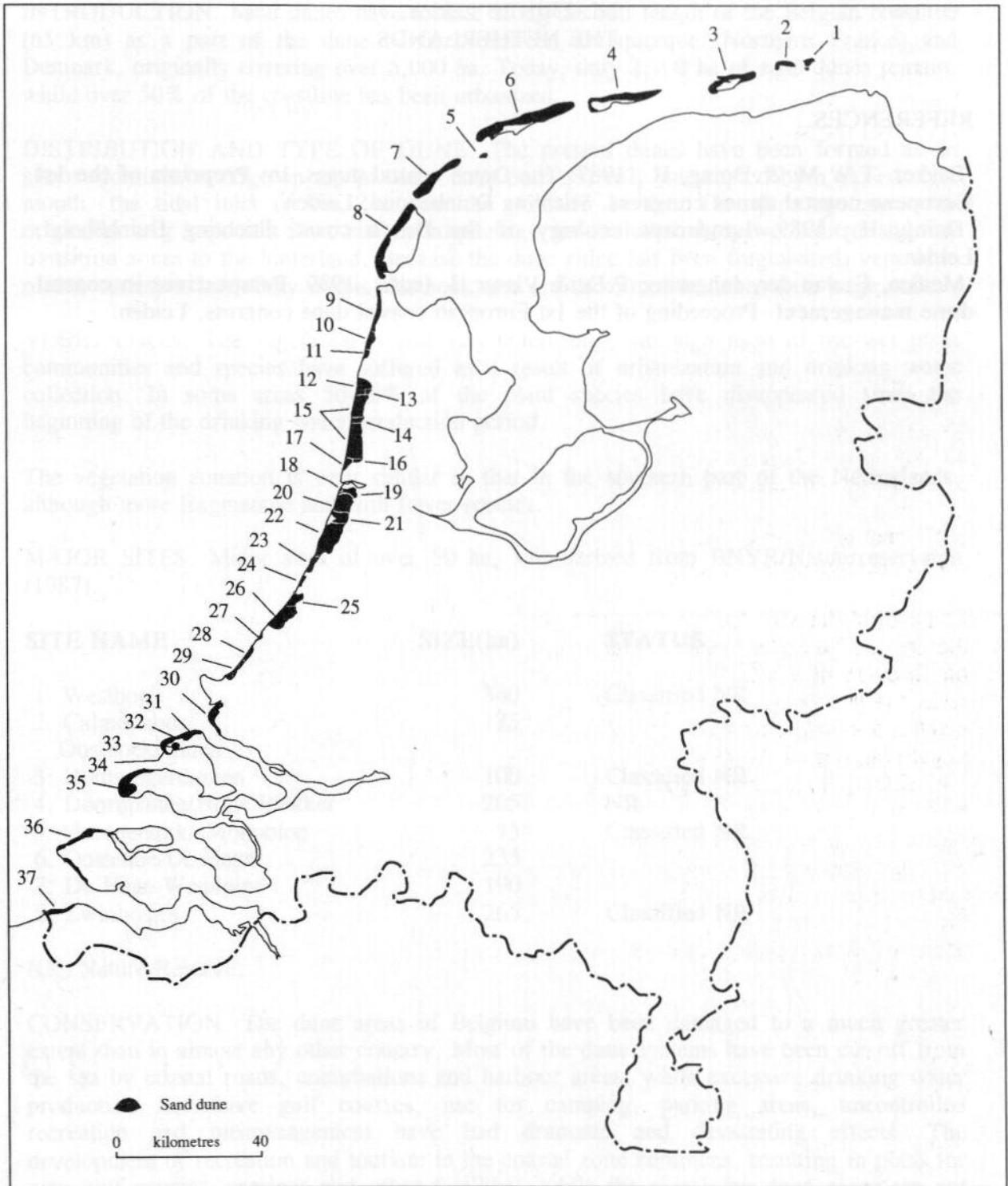
SITE NAME	SIZE (ha)	STATUS
1. Rottumeroog	250	NR (**)
2. Rottumerplaat	600	NR (**)
3. Schiermonnikoog dunes	2500	Pt. NP
4. Ameland dunes	2325	-
5. Griend	100	Bird reserve (*)
6. Terschelling dunes (incl. Bosplaat)	9441	Pt. NR (Bosplaat) (**)
7. Vlieland dunes	1485	-
8. Texel dunes	3792	-
9. Grafelijkheidsduinen/Donkere duinen	365	-
10. Zwanenwater	573	NR (*)
11. Pettemer duinen	310	-
12. Schoorlse duinen	2000	-
13. Bergerbos	150	-
14. Duinen van Six	300	-
15. Noordhollands Duinres.	4800	-

16. Heemskerkerduin	200	-
17. Westerhout	200	-
18. Velsen dunes	114	-
19. Duin en Kruidberg/Herenduin	860	NR (*), Pt NP
20. Kennemerduinen	1240	Pt NP
21. Bloemendaal-Zandvoort	1222	Pt NR (**)
22. Dunes Zandvoort-Langeveld	3500	Pt NR (**)
23. Dunes Noordwijk	750	Pt NR (**)
24. Coepelduinen	150	Pt NR (**)
25. Berkheide	993	Pt NR (**)
26. Meijndel	1950	Pt NR (**)
27. Westduinen, The Hague	230	Pt NR (**)
28. Solleveld/Ockenrode	320	Pt NR (**)
29. Kapittelduinen	280	-
30. Dunes of Voorne	1300	Pt NR (*)
31. Kwade Hoek	350	NR (*)
32. Middel- and Oostduinen	245	-
33. Westduinen, Goeree	156	NR (*)
34. Punt and outer dunes Goeree	293	-
35. Dunes of Schouwen	2500	NR (**)
36. Manteling/Oranjezon	517	NR (**)
37. Verdrongen Zwarte Polder/Zwin	200	NR

NR, Nature reserve; NP, National Park; (*) owned by non-governmental nature conservation organization; (**) protected by the Dutch Nature Conservation Act.

CONSERVATION. There are many major problems associated with the conservation of the dunes of the Netherlands. The large scale disappearance of wet dune environments in the first half of this century has occurred as a result of drinking water production. In some areas the ground water table has dropped several metres. The abundance of hundreds of plant and animal species has diminished and many of them have disappeared completely. Local pollution of the ground water, as a result of artificial infiltration of river water (also for drinking water supply purposes) has caused damage to the ecological quality of dune lakes and adjacent slacks as a result of a massive increase in nutrients. Development of dense, competitive grass vegetation (dominated by *Calamagrostis* and others) as a result of acid rain has also adversely affected dune vegetation. Extensive plantations of various (exotic) pine and fir species lower the water table even further and dramatically change the species composition of the vegetation. Increasing recreational pressure, including the use of off-road vehicles, causes further damage.

Water supply companies have tried to improve the situation by careful research and management, by reduction of dune water extraction and by changes to the extraction process. In addition mobility is seen as less of a problem than formerly. In 1983 the Dutch government gave the entire dune area the primary function of nature conservation. Since 1977 the Institute for Dune Conservation (Stichting Duinbehoud, funded by the Ministry of Agriculture, Nature management and Fisheries) has played a significant role in conservation and management issues.



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INTRODUCTION. Sand dunes have formed along the full length of the Belgian coastline (65 km) as a part of the dune barriers between Dunquerque (Northern France) and Denmark, originally covering over 5,000 ha. Today, only 2,700 ha of sand dunes remain, while over 50% of the coastline has been urbanized.

DISTRIBUTION AND TYPE OF DUNE. The present dunes have been formed as an almost continuous ridge on top of older dune barriers, only interrupted by a closed river mouth, the tidal inlet of the Zwin on the northern border. The dune systems were originally very important for their geomorphology and included many wet valleys and low transition zones to the hinterland. Because the dune ridge has been fragmented, very little of this variety is left. Only in the Westhoek area are there mobile dunes on a large scale.

VEGETATION. The vegetation is still very interesting, although most of the wet plant communities and species have suffered as a result of urbanization and drinking water collection. In some areas 50-60% of the plant species have disappeared since the beginning of the drinking water production period.

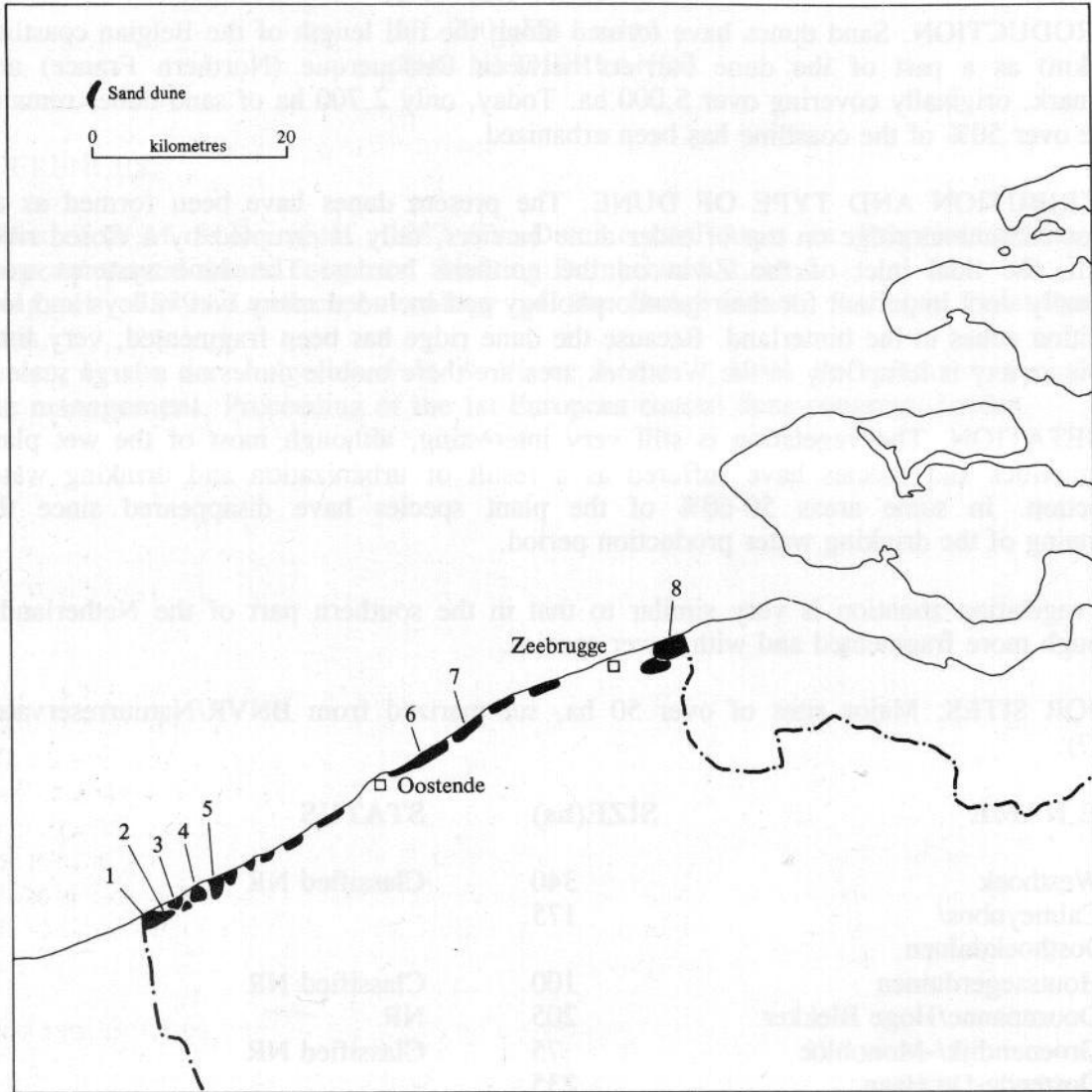
The vegetation zonation is very similar to that in the southern part of the Netherlands, although more fragmented and with fewer species.

MAJOR SITES. Major sites of over 50 ha, summarized from BNVR/Natuurreservaten (1987).

SITE NAME	SIZE(ha)	STATUS
1. Westhoek	340	Classified NR
2. Calmeynbos/ Oosthoekduinen	175	-
3. Houtsaegerduinen	100	Classified NR
4. Doornpanne/Hoge Blekker	205	NR
5. Groenendijk/-Monobloc	75	Classified NR
6. Oostende-De Haan	235	-
7. De Haan-Wenduine	190	-
8. Zwinbosjes	265	Classified NR

NR, Nature Reserve.

CONSERVATION. The dune areas of Belgium have been damaged to a much greater extent than in almost any other country. Most of the dune systems have been cut off from the sea by coastal roads, conurbations and harbour areas, while excessive drinking water production, extensive golf courses, use for camping, parking areas, uncontrolled recreation and mismanagement have had dramatic and devastating effects. The development of recreation and tourism in the coastal zone continues, resulting in plans for new golf courses, marinas and other facilities, while the remaining dune areas are not sufficiently protected. However, the recent Flanders' Environment and Nature policy (MINA-plan) promises more positive measures in the future. A very recent threat is the proposal by drinking water companies to create artificial infiltration areas. Such plans will result in very negative impacts on dune hydrology and ecology. (See the Netherlands).



INTRODUCTION. The sand dunes in Great Britain are found extensively around the whole coastline, though sites are fewer in number in the south east. Information is available on both the distribution and size of the resource and for many sites a detailed vegetation map is available. The information on the distribution of dunes is derived from inspection of 1:50000 Ordnance Survey maps together with additional more detailed survey information where available. There are approximately 56,000 ha of blown sand deposits, including areas which have been afforested or otherwise affected by human use which has not totally destroyed the dune land form.

DISTRIBUTION AND TYPE OF DUNE. The dune sites in Great Britain include examples of all the major types of dune. In the north west, particularly where the prevailing westerly winds are reinforced by dominant winds, large hindshore systems have developed. In the Outer Hebrides these include some of the best and largest examples of the extensive cultivated sandy plain or "machair" also present in the west of Ireland. On the east coast where predominant and prevailing winds are in opposition, landward movement is less obvious and spits, barrier islands and bay dunes are more frequent. The majority of dunes have a relatively high calcium carbonate content in the dune sand and dune heath is confined to a few scattered locations.

VEGETATION. Dunes in Great Britain have a long history of exploitation by man, notably for grazing by domestic stock or as rabbit warrens. As a consequence the vegetation which has developed is dominated by grassland or heathland depending on the original calcium carbonate content of the sand. There is virtually no native woodland and that which does exist is thought to be secondary in nature, resulting from a reduction or removal grazing animals. The water table can be high and species rich dune slacks are often present. Destabilisation brought about by recreational use can cause reworking of the sediment to form earlier stages in succession within the main part of the dune. Each of the major plant communities is outlined below:

Strandline. Typically this includes species of *Atriplex*, *Cakile maritima* and *Salsola kali*. Examples are scattered around the whole coastline in appropriate locations. In some areas sandy beaches occur in association with shingle and a number of rare plants may be present including the northern *Mertensia maritima* or in the south east, *Lathyrus japonicus*.

Foredune. The dominant dune forming species in Great Britain is *Ammophila arenaria*, though in the north *Leymus arenarius* may be equally important. *Elymus farctus* is also a frequent component of the early stages of colonisation particularly where salt spray reaches the upper parts of the beach.

Yellow dune. Although *Ammophila* is usually dominant, as the dunes become more stable, there are an increasing number of both annuals and perennials in the vegetation. In the south *Calystegia soldanella* and *Eryngium maritimum* are often present.

