



HARBASINS Report:

Monitoring of Beaches and Dunes in the Wadden Sea.

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TMAP REVISION – Dune Monitoring Report to the TMAG

1. Introduction

The aim of this report is to prepare a proposal for a revised monitoring strategy with regard to dunes and beaches in the TMAP. The main driver for this revision of the TMAP is the EC Habitats Directive which requires an assessment of the status of several dune types.

The results of the TMAP ad-hoc working group on dunes and beaches (March and September 2006) have been integrated in this report. The TMAG 06/2 meeting (7-8 Sept. 2006) requested the ad hoc group to focus on the comparability of the dune data and the question whether these data can be used for trilateral assessment of the major pressures on beaches and dunes.

2. Status

2.1 TMAP

The TMAP Common Package covers information on location and area of different dune succession types in the Wadden Sea. An overview of the TMAP Common Package parameter group “beaches and dunes” is given in **Annex 1**.

The Wadden Sea QSR 1999, an assessment of the main human impacts on dunes has been prepared but no quantitative information about the distribution of dune vegetation types could be compiled.

In the Wadden Sea QSR 2004, a considerable progress could be achieved: a quantitative analysis of dune vegetation on trilateral level was carried out for the whole Wadden Sea area for the first time (Petersen et al., 2005). By applying the same approach as for the salt marshes (Bakker et al., 2005), dune monitoring data from the three countries has been translated into a common system, the TMAP dune typology (**Annex 2, Table 1**). Quantitative GIS analysis of location and area of different dune succession types as required by the Wadden Sea Plan Targets was done in the QSR (**Annex 2, Table 2**). The TMAP typology also integrates the EC Habitats Directive dune habitat types (2110 – 2190) and has the following advantages:

- the existing various regional vegetation types using different keys (e.g. Schaminée, Drachenfels and others) can be translated into a common TMAP typology with one consistent level of detailing,
- data from various other sources can be integrated (such as from historical maps, relevées or other vegetation data) by using the advantage of GIS and databases,
- specific management related topics such as neophytes can be integrated,
- a Wadden Sea wide consistent GIS data analysis can be carried out in combination with other trilateral GIS data (such as salt marshes and birds).

2.2 EC Habitats Directive

The Habitat Directive requires that member states provide a report on the conservation status of habitats and species every six years.

A national report with a first assessment of the conservation status for all species and habitats of Community interest has to be delivered in 2007 (for the period 2001 – 2006).

A draft guidance has been prepared by the EC Habitats Committee in April 2006 which defines the way of assessing, monitoring and reporting in the view of the next progress report to be compiled by EU-Member States under Article 17 of the Habitats Directive in 2007 (EC, 2005; ETC/BD 2006).

An overview of the dune habitat types is given in **Annex 4**.

2.3 National Status

The Netherlands

A detailed field mapping of most of the Wadden island dunes is carried every 10 years using different vegetation keys. Some of the dunes are monitored by other management organization (e.g. RWS or NGOs such as Natuurmonumenten) which makes it more difficult to get the data harmonized and make them available for the TMAP. A enhanced cooperation on dunes in the Netherlands, a more stratified monitoring approach (combining remote sensing techniques and field mapping) and more regular monitoring frequency (at least a complete mapping every 10 years) should be aimed. Some not mapped 'white areas' exist and have still to be done.

Niedersachsen

Every 6 years, a mapping of all terrestrial habitats (dunes and salt marshes) is carried out by Lower Saxon Wadden Sea National Park. Aerial photographs and field mapping are combined into a consistent data pool enabling various GIS applications for the Lower Saxon Wadden Sea. In addition, permanent plots have been established which are monitored in a higher frequency. The next survey will be carried out in 2010 (see details in Annex 3). The monitoring costs vary between 10 – 50 Euro/ha depending on which level of detail is aimed for.

Schleswig-Holstein

The environmental agency (LANU) is in charge of monitoring and management of the dune areas which are mainly outside the National Park.

Mapping of dunes outside the National Park on islands of Sylt and Amrum were done for Natura 2000 areas and gave information about the percentage cover of the Habitats Directive dune types for these areas.

Denmark

The Danish NOVANA program covers monitoring of all habitat types in Denmark and defines the criteria for monitoring and assessment (NOVANA 2005). The overall monitoring strategy is deduced from the critical load approach. Criteria for the quality of a habitat are ecosystem function (changes in eutrophication, acidification, hydrology) and nature type structure (composition of the vegetation, height, cover of invasive species etc=measurements and observations.). The monitoring strategy is based on a net of sampling stations (about 1000 in the whole county) which are randomly selected within broadly defined habitat types. Each station has up to 20-60 sampling plots. A sampling point consist of a pinpoint-frame 0.5x0.5 m surrounded by a circles of 5 m radius, 200 stations are intensive stations monitored every year and 800 are extensive and monitored every 6 years.

In the Danish monitoring program the focus in the field is to collect data in a consistent matter. In the following analysis classification of the vegetation type are made as well as analysis of plant, soil and water chemistry.

In addition to NOVANA also characteristic species with regard to the Habitats and Birds Directive are monitored.

An inventory of the monitoring activities is in **Annex 3**

3. Analysis

The TMAP dune typology has been proven to be an efficient tool to describe the area and distribution of the dune succession types in the Wadden Sea in the QSR 2004. It has been adapted to various situations and enables an overview of the different dune habitats in the entire Wadden Sea Area and is detailed enough to detect long-term changes in the dune area.

