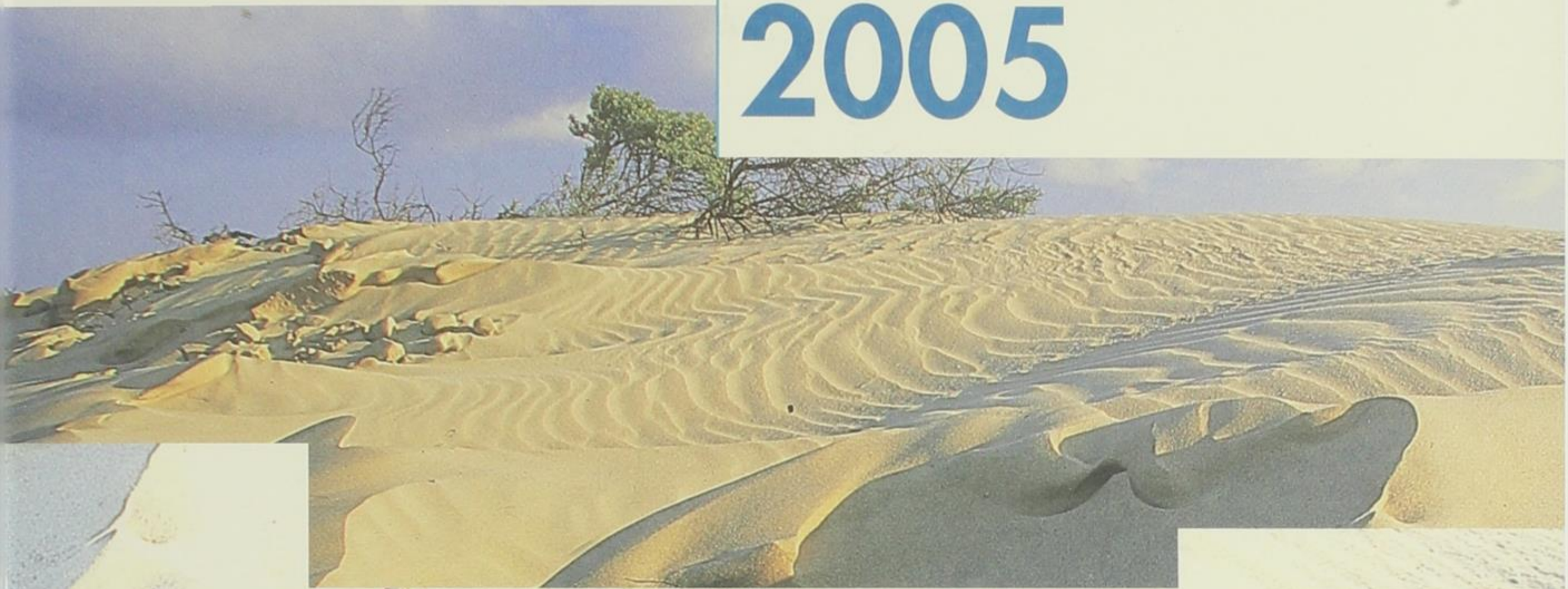


BOOK  
OF ABSTRACTS

# DUNES & ESTUARIES 2005




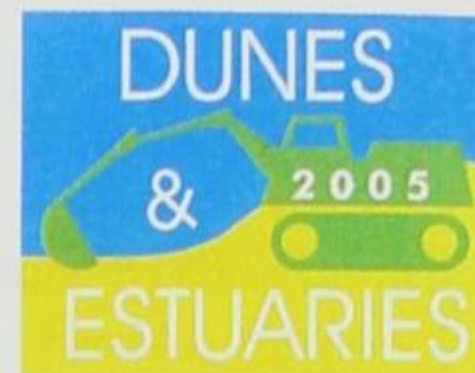
International conference on nature restoration  
practices in European coastal habitats  
Koksijde, Belgium  
19-23 September, 2005



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**BOOK OF ABSTRACTS**  
**DUNES & ESTUARIES 2005**  
*International conference on nature restoration  
practices in European coastal habitats*

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Koksijde, Belgium  
19-23 September 2005

Edited by

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## PREFACE

In 1993 the issuing of the decree on the protection of the coastal dunes by the Flemish Parliament meant the starting point of an intensified policy of the Flemish Regional Authority for the conservation of nature along Flanders coast.

Since then, nature conservation and restoration along the Flemish coast have known an unprecedented dynamic. This dynamic has for an important part been inspired by examples from other European countries. The Netherlands had its 'ecosystem perspective for the coastal dunes' before the concept of 'ecosystem perspective' was even known in Flanders and the wonderful work of the French Conservatoire du Littoral et des Rivages Lacustres was the edifying example for the Flemish purchase policy of coastal dunes. Ambitious Life nature-projects along the coasts of the United Kingdom and Denmark inspired similar initiatives of nature restoration in Flanders. Of course the input of Flemish scientists, volunteers in ngo's, political representatives, decision makers and civil servants of the environmental administration was and is still the main driving force behind the 'machine' that is trying to rescue the scarcely remaining natural areas along the strongly urbanised Flemish coast. But fact is that foreign examples have stimulated this Flemish enthusiasm and that the main forum in which stimulating information about nature restoration has been disseminated was provided by international conferences.

As during the last decade, the Flemish practice of planning, executing and monitoring natural restoration projects has significantly increased, the competent authority thought the time had come for the Flemish region to organise on its turn an international conference about nature restoration practices in European coastal habitats. Such an international conference was then included in the program of the Life nature-project 'FEYDRA', that was launched in 2002. The main aim of this conference, which in the meantime received the title 'Dunes & Estuaries 2005', is stimulating nature restoration along all European coasts by exchanging valuable knowledge and experience between managers and decision makers from all Atlantic European countries. The organisers chose deliberately to emphasise the practical aspects of land purchase, management and habitat restoration. The intention was to bring 'the people on the field' together and to let them learn from each other's achievements and failures.