Dune grassland. As a more stable form of dune develops, marram becomes less frequent and under domestic grazing regimes, calcareous grassland is the normal vegetation. This may be rich in species and often includes plants typically found in inland areas. These may include, in the south, *Anacamptis pyramidalis* amongst several other orchid species and in the north, *Primula scotica*, *Dryas octopetala* and *Juniperus communis*.

Slack. Dune slacks are found on many dunes and are often rich in species, particularly when associated with calcareous dunes. Species include a number of rarities such as *Liparis loeselii*.

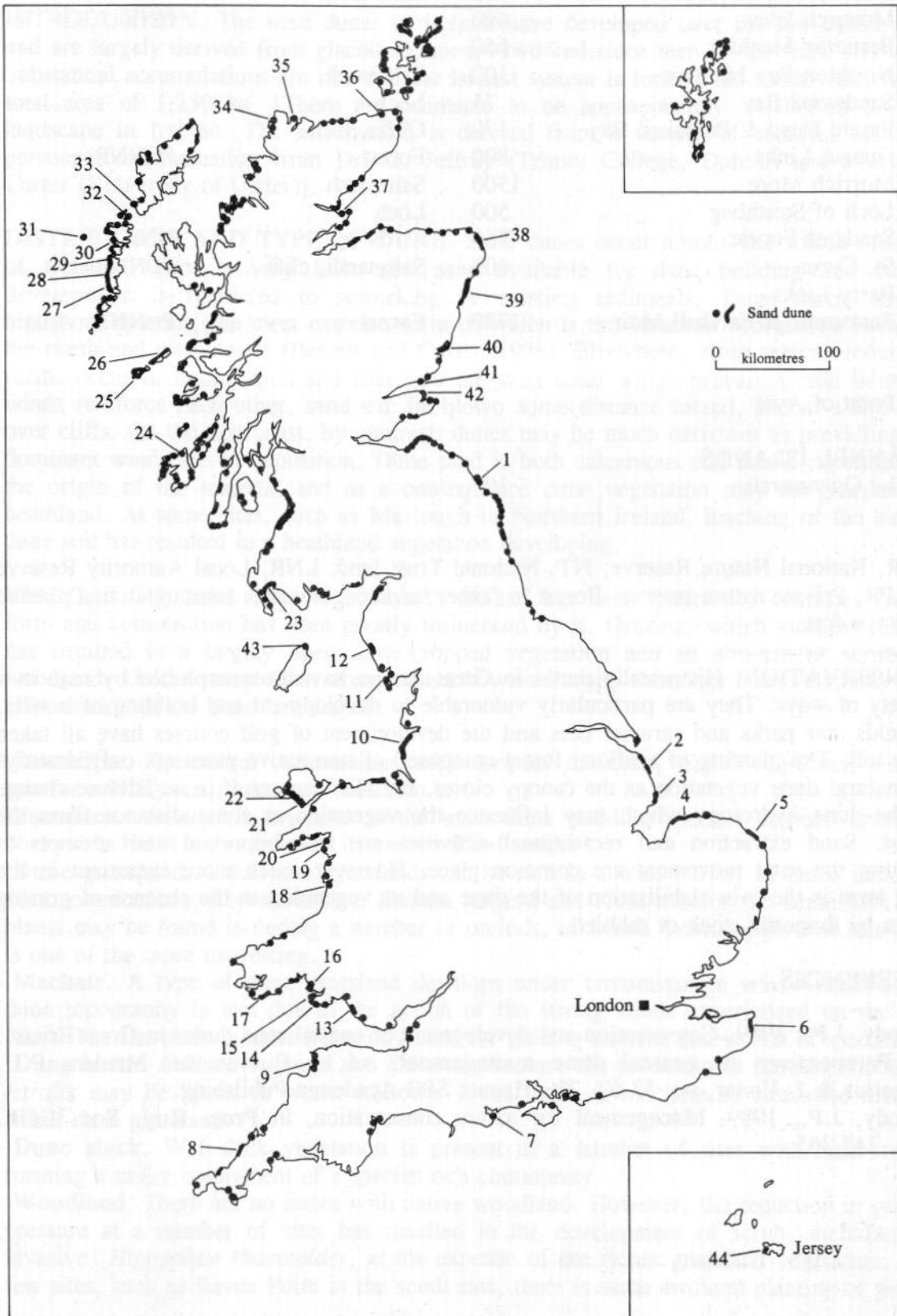
Dune heath. This community is dominated by *Calluna vulgaris*, which may be accompanied by *Erica cinerea* and *Empetrum nigrum* particularly in the north. In the wetter dune hollows *Erica tetralix* can be dominant.

Scrub. Most forms of scrub represent retrogressive succession and include *Hippophae rhamnoides* which is only thought to be native in south east England. Elsewhere it has often been introduced to prevent erosion and has become a dominant on some sites.

Woodland. There are no examples of primary woodland. *Betula pendula* can form secondary woodland and scrub in the absence of grazing.

MAJOR SITES. There are approximately 120 sites identified as Sites of Special Scientific Interest protected under the Wildlife and Countryside Act 1981. The sites listed in the table below and shown in the figure are all over 50 ha and considered to be of national importance as examples of dune habitat.

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
ENGLAND			
1. Lindisfarne	554	Saltmarsh	Pt.NNR
2. Saltfleetby	367	Saltmarsh	NNR
3. Gibraltar Point	279	Saltmarsh	NNR
4. North Norfolk Coast	700	Saltmarsh, shingle	NNR, NT, PR
5. Winterton	300	-	Pt.NNR
6. Sandwich & Pegwell Bay	480	Saltmarsh	-
7. Studland Heath	204	-	NNR
8. Penhale	542	-	-
9. Braunton Burrows	880	Saltmarsh	NNR
10. Sefton Coast	2109	Saltmarsh, forest	Pt.NNR, NT,
11. North Walney & Sandscale	340	Saltmarsh	Pt.NNR, NT
12. Drigg Point	344	-	LNR
WALES			
13. Kenfig	480	-	NNR
14. Oxwich	100	-	NNR
15. Whiteford Burrows	150	Saltmarsh	NNR, NT
16. Tywyn Gwendraeth	1700	Saltmarsh, forest	-
17. Stackpole Warren	150	Cliff	NNR
18. Ynyslas	125	-	NNR
19. Morfa Dyffryn	300	-	NNR
20. Morfa Harlech	450	Saltmarsh	NNR
21. Newborough Warren	525	Forest	NNR
22. Tywyn Aberffraw	250	-	-
SCOTLAND			
23. Torrs Warren	770	-	-
24. Killinallan	250	-	-
25. Hough Bay & Ballavullin Machair	250	Wetland	-
26. Crossapol & Gunna Machair	200	-	-
27. South Uist Machair	400	Wetland	-



28. Howmore Estuary Machair	900	Wetland	-
29. Loch Bee Machair	850	Loch	-
30. Baleshare & Kirkibost Machair	350	Saltmarsh	-
31. Monarch Isles	400	-	NNR
32. Berneray Machair	650	-	-
33. Northton Bay Machair	100	Saltmarsh	-
34. Sandwood Bay	75	Loch	-
35. Faraid Head & Balnakeil Bay	170	Cliffs, loch	-
36. Dunnet Links	800	Forest	Pt.NNR
37. Morrich More	1500	Saltmarsh	-
38. Loch of Strathbeg	500	Loch	-
39. Sands of Forvie	750	Cliffs	NNR
40. St. Cyrus	400	Saltmarsh, cliff	Pt.NNR
41. Barry Links	-	-	-
42. Tentsmuir & Earshall Muir	1780	Forest	Pt.NNR

ISLE OF MAN

43. Point of Ayre	-	-	-
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CHANNEL ISLANDS

44. Le Quennevais	100	-	-
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NNR, National Nature Reserve; NT, National Trust land; LNR, Local Authority Reserve and PR, Private nature reserve. Forest in "other habitats" indicates substantial area planted with conifers.

CONSERVATION. Historically dunes in Great Britain have been exploited by man in a variety of ways. They are particularly vulnerable to development and building of houses, airfields, car parks and caravan sites and the development of golf courses have all taken their toll. The planting of artificial forest composed of non-native pines not only destroys the natural dune vegetation as the canopy closes, but also can result in an adverse change in the dune hydrology which may influence the vegetation at some distance from the forest. Sand extraction and recreational activities are also important and attempts to stabilise the sand movement are common place. However much more important in the long term is the over-stabilisation of the dune and its vegetation in the absence of grazing either by domestic stock or rabbits.

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Doody, J.P., 1989. Management for nature conservation, in **Proc. Roy. Soc. Edin.** 96B. 247-265.

INTRODUCTION. The sand dunes in Ireland have developed over the last 5,000 years and are largely derived from glacial sediment reworked since then by the tides and wind. Substantial accumulations are rare and the largest system is Inch in the south west, with a total area of 1,250 ha. [There are estimated to be approximately 14,300 ha of dune landscape in Ireland. The information is derived from a variety of sources, including personal communication from Dr. D. Jeffrey (Trinity College, Dublin) and Prof. Bill Carter (University of Ulster)].

DISTRIBUTION AND TYPE OF DUNE. Sand dunes occur around the whole coastline of Ireland. There is very little new sand available for dune building and current development is restricted to reworking of existing sediments. Dune forms include hindshore systems, the most extreme form of which is the "machair" formation found on the north and west coasts (Bassett and Curtis, 1985). Elsewhere, more typical undulating forms occur including spits and bars. On the west coast where prevailing and dominant winds reinforce each other, sand can be blown some distance inland, and at a few sites over cliffs. On the east coast, by contrast, dunes may be much narrower as prevailing and dominant winds are in opposition. Dune sand is both calcareous and acidic depending on the origin of the material and as a consequence dune vegetation may be grassland or heathland. At some sites, such as Murlough in Northern Ireland, leaching of the surface dune soil has resulted in a heathland vegetation developing.

VEGETATION. Sand dune vegetation in Ireland has been grazed for centuries and its form and composition has been greatly influenced by it. Grazing, which includes rabbits, has resulted in a largely open close-cropped vegetation and an absence of scrub and woodland. Unlike many other areas of north west Europe there has been relatively little afforestation of the dune landscape.

Strandline. Ephemeral communities with *Atriplex laciniata*, *Cakile maritima*, *Galium aparine* and *Elymus farctus* are the norm.

Foredune. *Ammophila arenaria* is the main dune building species. *Leymus arenarius* does occur but it is restricted in its geographical range.

Dune grassland. Calcareous grasslands can be rich in a wide variety of herbs including *Lotus corniculatus*, *Thymus drucei*, *Echium vulgare* and *Viola tricolor*. At some sites rarer plants may be found including a number of orchids, of which *Orchis apifera* at Murlough is one of the more interesting.

Machair. A type of dune grassland develops under circumstances where much of the dune topography is lost due to the action of the strong winds experienced on the west coast. The flat plain is most frequently used for grazing animals and is rich in species.

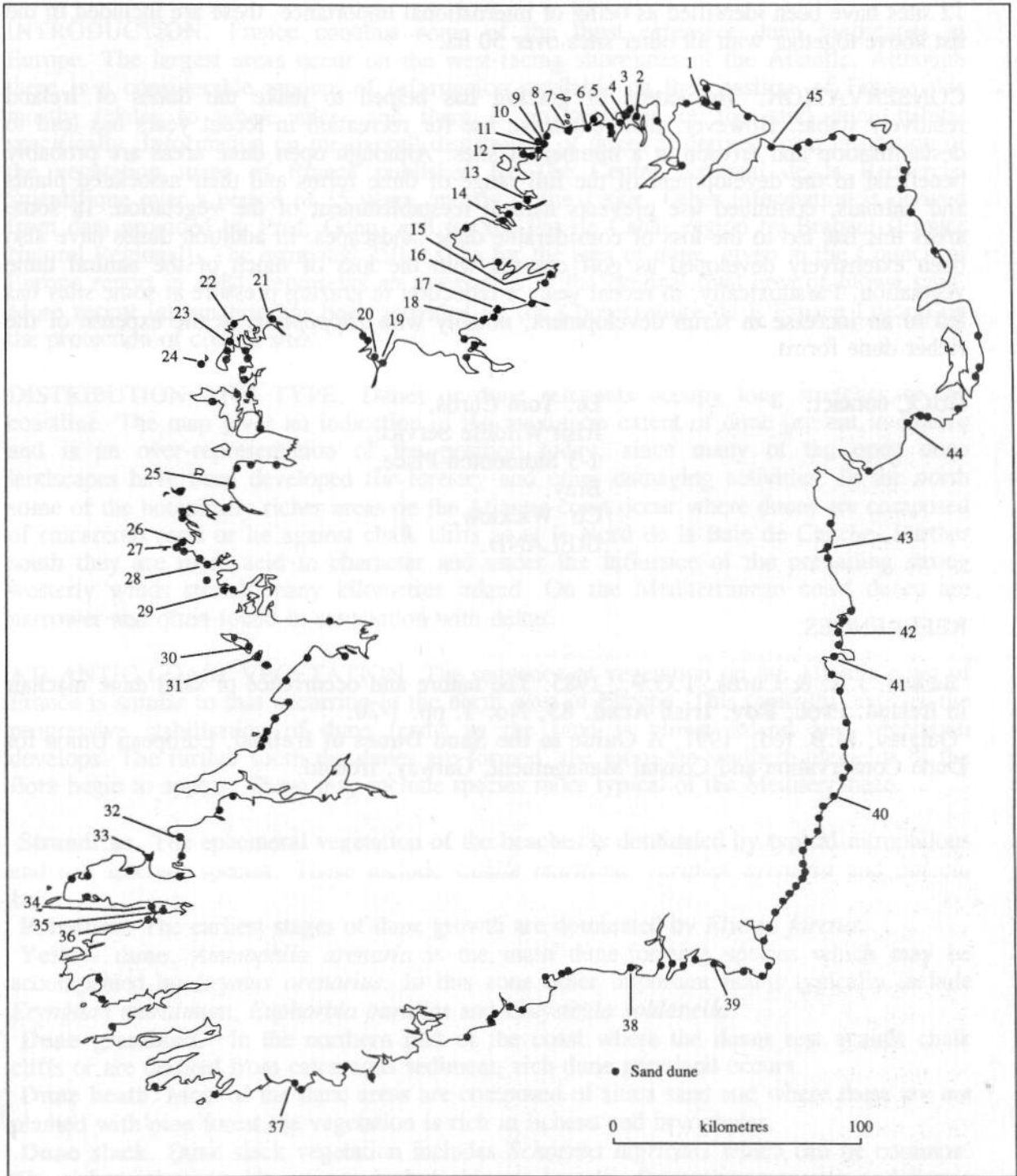
Dune heath. *Calluna vulgaris* and *Erica cinerea* are the predominant species, though *E. tetralix* may be found in wetter hollows. Dune heath is much more restricted than the richer dune grassland.

Dune slack. Wet slack vegetation is present at a number of sites with *Salix repens* forming a major component of a species rich community.

Woodland. There are no dunes with native woodland. However, the reduction in grazing pressure at a number of sites has resulted in the development of scrub, including the invasive *Hippophae rhamnoides*, at the expense of the richer grassland vegetation. At a few sites, such as Raven Point in the south east, there is some artificial planting of pine.

MAJOR SITES. The Southern Irish Government's Wildlife Service has recently carried out an appraisal of the coastal sand dunes as part of a process of designating Areas of Special Scientific Interest. This list is based on Quigley (1991).