3.1 Monitoring of dune types

The mapping of the entire beach and dune areas in the Wadden Sea should be carried out with a frequency of 6 – 10 years applying the national monitoring methods and vegetation classifications.

The TMAP typology is a tool to combine the different national systems to enable an overall trilateral assessment. With the TMAP typology, two levels of detail can be applied on the basis of the existing national monitoring programs:

a. Area and location of HD habitat types 2110-2190. This information can be delivered by all three countries. In Denmark, the habitat types “embryonic dunes” and “white dunes” are not mapped in because the priority has been given to the major dune habitat types like grey dunes, dune slacks and the *Empetrum* dune heath. Only designated habitat areas are monitored.

b. Area and location of vegetation types within the HD habitat types 2110-2190. This information can be delivered be The Netherlands and Niedersachsen on the basis of the existing vegetation mapping programs. However, in The Netherlands HD type

2110 ('embryonic dunes') in are mostly not, and sometimes HD type 2120 ('white dunes') insufficient covered because these types were lying outside the area of mapping or are not part of the area of the main mapping activities.

These levels of detail which can be address with the TMAP typology can be regarded as sufficient to get a trilateral overview of distribution and development of habitat types and vegetation.

3.2 Monitoring of beaches

The QSR showed that consistent information and monitoring data about beaches is limited and a trilateral assessment could not be carried out. A draft monitoring program, concerning beaches was discussed by the expert group (Table 1). The expert group concluded that, for the time being, a monitoring program on geomorphological and biological characteristics, as well as on human pressure on beaches, can not be finally defined mainly because of lacks in knowledge and suitable methods.

Therefore, the forthcoming QSR 2009 should be used to compile the existing data and information on beaches and to develop a TMAP beach monitoring strategy which is connected to the reporting requirements of the EC Habitats Directive.

Table 1. Outline of a beach monitoring program and proposed parameters

Beach monitoring	Theme	Subject	Parameter
Status	geomorphological	beach state index	breaker height (H cm), sand fall velocity (W cm/s) maximum tide range (MTR cm) wave period (T s)
		slope	height/length (m/m)
		width	m
	biological	macrobenthos	species composition biodiversity abundance zonation
		vegetation	Habitat type Annual drift line (HD type 1210)
		resting and breeding birds	species composition (especially Plovers and Sanderling), abundance
		seals	abundance
Human pressure	recreation	tourism	number tourist number beach pavillons dimensions beach cleaning dimensions of driving
	coastal defence	sand nourishment	size and location
		marram grass	size and location
		number hard constructions	size and location
		garbage	
	nature management	passive	restrictions human use
		active	dimensions ecological restoration
	oil-gas extraction	drop beach/seabed	size and location

3.3 Assessment of human impacts on dunes

In addition to the mapping (see 3.1) the trilateral assessment should concentrate on main issues of concern which deserve awareness on trilateral level:

1. Stabilization of dunes resulting in decreasing dune dynamics
2. Decrease of ground water level and impacts on dune slacks
3. Eutrophication of dunes by atmospheric deposition
4. Additionally, fragmentation of dune habitats (e.g. due to coastal defense or tourism industry should be addressed) (not part of QSR 2004)
5. Invasive species

The main human impacts relevant for a Wadden Sea wide assessment are therefore:

- coastal protection measures (with regard to issue no. 1)
- water extraction (no. 2)
- atmospheric input (no. 3)
- tourism (no. 2 and 4)
- invasive species (no. 5)

These main issues of concerns for beaches and dunes have to be addressed by operational experts groups in charge of beach and dune management. By defining the main management questions, these groups should compile which specific information and data are necessary to address these questions.

In this concept, the main purpose of the TMAP is to deliver basic and background information on human impacts on dunes. Analysis and development of management measures has then to be carried out by operational experts groups on regional/local level.

Coastal Protection

The impacts of coastal defence measures on beaches and dunes should be assessed by a trilateral working group integrating morphological, hydrological and biological aspects including effects on vegetation. Information on coastal protection measures (e.g. beaches and dunes as part of the coastal defence system, sand nourishment activities) have to be made available for trilateral assessment. This information can be obtained from the coastal protections authorities rather than from a monitoring program itself.

A more intensive cooperation with the CPSL group should be aimed at.

Ground water level

The effects of ground water extraction and reduced ground water table on vegetation cannot be monitored by measuring the amount of extracted water annually. A proper assessment in order to derive management measures requires a more integrated strategy also taking into account to local geomorphological and hydrological conditions. Therefore, it would be too premature to define TMAP parameters for this issue of concern at this stage.

A further exchange of knowledge with regard of the different hydrological systems on the islands involving geologists, hydrologists and ecologists is recommended.

The positive results of the water management and vegetation monitoring schemes on Norderney and Langeoog should be included in this approach (QSR 2004).

Atmospheric input

There is only few quantitative data on atmospheric input available mainly based on regional models. In Denmark, a regional model has been established together with regular in-situ measurements (flux sampler) and ecological indicators (N% content in lichens and mosses in grey dunes).

There is a need for more detailed data on nitrogen input on the Wadden Sea island when assessing the effects of atmospheric input on the dune vegetation.

Tourism

The amount of recreational pressure on beaches and dunes can be obtained by indicators such as numbers of tourists per region but it would be almost impossible to get figures on disturbances or to monitor these, especially when it concerns local effects like trampling.