For the practical organisation of this international conference the Coastal Union (EUCC) with its long tradition of networking and patronising international conferences and Flanders Marine Institute (VLIZ) with its vocation for collecting and disseminating data about the Flemish coast were obvious partners. The Municipality of Koksijde with its rich natural and cultural heritage offered the ideal location for the conference. The more so because the first large scale nature restoration work along our coast in 1995 (the demolition of the gigantic building of the Home Georges Theunis) as well as the largest part of the present Life nature-project 'FEYDRA', both took place on the territory of Koksijde.



We hope that the abstracts and proceedings of 'Dunes & Estuaries' will constitute a useful reference document that will further inspire many coastal nature managers to enhance the biodiversity and natural processes in their 'own stretch' of coast and so help to implement the European Habitat and Bird Directives. Finally we also hope that the Flemish experience will contribute to raise the awareness of other European regions and nations that it is better to preserve rather than to heal their coasts from an excessive urbanisation.

Jean-Pierre HEIRMAN



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# SEDIMENT CHARACTERIZATION IN 'THE IJZERMONDING' USING AN EMPIRICAL ORTHOGONAL FUNCTIONS: APPLICATION TO CASI

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The erodability of mudflats is strongly determined by the biophysical characteristics of sediments (Austen *et al.*, 1999). Mud, sand, benthic micro algae and water content determine sediment stability and are used as input data in hydrodynamic models.

Airborne hyper spectral remote sensing is identified to be effective for the quantification of biophysical characteristics of sediments in large and often inaccessible mudflats (Rainey *et al.*, 2003). In this paper an automated method to characterise sediments and related biological quantities is proposed. The method is based on a linear transformation of each spectrum in the hyper spectral cube. Different sediment types and land covers were classified using two dimensions of the transformed data space.

The methodology is applied to a hyper spectral image of the IJzermondig mudflat, acquired by the Compact Airborne Spectrographic Imager (CASI). Comparable results are obtained using the standard classification method employed in hyper spectral image processing. The superiority of the proposed method lies in its robustness (no interference from the operator), computational requirements, repeatability and objectiveness. The proposed method uses the underlying statistical information of the dataset while the standard method is mainly based on expert knowledge.

For the quantification of sand, mud, and chlorophyll-a as a measure of benthic diatoms, more research about the interaction of electromagnetic radiation with matter using controlled laboratory experiments is suggested.

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deflation, locally surface height was reduced considerably. After 3-5 years, stabilisation of the areas becomes more important, but the rate of stabilisation depends on the scale of the measures. In the area near Schoorl, where the sand is very poor in carbonates, most of the dune slack is stabilised by vegetation after 5 years. However, because of the notch in the foredunes, sand is blown from the beach and transported inland, resulting in deposition and the development of small dunes. In this case, the continuous supply of fresh beach sand is essential to keep the landscape alive. In the area near Zandvoort, large parts are stabilised after 8 years, and the landscape has changed into a mosaic of bare patches, pioneer vegetation, sand burial and stabilised surfaces. Only locally new dunes are formed, but mostly small. The landscape changed from a large sand drift area into a landscape with smaller scale dune activity and blowout development. In the parabolic dunes near Haarlem the reactivation resulted in huge erosion on the windward and crestal side of the dunes, while at the lee massive sand burial occurred. In one case, the parabolic shape of the dune was transformed to a dome shape. The dune now seems to be remobilised, moving over a distance of approximately 1-5 m.year<sup>-1</sup>.

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## **CONTRIBUTION TO THE METHODOLOGY FOR THE EVALUATION OF THE HABITATS CONSERVATION STATE**

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The setting up of the European natural sites network, Natura 2000, requires a definition of the initial conditions of the habitats in the designated perimeters.

For the evaluation of the conditions (state of conservation) of the vegetal communities, nowadays there is no objective and common methodology in France for different organisms making studies and preliminary maps to the realization of the 'Documents d'Objectifs' for the pSIC (proposal of site of Community importance).

Moreover, the habitats notions remain very complex and need a better definition both from a conceptual and a methodological point of view.

With this paper we want to introduce our approach and propose a methodology for the evaluation of the conservation state of the habitats of a natural site. Such method is based on the habitat conditions, principally distinguishing some objective criteria (e.g. structure or floristic composition) from others referring to the subjective appreciation (threats, environmental conditions...).

The first group of criteria depends on the analysis of the phytosociological measurement tables concerning and describing a vegetal association.

Each criterion has a numerical value and it is possible to attribute to each habitat one of the three following conservation levels (states).

1. favourable state
2. not representative yet not deteriorated state
3. unfavourable and deteriorated state

The definition of the habitat state is a particularly important phase to define the stakes and the reasons for the conservation and the management of a natural site.

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# **POTENTIALS OF AIRBORNE HYPERSPECTRAL REMOTE SENSING FOR VEGETATION MAPPING OF SPATIALLY HETEROGENEOUS DYNAMIC DUNES, A CASE STUDY ALONG THE BELGIAN COASTLINE**

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Most natural objects have characteristic features in the spectral signature that distinguish them from others. As many of these characteristic features occur in very narrow wavelength regions, remote sensing of these objects demands narrow band sensors. Broadband sensors, such as Landsat TM, average the reflectance over a wide range by which the narrow spectral features are lost or masked by other stronger features surrounding them. For this reason hyper spectral remote sensing is becoming a very performant alternative for the detailed monitoring of vegetation and other natural objects.