SITE NAME	AREA(ha)	OTHER HABITATS	STATUS
1. Doagh Isle Machair	440	-	ASI
2. Lough Nagreany	130	-	ASI
3. Melmore Machair	400	-	ASI
4. Tranarossan Machair	200	-	ASI
5. Rosapenna	300	-	ASI
6. Rinclevan	400	-	ASI
7. Dooley	150	-	ASI
8. Lunnagh Machair	135	-	ASI
9. Derrybeg Machair	140	-	ASI
10. Carnboy Machair	100	-	ASI
11. Kincaslough Machair	100	-	ASI
12. Cruit Lower Machair	280	-	-
13. Lettermacaward Machair	150	-	ASI
14. Sheskinmore	600	-	ASI
15. Mullanasole	350	-	ASI
16. Finner	350	-	ASI
17. Bunduff Machair	150	-	ASI
18. Streedagh Point	160	-	ASI
19. Inishcrone	100	-	ASI
20. Bartragh Isd.	400	-	ASI
21. Garter Hill Machair	320	-	ASI
22. Termoncarragh Lough	150	-	ASI
23. Cross Lough Machair	280	-	ASI
24. Inishkea North Machair	150	-	ASI
25. Dooaghtry Machair	500	-	ASI
26. Mannin Bay Machair	500	-	ASI
27. Aillebrack Machair	300	-	ASI
28. Dog's Bay Machair	150	-	ASI
29. Mweenish Island Machair	150	-	-
30. Eararna	300	-	-
31. Inishmaan Machair	300	-	-
32. Ballyheige	250	-	ASI
33. Castlegregory	350	-	ASI
34. Inch	1250	Mudflat, saltmarsh	ASI
35. Lough Yganavan	180	-	ASI
36. Rossbehy	500	-	ASI
37. Castle Freke	200	-	ASI
38. Tramore	300	-	ASI
39. Ballyteige Burrow	440	-	ASI
40. Mizen Head	150	-	ASI
41. North Bull	650	Mudflat, saltmarsh	ASI
42. Malahide Island	150	-	ASI
43. Batray	150	-	ASI
44. Murlough Dunes	-	Sand flat, woodland	NNR, NT
45. Magilligan Dunes	1200	-	NNR



ASI, Areas of Scientific Interest in the Republic of Ireland; NNR, National Nature Reserves, Northern Ireland; NT, National Trust.

12 sites have been identified as being of international importance, these are included in the list above together with all other sites over 50 ha.

CONSERVATION. The extent of grazing has helped to make the dunes of Ireland relatively stable. However, their extensive use for recreation in recent years has led to destabilisation and erosion at a number of sites. Although open dune areas are probably beneficial to the development of the full range of dune forms and their associated plants and animals, continued use prevents natural reestablishment of the vegetation. In some areas this has led to the loss of considerable dune landscapes. In addition dunes have also been extensively developed as golf courses with the loss of much of the natural dune vegetation. Paradoxically, in recent years a reduction in grazing pressure at some sites has led to an increase in scrub development, notably with *Hippophae*, at the expense of the richer dune forms.

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- Bassett, J.A. & Curtis, T.G.F., 1985. The nature and occurrence of sand dune machair in Ireland. *Proc. Roy. Irish Acad.* 85, No. 1. pp. 1-20.
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INTRODUCTION. France contains some of the most extensive dune landscapes in Europe. The largest areas occur on the west-facing shorelines of the Atlantic. Although there is a considerable amount of information available on the coastline of France this mostly relates to whole sites, and there is no synthesis of the sand dune habitat specifically. Information on the overall distribution of dunes is derived from inspection of the vegetation maps of France published by The Centre National de la Recherche Scientifique over a period of 15 years, mostly in the 1960s. Other information is derived from data provided by Prof. Géhu, and for the Pas de Calais region by Brabant (Espace Naturel Régional). The estimated 250,000 ha for the area of dune, given in the Council of Europe report in 1984, represents an assessment of the original total area of blown sand. More recent information has been provided by the Conservatoire de L'Espace Littoral on the protection of coastal sites.

DISTRIBUTION AND TYPE. Dunes or dune remnants occupy long stretches of the coastline. The map gives an indication of the maximum extent of dune present in France and is an over-representation of the position today, since many of the open dune landscapes have been developed for forestry and other damaging activities. In the north some of the botanically richer areas on the Atlantic coast occur where dunes are composed of calcareous sand or lie against chalk cliffs as at le Nord de la Baie de Canche. Further south they are more acid in character and under the influence of the prevailing strong westerly winds stretch many kilometres inland. On the Mediterranean coast dunes are narrower and often found in association with deltas.

ATLANTIC COAST VEGETATION. The sequence of vegetation on the Atlantic coast of France is similar to that occurring in the north west of Europe. This typically involves the progressive stabilisation of dune forms as the sand is blown inland and vegetation develops. The further south the dunes are formed, the more the southern elements of the flora begin to appear. These may include species more typical of the Mediterranean.

Strandline. The ephemeral vegetation of the beaches is dominated by typical nitrophilous and salt tolerant species. These include *Cakile maritima*, *Atriplex arenaria* and *Salsola kali*.

Foredune. The earliest stages of dune growth are dominated by *Elymus farctus*.

Yellow dune. *Ammophila arenaria* is the main dune-forming species which may be accompanied by *Leymus arenarius*. In this zone other important plants typically include *Eryngium maritimum*, *Euphorbia paralias* and *Calystegia soldanella*.

Dune grassland. In the northern part of the coast where the dunes rest against chalk cliffs or are derived from calcareous sediment, rich dune grassland occurs.

Dune heath. Most of the dune areas are composed of silica sand and where these are not planted with pine forest the vegetation is rich in lichens and bryophytes.

Dune slack. Dune slack vegetation includes *Schoenus nigricans* which can be common. The richer calcareous dunes may include *Liparis loeselii*, *Spiranthes aestivalis* and *Serpia lingua*.

Scrub. Scrub typically includes *Hippophae rhamnoides*, *Sambucus nigra* and *Ulex europaeas*.

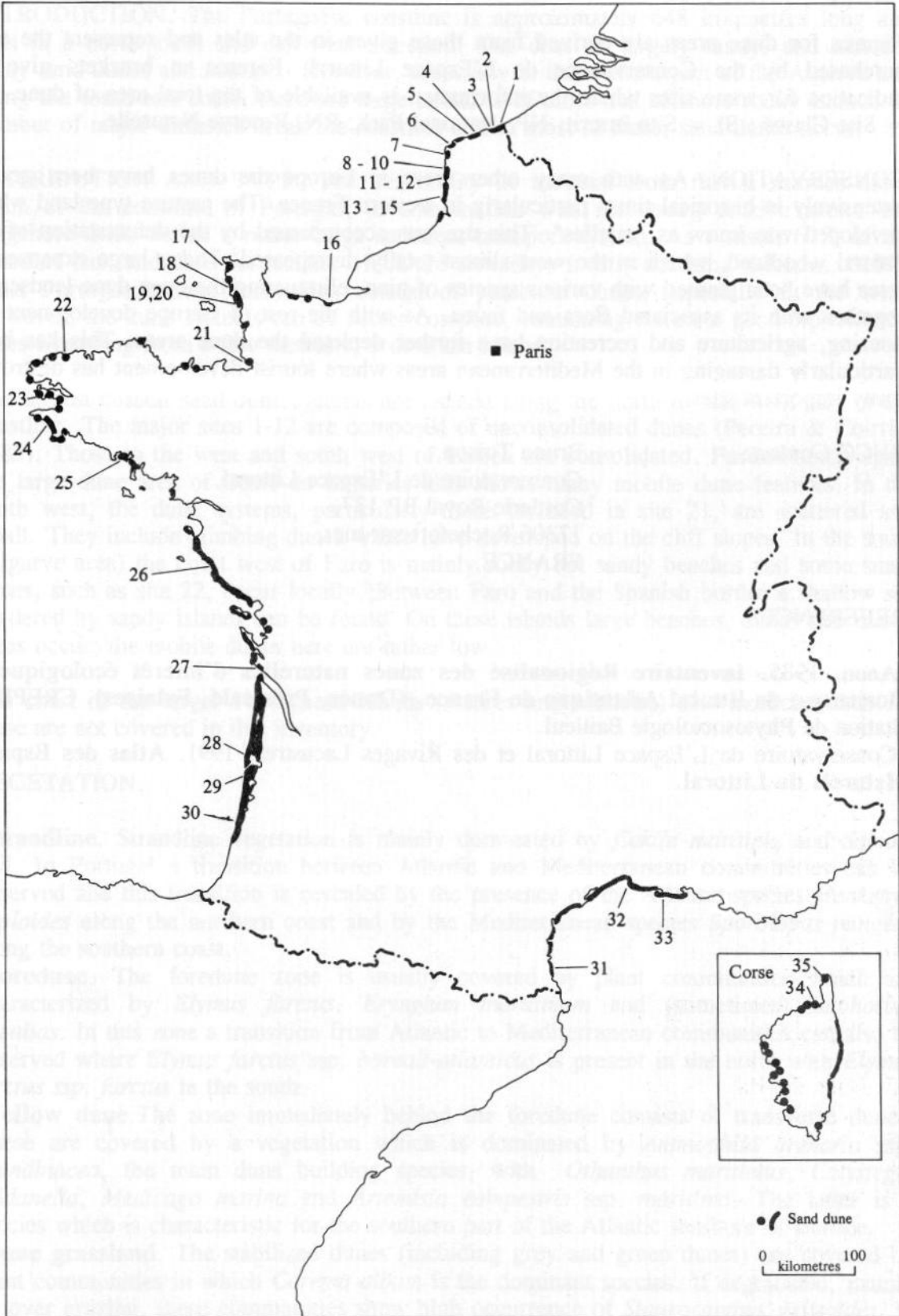
Woodland. Natural woodland is scarce on the French coast. Primary birch forest does occur in the north and east. Further south on the wider dunes of Les Landes, oak forest with *Quercus ilex* is the probable natural climax vegetation.

Afforested areas. Maritime pines (*Pinus maritima*, *P. pinaster* and *P. pinea*) have been extensively planted over much of the dune landscape of France particularly on the large expanses of dune which face the exposed Atlantic coast. In places these have been underplanted with oak which on the acid sands of Les Landes includes *Quercus ilex* and *Q. suber*.

MEDITERRANEAN COAST VEGETATION. The typical sequence of zonation shown on the Atlantic coast is less obvious here. However, mobile dunes still have *Ammophila arenaria* which now includes abundant *Medicago maritima*. The more open natural dune is rich in species. Stands of stone pine (*Pinus pinea*) occur and in the Camarge have an undergrowth of species such as *Daphne gnidium*, *Cistus solvifolius* and *Rosmarinus officinalis*.

MAJOR SITES. The list of sand dunes in France has been derived from the recently published Atlas des Espaces Naturels du Littoral.

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
1. Dunes du Perroquet	(300) 98	-	SC
2. Dunes Marchand	(120) 108	-	SC
3. Dunes Dewulf	(300) 34	-	SC
4. Le Platier d'Oye	(200) 158	Wet meadow	RN
5. Le Fort Vert	(180) -	-	-
6. Dune d'Aval, Dune du Chatelet	(150) 66	-	SC
7. Dunes de la Slack	(210) 193	-	SC
8. Ecault	161	Woodland	-
9. Mont Saint-Frieux	(1200) 467	Chalk grassland	-
10. Baie de Canche (N)	(1000) 466	-	-
11. Dune de Berck	(1000) 46	-	-
12. Baie d'Authie (N)	(200) 119	-	-
13. Dune de l'Authie }	160	-	-
14. Le Royon }	(2000) 99	-	-
15. Le Marquenterre }	409	Plantation, lagoon	SI
16. Estuaire de l'Orne	(250) 134	-	-
17. Dunes de Vauville	44	-	Pt.SC
18. Dunes d'Hatainville	375	-	SC
19. Dunes de Lindbergh	88	-	-
20. Havre de Surville	165	-	-
21. Dunes de Dragey	24	-	SC
22. Dunes de Keremma	(200) 185	-	SI
23. Dune de Dinan	40	-	Pt.SC
24. Baie d'Audierne	(800) 542	-	SC
25. Dune du Mat Fenoux	(500) 196	-	Pt.SC
26. Dunaire de la Sauzaire	(400) -	-	-
27. Les Combots d'Ansoine	954	-	-
28. Cap Ferret	(800) 169	-	-
29. Dune du Pilat	(400) -	-	-
30. Dune de Pen Bron	(160) -	-	SC
31. Le Lido	(894) -	Lagoon	-
32. Point de l'Espiguette	108	Lagoon	-
33. Camargue	-	-	NP



CORSICA

34. Agriate-Ostritini	(200) - -	SC
35. Cap Cosse-Barcaggio	(300) - -	SC

Figures for dune areas are derived from those given in the atlas and represent the area purchased by the Conservatoire de L'Espace Littoral. Figures in brackets give an indication for some sites where the information is available of the total area of dune. SC = Site Classé ; SI = Site Inscrit; NP, National Park; RN, Reserve Naturelle.

CONSERVATION. As with many other areas in Europe the dunes have been grazed extensively in historical times particularly in western France. The pasture type land which developed was known as "mielles". This use was accompanied by the deforestation of the natural woodland, which in the west almost totally disappeared. Today large expanses of dune have been planted with various species of pine, eliminating the open dune landscape, together with its associated flora and fauna. As with the rest of Europe development for housing, agriculture and recreation have further depleted the dune areas. This has been particularly damaging in the Mediterranean areas where tourist development has destroyed many important sites.

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INTRODUCTION. The Portuguese coastline is approximately 648 kilometres long and runs in a north-south and east-west direction. The coast is largely sandy, and includes many sand dunes and marshes. However, especially in the western part of the Algarve and along the south-east coast, there are large stretches of cliffs and offshore rocky islands. A number of major estuaries break the coastline and in most of these, sand dunes occur.

DISTRIBUTION AND TYPE. The availability of material from fluvial sources along much of the coastline of Portugal, in combination with the strong erosive action and longshore drift, define a rather large sediment transport system. As a result 60% of the coastline has sand dune formations which are nowadays mostly deflating (Martins, 1989). Most Portuguese dune formations consist of parabolic dunes, especially in the west. However, the dune systems can be rather complex, containing different geomorphological types extending from a few metres to 5 or 6 km inland.

The largest coastal sand dune systems are located along the north to mid-west part of the coastline. The major sites 1-12 are composed of unconsolidated dunes (Pereira & Coirria, 1985). Those to the west and south west of Lisboa are consolidated. Further south again the large dune area of Costa da Caparica also shows many mobile dune features. In the south west, the dune systems, particularly those included in site 21, are scattered and small. They include climbing dunes which have developed on the cliff slopes. In the south (Algarve area) the coast west of Faro is mainly rocky but sandy beaches and some small dunes, such as site 22, occur locally. Between Faro and the Spanish border a shallow sea bordered by sandy islands can be found. On these islands large beaches, dunes and marsh areas occur; the mobile dunes here are rather low.

The coast of the larger Portuguese islands (Azores and Madeira) also include dunes but these are not covered in this inventory.

VEGETATION.

Strandline. Strandline vegetation is mainly dominated by *Cakile maritima* and *Salsola kali*. In Portugal a transition between Atlantic and Mediterranean communities can be observed and this transition is revealed by the presence of the Atlantic species *Honkenya peploides* along the northern coast and by the Mediterranean species *Sporolopus pungens* along the southern coast.

Foredune. The foredune zone is usually covered by plant communities which are characterized by *Elymus farctus*, *Eryngium maritimum* and (sometimes) *Euphorbia paralias*. In this zone a transition from Atlantic to Mediterranean communities can also be observed where *Elymus farctus* ssp. *boreali-atlanticus* is present in the north with *Elymus farctus* ssp. *farctus* in the south.