An appropriate indicator which can be obtained by monitoring is the area covered by settlements and local infrastructure. This land use data should be compiled every 5 years by aerial photographs (if available).

Furthermore, information on beach cleaning should be compiled because this activity has a negative effect on embryonic dunes.

Invasive species

The question to be addressed by monitoring and management has to be defined on a regional level by an operational working group. It does not make sense to establish a general monitoring program for all kind of invasive species for the whole dune area.

The species with main concern such as *Rosa rugosa* have already been included in the TMAP typology. The Danish Forest and Nature Agency has elaborated an official list of invasive species. The monitoring are based on this list.

Monitoring parameters

A proposal for the selection of parameters for the TMAP is given in Table 2 taking into account the available information and national monitoring programs. In addition, further information from regional and local sources has to be included in the assessment (as already done in the QSR 2004).

Table 2: Parameters on human impact on dunes (in bold: to be monitored in the TMAP)

Topic	Parameters	Frequency	Area	Remark
<i>Data to be obtained by TMAP:</i>				
Atmospheric input	kg N / ha / year	Annually	- whole area, - selected islands	Model calculation and field measurements
	Lichen/moss ratio in grey dunes	annually	Denmark	NOVANA
Tourism	Area covered by settlements and infrastructure	Every 6 years	Whole area	Land use data (from aerial photographs (if available) or other sources)
Invasive species	selected invasive species and forestation	Every 6 years	Whole area	Local/regional topic to be addressed by operational group.
<i>Data from existing sources (no specific monitoring by TMAP):</i>				
Coastal protection measures	Areas with coastal protection measures, Areas with beach nourishment	Every 6 years	Whole area	Regular update of basic information (from existing information)
Hydrology: water extraction	m ³ / year ground water level	Annually	Islands with ground water extraction	From existing data sets

3.4 Field surveys

Field surveys should be carried out with a higher frequency than the monitoring of vegetation or habitat types for the entire area. It should cover parameter related to function and structure of the specific habitat.

In order to assess the development of dune types in more detail and to react e.g. on short term development, at least an annual monitoring is necessary. This is done in the Netherlands and Germany with the concept of permanent plots and in Denmark within the NOVANA stations and plots by stochastic statistical sampling.

On trilateral level this is done to assess the issues no. 1 'stabilization of dunes', no. 2 'groundwater extraction' and no. 3 eutrophication.

3.5 Assessment criteria

In the Wadden Sea QSR 2004, the TMAP vegetation typology and the HD dune types were used to assess the Targets with regard to an increased natural dynamic in connection with the offshore zone and a complete natural vegetation succession. An overall assessment of the Wadden Sea Plan Targets were made and it could be concluded that about two-thirds of the Wadden Sea dunes consist of mid-successional types and that the species rich grey dunes and dune slacks have further decreased.

The QSR 2004 demonstrated that the Wadden Sea Targets can be assessed with the available data sets although for some regions detailed information was missing.

Almost all dune areas have been designated under the Birds and Habitats Directives. As a consequence, the quantity and quality of all qualifying habitat types and species should be maintained and reinforced. This means that not only the mere presence of all vegetation succession stages (HD-habitat types) should be guaranteed, but also the presence of their constituents (the characteristic plant and animal species and communities) and their structure and function.

These criteria must be explicitly imposed on the Wadden Sea Plan Target concerning the presence of complete natural dune succession series. Therefore, the evaluation of this target and consequently the monitoring activities must be directed more explicitly to obtaining information about the presence of the whole range of characteristic species and communities as required by the Habitats Directive.

Therefore, further assessment parameters covering structure and function, as well as characteristic species and communities, should be part of the Target evaluation and the TMAP.

4. Proposal for a revised TMAP

The results of the trilateral data assessment in the QSR 2004 revealed that the TMAP typology is a valuable instrument to assess the status of the Wadden Sea dunes especially with regard to the occurrence of a complete vegetation succession.

Further information of the conservation status of the dune habitats (HD types 2110 – 2190) will be available from field surveys conducted in the national programs.

The revised TMAP for dunes covers the common monitoring parameters applied in all three countries in a comparable ways. This enables comparing the development of dune vegetation in the different parts of the Wadden Sea.

The main issues of concerns for beaches and dunes (stabilization, ground water level, eutrophication, recreational pressure, invasive species) have to be addressed by operational experts groups in charge of beach and dune management. By defining main management questions, these groups should compile which specific information and data are necessary to address these questions.

In this concept, the main purpose of the TMAP is to deliver basic and background information on human impacts on dunes. Analysis and development of management measures has then to be carried out by operational experts groups on regional/local level.

Beach monitoring could not yet be implemented in the TMAP because of lacking knowledge and methods. Therefore, the forthcoming QSR 2009 should be used to compile the existing data and information on beaches and to develop a TMAP beach monitoring strategy which is connected to the reporting requirements of the EC Habitats Directive.

It is proposed:

- a. Existing national mapping of dunes should be continued in order to deliver input into the TMAP dune typology to assess the overall occurrence of dune types in the Wadden Sea,
- b. Monitoring parameters for assessing structure and function, species and communities should be included in the TMAP,
- c. Human impact parameters for dunes should be included in the TMAP with regard to atmospheric input and land use,
- d. Operational groups should be established for defined issues of concern to prepare proposals for monitoring and management measures; in this context, a trilateral workshop on hydrology and geomorphology should be carried out,
- e. The comparability of monitoring parameters, methods, frequencies and stations should be further tuned on the national and trilateral level to enhance interpretation of the results for the entire Wadden Sea Area

A proposal for a revised TMAP is in Table 3.