This study focused on the use of airborne hyper spectral data to classify the vegetation in the dynamic zone of the Belgian dunes. Hyper spectral data with different spatial and spectral resolutions were available for this project. They were collected during airborne campaigns in October 2002 and June 2004. Additionally, extensive botanic field surveys were performed to make a spectral library of the plant species and plant associations to be distinguished. All hyper spectral data were radiometrically, geometrically and atmospherically corrected after which a supervised approach was adopted to classify the imagery. Initially, three different classification methods were tried out. The first method was based on the analysis of the spectral reflectance profiles in the part of the spectral range, which is best suited to distinguish different plant species, associations and structures. This analysis was mainly performed with standard ENVI software and IDL programs, which were specifically written for this study. In the second method a wavelet transformation was performed to transform the data cube into a new one, which is better suited for feature extraction. Feature extraction is necessary because in a hyper spectral data set the number of features is often too large to yield a good classification. A sequential floating forward selection algorithm allowed the reduction of the features. The final classification used the Fisher's linear discriminant analysis. In the third method an object-oriented classification, performed with eCognition software, was adopted. In this case the analysis was not based on single pixels, like in the first two methods, but on homogeneous image objects, which were extracted during a segmentation step. After exploring the possibilities of the three methods one integrated approach was developed and this was used to classify the most recent data (dating from June 2004).



From the beginning of this research project, two customers were strongly involved. The 'Administratie Waterwegen en Zeewezen' of the Flemish Government needs accurate vegetation maps of the dynamic dune areas to be able to estimate the strength of the seawall and to decide whether specific protection measures are required. Furthermore, the Administratie Waterwegen en Zeewezen is responsible for the public management of several nature reserves in the dunes. The Institute of Nature Conservation on the other hand, is carrying out ecological research in the coastal dunes for over 15 years. It is mainly aiming at supporting and monitoring the conservation measures taken by the Nature Division of the Flemish Government, which manages most of the coastal dunes. A main concern of this research is finding new methods for efficient, detailed and cost-efficient vegetation mapping. To meet the needs of both customers two tailor-made classifications were made.





## **THE SCHELDT INFORMATIONCENTRE: AN INFORMATION PLATFORM FOR THE ESTUARY OF THE RIVER SCHELDT**

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The Scheldt InformationCentre acts as an information platform for the estuary of the river Scheldt. This centre is active in The Netherlands and recently also in Flanders. Its area of interest concerns the tide-related part of the river Scheldt, i.e. from Ghent (B) to the mouth in Vlissingen (NL).

The main task of the Scheldt InformationCenter is putting information about the estuary area at the disposal of everybody interested in the subject. Additionally, the institute acts as a contact point. The Scheldt InformationCenter contributes also to popularising less accessible reports and publications and has therefore an interface function between the public authorities, the scientific community and the public at large. Coordinating Scheldt-related projects is another task of the institute. In all activities, the different functions of the estuary, safety, policy and management are central issues.

By informing everybody about the river Scheldt, the institute hopes to widen the involvement and public awareness of this estuary, a river so important for Sealand (NL) as well as Flanders (B).



## **MORPHOLOGICAL AND SEDIMENTOLOGICAL MONITORING OF A MAN-INDUCED ACCRETIONARY BEACH – DUNE SYSTEM (CA' ROMAN, VENICE, ITALY)**

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A detailed morphodynamic and sedimentological survey has been carried out on one of the few sites along the barrier islands of the Venice lagoon where a complete coastal dune system still survives, recently included in pSIC. The high aeolian transport potential, as well as the accretionary trend caused by the shoreline advance updrift to the northern Chioggia jetty, gave rise to the formation of a large dune assemblage during the last Century. The collected data, together with the historical documentation analysis, have fostered the reconstruction of the evolutionary history, and a better knowledge of the processes regulating the formation and the development of coastal dunes in this geographical area.

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# ARE COASTAL DUNE MANAGEMENT ACTIONS FOR BIODIVERSITY RESTORATION AND CONSERVATION UNDERPINNED BY INTERNATIONALLY PUBLISHED SCIENTIFIC RESEARCH?

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Scientific research in coastal dunes of Europe has mainly focused on understanding processes of soil and landscape development, vegetation succession and its interaction with animal ecology. Both fundamental and applied questions were dealt with. In theory, the results of these investigations should underpin nature management practices and should give a solid foundation to monitoring.

In this contribution, we review past and present scientific research in the Atlantic coastal dune region and its most important consequences for nature management, nature restoration, landscape conservation and monitoring. Results are contrasted with contemporary management practices in order to detect management shortcomings and fields where scientific research needs to be extended in order to fine-tune, often expensive, management practices.

We will discuss to which amount common ecological theories (genetic diversity in fragmented populations, disturbance, stress and diversity, adaptive strategies of species at the margin of their range, ...) can be projected onto the coastal dune ecosystem and whether these are relevant for nature conservation.



## **THE IMPORTANCE OF GROUNDWATER AND OTHER ECOHYDROLOGICAL IMPACTS IN THE MANAGEMENT OF SALT MARSH PLANT COMMUNITIES**

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Salt marshes are characterized by the presence of plants tolerant of some degree of salinity; although freshwater can also be a significant component. Sources and routes of fresh water can include fresh water river flow into the estuary, fresh groundwater flow along a defined aquifer or channel or diffuse surface seepage as a result of rain. In addition both fresh and salt-water flows can be the agents of transport to and from the marsh itself of sediment, mineral nutrients, pollutants and particulate or dissolved organic carbon (Hazelden and Boorman, 1999).

A common feature of many valley salt marshes is the presence of seepages of fresh water, local upwelling or flow through permeable soil layers, along the edges of the upper marsh. They can often be distinguished by the presence of plant species not fully tolerant of seawater. The commonest is *Phragmites australis* which can be seen as isolated clumps marking localized fresh water seepages or generally widespread in areas where the soil salinity is reduced by a generalized fresh water input.

While surface and ground water flow can provide necessary plant nutrients excessive nutrient loading can result in hyper-eutrophic conditions with major effects on the biodiversity. Groundwater flows can cause the transport of these nutrients over considerable distances necessitating the use of special techniques to determine their source (Mayer *et al.*, 2000). This study also showed that excessive nutrient levels could be transported through to near-shore sediments with possible effects on marine habitats. This is an extreme situation and more generally salt marshes can be regarded as sinks which control the eutrophication of coastal waters by removing excessive nutrients from the system (Teal & Howes, 2000).