Yellow dune. The zone immediately behind the foredune consists of transverse dunes. These are covered by a vegetation which is dominated by *Ammophila arenaria* ssp. *arundinacea*, the main dune building species, with *Othanthus maritimus*, *Calystegia soldanella*, *Medicago marina* and *Artemisia campestris* ssp. *maritima*. The latter is a species which is characteristic for the southern part of the Atlantic seashore of Europe.

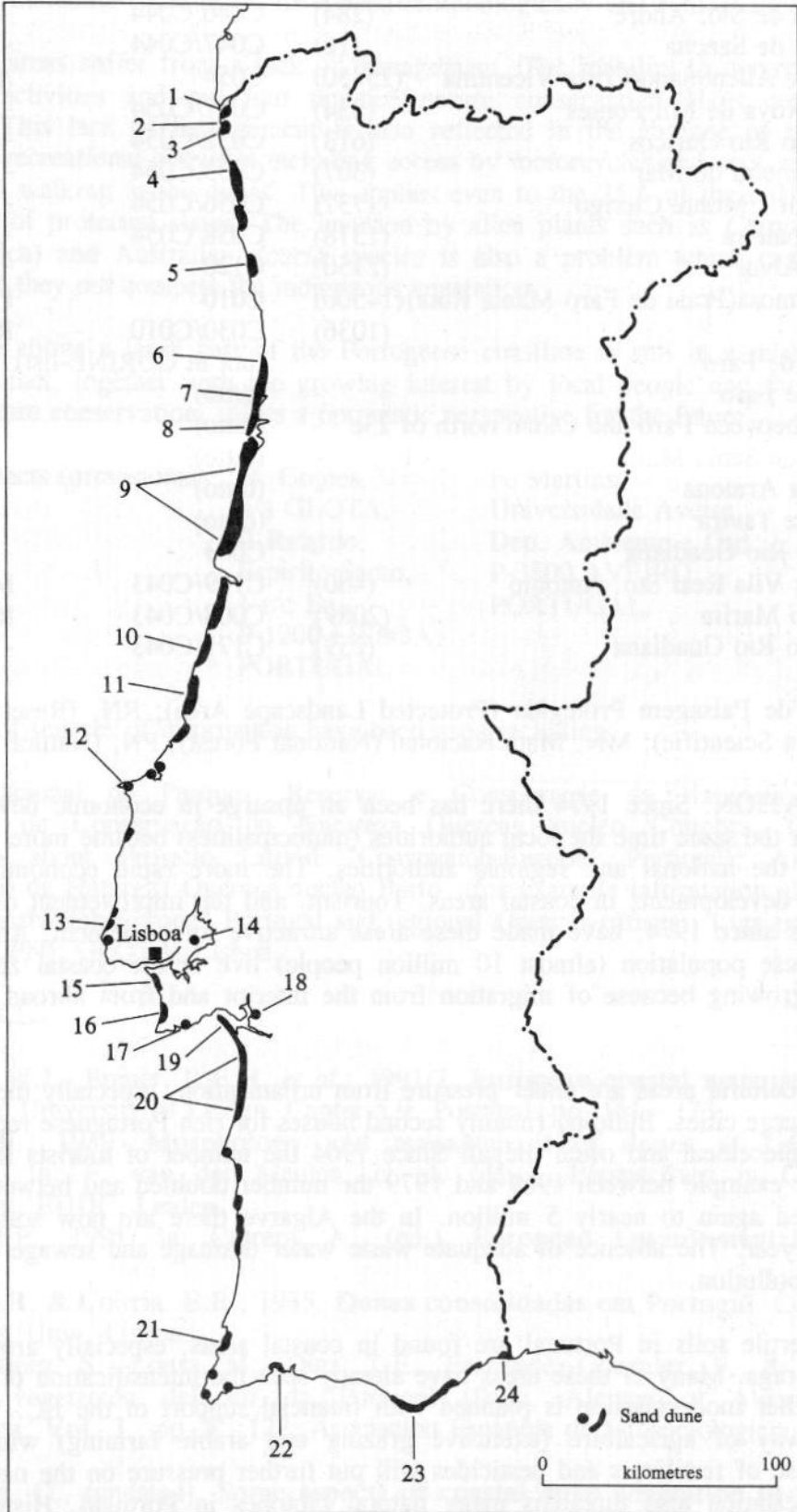
Dune grassland. The stabilized dunes (including grey and green dunes) are covered by plant communities in which *Corema album* is the dominant species. If degraded, mainly by over grazing, these communities show high occurrence of *Stauracanthus gelstoides*. In

the stabilized dunes south of the Tagus river another important plant community, with *Thymus carnosus* present as a major species, occurs. This *Thymus carnosus* community is replaced by a *Thymus carnosus* and *Crucianella maritima* community in the south-west.

Woodland. Woodland is common in the stabilized dunes, in the climbing dunes and in the inner dune ridges of other dune types. It is mainly dominated by *Pinus pinaster* (sometimes *P. pinea*), *Juniperus phoenicea* and *Quercus* spp. In the northern and mid part of the coastline several introduced *Acacia* spp. from Australia play a local, but increasingly important role in the development of dune scrub and woodland.

MAJOR SITES. The total distribution of coastal dunes is derived from inspection of the Carto de Portugal 1:200000 scale (Instituto Geográfico e Cadastral). The list of important areas which contain sand dunes and lagoons presented below is only provisional. All areas which contain sand dunes as identified by the CORINE/BIOTOPES project (Provisional version, 1991) have been included. (NB, some sites may have little or no dunes and recent information suggests that site 1 falls into this category). Not all areas of pine plantation (pinhals) located on former dunes have been included.

SITE NAME	AREA(ha)	CORINE CODES	STATUS
1. Vale do Minho	(2400)	C128	-
2. Costa Verde	(1720)	C129	-
2a. Moledo / Camarido (south of Foz do Minho)	(610)	C130/C129	-
2b. Gelfa	(210)	C131/C129	-
2c. Afife	(400)	C132/C129	-
2d. Areosa / Carreço	(500)	C133/C129	-
3. Foz do Rio Lima	(1600)	C134	-
4. Litoral de Esposende	(3000)	C048	APP
4a. Foz Rio Neiva	(520)	C135/C048	-
4b. Foz Rio Cavado	(740)	C136/C048	-
4c. Agaçadoura	(150)	C137/C048	-
5. Mindelo (south of Foz do Rio Ave)	(247)	C138	-
6. Barrinha de Esmoritz	(210)	C139	-
7. Costa do Furadouro	(617)	C140	-
8. Ria de Aveiro		C109	-
8a. Dunas de San Jacinto	(666)	C011/C019	RN
8b. Costa Nova (Aveiro)	(2665)	C029/C019	-
9. Costa de Quiaios / Mira	(15200)	C075	-
9a. Dunas de Mira	(3090)	C083/C075	-
9b. Dunas de Cantanhede	(3160)	C082/C075	-
10. Dunes and Pinhal de Leiria s.l.	(39000)	C073	-
10a. Forest do Urso	(6311)	C089	MN
11. Lagoa de Obidos	(2600)	C067	-
12. Peniche, Papoa, Ilha das Pombas	(1300)	C075	-
13. Sintra / Cascais	(14500)	C016	APP
13a. Cresmina	(650)	C146/C016	-
14. Estuario do Tejo	(14563)	C009	RN
15. Arriba Fossil da Costa da Caparica	(1635)	C063	APP
16. Lagoa de Albufeira	(510)	C084	-
17. P.N. da Arrabida	(< 10)	C002	-
18. Estuaria do Sado	(24000)	C013	-



19. Dunes west of Vale do Juncal		not in CORINE-list)	
20. Costa da Gale	(5750)	C044	-
20a. Lagoa de Melides	(26)	C045/C044	-
20b. Lagoa de Sto. André	(284)	C046/C044	-
20c. Lagoa de Sancha	(16)	C047/C044	-
21. Sudoeste Alentejano/Costa Vicentina	(25850)	C054	APP
21a. Vila Nova de Mil Fontes	(834)	C051/C054	-
21b. Foz do Rio Ouricos	(613)	C052/C054	-
21c. Zambujeira do Mar	(307)	C053.C054	-
21d. Aljezur / Monte Clerigo	(737)	C056/C054	-
21e. Carrapateira	(1378)	C058/C054	-
22. Ria de Alvor	(2150)	C120	-
23. Ria Formosa(Praia de Faro-Manta Rota)	(14500)	C010	PN
23a. Ludo	(1036)	C030/C010	RS
23b. Praia de Faro	-	(not in CORINE-list)	
23c. Ilha de Faro	-	(ditto)	
23d. Ilhas between Faro and Olhão north of 23e	-	(ditto)	
23e. Cabo de Santa Maria	-	(ditto)	
23f. Ilha da Armona	-	(ditto)	
23g. Ilha de Tavira	-	(ditto)	
24. Vale do Rio Guadiana	-	C043	-
24a. Dunas Vila Real Sto. Antonio	(460)	C119/C043	MN
24b. Castro Marim	(2089)	C008/C043	RN
24c. Foz do Rio Guadiana	(259)	C171/C043	-

APP, Area de Paisagem Protegida (Protected Landscape Area); RN, (Reserva Natural); RS, (Reserva Scientific); MN, Mata Nacional (National Forest); PN, (Natural Park).

CONSERVATION. Since 1974 there has been an upsurge in economic development in Portugal. At the same time the local authorities (municipalities) became more powerful, at the cost of the national and regional authorities. The more rapid economic growth is reflected in developments in coastal areas. Tourism, and the improvement of agriculture and fisheries since 1974, have made these areas attractive for settlement. About 75% of the Portuguese population (almost 10 million people) live in the coastal zone and this number is growing because of migration from the interior and from abroad (Portuguese remigrants).

Coastal agricultural areas are under pressure from urbanization, especially the fertile land around the large cities. Building (mainly second houses for rich Portuguese remigrants and tourists) is piecemeal and often illegal. Since 1964 the number of tourists has increased rapidly. For example between 1969 and 1979 the number doubled and between 1979 and 1985 doubled again to nearly 5 million. In the Algarve there are now some 7 million visitors per year. The absence of adequate waste water drainage and sewage disposal can cause local pollution.

The most fertile soils in Portugal are found in coastal areas, especially around Lisboa, Porto and Braga. Many of these areas have already seen the intensification of agricultural use and further modernisation is planned with financial support of the EC. With this, a traditional way of agriculture (extensive grazing and arable farming) will disappear. Increasing use of fertilizers and pesticides will put further pressure on the natural coastal zone. Afforestation also threatens many natural biotopes in Portugal. Historically, the

planting of forests of *Pinus pinaster* (pinhals) has been a traditional way of controlling sand drift in dune areas. Today the planting of *Eucalyptus* has become very common and many areas including some dunes have been morphologically and ecologically destroyed.

Most dune areas suffer from a lack of management. The inability to control the various damaging activities and put into practice nature conservation plans compounds the problems. This lack of management is also reflected in the absence of restrictions to tourist and recreational activities including access by motorcycles and cars, camping, sun-bathing and walking in the dunes. This applies even to the 25% of the coastal area with some form of protected status. The invasion by alien plants such as *Carpobrotus edulis* (South Africa) and Australian *Acacia* species is also a problem which can affect large areas where they out compete the indigenous vegetation.

Despite the above a large part of the Portuguese coastline is still in a relatively natural state. This fact, together with the growing interest by local people and the government towards nature conservation, offers a optimistic perspective for the future.

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A number of sources of information have been used including:

Serviço Nacional de Parques, Reservas e Conservação da Natureza (SNPRCN); Associação de Conservação da Natureza Quercus nucleo Coimbra, (for example information about Projecto Litoral "Coastwatch-Europe" Portugal); Associação de Conservação da Natureza Quercus nucleo Porto, (for example information about Projecto Litoral "Coastwatch-Europe" Portugal and regional Quercus-offices); Liga para Protecção Natureza (LPN); GEOTA, Lisboa.

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INTRODUCTION. The Spanish coastline, the Balearic and Canary islands included, is about 6145 km. The Peninsula coast can be divided into three major regions. The northern Atlantic coast (2,012 km) which consists mainly of cliffs and rivermouths with bays and some small sand dune sites. The Mediterranean coast (1,063 km) has rocky shores and coastal plains with sandy and pebble beaches and a small number of dune systems. Finally the southern Atlantic coast (949 km) is composed predominantly of sandy shores and dunes.

The Balearic Islands' coasts (1,186 km coast) mainly consist of cliffs, bays and sandy beaches with some Holocene and Pleistocene dunes. The Canary Islands (1,477 km coast) are of volcanic origin, but include a number of dune systems.

DISTRIBUTION AND TYPE OF DUNE. The most extensive dune systems, barrier islands and spits can be found in western Andalucía on the southern Atlantic coast. Several river deltas which have brought much sediment to the sea and helped to create one of the most important dune systems in Europe which lies within the Coto Doñana National Park. The park consists of beaches, foredunes, high mobile dunes (up to 30 meters) and stabilized dunes which enclose a major wetland. By comparison, the systems on the eastern Mediterranean coast are smaller and more scattered than those in the south and are often relatively low (not more than 20 m). On the northern Atlantic coast, dune areas are scarce because of the lack of sediment in the nearshore zone and the absence of major fluvial sources. Apart from Corrubedo in Galicia only a few small dunes exist near river mouths. Finally there are climbing dunes on the slopes of some cliffs. In Spain these can only be found along the Cantabrian coast, although fossil climbing dunes appear in Serra Gelede near Alicante.

The coasts of the Balearic Islands and Canary Islands are mainly rocky but some parts are dominated by sandy beaches and dunes.

VEGETATION. Because of the subtropical climate and its situation west of the African continent and close to the tropic of Cancer, the coastal vegetation of the Canary islands is completely different from the vegetation of the rest of Spain and has a large number of endemic species. A description of the vegetation of the Canary Islands is therefore not included in the summary which follows.

Strandline. The strandline is predominantly bare, but in the Mediterranean zone *Cakile maritima* ssp. *aegyptiaca*, *Salsola kali* and *Polygonum maritimum* can be found.

Foredune. Embryonic dunes are usually covered with communities characterized by *Elymus farctus*, sometimes accompanied by *Eryngium maritimum*, *Calystegia soldanella* and *Sporobolus pungens*.