Table 3: Proposed parameter groups of a revised TMAP.

Parameter group	Parameter	Method	Frequency	Area	Remark
Location and area of beaches and dunes	HD-habitat types (ha)	According national guidelines (HD 2100-2190)	Every 6 years	Whole area	Transfer into TMAP dune typology (GIS) (HD 2110 and 2120 not covered in DK, not complete in NL)
	Vegetation types (ha)	According national guidelines (vegetation keys)	Every 6 years	Whole area DK: on representative station level	Transfer into TMAP dune typology (GIS) (on at least HD level)
Vegetation	Species composition	According national guidelines	Annually	Selected sites (at permanent plots, transects or random sampling plot)	Assessment of species occurrence and distribution. Comparability of methods to be further developed.
Atmospheric input	kg N / ha / year	Model calculation and field measurements	Annually	- whole area, - islands	Danish regional model to be extended to entire Wadden Sea
	Lichen cover in grey dunes	NOVANA	Annually	Danish islands	Await experiences from NOVANA
Tourism	Area covered by settlements and infrastructure	Land use data (from aerial photographs (if available) or other sources)	Every 6 years	Whole area	Indicator for recreational pressure on dunes
Invasive species	Selected invasive species	TMAP typology According to official invasive list in DK	Every 6 years	Whole area or on representative monitoring stations	Local/regional topic to be addressed by operational group.

References

Petersen et al., 2005. Chapter 9.2 Dunes. In: Essink et al. 2005. Wadden Sea Quality Status Report 2004. Wadden Sea Ecosystem No. 19.

EC, 2005. Note of the Habitats Committee. Assessment, monitoring and reporting of conservation status – Preparing the 2001-2007 report under Article 17 of the Habitats Directive. Brussels, 15 March 2005.

ETC/BD 2006. Assessment, monitoring and reporting of conservation status – Preparing the 2001-2007 report under Article 17 of the Habitats Directive: Explanatory Notes & Guidelines. Draft 3, April 2006.

Essink et al. 2005. Wadden Sea Quality Status Report 2004. Wadden Sea Ecosystem No. 19.

NOVANA, 2005. National Monitoring and Assessment Programme for the Aquatic and Terrestrial Environments. Programme Description – Part 2. NERI Technical Report, 537.

ANNEX 1

STATUS TMAP Common Package

Monitoring of dunes in the Wadden Sea has been carried out as part of the TMAP Common Package since 1997 (Stade Declaration, 1997) (TMAP Manual 1997).

The aim of the TMAP is to provide a scientific assessment of the status of the ecosystem and to assess the status of implementation of the Targets (QSR 1999, 2004).

The monitoring of dunes (including beaches) is carried out to assess changes in

- location and area of different dune types
- natural dune succession

taking into account climate changes, coastal protection measures, and human utilization (e.g. tourism).

With regard to beaches and dunes (including beaches, primary dunes, beach plains, primary dune valleys, secondary dunes and heathland behind the dunes) the following Targets apply (Wadden Sea Plan 1997):

- increased natural dynamics of beaches, primary dunes, beach planes and primary dune valleys in connection with the offshore zone;
- an increased presence of a complete natural vegetation succession;
- favorable conditions for migrating and breeding birds.

Table 1: Overview of Parameter Groups adopted as part of the TMAP Common Package in the Stade Declaration (1997) with regard to dunes.

Parameter Group	Parameters	Area	Frequency	Guideline	Time series in QSR
Location and area of beaches and dunes	Location and area of different dune succession types	Whole Wadden Sea Area	Every 5 years	TMAP	

Annex 2: QSR 2004 Table 1: TMAP Dune Typology

TMAP-type:	Dune types	Vegetation:	EC HD types
Xerosere:			
X.0	Dunes		
X.1	Beach plains	No vegetation	
X.2	Beach driftline		
X.2.0	Beach driftline, unspecified		
X.2.1	Cakile maritima type	Cakiletum maritimae	
X.3	Embryonic dunes		2110
X.3.0	Embryonic dunes, unspecified		2110
X.3.1	Elymus farctus type	Elymo-Agropyretum, Honkenyo-Agropyretum juncei	2110
X.4	White dunes		2120
X.4.0	White dunes, unspecified		2120
X.4.1	Ammophila arenaria type	Elymo-Ammophiletum, Ammocalamagrostis baltica unit	2120
X.5	Dune grassland		2130
X.5.0	Dune grassland, unspecified		2130
X.5.1	Corynephorus canescens type (+/- dominant Campylopus introflexus)	Violo-Corynephorum (+/- Campylopus introflexus), Corynephorion vegetation	2130
X.5.2	Koeleria arenaria type	Tortulo-Phleetum, Phleo-Tortuletum, Festuco-Galietum, Airetum praecocis, Koelerion vegetation	2130
X.5.3	Botrychium lunaria type	Botrychio-Polygaletum, Nardo-Galion vegetation	2130
X.5.4	Carex arenaria type	Carex arenaria unit	2130
X.5.5	Deschampsia flexuosa type	Deschampsia flexuosa unit	2130
X.6	Dune heath		mostly 2140
X.6.0	Dune heath, unspecified		mostly 2140
X.6.1	Empetrum nigrum type	Hieracio-Empetretum, Polypodio-Empetretum	2140
X.6.2	Calluna vulgaris type	Hieracio-Empetretum – dom. Calluna vulgaris	2150
X.7	Dune scrub		
X.7.0	Dune scrub, unspecified		
X.7.1	Hippophae rhamnoides type	Hippophae-Sambucetum nigrae, Salici arenariae-Hippophaetum	2160
X.7.2	Salix repens agg. type	Dry – fresh Salix repens ssp. argentea (arenaria) and repens ssp. repens vegetation, Pyrolo-Salicetum, Rosa spinosissima-Salix arenaria unit	2170
X.7.3	Rosa canina type	Rhamno-Prunetea vegetation	-
X.7.4	Rosa rugosa type	Rosa rugosa unit	-
X.8	Dune woodland		
X.8.0	Dune woodland, unspecified		
X.8.1	Populus tremula type	Populus tremula / Betula pendula / Quercus robur vegetation	2180
X.8.2	Pinus spp. Type	Pinus spp. Vegetation	
X.9	Open dune areas	No vegetation	mostly 2130
X.10	Eutrophic dune areas	Dry vegetation with: Urtica spp., Epilobium angustifolium, etc.	mostly 2130
X.11	Salty dune areas	Combination of Xeroserie and Haloserie vegetation	mostly 2130
X.12	Wandering dunes		