Studies continue to collect real-time data on the ecohydrology of salt marshes and to develop mathematical models to interpret the various processes involved (Crowe *et al.*, 2004). More is known about groundwater dynamics in wet coastal grasslands, even to predicting changes (Mohrlok, 2002). Reeves and Fairborn (1996) installed extensive instrumentation to enable the development of a numerical model to study the groundwater dynamics of the forest marsh interface. The next major step will be to integrate these various models, possibly through the use of a decision based support system, in such a way that for any given salt marsh the underlying ecological processes, including the magnitude and direction of the various fluxes, can be understood sufficiently to develop effective management techniques.





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# **EELGRASS (*ZOSTERA MARINA* L.) IN THE WESTERN WADDEN SEA: MONITORING, HABITAT SUITABILITY MODEL, TRANSPLANTATIONS AND COMMUNICATION**

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Many acres of eelgrass had disappeared during the last century throughout its distribution area due to several reasons: Wasting disease, coastal engineering, pollution and fishery activities. However, positive changes in the environment did not result in eelgrass recovery. Eelgrass is a key species that attracts many organisms living in the meadows and also provides a food resource. Additionally, eelgrass stabilizes sediments and reduces wave activities and could be considered an eco-engineer. Therefore, reintroduction of this species became highly favorable.

The Dutch Ministry of Transport, Water Management and Public Works instructed the University of Nijmegen to carry out a 4-year (2002-2005) funded project 'Reintroduction of eelgrass (*Zostera marina* L.) in the western Wadden Sea' with the goal to create a stable eelgrass population that could become a source for further recovery and expansion in the western Wadden Sea. This paper gives an overview of the project's activities and results.

The main transplantation area 'Balgzand' was carefully selected on the basis of a range of selection criteria. The geomorphological diversity of the Balgzand flats allowed transplantations at different planting sites, which increased the chance of transplant survival by spreading risks in this dynamic ecosystem. Transplantations were carried out in proximity of artificial and natural mussel beds, away from mussel beds and at locations varying in depth. Furthermore, the size and density of planting units were varied to develop the optimal transplantation technique.



Respectively 2000 and 2300 eelgrass shoots were transplanted in the first two years of the project. Transplantation success was measured by plant survival and development. Furthermore, a range of biological and physical-chemical parameters was studied.

Transplantation success was poor in the year 2002 due to a chain of unfortunate events. This experience was instructive though, and transplantation in 2003 became very successful: high survival rates of the transplants with abundant development of reproductive shoots. Simultaneously, over 20 eelgrass plants that had been transplanted in preliminary experiments in 1999 expanded to an eelgrass population of 5.2ha.

At the moment of writing the abstract (May 2004) seedlings had been found and another transplantation of about 1500 shoots was planned in June 2004.



# THE IMPORTANCE OF SEED BANK KNOWLEDGE FOR THE RESTORATION OF COASTAL PLANT COMMUNITIES – A CASE STUDY OF SALT MARSHES AND DUNE SLACKS AT THE BELGIAN COAST

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Knowledge on seed bank density and species composition is crucial for predicting the probability that target species will establish in the plant community on a restored site. A general overview of data available for plant species occurring in coastal plant communities showed that information on seed persistence is up to now very limited. The available data suggest that restoration of coastal plant communities cannot rely on the seed bank, except for annual species of salt marshes, and that the seed bank is to a large extent composed of species of nutrient rich habitats. This was confirmed by two case studies in dune slacks and salt marshes on the Belgian coast. Seed density in dune slacks was found to be relatively high, but the seed bank contained almost exclusively seeds of species of nutrient rich habitats, resulting in a very low similarity ratio between seed bank and vegetation. Germination from the seed bank would rather hamper the establishment of target species because competitive pressure imposed by fast growing species of nutrient rich habitats would increase. In salt marshes, the similarity between seed bank and vegetation was higher, because there is a higher contribution of typical salt marsh species in the seed bank, although not all target species are equally represented. To allow predictions of future species composition on restored sites, seed bank studies should be an essential part of each coastal restoration project.





## **DEVELOPMENT OF A DECISION SUPPORT SYSTEM FOR LIFE-NATURE AND SIMILAR PROJECTS: FROM TRIAL-AND-ERROR TO KNOWLEDGE BASED NATURE MANAGEMENT**

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The very high environmental pressure on ecosystems has increased the need for active nature management. To perform the proper restoration measures a considerable knowledge of ecosystem functioning is required, in particular about the biogeochemistry and about habitat requirements of organisms. Although the amount of available knowledge on these subjects has increased rapidly, many conservation and restoration projects report partial or complete failures. There is a wide range of possible causes, but one of the most frequently occurring reasons is the lack of essential information for the planning and carrying out of restoration measures. A decision tree that offers easy access to up to date knowledge and practical experience could help to increase success rates. In the framework of a LIFE-Nature Co-op project we aim to make such a tool for coastal dunes and raised bogs. Nature conservationists and scientists of different European countries participate in this project.

In an ideal situation, the planning of restoration measures should contain at least the following elements: 1) description of the problem in the management area, including shifts in species composition, 2) investigations leading to the underlying causes of this problem, 3) listing causes and possible solutions, 4) defining a restoration strategy, 5) assessment of the possible side-effects of the restoration measures on the whole ecosystem level, 6) restoration measures, 7) monitoring, and 8) evaluation of the (side) effects. Our tool will help to elucidate the threats to the ecosystem and the possible (side) effects of restoration measures.

Starting point of the tool can be a measure planned by the user, including the expected result. To arrive at the proper restoration strategy for an ecosystem, the tool will check for at least the following components:

- Is there a legitimate restoration goal, given a certain kind of ecosystem?
- Can this goal be reached by the proposed restoration measure?
- Which (groups of) organisms can profit from the restoration and which (groups of) organisms will be harmed? Does the ecosystem as a whole profit from the measure?
- What is the possible function of the restoration area for the biodiversity in the direct environment? How will restoration measures affect this role?



- In what way can the success rate be enhanced, for example by adjusting the scale, timing or intensity of the measure?
- Are there alternative measures that can lead to a better result?
- Which (groups of) organisms are suitable bio-indicators? How can they be monitored?