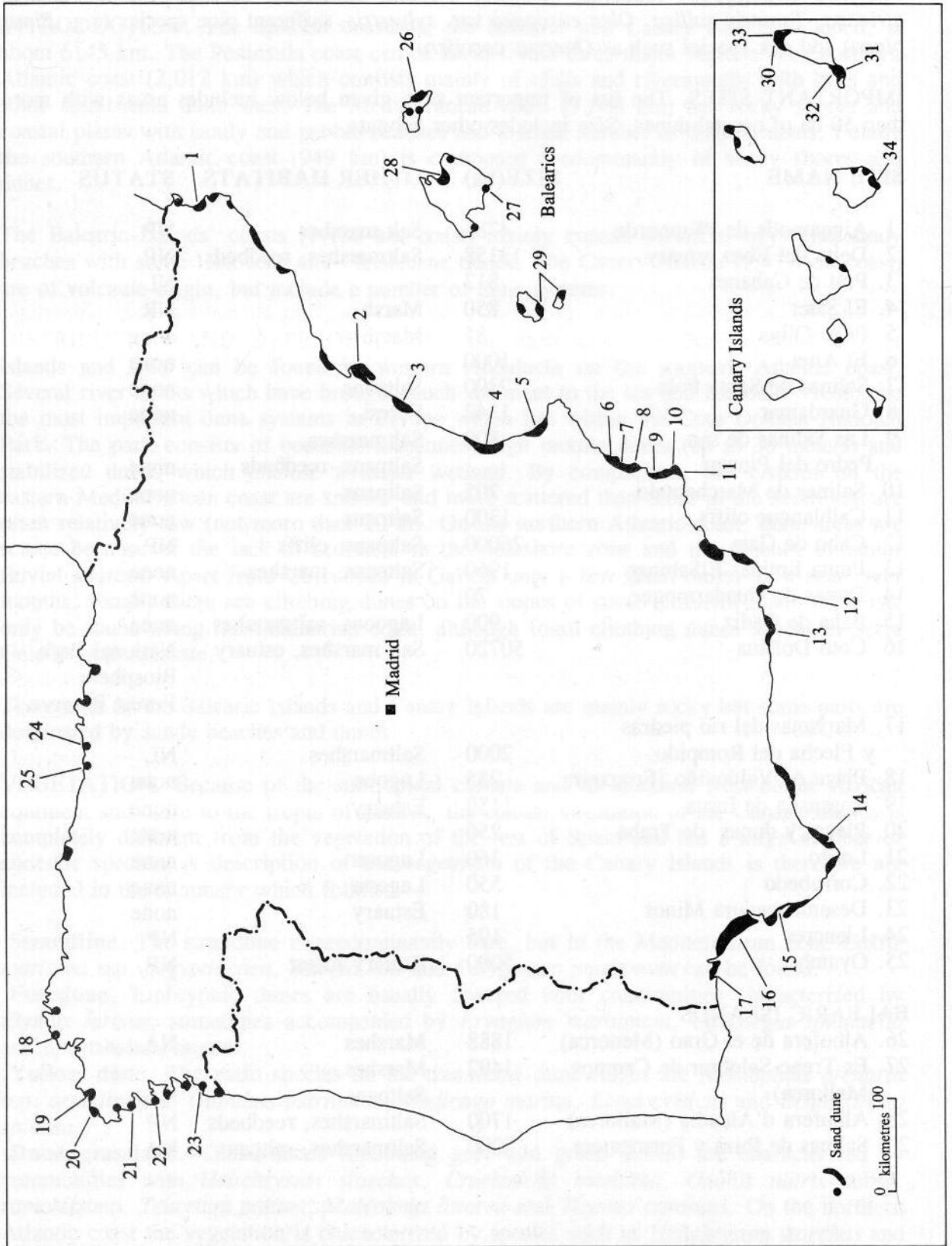
Yellow dune. The main species on the transverse dune ridges are *Ammophila arenaria* ssp. *arundinacea*, *Otanthus maritimus*, *Medicago marina*, *Lotus creticus* and *Echinophora spinosa*.

Dune grassland. These dunes (including grey and green dunes) are characterized by communities with *Helichrysum stoechas*, *Crucianella maritima*, *Ononis natrix* subsp. *ramosissima*, *Teucrium polium*, *Malcolmia littorea* and *Thymus carnosus*. On the northern Atlantic coast the vegetation is characterized by species such as *Helichrysum stoechas* and *Ephedra distachya*.

Woodland. Tall scrub mainly consists of *Juniperus macrocarpa* and *J. phoenicea* although in mobile dunes *J. oxycedrus* is more abundant. Woodlands mainly consist of *Phillyrea angustifolia*, *Rhamnus oleoides*, *Pistacia lentiscus*, *Corema album*, *Tamarix africana*, *Tamarix gallica*, *Olea europaea* var. *sylvestris*, different pine species (e.g. *Pinus pinea*) and oak species such as *Quercus coccifera*.

IMPORTANT SITES. The list of important sites given below includes areas with more than 50 ha of coastal dunes. Size includes other habitats.

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
1. Aiguamolls de l'Emporda	4783	Salt marshes	NP
2. Delta del Ebro estuary	13158	Saltmarshes, reedbeds	NP
3. Prat de Cabanes	812	-	NL
4. El Saler	850	Marsh	NR
5. Pego-Oliva	85	Marsh	none
6. El Altet	1000	-	none
7. Salinas de Santa Pola	2390	Salt pans	none
8. Guardamar	1342	Forest	none
9. Las Salinas de san Pedro del Pinatar	800	Saltmarshes, Salt pans, reedbeds	none
10. Salinas de Marchamalo	205	Salt pans	none
11. Calblanque cliffs	1300	Salt pans	none
12. Cabo de Gata	26000	Salt pans, cliffs	NP
13. Punta Entinas-ElSabinar	1960	Salt pans, marshes	none
14. Dunas de Guadarranque	70	-	none
15. Baha de Cádiz	900	Lagoons, saltmarshes	none
16. Coto Doñana	50720	Salt marshes, estuary	National Park Biosphere Forest Reserve
17. Marismas del rio piedras y Flecha del Rompido	2000	Saltmarshes	NL
18. Playa de Valdoviño /Frouxeira	255	Lagoon	none
19. Ensenada de Insua	1150	Estuary	none
20. Playas y dunas de Traba	250	-	none
21. Louro	360	Lagoon	none
22. Corrubedo	550	Lagoon	none
23. Desembocadura Minor	180	Estuary	none
24. Liencres	195	-	NP
25. Oyambre	5000	Estuary, forest	NP
BALEARIC ISLANDS			
26. Albufera de el Grao (Menorca)	1888	Marshes	NA
27. Es Trenc-Salobrar de Campos (Mallorca)	1492	Marshes, Salt pans	NA
28. Albufera d'Alcudia (Mallorca)	1700	Saltmarshes, reedbeds	NP
29. Salinas de Ibiza y Formentera	2000	Saltmarshes, salt pans	NA



CANARY ISLANDS

30. Las dunas de Corralejo (Fuerteventura)	1600	-	NP
31. Saladar (Fuerteventura)	100	Saltmarshes	NL
32. Jandia (Fuerteventura)	-	Cliffs	NP
33. Jable de Lajares (Fuerteventura)	2700	-	none
34. Las dunas de Maspalomas (Gran Canaria)	405	Lagoon	NL

Two additional sites have been identified which are not shown on the map:

35. Ortigueira	2900	lagoon	none
36. Caldebarcos-Carnota	860	saltmarshes	none

NP, Natural Park; NL, Natural Landscape; NR, Nature Reserve.

CONSERVATION. Many dune areas in Spain have been destroyed or altered in the last few decades, especially in the Mediterranean and southern Atlantic coastal zone. The main cause has been the increase in tourism, which resulted in the extraction of sand for construction activities and the building of hotels, houses and boulevards. Many dune areas have also been afforested with *Pinus* spp. or *Eucalyptus* spp. destroying most of the natural vegetation. Construction works, such as the building of harbours and the canalization of rivers, has restricted the sand supply to the beaches and as a consequence the dune areas have decreased through erosion of both beaches and dunes.

Since 1988 the Spanish Shores Act (*Ley de Costas*) has come into force. This law emphasizes provision for public access and promotes the protection of the coastal zone (up to a maximum of 500 metres, landward) against further destruction by building activities. This law has only just come into force and its effectiveness has not yet been completely established.

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INTRODUCTION. Sand dunes are frequently found along the coasts and major islands of Italy, mostly associated with estuaries and lagoons. The largest dune system is on the NW shore of the Adriatic Sea between Grado and Rimini, a length of almost 200 km. There is no overall figure for the total area of dune, though most if not all of the larger sites are considerably reduced in size due to building, mostly for tourist development, sand extraction and other forms of exploitation. The information provided by the author has been supplemented by data from Michele Zilli, (Ministero Agricoltura e Foreste) and for the area around Rome from Massimo Leone (Fondi).

DISTRIBUTION AND TYPE OF DUNE. Many of the dunes probably originated during the thermal optimum after the last glaciation (5,000 years ago). They have since been broken by rivers and their subsequent development has been a product of natural erosive forces and use by man. Today dunes are present around the whole coastline but only in a few protected areas, like the National Park of Circeo, can natural development be seen. The sand is predominantly calcareous.

VEGETATION. A Mediterranean vegetation is present on dunes around the west coast and on the islands. The flatter coastlines around Venice and Romagna has a central European character.

Strandline. The first community on the open sand, exposed to strong winds and salt spray, is dominated by *Cakile maritima* and other pioneers.

Foredune. Embryo dunes are colonised by *Elymus farctus*, and includes *Eryngium maritimum*. As the dunes grow in height, up to a maximum of 5-7 metres, a community dominated by *Ammophila arenaria* with *Medicago marina* becomes prominent.

Dune grassland. Dune grassland is restricted to northern Italy, particularly around Venice which has a central European climate. *Scabiosa argentia* var. *alba* is prominent and the community is rich in *Brometalia* spp. On the Mediterranean coast these species are replaced by dwarf shrubs such as *Crucianella maritima*.

Dune heath. Most dunes are colonised by *Juniperus macrocarpa*, rarely by maquis shrubs such as *Pistacia lentiscus*, *Phillyrea angustifolia* and *Daphne gnidium*. Near Venice these may include *Juniperus communis*.

Woodland. The climax vegetation is dominated by evergreen oak forest with *Quercus ilex*, which can occur as a pure stand or with deciduous elements. In the mouths of some rivers *Fraxinus* and *Populus* species are widespread. Several species of pine occur in plantations and in some dune systems these can be extensive. *Pinus pinea* is most frequently encountered as a planted species, as are *P. halepensis* and *P. pinaster*. However the last two are sometimes found growing as native plants, though in relatively restricted geographical areas.

MAJOR SITES. This list and accompanying map are derived from the three sources mentioned above. Location of dunes on the map represents an attempt to give an indication of their wider distribution. It is clear that for many of these areas such as those south of Venice, little dune habitat remains, see Cencini *et al.* (1988).

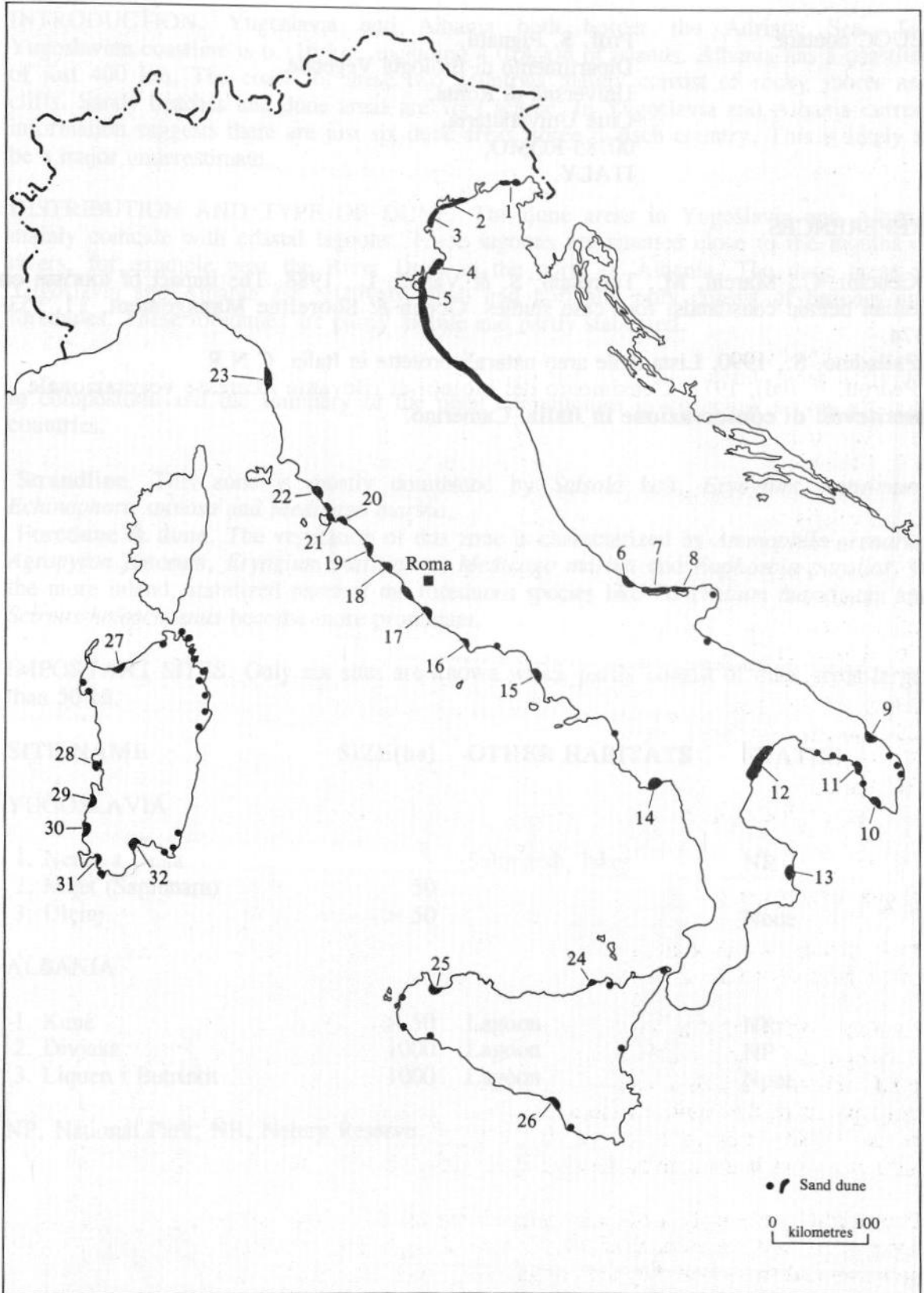
SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
1. Laguna di Grado	5300	Lagoon, saltmarsh	-
2. Cavallino	-	-	NR
3. Bosco Nordio	150	Pine woodland	SF
4. Scano Boa	634	Marshland	None
5. Contarina	152	Woodland	None
6. Campomarino	100	Scrub	None
7. Lesina	1500	Woodland	None
8. Varano	20	Pine woodland	SF
9. Le Cesine*	(348)	Woodland	-
10. Ugento	65	Pine woodland	None
11. Palude del Conte	25	Maquis	None
12. Metaponte*	(240)	Woodland	-
13. Foce del Neto	600	Marshland	ZR
14. S. Iconia	440	Pine woodland	-
15. Castlevolturmo*	(268)	Woodland	-
16. Circeo	250	Scrub	NP
17. Castelfusano	300	Maquis, pines	SF
18. Macchiatonda*	(250)	Saltmarsh	-
19. Capalbio	496	Maquis, pines	ZR
20. Salina di Tarquinia*	(1700)	saltmarsh	-
21. Feniglia	470	Marshland	SF
22. Uccellina	150	-	NR
23. Selva Pisana	200	Marshland	SF
24. Tindari	75	-	SL
25. Alcamo	100	Maquis	None
26. Biviere di Gela*	(256)	Saltmarsh	-
27. Platamona	800	Maquis	None
28. S'ena Arrubia*	(223)	Saltmarsh	-
29. Rio Piscinas	800	Maquis	None
30. Buggerru	120	Maquis	None
31. Porto Pino	350	Pine woodland	SL
32. Stagno di Cagliari*	(3466)	Saltmarsh	-

NR, Nature Reserve; NP, National Park; ZR, Zoological Reserve; SF, State Forest; SL, Scenic Landscape.

* Additional information provided by Michele Zilli, Ministero Agricoltura e Foreste; (area) includes adjacent habitats (Palladino, 1990).

CONSERVATION. The once extensive dune systems in Italy have been used for tourist developments. The building of hotels and summer houses, extraction of sand for these and other related work has caused irreversible destruction of these dune areas. Detailed descriptions of the nature of the losses for a selected number of sites are given in Cencini *et al.* (1988). For at least one site, "I Maconi" in Sicily, major development for agriculture has had a similar devastating effect on the dune flora and fauna.