TMAP-type:	Dune slack types	Vegetation:	EC HD types
Hygrosere:			
H.0	Dune slacks (humid)		2190
H.1	Pioneer dune slacks		
H.1.0	Pioneer dune slacks, unspecific		
H.1.1	Centaureum littorale type	Centauro-Saginetum	
H.1.2	Radiola linoides type	Cicendietum filiformis, Isoeto-Nanojuncetea vegetation	
H.1.3	Littorella uniflora type	Littorelletea uniflorae vegetation	
H.1.4	Lycopodiella inundata type	Sphagno-Rhynchosporetum, Lycopodio-Rhynchosporetum	
H.2	Dune slack fens		
H.2.0	Dune slack fens, unspecific	Juncus spp., Potentilla anserina vegetation etc.	
H.2.1	Carex trinervis type	Caricetum trinervi-nigrae, Caricion nigrae vegetation	
H.2.2	Schoenus nigricans type	Juncus baltici-Schoenetum nigricantis, Juncus subnodulosus unit, Caricion davallianae vegetation	
H.2.3	Calamagrostis epigejos type	Calamagrostis epigejos unit	
H.3	Dune slack heath		
H.3.0	Dune slack heath, unspecific		
H.3.1	Erica tetralix type	Empetro-Ericetum, Narthecium ossifragum vegetation	
H.3.2	Oxycoccus macrocarpos type	Oxycoccus macrocarpos vegetation	
H.3.3	Molinia caerulea type	Molinia caerulea unit	
H.4	Dune slack reedbed		
H.4.0	Dune slack reedbed, unspecific		
H.4.1	Phragmites australis type	Scirpo-Phragmitetum, Schoenoplecto-Phragmitetum, Typho-Phragmitetum	
H.4.2	Carex spp. Type	Magnocaricion units	
H.5	Dune slack willow shrubbery		
H.5.0	Dune slack willow shrubbery, unspecific		
H.5.1	Salix cinerea type	Salix cinerea-Salix arenaria unit, Salicetum cinereae – salicetosum repentis	
H.5.2	Myrica gale type	Myricetum galis	
H.6	Dune slack woodland		2180
H.6.0	Dune slack woodland, unspecific		
H.6.1	Betula pubescens type	Betula pubescens unit, Empetro-Betuletum carpaticae	
H.6.2	Alnus glutinosa type	Alnus glutinosa unit	
H.7	Open dune slack areas	No vegetation	
H.8	Aquatic vegetation in dune slacks – Hydrosere	Charetea fragilis, Potamogetoneta, Utricularietea vegetation	
H.9	Eutrophic dune slack areas	Humid vegetation with: Epilobium hirsutum, Cirsium vulgare a. arvense etc.	

Table 2: Distribution of dune types in the Wadden Sea (TMAP-types; EU-Habitat types)
(In percentages per country/state and island. The vegetation types are arranged in successional order. The last column gives the total area in hectares. The last row gives the percentages per dune type of the total area of the Wadden Sea dunes) (source: QSR 2004).