The decision support tool will be freely accessible via an interactive interface that selects the information relevant to the user's situation. All essential information will be presented in short texts, supported by examples of field situations. By using this tool, project managers will be able to deal with ecological knowledge at the proper moments in the process of planning and taking restoration measures. Problems encountered in previous projects can be avoided and successful solutions to problems in earlier projects can be adopted. This can significantly optimize the restoration measures and minimize the occurrence of failures and unforeseen negative side effects in ongoing and future nature conservation and restoration projects.



## **GEOMORPHOLOGY AND EVOLUTION OF THE RAVENNA'S DUNE SYSTEM (ITALY)**

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The main purpose of this work is to characterize the dunes of the Ravenna coast and to propose their best management. In order to evaluate their recent evolution, aerial photographs of the studied area (the coastline from Porto Garibaldi to Cervia in the years 1954, 1972, 1988, 1994 and 2000) have been analysed using a GIS. In the year 2000 the area occupied by the dunes was one quarter of the total area covered in the year 1954. From the seventies until now, an increasing number of bathing establishments built on dunes can be observed. This, in the majority of the areas, caused the complete disappearance of the dune systems.

Some phyto-sociological surveys have been carried out aiming at calculating species diversity, evaluating the degree of naturalness of each dune and outlining the evolution of the vegetation, based on the data collected in the seventies. The observed vegetation communities are not clearly defined, because of the stress caused by tourism. The highest diversity of species and the main stability due to the presence of the *Tortuleto-Scabiosetum* community were observed in the only dune that has a fence.

Moreover, in order to establish dunes efficiency, to work out reliable future scenarios and to define the recovery chances of some dunes, the following features have been evaluated: crest height, steepness index, lateral continuity, conservation state and sedimentological characteristics.

In two study areas, a simulation using FDM (Fugitive Dust Model) has been carried out, with the purpose of evaluating their hypothetical natural evolution. The FDM is a software, created by EPA (Environmental Protection Agency), which calculates the aeolian transport and dust deposition. The FDM model readapted to the dune system allowed us to outline dune evolutionary trends and was a useful tool for a qualitative evaluation. Moreover, it has been an important component for decision making in the management measures.



## **INTERNATIONAL LEGAL POSSIBILITIES AND OBLIGATIONS FOR NATURE CONSERVATION IN PORTS**

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Harbours are often situated in valuable coastal areas, such as estuaries and mudflats. In the past, large areas of coastal land and sea were claimed for port development without taking into account the nature values in that area. Only economic arguments were taken into consideration. This often resulted in a serious degradation of nature areas and loss of biodiversity (because of large infrastructure works, dredging activities etc.). Sometimes large ecological valuable areas, although not yet in use for port activities, were designated as port areas in spatial planning instruments or strategic harbour plans. Although these nature areas remain intact, their future is uncertain and they often become degraded due to a lack of appropriate nature management. Occasionally, new opportunities for nature conservation can be created because of port development. This is for instance the case for sand suppletion areas, which are not immediately used for harbour activities, but in the meantime serve as a refuge or breeding ground for seabirds. Once these areas will effectively be used as port areas, the nature values will be lost. The lack of a sustainable policy in the past, inevitably led to conflicts with other users in the coastal zone. This sometimes resulted in court cases and even halted further possibilities for port development.

In the last years, new insights came into being on nature conservation and nature development, ecological networks, integrated coastal zone management and sustainable development. These ideas create new possibilities for nature conservation in coastal areas. They might also shift the balance towards a more sustainable port development and to win-win situations for both industry and nature. Conflicts between different user groups in the coastal zone might thus be avoided.

The following questions need to be answered: what are the legal possibilities and obligations for nature conservation and nature development in coastal areas; how can these international instruments be applied in harbour areas; are these instruments adapted to achieve a sustainable use of the coastal zone and acquire win-win situations for harbours and nature?

This paper will first give an overview of general principles of environmental policy relating to nature conservation and nature development (such as the restoration and compensation principle). It will examine the legal possibilities and obligations for nature conservation and nature development in international treaties (such as the Ramsar convention) and EU directives (Birds and Habitat Directives) and will specifically focus on the application of these instruments in coastal areas. Also, the legal procedures for conservation and compensation (such as the procedure of article 6 of the Habitats Directive) will be mentioned. It will look into the legal possibilities for the establishment of the site's conservation objectives within harbour areas. It will examine the concept of temporary nature areas. The paper will give some examples of the relationship between harbours and nature conservation in several European countries. As there are often problems with the implementation of the Birds and Habitats Directives in harbour areas, the paper will look into relevant case law of the European Court of Justice.





## DONKEYS AS MOBILE LINKS FOR PLANT SEED DISPERSAL IN COASTAL DUNE ECOSYSTEMS

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Dispersal of seeds is a key process in plant ecology. Especially in fragmented and highly dynamic landscapes, such as dune ecosystems, plant metapopulations are only viable if colonization of newly formed suitable patches is likely. Successful long-distance dispersal is thus indispensable. Through the external and internal transport of plant seeds (epizoochory and endozoochory), large herbivores can facilitate such long-distance dispersal, hereby functioning as 'mobile links' between habitat patches. Epi- and endozoochory differ in various aspects. Different plant and seed properties influence the capacity of seeds to adhere to animal fur or to survive passage through their digestive tract. Still, both dispersal processes are not as selective as often thought, and may have a considerable influence on plant dynamics. In this study, we compared epi- and endozoochory by free-ranging donkeys in the coastal dune nature reserve 'Houtsaegerduinen', Belgium.