Pine forests are mostly artificially planted and have as elsewhere in Europe, changed the appearance and vegetation of the dunes. Though these forests are very sensitive to pollution and fire-prone they are conserved for their high scenic value.



Coastal defence works (including concrete dams) and urbanisation are also causing further degradation of the environment. The impact on the dune habitat is serious and many areas are badly affected.

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EUCC Sand dune inventory YUGOSLAVIA & ALBANIA

Veronique Loeffen & Robert Tekke

INTRODUCTION. Yugoslavia and Albania both border the Adriatic Sea. The Yugoslavian coastline is 6,116 km, including 4,024 km of islands. Albania has a coastline of just 400 km. The coasts of these two countries mainly consist of rocky shores and cliffs. Sandy beaches and dune areas are very scarce. In Yugoslavia and Albania current information suggests there are just six dune areas, three in each country. This is likely to be a major underestimate.

DISTRIBUTION AND TYPE OF DUNE. The dune areas in Yugoslavia and Albania mainly coincide with coastal lagoons. These lagoons are situated close to the mouths of rivers, for example near the River Drini in the north of Albania. The dune areas in Yugoslavia and Albania are relatively small and normally only consist of beaches and foredunes. These foredunes are partly mobile and partly stabilized.

VEGETATION. The vegetation in the Yugoslavian and Albanian coastal dunes is similar in composition and the summary of the plant communities given below serves for both countries.

Strandline. This zone is mostly dominated by *Salsola kali*, *Eryngium maritimum*, *Echinophora spinosa* and *Medicago marina*.

Foredune & dune. The vegetation of this zone is characterized by *Ammophila arenaria*, *Agropyron junceum*, *Eryngium maritimum*, *Medicago marina* and *Euphorbia paralias*. In the more inland, stabilized parts of the foredunes species like *Pancratium maritimum* and *Scirpus holoschoenus* become more prominent.

IMPORTANT SITES. Only six sites are known which partly consist of dune areas larger than 50 ha.

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
YUGOSLAVIA			
1. Neretva Delta	-	Saltmarsh, lakes	NR
2. Mljet (Saplunara)	50		
3. Ulcinj	> 50		None
ALBANIA			
1. Kune	> 50	Lagoon	NR
2. Divjaka	1000	Lagoon	NP
3. Liqen i Butrintit	1000	Lagoon	None

NP, National Park; NR, Nature Reserve.

CONSERVATION. Not much information is available on the threats and conservation of the dune areas in Albania and Yugoslavia.

In Yugoslavia, most of the coast is urbanised. The beaches and the only major dune area, Ulcinj, are under threat from tourist development. The beaches are mechanically cleaned, and the building of tourist facilities destroys the dunes and their vegetation. The dunes of Ulcinj are also threatened by increasing agricultural activities. The administration for nature conservation is organized at republic level, rather than at national level. Each republic has its own Institute for Nature Conservation. Several forms of site protection exist but the dune area of Ulcinj has no conservation status as yet.

In Albania, by contrast, because of the political and economic isolation, there are hardly any tourist or industrial developments in the coastal zone. The responsibility for nature conservation lies on a national level. At least two forms of protected areas exist: National Parks in which grazing, forestry and hunting are prohibited and Natural Reserves which are established for the conservation and management of one or more species.

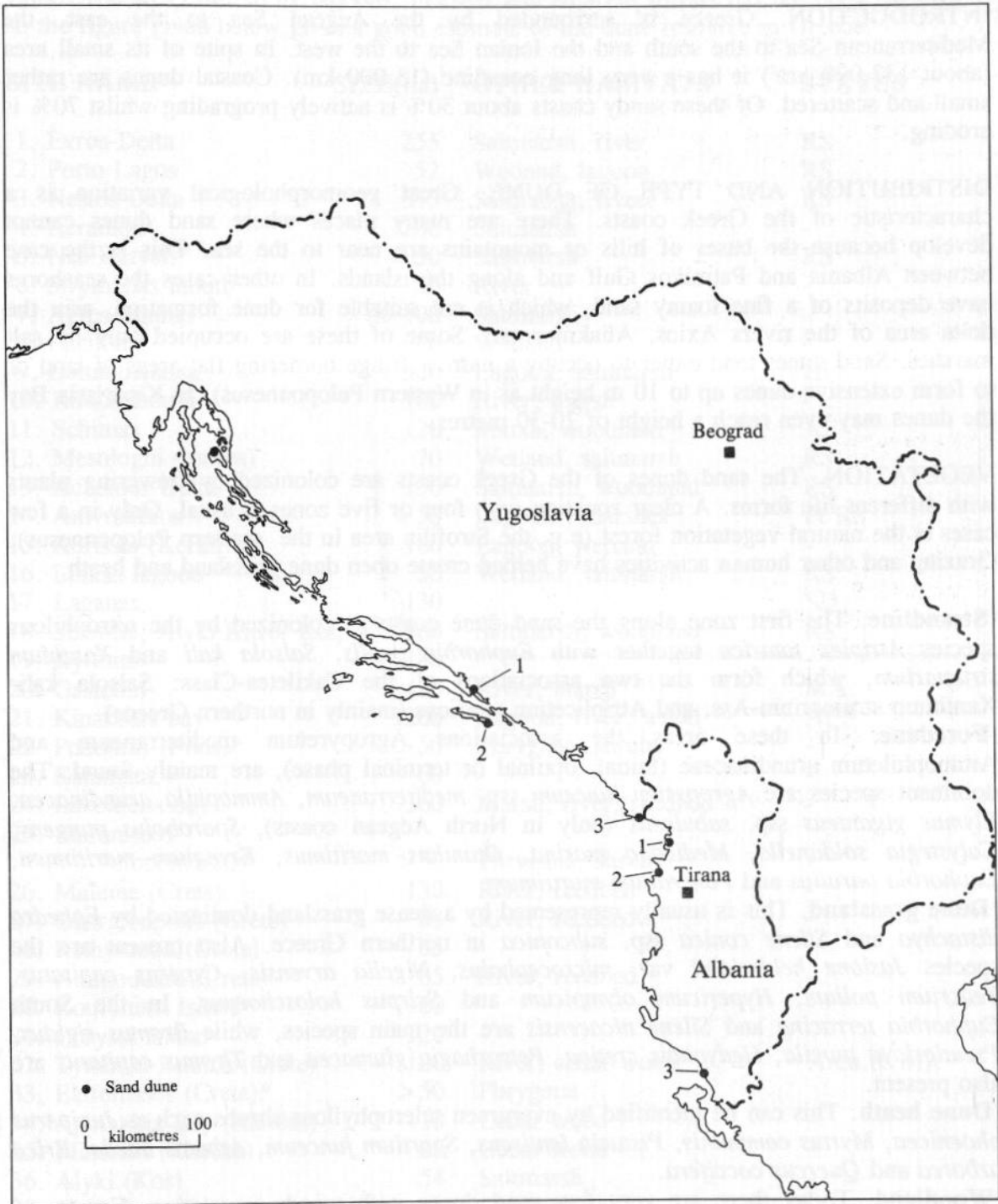
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INTRODUCTION. Greece is surrounded by the Aegean Sea to the east, the Mediterranean Sea to the south and the Ionian Sea to the west. In spite of its small area (about 132,000 km²) it has a very long coastline (13,000 km). Coastal dunes are rather small and scattered. Of these sandy coasts about 30% is actively prograding whilst 70% is eroding.

DISTRIBUTION AND TYPE OF DUNE. Great geomorphological variation is a characteristic of the Greek coasts. There are many places where sand dunes cannot develop because the bases of hills or mountains are near to the sea. This is the case between Albania and Patraikos Gulf and along the islands. In other cases the seashores have deposits of a fine loamy sand, which is not suitable for dune formation, as in the delta area of the rivers Axios, Aliakmon etc. Some of these are occupied only by salt marshes. Sand dunes tend either to occupy a narrow fringe bordering flat areas of land or to form extensive dunes up to 10 m height as in Western Peloponnesus). In Kiparissia Bay the dunes may even reach a height of 20-30 metres.

VEGETATION. The sand dunes of the Greek coasts are colonized by flowering plants with different life forms. A clear zonation with four or five zones is usual. Only in a few cases is the natural vegetation forest (e.g. the Strofilia area in the western Peloponnesus). Grazing and other human activities have helped create open dune grassland and heath.

Strandline. The first zone along the sand dune coasts is colonized by the nitrophilous species *Atriplex tatarica* together with *Euphorbia peplis*, *Salsola kali* and *Xanthium strumarium*, which form the two associations of the Cakiletea-Class: *Salsola kali-Xanthium strumarium*-Ass. and *Atriplicetum tataricae* (mainly in northern Greece).

Foredune. In these areas the associations *Agropyretum mediterraneum* and *Ammophiletum arundinaceae* (initial, optimal or terminal phase), are mainly found. The dominant species are *Agropyrum junceum* ssp. *mediterraneum*, *Ammophila arundinacea*, *Elymus giganteus* ssp. *sabulosus* (only in North Aegean coasts), *Sporobolus pungens*, *Calystegia soldanella*, *Medicago marina*, *Otanthus maritimus*, *Eryngium maritimum*, *Euphorbia paralias* and *Pancratium maritimum*.

Dune grassland. This is usually represented by a dense grassland dominated by *Ephedra distachya* and *Silene conica* ssp. *subconica* in northern Greece. Also present are the species *Jasione heldreichii* var. *microcephalus*, *Nigella arvensis*, *Cyperus capitatus*, *Teucrium polium*, *Hypericum olympicum* and *Scirpus holoschoenus*. In the South *Euphorbia terracina* and *Silene nicaeensis* are the main species, while *Bromus rigidus*, *Pseudorhiza pumila*, *Hedypnois cretica*, *Petrorhagia glumacea* and *Thymus capitatus* are also present.

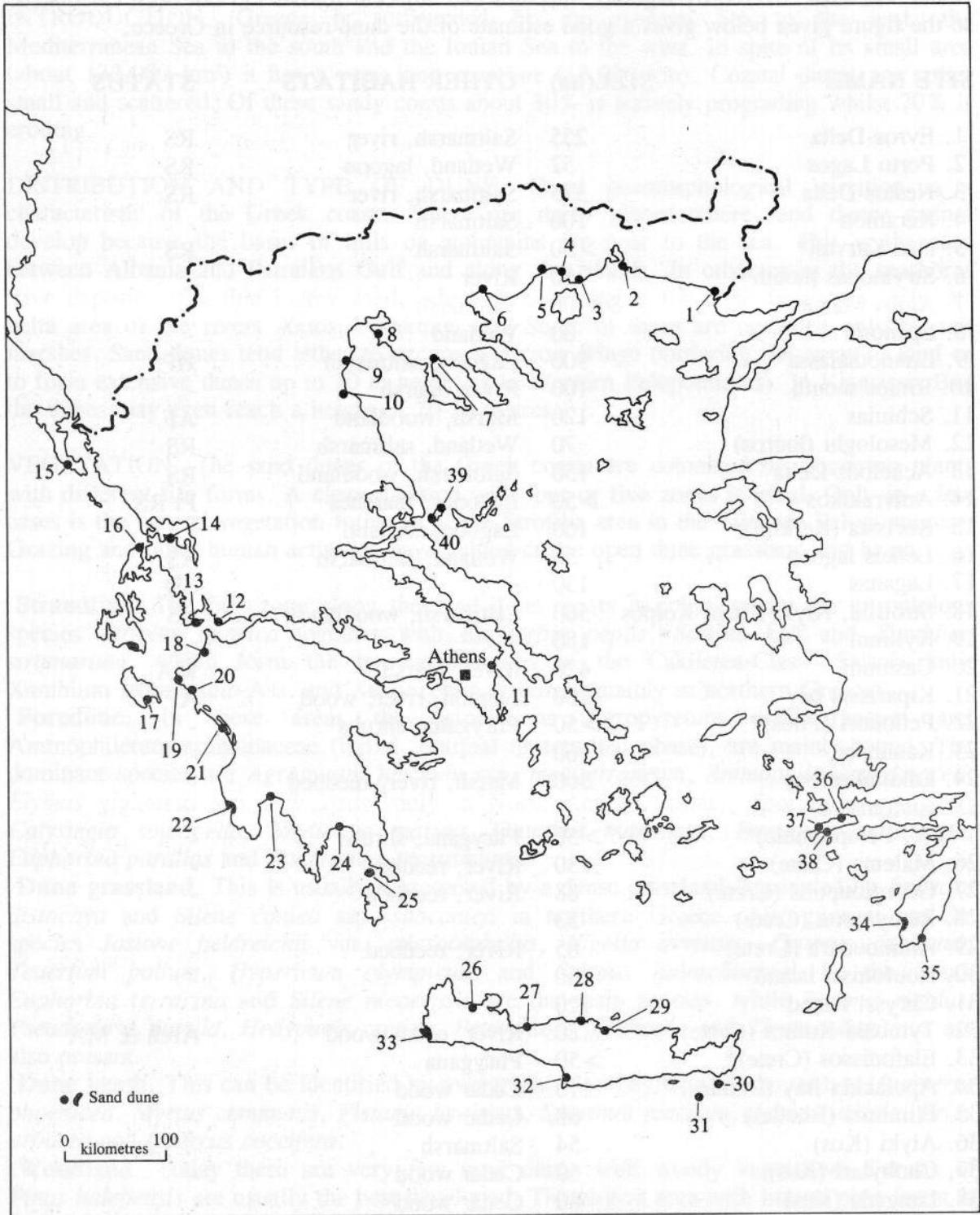
Dune heath. This can be identified by evergreen sclerophyllous shrubs such as *Juniperus phoenicea*, *Myrtus communis*, *Pistacia lentiscus*, *Spartium junceum*, *Arbutus unedo*, *Erica arborea* and *Quercus coccifera*.

Woodland. Today there are very few sand dunes with woody vegetation. Forests of *Pinus halepensis* are usually the best developed. The largest area with littoral pine forest is found in the western Peloponnesus (coastal area of Strofilia). Other species include, *Pinus pinea* and *Quercus macrolepis*, which form a zonation of forest stands from the coasts inland. The species of the shrub layer include elements of the maquis and phrygana (low scrub on dry stony soils) vegetation.

MAJOR SITES. The sites listed below comprise dune areas larger than 50 ha. There are many smaller areas which are also important for their biological, ecological or aesthetic value. The area covered by lagoons, marshes and adjacent forests has not been calculated, so the figure given below gives a good estimate of the dune resource in Greece.