TMAP-types	X.3	X.4	X.5	X.6	X.7	X.7.1	X.7.2	X.8	X.8.2	H.0	H.1	H.2	H.2.2	H.3	H.4	H.5	H.6	H.8	
EU-Habitat-types	2110	2120	2130	2140		2160	2170	2180		2190	2190	2190	2190	2190	2190	2180	2190		
	(%)																		(ha)
NETHERLANDS	1.9	10.8	46.4	10.4	0.8	3.9	0.1	6.6	4.4	0.0	0.4	4.0	0.7	0.5	2.1	2.5	4.2	0.2	11313.9
Texel	0.6	14.3	44.5	9.1	0.5	4.6	0.1	4.8	2.1	0.0	0.3	1.7	1.9	0.4	2.4	3.7	8.8	0.2	2865.8
Vlieland	0.2	6.6	48.5	11.8	1.6	1.3	0.0	23.3	0.0	0.2	0.0	2.4	0.1	1.2	2.6	0.1	0.0	0.0	1262.7
Terschelling	3.0	10.7	40.1	18.4	0.0	0.6	0.3	3.8	11.2	0.0	0.5	5.4	0.6	0.6	1.1	2.0	1.4	0.1	3915.3
Ameland	1.6	6.5	60.0	2.2	2.5	2.1	0.0	8.3	0.0	0.0	1.1	6.7	0.0	0.2	4.2	3.0	0.8	0.8	1997.8
Schiermonnikoog	4.0	14.0	46.9	0.0	0.1	17.9	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.6	2.5	12.2	0.0	1272.3
Niedersachsen	5.3	16.5	40.2	4.4	3.2	11.3	1.5	2.5	0.6	0.2	0.7	3.6	0.9	0.2	3.5	1.3	3.2	1.0	4440.5
Borkum	10.3	12.8	30.3	1.0	3.6	17.3	0.4	2.7	0.5	0.0	0.9	4.3	1.1	0.1	5.7	1.7	7.1	0.0	1228.6
Juist	1.6	9.0	53.9	3.1	10.1	10.0	0.0	0.0	0.0	2.2	0.9	0.0	3.2	0.0	3.5	2.6	0.0	0.0	436.9
Memmert	15.4	2.8	66.7	0.8	0.2	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.1
Norderney	1.6	21.2	43.8	1.9	0.0	6.6	1.1	2.9	1.5	0.0	0.3	3.5	0.7	0.6	5.4	1.5	4.1	3.2	900.9
Baltrum	1.4	29.8	33.1	0.7	0.8	15.1	1.4	2.3	0.7	0.0	1.9	6.2	0.2	0.0	3.3	2.0	1.1	0.1	248.1
Langeoog	2.9	19.4	28.2	8.7	0.0	14.9	5.9	5.6	0.8	0.0	0.7	7.5	0.0	0.2	1.3	0.5	1.9	1.6	812.5
Spiekeroog	11.3	3.5	63.8	12.4	4.5	3.7	0.0	0.0	0.0	0.0	0.5	0.0	0.1	0.0	0.1	0.1	0.0	0.0	454.3
Wangerooge	0.0	3.2	65.2	10.6	16.2	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.0	0.0	198.8
Mellum	5.8	30.6	61.5	0.0	1.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.9
Minsener Oog	0.0	99.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	82.8
SCHLESWIG-HOLSTEIN	20.3	6.5	12.6	51.6	0.0	0.0	1.0	0.3	0.0	7.6									1499.7
Eiderstedt	0.0	10.7	30.2	24.8	0.0	0.0	1.3	2.7	0.0	30.2									149.0
Föhr	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0									1.0
Amrum	69.0	13.1	2.3	13.8	0.0	0.0	0.0	0.0	0.0	1.8									435.0
Sylt	0.4	2.7	14.7	74.0	0.0	0.0	1.4	0.0	0.0	6.7									914.7
DENMARK	8.8	2.6	20.2	41.2	0.0	0.0	0.7	0.0	9.1	17.5									2645.0
Römø	13.4	2.5	3.7	47.2	0.0	0.0	0.7	0.0	13.8	18.7									1731.1
Mandø	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0									6.7
Fanø	0.0	0.2	48.2	32.3	0.0	0.0	0.7	0.0	0.0	18.6									746.4
Skallingen	0.2	14.6	64.5	20.7	0.0	0.0	0.0	0.0	0.0	0.0									160.7
WADDEN SEA AREA	5.0	10.6	39.0	16.2	1.2	4.7	0.6	4.3	3.9	3.0	0.4	3.1	0.6	0.3	2.0	1.7	3.1	0.3	19887.8

The general pattern of dune types of the xerosere consists of mid-successional types dominating pioneer stages as well as dune scrubs and woodland. Overall, grey dunes (X.5-types) cover about 40% of the Wadden Sea dune area. In Schleswig-Holstein (12.5%) and Denmark (20%) their presence is outweighed by the very large area of dune heaths (X.6). Dune heaths cover about 50% of the total dune area in Schleswig-Holstein and about 40% in Denmark). The dune heath area is much smaller in The Netherlands (about 10%) and Niedersachsen (about 5%) and seems to be restricted to only some of the islands.

ANNEX 3

Inventory Dune Monitoring (version 4 October 2006)

	The Netherlands		Niedersachsen	Schleswig- Holstein	Denmark
1. General	(Lammerts, 6.3.06)	(Slim, Alterra 6.3.06)	(Hecker, NLPV 29.9.06)	(Kohlus, NPA, 7.3.06)	(Nielsen, NERI, 4.10.06)
1.1 Institutes	Evert Jan Lammerts, Staatsbosbeheer (SBB) Groningen, Roel Douwes, Natuurmonumenten, Assen, Henk de Vries, It Fryske Gea, Olterterp, Aante Nicolai, Rijkswaterstaat	1 Ministerie van Defensie 2 Vereniging tot behoud van natuurmonumenten in Nederland (NGO) 3 Private organisations 4 Alterra	Norbert Hecker, Nationalparkverwaltung (NLPV) Olaf von Drachenfels Niedersächsischer Landesbetrieb für Wasserhaushalt, Küsten- und Naturschutz (NLWKN)	Jörn Kohlus, Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer (NPA), Jürgen Gemperlein, Landsamt für Natur- u. Umweltschutz (LANU)	National Environmental Research Institute, Silkeborg., Ribe and Sønderjyllands Amt,
1.2 Title	Mapping of dunes by all management organizations	1 2 3 4 Duinvalleikartering Ameland	Mapping of dunes and beaches in the National Park (by NLPV)	a. Mapping of dunes in the National Park (by NPA) b. Mapping of dunes on islands (by LANU)	NOVANA
1.3 Aim	Management of dunes	1 Nature management in framework of military use 2 Nature management 3 Agricultural use 4 Soil subsidence (risk analysis)	1. Habitats Directive (favorable conservation status) 2. Management of selected dune slack areas	Management of dunes	Habitats Directive (favorable conservation status)
2. Aerial surveys					
2.1 Area and frequency	Total area, every 10 years, in June/July	1 Regularly 2 Irregularly 3 No survey 4 Every 2 yrs (2001, 2004, 2006 etc.)	Total area every 5 – 7 years: 1991 1997 2002	a. Dunes in St. Peter, every 5 years, (1996, 2000, 2005), in July/August b. Dunes on islands: Inventory Habitats Directive	