Through *in vitro* germination of zoochorous material collected by fur brushing and dung collection, we identified 6693 seedlings of 68 plant species, covering 20% of the species recorded in the study area. Although there were some species in common, the epizoochorously dispersed flora was complementary to the endozoochorously dispersed flora in terms of species composition and plant traits. The post-dispersal fate of the seeds depends on the spatial distribution of the dispersed seeds in the landscape and the suitability of the local environmental conditions. Because of the high potential of zoochory to direct the spatial distribution of seeds in fragmented landscapes, we simulated the movement of large herbivores and the simultaneously generated seed shadow using a spatial explicit simulation model, based on observational data on movement rates and habitat preferences to calibrate the movement of the large herbivores, and using parameters describing consecutive phases of the seed dispersal process. In the case of epizoochory, these parameters were derived from experimental studies, using a selection of model seeds to quantify the capacity of seeds to adhere to animal fur, and the detachment rates of these seeds from the fur of moving animals. In the case of endozoochory, parameters based on seed retention times in the digestive



tract of animals and on survival chances of seeds in the gut can be used to simulate endozoochorously-generated seed shadows.

We conclude that long-distance dispersal by large herbivores may be a crucial aspect of vegetation dynamics between (ephemeral) habitat patches in highly fragmented landscapes, where plants rely on efficient dispersal to survive.

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## **EVALUATION OF THE EFFECTS OF RECENT NATURE DEVELOPMENT MEASURES IN THE YSER ESTUARY ON GROUND BEETLE AND SPIDER ASSEMBLAGES**

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Since 1990, populations of ground beetles and spiders are continuously monitored in the coastal dune and saltmarsh habitats of the Yser estuary (Nieuwpoort), within the context of a long-term study on invertebrate diversity, population dynamics and ecological and genetic effects of habitat fragmentation. As a part of this study, pitfall trap sampling is being performed without interruption for more than 14 years along a transect from seaside marram dunes to inland moss dunes and dune grassland. Faunal assemblages are compared with those from surrounding habitats and microhabitats in the same study area. The studied invertebrates belong to the most appropriate bio-indicators for saltmarshes and different coastal dune habitats. Amongst other characteristics, these animal groups show a high biodiversity and/or abundance and productivity, a lot of highly specialized and stenotopic species and a high variation in their dispersal power. They offer unmatched possibilities as model organisms for studies on differing spatial and temporal scales. By now, we know in detail the faunal composition of practically all available habitats in the immediate vicinity of the river Yser estuary.

Our long-term study is an ideal framework to monitor the effects of the nature development activities that started in 2001 in the area (cf. project 'MONAY'), in order to evaluate, understand, and possibly even predict changes in faunal assemblage structure and population dynamics. We started sampling newly created habitats immediately after nature development management activities were finished. Our long-term sampling has been continued on a number of reference sites from the main habitat types in the area ('old' dune habitats, 'old' saltmarsh). Besides, intensive short-term sampling is now also performed on a large number of sites along transects in the entire nature development area, in a combined scheme by simultaneous monitoring of target invertebrate species and abiotic as well as vegetation characteristics.

Results of five large sampling campaigns in 2001-2003 (more than 25.000 carabid beetles and spiders, more than 200 species) show a number of additional ground beetle and spider species and assemblages for the study area, never observed before, including intermediate assemblages between those from 'old' marram dune, dune grassland and transitions to saltmarsh habitat. Some completely new habitat types were created such as a brackish dune pond, dikes, and marshy areas associated with freshwater seeping at the base of newly constructed dikes. Assemblages of ground beetles and spiders have quickly colonized all of these habitats, although the speed of



colonization is habitat-specific and differs between beetles and spiders. Among these arthropods, we observe not only ruderal species but also a number of species with high conservation interest. Our preliminary results however seem to indicate that such species could be lost again in short time, unless natural dynamic processes are kept ongoing. Such processes generate special assemblages typical for first stages of succession in saltmarshes and dune slacks. It is, however, still unclear whether the newly created saltmarsh habitats will evolve as hoped for, because of the observation that the newly deposited sediments in the saltmarsh are relatively coarse-grained (sand instead of silt). Further invertebrate monitoring is therefore imperative not only for a better understanding of the patterns and processes generated by the nature restoration measures, but also as a possible early warning system for the need of additional management measures in the future.

The first stage consisted in understanding the biodiversity of the sites. They were studied from a range of ecological parameters, including diversity, the number of species, the number of genera, the number of families and the number of orders. The results showed that the diversity of the sites was high, but that the number of species was low. This suggests that the sites are in an early stage of succession.

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The aim of the second stage is to develop predictive scenarios on future evolution of the study. Therefore, the existing models have been compared in order to identify which model best describes the succession of the sites. The results showed that the succession of the sites is best described by the model of the succession of the sites. The aim of the second stage is to develop predictive scenarios on future evolution of the study. Therefore, the existing models have been compared in order to identify which model best describes the succession of the sites. The results showed that the succession of the sites is best described by the model of the succession of the sites.





## **MORPHOLOGICAL EVOLUTION AND MANAGEMENT PROPOSALS IN THE AUTHIE ESTUARY, NORTHERN FRANCE**

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The Authie is a small macrotidal estuary largely infilled by marine sand and affected by flood dominant tides and waves. The shallow estuary mouth exhibits a relatively large intertidal zone of about 2.2 km<sup>2</sup> with saltmarshes and on the south bank a massive sand spit platform. It confines the main Authie channel towards the north bank, threatening the dune barrier and the health and seaside-resort of Berck. The localized erosion and the generalized sedimentation have been focused for a long time. It poses a number of severe management problems, notably estuarine shoreline protection, and calls into question the very survival of the estuary itself. The Regional authority has been aware of these problems and undertook a study on estuary restoration.

The first stage consisted in understanding the morphological changes within the estuary. They were deduced from analyses of historical documents, bathymetric charts and from the analysis of successive series of scale-rectified aerial photographs covering the last five decades. The main hydrodynamic processes and transport trends involved in these changes are analysed from observations and measurements of currents and waves. The results show that the width of the estuary mouth has decreased over the centuries. It suggests that the progradation rate of the south bank is superior to the rate of erosion of the north bank, resulting in a dramatically tidal prism from 3.5 km in 1671 to 1.8 km in 1953. Moreover, the trends observed suggest that morphological changes have been linked to empoldering and the progressive construction of defence structures. A topographical survey complemented analyses and highlighted a recycling of this sand, eroded from coastal dunes lining the estuary, transported by tidal drifts into the intertidal inner estuarine sink.