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
1. Evros-Delta	255	Saltmarsh, river	RS
2. Porto Lagos	52	Wetland, lagoon	RS
3. Nestos-Delta	375	Saltmarsh, river	RS
4. Keramoti	100	Saltmarsh	-
5. Nea Karvali*	> 50	Saltmarsh	RS
6. Strymonas mouth	50	River	-
7. Agios Mamas	80-100	Saltmarsh	-
8. Epanomi	80	Wetland	-
9. Limnothalassa	900	Lagoon, saltmarsh	HP
10. Rinos mouth	100	River, marsh	-
11. Schinias	120	Marsh, woodland	AF
12. Mesologhi (Iouros)	70	Wetland, saltmarsh	RS
13. Acheloos-Delta	150	Saltmarsh, woodland	RS
14. Amvrakikos	> 50	Lagoons, marshes	Pt RS
15. Korissia (Kerkira)	160	Lagoon, wetland	-
16. Lefkas lagoon	50	Wetland, saltmarsh	RS
17. Laganas	130	-	SD
18. Strofilia, Alyki Kitro, Kolpos	560	Saltmarsh, woodland	RS
19. Kyllinni	180	-	-
20. Gastouni	420	River, marsh	MA
21. Kiparissia bay	1200	Lagoon, river, wood	AF
22. Petiohori (Pilos)*	> 50	Phrygana, shrubs	-
23. Kalamata	60	-	-
24. Lakonikos bay	360	Marsh, river, reedbed	-
25. Elafonissos (W. Peloponnese)*	> 50	Phrygana, shrubs	-
26. Maleme (Crete)	130	River, reedbed	-
27. Georgioupolis (Crete)	88	River, reedbed	-
28. Rethymoon (Crete)	53	-	-
29. Ammoudara (Crete)	85	River, reedbed	-
30. Koufonissi Island	60	-	-
31. Chryssi Island	120	-	-
32. Tymbaki-Komos (Crete)	120	River, cedar wood	Arch.& MA
33. Elafonissos (Crete)*	> 50	Phrygana	-
34. Apolakkia Bay (Rhodes)	110	Cedar wood	-
35. Plimmiri (Rhodes)	68	Cedar wood	-
36. Alyki (Kos)	54	Saltmarsh	-
37. Chohylari (Kos)	60	Cedar wood	-
38. Langada (Kos)	80	Cedar wood	-
39. Madrakl (Skiathos)*	> 50	Woodland, heathland	-
40. Koukou aries (Skiathos)*	> 50	Woodland, saltmarsh	-

RS, Ramsar Site; HP, Hunting Prohibited; AF, Aesthetic Forest; SD, Special Decree; MA, Military Area.



A large part of the data in this report was collected in the course of the sea turtle survey conducted by the Sea Turtle Protection Society of Greece, during the years 1989-1991. Further information was received by the editor from the Hellenic Ornithological Society (K. Vassilakis and E. Economidou), who identified a number of additional sites. These are asterisked (*) in the table above.

CONSERVATION. In Greece the sand dune vegetation is natural in character. The major influences on the sand dunes are the increased tourism and the building of country houses near the beach. Many lagoons and marshes next to the dunes have been drained. Grazing pressure and sand extraction are of secondary importance. Because of the continuously increasing tourist pressure the characteristic species *Pancretium maritimum* has disappeared from many areas and the vegetation of the Ammophiletea-class has been disturbed.

The lack of an inventory of sand dune sites and investigation of sand dune ecosystems in Greece has seriously hampered the timely implementation of protection measures. As has been observed for other types of ecosystems, it is possible to apply experience from other countries in national protection policies in order to help protect the remaining undisturbed sand dune systems. Only dune areas with pine or cedar woods are protected, because they are considered to be forest lands and are therefore protected by forestry legislation.

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INTRODUCTION. Romania borders the Black Sea and along the coast there are a number of dune areas. The southern coast consists of a pattern of cliffs interspersed with beaches which continue to Constanta. The coast north of Constanta is mainly sandy with some extensive dune areas such as in the Danube delta.

DISTRIBUTION AND TYPE OF DUNE. On most of the coastline of Romania there are no dunes and where they do exist they are small and not well developed. Normally they form a narrow zone, though there are more extensive dune areas in the western Black Sea coast, in the Danube delta. This delta consists of several large and small tributaries of the Danube river with marshes, reedbeds, lakes, lagoons and dunes. In this delta old beach barriers are present as well as younger dune formations with shifting sands. Most of the beach barriers and dunes in the delta are stabilized, but more mobile dunes can be found closer to the Black Sea. Nowadays shifting dunes are the result of overgrazing.

VEGETATION. There is little information available on the composition of the vegetation in the dune areas of Romania. Therefore only the species which are characteristic of the strandline, foredunes and woodland are mentioned.

Strandline. In this zone, close to the sea, *Salsola kali*, *Euphorbia peplis* and *Centaurea arenaria* occur, sometimes with *Atriplex portulacoides* and *Suaeda maritima*

Foredune. The most prominent species are *Eryngium maritimum*, *Pancratium maritimum*, *Ammophila arenaria*, *Euphorbia paralias*, *Carex arenaria*, *Agropyrum junceum* and *Medicago marina*.

Woodland. *Populus alba*, *Salix rosmarinifolia*, *Hippophae rhamnoides* and *Tamarix ramosissima* are amongst the species which occur in the scrub / woodland zone.

More is known about the vegetation on the old beach barriers and dunes of the Danube delta. For example, in the dune depressions the vegetation consists of native natural forest in its climax phase with species such as *Fraxinus pallisiae*, *F. angustifolia*, *Quercus robur* and *Q. pedunculiflora*. In the drier areas *Rosa canina*, *Berberis vulgaris*, *Sambucus nigra*, *Cornus sanguinea* and *Rubus caesius* are more dominant. The herbaceous layer is very diverse with species such as *Aristolochia clematis* and *Convalaria majalis*.

On the dune ridges between the low-lying forest areas, dune grasslands have developed. On these ridges plants can be found which are specially adapted to dry conditions. Dominant species are *Euphorbia sequieriana*, *Carex ligerica* and *Ephedra distachya*. Species which play an important role in stabilising the more mobile dune sands in the Danube delta are *Polygonum arenarium*, *Cynodon dactylon* and *Tribulus terrestris*.

MAJOR SITES. The areas given in the table below include adjacent habitats.

SITE NAME	SIZE(ha)	OTHER HABITATS	STATUS
1. Danube Delta:			
-Perisor-Zatone-Sacalin	15400	lakes	NR
-Periteasca-Leahova			
-Gura Portitei	3900	marshes, lakes	NR
2. Lacul Techirgol	1170	former coastal bay and saline lake	None

NR, Nature Reserve.

CONSERVATION. In Romania only the problems concerning the Danube delta are known. Although the delta is still fairly natural there are some problems. The most important ones affecting the dunes are overgrazing, the planting of exotic trees and the canalization of the Danube river. The last of these causes changes in the sedimentation rates and pattern which in some areas are already causing erosion.

The conservation of the coastal zone in Romania is the responsibility of a national commission which designates and administers protected areas. Within each county there are local commissions responsible for environmental conservation. Natural areas can be designated as national parks and nature reserves. National parks do not yet exist in the Romanian coastal zone, though there are some nature reserves. These reserves can be divided into a large number of categories, botanical, zoological, ornithological, speleological etc.

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Wilhelm, H., 1935. **Beiträge zur Pflanzengeographie der mediterranen Sandstrand und Küstendünegebiete**, Berlin.

INTRODUCTION. The Bulgarian Black Sea coastline has a length of 380 km. The sand dunes and beaches occupy 34% of the coastal strip with a total area of 1,600 ha. In some places the sandy coasts alternate with cliffs and rocky shores, especially in the north.

DISTRIBUTION AND TYPE OF DUNE. There are four large sand dune areas (over 50 ha) and seven large sand strips which occupy over 80% of the entire sandy coastline of Bulgaria. The three largest sand dune areas are located, in the region of the Kamchiya biosphere reserve between Kamchiya and Skorpilovtzi, near the town of Nessebur between Sozopol and the Ropotamo National Park, and finally in the vicinity of Primorsko, respectively. The dunes in Ropotamo National Park were formed on low hills covered by sand 1 to 10 metres deep.

VEGETATION. There is a great variety in the vegetation on the coastal dunes of Bulgaria. A number of plant communities are formed on the sand dunes and sandstrips depending on the presence of mobile sand, the degree of plant growth, competition between species and age of the dunes.

Strandline and foredune. The dominant species in this part of the dunes are *Eryngium maritimum* and *Cakile maritima*, while *Euphorbia paralias*, *Euphorbia peplis* and *Stachys maritima* are rarer. *Salsola ruthenica* is also present with *Cakile maritima* and to a lesser extent with *Polygonum maritimum*, *P. mesembriticum*, *Xanthium italicum*, etc. On more humid soils there are open communities where *Elymus farctus*, *Eryngium maritimum*, *Lactuca tatarica* etc. are present.

Yellow dune. Here perennial species dominate such *Ammophila arenaria*, *Leymus racemosus* ssp. *sabulosus*, *Elymus farctus*, *Cionura erecta*, *Artemisia campestris*, *Artemisia lerchiniana*. In the flatter and lower lying areas species like *Silene thymifolia*, *Centaurea arenaria*, *Galilea mucronata*, *Festuca vaginata*, *Peucedanum arenarium*, *Carex colchica*, *Lepidotrichum uechritzianum*, *Lurinea albicaulis* and *Astragalus onobrychis* become more important. On the older, more stabilized dunes, with a denser vegetation structure, communities of *Tamarix ramosissima* and *T. tetrandra* occur.

Dune slack. In the low areas among the sand dunes where there is a high level of underground water, plant communities with *Phragmites australis*, *Schoenus nigricans*, *Juncus nigricans*, *Juncus maritimus*, *Juncus littoralis*, *Agrostis stolonifera* occur. In these communities *Holoschoenus vulgaris*, *Calamagrostis epigeios* and *Carex extensa* are common. In some places *Erhianthus ravennae* can also be found.

Dune grassland. Typical species for the dune grasslands along the Black Sea coast are *Chrysopogon gryllus*, *Poa bulbosa*, *Bromus tectorum*, *Cynodon dactylon* and *Teucrium polium*.

Woodland. Some examples of species which occur in the dune woodlands of Bulgaria are *Carpinus orientalis*, *Tilia tomentosa* and *Quercus cerris* in the region of the Ropotamo park and *Quercus pedunculiflora* in the region of the Kamchiya reserve. In the forest undergrowth species like *Crataegus monogyna* can be found. In the hollows between the wooded ridges *Ulmus minor*, *Fraxinus oxycarpa* and *Celtis australis* prevail.

In the Bulgarian dunes there are number of rare and threatened plants like *Blackstonia perfoliata*, *Centaurea arenaria*, *Verbascum glanduligerum* (endemic for the Balkan peninsula), *Pancratium maritimum* and *Trachomitum venetum* amongst others.

MAJOR SITES. The following regions have sand dune areas larger than 50 ha.

SITE NAME	SIZE(ha)	STATUS
1. Kamchiya-Skorpilovtsi	330	230 ha BR
2. Sozopol to Ropotamo	200	186 ha Pt NP
3. Nessebur	139	-
4. Primorsko	50	-

NP, National Park; BR, Biosphere Reserve.

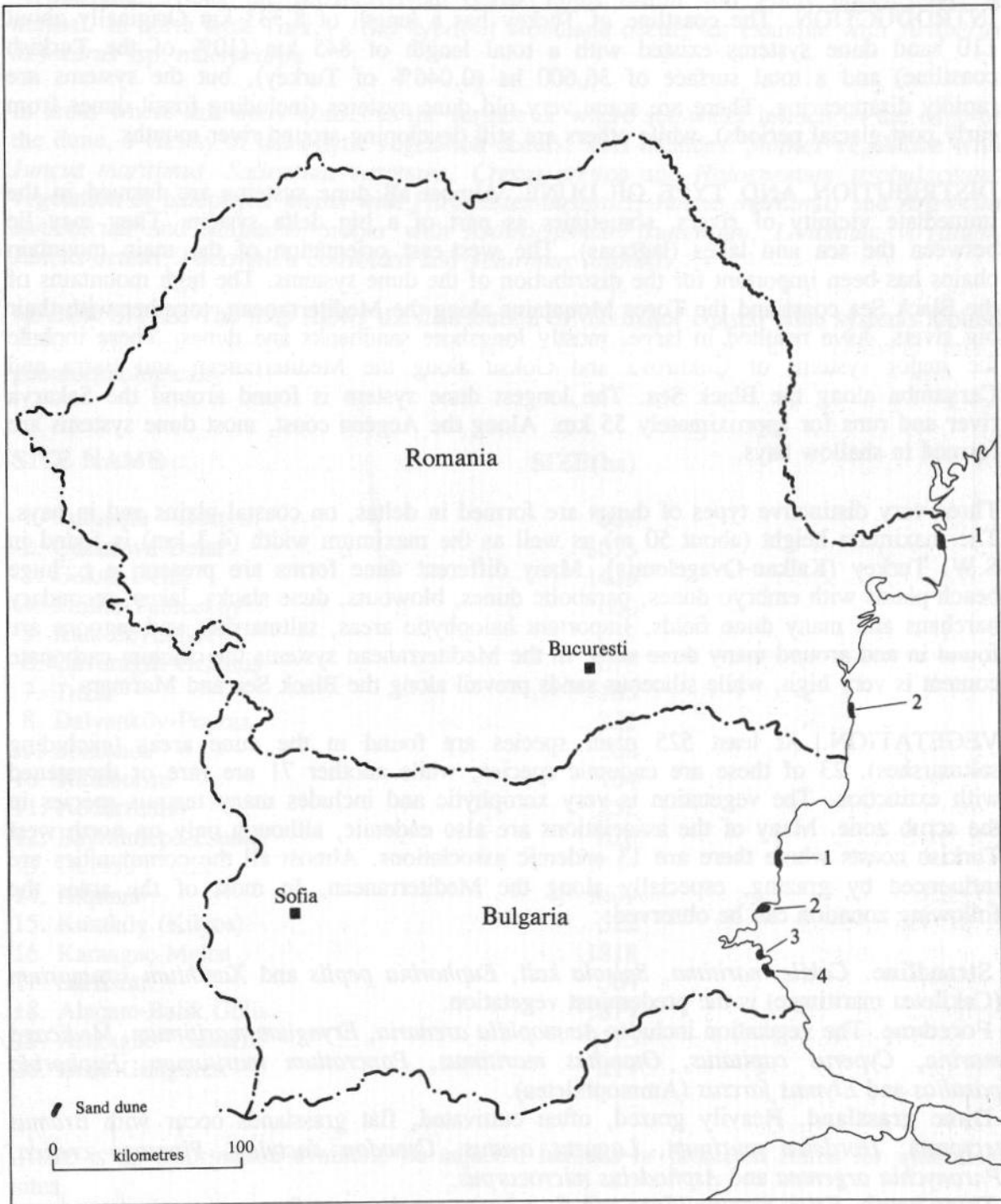
CONSERVATION. The main threats to the sandstrips and dunes of Bulgaria are the building of holiday complexes and associated roads, the use of sand dunes for other building purposes and the subsequent disturbance by tourist activities as occurs on "Sunny Beach" near Nessebur. In this area the sand dunes have been destroyed partly by tourist developments. Part of the area is now protected and plans have been made to restore the damage. Nature conservation in Bulgaria has a central authority. There are four types of protective designations, National Parks, Protected Landscapes, Nature Reserves and Natural Monuments. So far 596 ha of the Bulgarian coastline have been declared as protected areas. These include 45% of the most important sandstrips and dune areas. The nature reserve status of the protected areas within the Kamchiya Biosphere Reserve and the Ropotamo National Park are most important. The latter has been a National Park since 1960 and it is envisaged it will be extended in area in the future.

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INTRODUCTION. The coastline of Turkey has a length of 8,333 km. Originally about 110 sand dune systems existed with a total length of 845 km (10% of the Turkish coastline) and a total surface of 36,600 ha (0.046% of Turkey), but the systems are rapidly disappearing. There are some very old dune systems (including fossil dunes from early post-glacial periods), while others are still developing around river mouths.

DISTRIBUTION AND TYPE OF DUNE. Almost all dune systems are formed in the immediate vicinity of rivers, sometimes as part of a big delta system. They may lie between the sea and lakes (lagoons). The west-east orientation of the main mountain chains has been important for the distribution of the dune systems. The high mountains of the Black Sea coast and the Toros Mountains along the Mediterranean, together with their big rivers, have resulted in large, mostly longshore sandbanks and dunes. These include the major systems of Çukurova and Göksu along the Mediterranean and Bafra and Çarşamba along the Black Sea. The longest dune system is found around the Sakarya river and runs for approximately 55 km. Along the Aegean coast, most dune systems are formed in shallow bays.