	The Netherlands		Niedersachsen	Schleswig- Holstein	Denmark
2.3 Methods	e.g.: [Aerial photographs, scale 1:5,000 or 1:10,000, false color, 60% overlap, stereoscopic interpretation. Ground truth (verification one year after aerial survey)]	1 Aerial photographs 2 Aerial photographs 3 Sometimes aerial photographs 4 DTM, Kriging, aerial photographs	Aerial photographs, scale 1:10,000 or pixel size 32 cm, CIR, 1991 and 1997: stereoscopic interpretation. Ground truth (interpretation key, since 2004 classification (with software) of digital aerial photos after defining and using reference areas, ground truth surveys one or two years after aerial survey). (in combination with salt marsh monitoring)		Aerial photographs, polygons of dominating habitat type.
2.4 GIS	[calculation of changes in dune area, vegetation].	1, 2, 4 Arc GIS, but older maps analogous	ArcGIS: Statistics, digital maps, analysis	ArcGIS, digital maps.	
2.5 Classification	HD types (2110, 2120, 2130, 2140, 2150, 2160, 2170, 2180, 2190) Vegetation types [according to] TMAP dune types	1, 2, 4 Several types of classification; to be transformed into classification De Vegetatie van Nederland to be transformed into Htypes	HD types (2110, 2120, 2130, 2140, 2150, 2160, 2170, 2180, 2190) Three different keys: 1. BfN Key – 4 types (Biotoptyp Küstendüne, Dünenal, Klifftranddüne: Binsenquecken-Vordüne, Strandhafer-Weißdüne, Graudüne, Gehölzbestand der Küstendünen 2. Mapping key of Lower Saxony (16 Types) 3. Ringot key (6 types) TMAP dune types (in 2003 / 04 used key)	HD dune types (2110, 2120, 2130, 2140, 2150, 2160, 2170, 2180, 2190) and related types. Keys (5 types: Binnendüne, Dünen- und Strandwall-Grasfluren, Dünenheide, Dünengehölze, Küstendüne, Strandwall, Feuchte Dünenalvegetation LANU: Mapping by Fa. Triops & Leguan; 2005 Amrum and Sylt as HD Habitat Types, detailed biotope mapping (Pinneberger Schema) (Vegetation, impacts, structure) Only in HD Areas (% of HD type per total HD area) NPA Until now: plant communities, no biotope types.	HD types (2110, 2120, 2130, 2140, 2150, 2160, 2170, 2180, 2190)

	The Netherlands		Niedersachsen	Schleswig- Holstein	Denmark
3.Field surveys					
3.1 Area and frequency	Complete vegetation maps in SBB-dunes and RWS areas every 10 years; in other areas less regularly	1, 2, 4 Permanent plots	Selected dune areas with permanent plots (every 1 – 5 years), ground truth and aerial photographs	Dunes at St. Peter Ording Other sites (outside NP)	4 intensive dune stations (annually) 10 extensive stations (every six years) [number and location of ext. sites will be determined in April 2006]
3.2 Vegetation	Vegetation types (local types and SBB-types which can be translated in habitat-types and TMAP/redlist species Neophytes	1 Vegetation types 2 'Doeltypen' 3 Vegetation types 4 Local vegetation types, inventory of Red List species, HD species	Vegetation types, (after Braun-Blanquet).		a. Area (ha) b. Eutrophication (average Ellenberg indicator value for nitrogen on species list; C/N; N content in leaves, N-deposition, coverage of bushes and trees, water table (July/August) c. Typical species (population index for each typical species)
3.3. Others	Groundwater extraction Groundwater levels Breeding birds	4 Groundwater level	Groundwater extraction	Groundwater extraction	
4 Data handling	ArcGIS	4 Alterra is collecting all digitalized maps in database for 'nulmeting gunstige staat van instandhouding'	NLPV: geographical data in ArcGIS (images, shape, coverage or geodatabase) Permanent plots in Turbowin and selected pp in ArcGIS	NPA: GIS, database at NPA, geographical data in ArcGIS, LANU:	National database for terrestrial habitat types and species
5 Quality assurance		No real guidelines	Internal guidelines for aerial surveys and field mapping.		Technical instructions for mapping of terrestrial nature types. Each habitat type has a set of parameters defining technical criteria of favorable conservation status.. Laboratory analysis are accredited