The aim of the second stage is to develop predictive scenarios on future evolution of the estuary. Therefore, engineering models have been computed in order to simulate sediment dynamics and several defence schemes and a relocation of the sand platform are proposed. They were also complemented by biological studies on potential impacts of the operation on fauna and flora (benthos and salt-marshes communities). The long-term objective of the Regional authority is to define the best strategy, fighting the north bank erosion and the generalized sedimentation. But the heightened awareness of the socio-economic and the environmental values of intertidal zones gives rise to recommendations of an integrated management of the Authie, notably the interaction between the environment and the shellfish farming ecosystems. Studies on human impact on intertidal ecosystems are essential for the Authie estuary sustainable development.



## SAND DUNE INVENTORY OF EUROPE

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An inventory of sand dunes in Europe was published more than 10 years ago in 1991 (Doody ed. 1991). The original report was based on contributions from specialists around Europe working on coastal sand dunes. Short summary reports and maps were prepared for the following countries:

North West Europe	France and the Iberian Peninsula	Eastern Mediterranean
Iceland	France	Italy
Norway	Portugal	Yugoslavia and Albania
Sweden	Spain	Greece
Finland		Romania
Poland		Bulgaria
Denmark		Turkey
Germany		
The Netherlands		
Belgium		
Great-Britain		
Ireland		

The report will be extended to include a number of new accession countries to the European Union. The country reports will be updated to give the present status of sand dunes in Europe. It will also provide an overview of the key management issues and how these are being addressed.

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Doody., J.P. ed. 1991. Sand Dune Inventory of Europe, Joint Nature Conservation Committee, Peterborough, the European Union for Coastal Conservation, Leiden, 80 pages.



## **SHORELINE MANAGEMENT – CONSERVATION, MANAGEMENT OR RESTORATION?**

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The estuarine shoreline forms the margin between the land and the sea. It is composed of a wide variety of habitats with attributes and interests associated with both the marine or land environment. Sand dunes support essentially terrestrial plant and animal communities. By contrast saltmarshes are dominated by plants tolerant to saltwater. In between there are other habitats and a suite of transitional and successional features of considerable variety.

Sand dunes and estuarine habitats are dynamic and show natural and sometimes rapid changes. Their ability to absorb wave energy or move in response to changing sea levels and storms is a significant feature. Too often in the past humankind has failed to recognise these attributes and sought to control this movement.

In areas where socio-economic development has taken place the protection of land from erosion and flooding has become a major preoccupation. Where sea level is rising relative to the land or there is a sediment budget deficit a 'coastal squeeze' takes place. This not only threatens the existence of many wildlife habitats and associated species, but also the ability of the coast to protect us from the ravages of the sea (flooding and erosion).

This paper will review the way we have compromised coastal habitats, putting at risk the plants and animals that live there. It will consider the problems for a number of species and habitats at the margin of the sea in the light of these developments. It will identify the positive values associated with conservation management and restoration of this tremendous resource. In particular it will consider the importance of developing sustainable habitats for wildlife, coastal defence and other economic uses.

Lessons learnt from two European studies will be presented in further papers showing some of the possible ways of 'living with the sea'. These are:

- The EURosion study funded by the European Commission;
- And the LIFE project 'Living with the Sea'.



## THE FRENCH POLICY EXPERIENCE OF PURCHASING COASTAL AREAS

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Created in 1975 by the French Government, the Conservatoire du Littoral is responsible for:

- the acquisition and the protection in perpetuity of the most sensitive and endangered coastal land:
  - along the coast of metropolitan France and overseas territories
  - around lakes larger than 1,000ha
- the management by local government of the lands acquired in order to open them to public access and to ensure the protection of natural values.

Over the years, the Conservatoire has defined three main criterias for selecting land for acquisition:

- the site is threatened by urbanisation, being divided up or being made artificial (for example, the infilling of wetlands);
- the site is deteriorated and needs rapid restoration;
- the site is closed to the public whereas it should be open to everyone.

At 1 June 2005 the Conservatoire du littoral owns 73,600ha in France (3,200ha in Nord-Pas-de-Calais), protected more than 880km of coast (37km in Nord-Pas-de-Calais), i.e. 10% of the metropolitan coast (25% in Nord-Pas-de-Calais). With the application of a new legal act (27/02/02) the Conservatoire du Littoral became one of the French government tools for ICZM with new competences on maritime properties.





## **MOTIIVE - MARINE OVERLAYS ON TOPOGRAPHY FOR ANNEX II VALUATION AND EXPLOITATION**

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The 6<sup>th</sup> RTD Framework Programme (FP6) includes an Aeronautics and Space priority for 2002-2006, focusing on the research areas Galileo, satellite communication and GMES - Global Monitoring for Environment and Security. GMES, considered a pillar of the Space programme, has six priority thematic areas, including Ocean and Marine Applications. Concurrent with GMES services implementation is the EC's INSPIRE initiative, Infrastructure for Spatial Information in Europe, which identified core and thematic data elements of the proposed European Spatial Data Infrastructure (ESDI), to be implemented in the next decade.

In the FP6 work programme, the GMES component of the Space priority is to develop synergies between existing information services and technologies, including interoperability of data processing and delivery systems, the focus of the current call for data harmonisation support actions.

MOTIIVE addresses harmonisation requirements between the INSPIRE core data component elevation (terrestrial, bathymetric and coastal) and INSPIRE marine thematic data for sea regions, oceanic spatial features and coastal zone management areas. MOTIIVE incorporates workpackages specifically to investigate alleged improved cost-benefit aspects attributed by other studies to increased harmonisation between core and thematic INSPIRE datasets, while fulfilling the infrastructure requirements of the GMES Ocean and Marine Applications theme, which were determined in the GMES Service Element (GSE) pilot projects. The proposed GSE Stage 2 implementation includes Marine Coastal Environment Services, for which results of the MOTIIVE project will be highly relevant. MOTIIVE will deliver its interoperability toolsets by mid- to late-2006, on current plan, and the GSE Stage 2 services are to be fully operational by 2007-2008.