Three very distinctive types of dunes are formed in deltas, on coastal plains and in bays. The maximum height (about 50 m) as well as the maximum width (4.3 km) is found in S.W. Turkey (Kalkan-Ovagelemiş). Many different dune forms are present, e.g. huge beach plains with embryo dunes, parabolic dunes, blowouts, dune slacks, lakes, secondary barchans and many dune fields. Important halophytic areas, saltmarshes and lagoons are found in and around many dune sites. In the Mediterranean systems the calcium carbonate content is very high, while siliceous sands prevail along the Black Sea and Marmara.

VEGETATION. At least 525 plant species are found in the dune areas (excluding saltmarshes). 23 of these are endemic species, while another 71 are rare or threatened with extinction. The vegetation is very xerophytic and includes many maquis species in the scrub zone. Many of the associations are also endemic, although only on north west Turkish coasts where there are 13 endemic associations. Almost all the communities are influenced by grazing, especially along the Mediterranean. In most of the areas the following zonation can be observed:

Strandline. *Cakile maritima*, *Salsola kali*, *Euphorbia peplis* and *Xanthium strumarium* (*Cakiletea maritimae*) is the predominant vegetation.

Foredune. The vegetation includes *Ammophila arenaria*, *Eryngium maritimum*, *Medicago marina*, *Cyperus capitatus*, *Otanthus maritimus*, *Pancratium maritimum*, *Euphorbia paralias* and *Elymus farctus* (*Ammophiletea*).

Dune grassland. Heavily grazed, often cultivated, flat grasslands occur with *Bromus tectorum*, *Hordeum murinum*, *Lagurus ovatus*, *Cynodon dactylon*, *Plantago cretica*, *Paronychia argentea* and *Asphodelus microcarpus*.

Dune heath. *Erica manipuliflora* and *E. arborea* are the most frequent species.

Dune slack. These often species-rich areas include *Trachomitum venetum*, *Inula viscosa*, *Schoenus nigricans*, *Holoschoenus vulgaris*, *Phyla nodiflora*, *Mentha aquatica*, *Orchis palustris* and *Phragmites australis*.

Dune scrub. In some areas vegetation with species such as *Sarcopoterium spinosum*, *Verbascum sinuatum* and *Lavandula stoechas* occurs in lower areas in between dune ridges. More typically the vegetation is composed of the *Quercetea ilicis*, which includes

species such as *Rhamnus oleoides*, *Pistacia lentiscus*, *Osyris alba*, *Myrtus communis*, *Phillyrea latifolia*, *Vitex agnus-castus*, *Nerium oleander* and *Daphne gnidioides*.

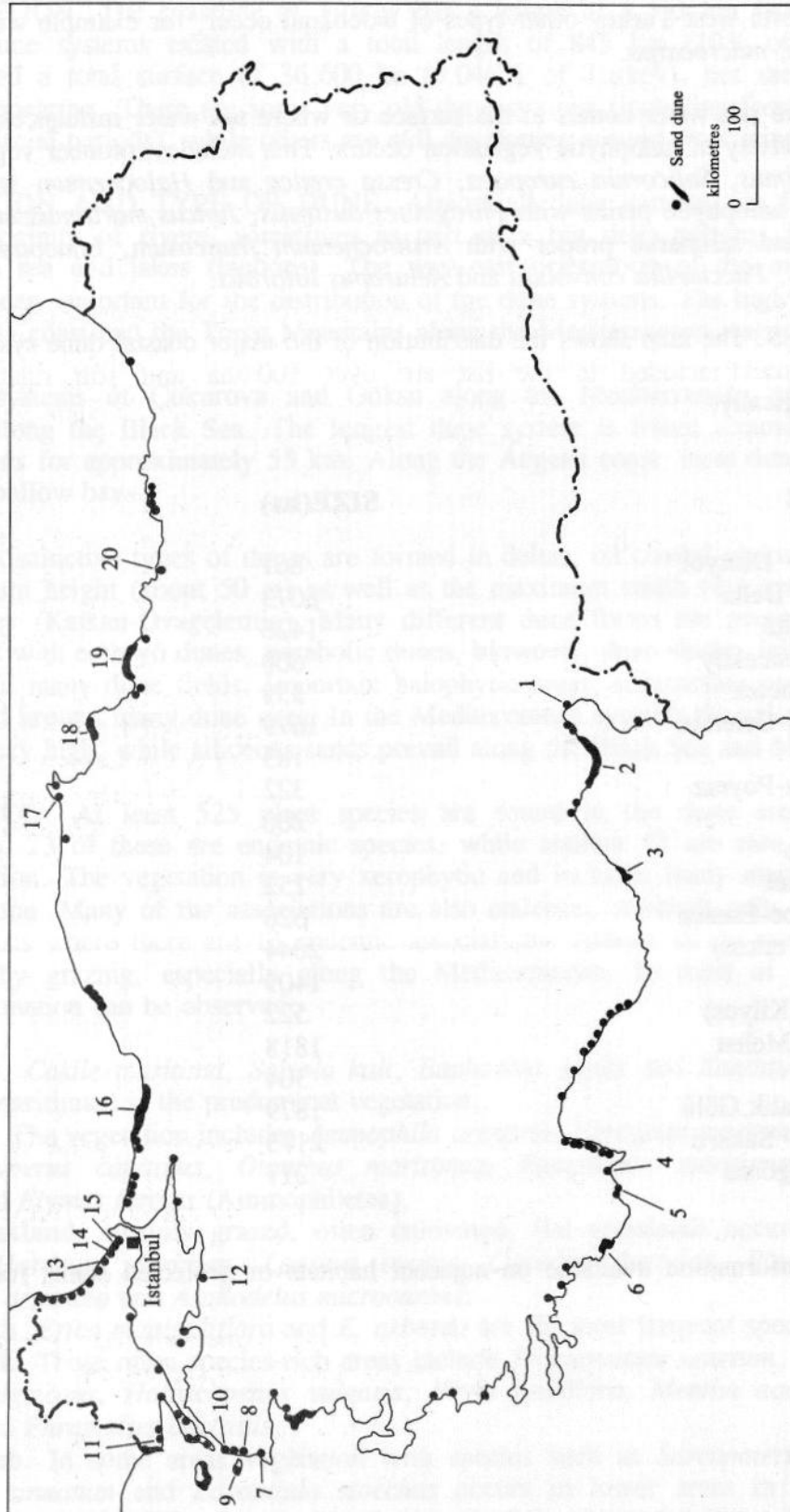
Woodland. Along the Mediterranean coasts *Pinus brutia* and *Pinus pinea* forest is normal. In north west Turkey other types of woodland occur, for example with *Juniperus oxycedrus* ssp. *macrocarpa*.

In areas where salt water comes to the surface or where sea water influences the edge of the dune, a variety of halophytic vegetation occurs. This includes: pioneer vegetation with *Juncus maritimus*, *Salicornia europaea*, *Cressa cretica* and *Halocnemum strobilaceum*; vegetation of halophytic plains with *Phragmites australis*, *Juncus maritimus* and *Artemisia santonicum* and saltmarsh proper with *Arthrocnemum fruticosum*, *Limonium virgatum*, *Juncus acutus*, *Puccinellia convoluta* and *Aeluropus littoralis*.

MAJOR SITES. The map shows the distribution of the major coastal dune systems around 1970. The sites included in the list are over 100 ha and still relatively intact geomorphologically.

SITE NAME	SIZE(ha)
1. Turunçlu - Dörtyol	861
2. Çukurova Delta	8073
3. Göksü Delta	1426
4. Finike-Yeniceköy	600
5. Kale-Beymelek	339
6. Gavuragili-Gelemis	1679
7. Tuzla	183
8. Dalyanköy-Poyraz	322
9. Bozcaada	200
10. Kumburnu	104
11. Abdürrahim	252
12. Bayramtepe-Esence	626
13. Durusu (Terkos)	2044
14. Akpınar	1409
15. Kumköy (Kilyos)	522
16. Karaagaç-Melen	1818
17. Sarikum	304
18. Alaçam-Balık Gölü	1879
19. Asaragac - Sakarli	2175
20. Ordu-Güngören	217

There is no information available on adjacent habitats or protected status for individual sites.



CONSERVATION. Overgrazing, especially by goats, has been the most important influence on the vegetation of almost all dune systems for centuries. When combined with burning by shepherds, this has resulted in enormous damage to vegetation which in turn has often led to erosion and deflation of the dune system.

Afforestation projects, partly designed to stabilise the dunes, began on a small scale in 1885. However it was not until 1970 when major afforestation took place. Nowadays, many projects are carried out and they are continuing on a massive scale. Between 1961 and 1990, 10,672 ha of coastal dune (29% of the Turkish coastal dunes) were afforested. There is a new 5,000 ha afforestation project in Yumurtalik (Çukurova), which threatens to destroy the surviving dune vegetation in this area. Natural vegetation is removed and replaced mostly by *Acacia cyanophylla* and *Eucalyptus camaldulensis* (both exotic), while *Pinus pinea* has been commonly used in recent years. *Pinus maritima*, *Cupressus sempervirens*, *Spartium junceum*, *Robinia pseudoacacia* and *Tamarix smyrnensis* are also planted. These projects are very harmful to the plant communities and species diversity. If afforestation is necessary, it should only be carried out with local dune scrub species, many of which are adapted to the dune environment.

Many dune fields have been, or are being brought into cultivation, mostly since 1970. There are also many projects for horticulture, and sand extraction increased during the same period for soil improvement, buildings and industrial complexes. Several thousand hectares have suffered considerable damage in this way. A growing number of dune systems have suffered from road construction, especially since the massive tourism and residential building boom in the 1980s. At least 5,000 ha have been destroyed. Through the combination of these developments, only about 30 out of the original 110 dune areas surveyed (27%) are left relatively intact. Since 1980 approximately 1,000 ha of dunes and beaches have been destroyed each year. This destruction and the growing tourist pressure on beaches has resulted in a serious threat to monk seals and marine turtles (e.g. the endangered loggerhead sea turtle, *Caretta caretta* and the green turtle, *Chelonia mydas*).

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DISCUSSION.

The results presented above give a brief outline of the sand dune resource for most European countries, stretching from Iceland in the north west to Turkey in the East. Inevitably the results are incomplete, either because it has proved difficult to obtain detailed information, or because of limitations of space. However, it is hoped that the general and wide-ranging descriptions, are helpful.

The identification of the size of the overall resource, its importance from a nature conservation point of view and the extent of man's impact upon it provide a first stage in establishing the basis for the identification of important sites and policy issues affecting their conservation and that of the coastal resource generally. The report has only addressed broad issues. However, it is clear that there are common themes which are important to the survival of the dune habitat.

The descriptions have concentrated on the physical characteristics of the dune and the importance of its vegetation. Information about the fauna has not been included because of limitations on space. However, it is clear that sand dunes play a significant role in providing habitat for a wide variety of animals, and for some species such as invertebrates of open sandy areas, they may be the only habitat in which they occur. In addition sand dunes also provide important refuges for rare species restricted in their distribution elsewhere as a result of development pressures and agricultural intensification.

The dune avifauna includes breeding colonies of terns such as the sandwich (*Sterna sandvicensis*) and the little tern (*S. albifrons*) which nest on open sand. Other species including the eider duck (*Somateria mollissima*) and the shelduck (*Tadorna tadorna*) nest in the ground vegetation, whilst several birds of prey, such as harriers (*Circus aeruginosus*, *C. pygargus* and *C. cyaneus*) and owls (*Asio flammeus* and *A. otus*) may hunt and breed there. At a few sites tree nesting species such as the squacco heron (*Ardeola ralloides*) and the purple heron (*Ardea purpurea*) are present. Other species include the spoonbill (*Platalea leucorodia*) which feeds in lagoons often intimately associated with sand dune systems.

Rabbits (*Oryctolagus cuniculus*) occur in abundance in all areas and are stock food for the fox (*Vulpes vulpes*) populations which occur in the mainland dunes. Polecat (*Mustela putorius*), weasel (*M. nivalis*), several species of bats, voles, mice and shrews occur in most of the areas, while the roe deer (*Capreolus capreolus*) and red squirrel (*Sciurus vulgaris*) are less frequent.

Among reptiles and amphibians are sand lizard (*Lacerta agilis*), natterjack toad (*Bufo calamita*) and the edible frog (*Rana esculenta*).

Portugal provides an example of the importance of dunes for vertebrates. In the south-east, sandy islands, marshes, tidal mudflats and dunes along the coast provide habitat for breeding and migratory birds. Important areas include the Castro Marim and Ria Formosa. The rare, Madeiran petrel (*Oceanodroma castro*) has its only breeding site in continental Europe on the Berlengas Islands (near Peniche). The coastal area is also important for two endangered mammals, the Iberian lynx and the monk-seal. Almost all amphibian and reptile species which occur in Portugal have their main stronghold in the dune areas.

In Spain mammals such as the red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*) are found in the larger dune systems. In the Coto Doñana the lynx (*Lynx pardina*) survives. In smaller dune systems the wild cat (*Felis silvestris*) and genet (*Genetta genetta*) may be present. In the Spanish dunes bats are common, especially when they are close to water. The most common species include mouse-eared bats (*Myotis myotis* and *M. emarginatus*) and the horseshoe bats (*Rhinolophus ferrum-equinum* and *R. hipposideros minimus*). In the inner dunes birds of prey, such as the buzzard (*Buteo buteo*), Imperial Eagle (*Aquila Heliaca*) and the red kite (*Milvus milvus*). The Spanish dune fauna also includes many reptiles and amphibians including the sand lizard (*Lacerta agilis*) and the ocellated lizard (*L. lepida*) which are the most common. In some areas in Andalucia the threatened chameleon (*Chameleo chameleon*) is also present.

CONCLUSION.

Sand dunes are an important resource not only as significant habitats in their own right, but also because they provide areas where a wide variety of specially adapted and rare plants and animals occur. It is clear that man has had and continues to have a major impact on the development and survival of dunes across Europe. Sand dunes are also important for recreation, sea defence and agriculture. These uses are not always compatible and historically much sand dune landscape has been destroyed. Amongst some of the significant impacts are afforestation, agricultural intensification and the building of summer houses and other recreational development. Many of these have already caused a significant loss of dune landscape.

In north west Europe, for example, extensive pine plantations have altered the natural habitat. The sand instability that these were set to overcome may have been largely caused by man's own misuse of the systems by overgrazing and other destabilising activities. More recently, development of other kinds, such as building for recreational use, car parks, golf courses and water abstraction have caused further loss. Today most sand dunes are represented by areas significantly smaller than their original size, and where human interference has adversely affected their natural development.

In the Mediterranean losses of sand dune habitat have been no less severe, though here the predominant activity has been the building of mass tourist facilities. The speed at which the wholesale destruction of sand dunes has occurred and the way in which this appears to have spread in an uncontrolled fashion eastwards from the Spanish coast is an indictment of man's selfish attitude to the natural environment.

Despite the enormous losses it is still not too late. As the inventory shows there are many surviving areas of important dunes. These must be protected. Future use must take account of the value of the remaining areas. Thus instead of building summer houses for the indigenous population or mass tourist facilities for foreigners in the dunes and with dune sand for construction material, the dune landscape should be seen as an integral part of the landscape, to be conserved in its own right. Managing these areas in a sympathetic way should then ensure their survival not only for wildlife but also for the benefit of man. In addition in areas where total destruction of the dune has not occurred, it may be possible to rehabilitate them. The removal of artificial forests and the reestablishment of natural dune processes would be a major benefit in some areas.

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