ANNEX 4 Habitats Directive: Dune Habitat Types in the Wadden Sea Area

Habitat Type	Designated in	NL	Nds (NP)	SH (NP)	SH (islands)	DK
2110 Embryonic shifting dunes		X	X	X	X	X
2120 Shifting dunes along the shoreline with <i>Ammophila arenaria</i> ("white dunes")		X	X	X	X	X
2130 *Fixed dunes with herbaceous vegetation ("grey dunes")		X	X		X	X
2140 *Decalcified dunes with <i>Empetrum nigrum</i> (brown dunes)		X	X		X	X
2150 *Atlantic decalcified fixed dunes (<i>Calluno-Ulicetea</i>)			X		X	
2160 Dunes with <i>Hippophae rhamnoides</i>		X	X			
2170 Dunes with <i>Salix repens</i> ssp <i>argentea</i> (<i>Salicion arenariae</i>)		X	X		X	X
2180 Wooded dunes of the Atlantic, Continental and Boreal regions		X	X		X	X
2190 Humid dune slacks		X	X		X	X

HD Conservation Objectives (all draft/preliminary versions)

Denmark

Conservation objective: maintaining or restoring favourable conservation status for the species and natural habitat listed for which the areas have been designated to.

Criteria for favourable conservation status (FCS) have been elaborated and shall form the basis for establishing conservation objectives (CO), for nature planning, and for monitoring programmes for assessing the favourable conservation status of the natural habitats and the species.

On the basis of the general criteria in the Habitats Directive of favourable conservation status (area, structure, function, species) more specific, precise criteria have been developed to describe when the conservation status of each habitat type and species can be considered to be favourable. These criteria should meet the following requirements:

- They should be able to form the basis for monitoring the conservation status of the habitat type or the species;
- They should be biologically relevant, and provide a basis for the protection of nature;
- They should be immediately intelligible, and based on professionally reasonable simplifications;
- The monitoring methods should be operational, and repeatable;
- They should be quantifiable.

Germany

Lower Saxony

Definition of criteria to assess conservation status of habitat types of coastal dunes (ABC system) in preparation.

Same general conservation objectives as in Schleswig-Holstein.

Schleswig-Holstein

General conservation objectives:

To guarantee, as far as possible, that natural process can proceed in an undisturbed way:

- to maintain the natural geomorphological dynamic
- to maintain the largely natural hydrophysical and hydrochemical conditions and processes,
- to maintain the largely natural sediment and current conditions in the coastal area,
- to maintain the biotope complexes and the typical habitat structures and functions in natural condition,
- to maintain a high water quality
- to maintain areas with a largely undisturbed.

Specific conservation objectives have been formulated for priority habitats (see table) and are currently under preparation for all coastal Federal States (Schleswig-Holstein, Niedersachsen, Hamburg, Mecklenburg-Vorpommern).

Table: Conservation objectives (draft version) in the Netherlands and Schleswig-Holstein

	The Netherlands	Schleswig-Holstein (for priority types) (under preparation for all states)
2110 Embryonic shifting dunes	Objective: Preservation of area and quality. Notes : The embryonic dunes habitat type is in a favourable state of preservation. The Wadden Sea is one of the most important areas in the Netherlands for this habitat type. The type also occurs in adjoining Natura 2000 areas on the Wadden islands and in the North Sea Coastal Zone. The preservation of dynamic dune areas is a precondition for the preservation of this type.	Erhaltung <ul style="list-style-type: none"> • der natürlichen Sediment- und Strömungsverhältnisse im Küstenbereich mit frisch angeschwemmten Sänden, • der natürlichen Sanddynamik und Dünenbildungsprozesse, • der ungestörten Vegetationsfolge (Sukzession), • der Vegetationsbestände ohne Bodenverletzungen.
2120 Shifting dunes along the shoreline with <i>Ammophila arenaria</i> ("white dunes")	Objective: Preservation of area and quality. Notes. The white dunes habitat type is found over an extensive area and is of good quality. The preservation of dynamic dune areas is a precondition for the preservation of this type. The habitat type is also found in adjoining Directive areas on the Wadden islands and in the North Sea Coastal Zone. In natural circumstances there can be substantial annual variations in the area covered by this habitat type.	Erhaltung <ul style="list-style-type: none"> • der natürlichen Bodenentwicklung und der natürlichen Wasserstände in den Dünenbereichen, • der Mosaikkomplexe mit anderen charakteristischen Lebensräumen bzw. eingestreuten Sonderstrukturen wie z.B. Sandflächen, Silbergrasfluren, Sandmagerrasen oder Heideflächen, • der natürlichen Sand- und Bodendynamik, • vorgelagerter, unbefestigter Sandflächen zur Sicherung der

		<p>Sandzufuhr, • der natürlichen Dünenbildungsprozesse.</p>
<p>2130 *Fixed dunes with herbaceous vegetation ("grey dunes")</p>	<p>Objective: Preservation of area and quality of sites where the habitat type grey dunes, lime-deficient (subtype B), is well-developed and improvement of the quality of sites where the grey dunes habitat type, lime-deficient (subtype B) is moderately developed.</p> <p>Notes: The habitat type grey dunes, lime-deficient (subtype B), is found on a limited scale in the region (e.g. on the islands of Rottumeroog, Rottumerplaat and Griend). It applies in particular to dune grasslands with a relatively lime-deficient substrate (grey dunes, lime-deficient (subtype B)).</p>	
<p>2190 Humid dune slacks</p>	<p>Objective: Increase in area and improvement of quality of humid dune slacks, lime-rich (subtype A).</p> <p>Notes: The habitat type humid dune slacks, lime-rich (subtype A), is found on stretches of beach on the eastern side of the Wadden islands. The vegetation on these beaches is very young. It is thought likely that the habitat type humid dune slacks will become more extensive as a result of vegetative succession.</p>	