MOTIIVE's nine partners (and two sub-contractors) are actively involved in marine related information projects as data providers or users, and in interoperability standardisation activities, with specific OGC (Open Geospatial Consortium) work experience. They participated in three GSE pilot projects, in several RTD projects concerning data interoperability in the marine and coastal environments (ARION, COASTMON, COASTBASE, EUROSION, HIPOCAS, MARS AIS, DISMAR, marineXML), and currently participate in GMES projects MERSEA and, at national level, in implementation of the EC Water Framework Directive and EC ICZM (Integrated Coastal



Zone Management) Recommendation, plus international programmes such as EuroGOOS.

Deliverables from MOTIIVE include proposals for a (tested) coastal/marine ontology, a UML marine data model and feature catalogue, marineXML schemas relevant to different sectors of the marine/coastal community, and formation of an OGC Working Group and/or SIG (Special Interest Group) to formalize, validate and promulgate the results of the project on completion at the end of 2006. An OGC Interoperability Experiment is planned to test the quality and appropriateness of the OGC-compliant tools, XML schemas and services. The project will deliver a fully tested methodology and guidelines on using the OGC-compliant tools developed in the project aimed at achieving greater benefits at less cost when harmonising disparate datasets across disciplinary and geographic boundaries, especially land-sea-air boundaries.

MOTIIVE is expected to begin in April 2005, running for two years, in parallel with the allied RISE project (Reference Information Specifications of Europe) and ORCHESTRA project (Open Architecture and Spatial Data Infrastructure for Risk Management) and the INSPIRE Pilot Project. All three projects are test beds for devising and testing implementing rules for the INSPIRE draft Directive and specific tasks exist in all three projects for joint liaison.

During the project, the existing lack of a formalized ontology in which to view the world as an important and visible expression of managing the complexity of the diversity of coastal habitats.

The increased recognition of coastal defences throughout the world in the United Kingdom as a not effective and sustainable measure to manage the world and increased coastal erosion, it is widely accepted that coastal defences and structures in particular, play an important part in understanding the impact of coastal erosion (Coastal Defences (Hoffman et al., 2001), Hall & Nealson, 1995 and Roberts, 1993). Jeffrey et al. (1999) showed that when structures were removed the 100 year wave line was moved landward underpinning water depths. As research with defences on at sea linear increases in the height of the sea wall, it is expected to also increase the protection, making considerably to coastal wall building and management (Chen et al., 1990; King & Jones, 1993). In addition, how coastal defences are created will mainly in the increasing and significantly more can be made.

To date most research effort has concentrated on increasing the biological and physical development of defences since in 1993 the Department for Environment, Food and Rural Affairs (Defra) commissioned research to improve some of the techniques about retaining agricultural land to be made habitat by managed realignment, specifically - will normal re-alignment become a habitat when the realignment site and if so, over what time scale and what are the potential effects to the wider system, and it is possible to set the parameters of natural realignment directly or indirectly? The project was focused on the management site of Tullerton, Essex, south-east England (Coker, 2002).



## RESTORATION OF INTERTIDAL HABITATS BY THE MANAGED REALIGNMENT OF COASTAL DEFENCES, UK

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Replacing coastal habitats where they are eroded, inundated or otherwise impacted upon is particularly important given the high level of ecosystem service they provide. Saltmarsh creeks provide spawning and nursery areas for many fish species and the vegetation provides roosting, nesting and feeding sites for birds. In addition to the specialist flora and fauna directly associated with tidal saltmarshes they are areas of high productivity providing a source of organic matter and nutrients for adjacent marine habitats. Their biodiversity and functional value is recognized in law under the European Union Habitats Directive (Anon, 1992). The directive seeks to maintain 'no-net-loss' in total habitat area. The UK's Biodiversity Action Plan (BAP) commits the Government to develop strategies to conserve and, where possible, enhance biodiversity (Anon., 1999). Managed realignment (the setting back of coastal defences inland) is widely viewed as an important and viable technique in meeting BAP objectives for the creation of intertidal habitats.

The managed realignment of coastal defences is increasingly being used in the United Kingdom as a cost effective and sustainable response to rising sea levels and increased storm events. It is widely accepted that coastal wetlands, and saltmarshes in particular, play an important part in ameliorating the effect of wave action on coastal defences (Moller *et al.*, 2001, Toft & Maddrell, 1995 and Pethick, 1992). Moller *et al.* (1999) showed that wave attenuation over saltmarsh was 50% higher than over sand flat, even under similar water depths. As saltmarsh width decreases an almost linear increase in the height of the sea wall is necessitated to offer comparable protection, adding considerably to capital wall building and maintenance costs (Dixon *et al.*, 1998; King & Lester, 1995). By setting back coastal defences and creating saltmarsh in the intervening area considerably savings could be made.

To date most research effort has concentrated on monitoring the biological and physical development of realignment sites. In 1993 the Department for Environment, Food and Rural Affairs (Defra) commissioned research to remove some of the uncertainties about returning agricultural land to intertidal habitat by managed realignment, specifically - will natural re-colonisation recreate saltmarsh within the realignment site and, if so, over what time scale; will there be any deleterious effects to the existing saltmarsh; and is it possible to aid the processes of natural colonisation directly or indirectly? The project was focused on the realignment site at Tollesbury, Essex, south-east England (Garbutt, 2003).



Results from the Tollesbury experiment and several other sites have shown that with fairly minimal pre-treatment and management by allowing tidal ingress through a simple, relatively small breach the landward realignment of sea defences will quickly produce intertidal mudflats on low-lying agricultural land which are colonised by saltmarsh plants and invertebrates. What is unclear however is the time scale needed to produce intertidal habitats that are functionally equivalent to (semi-) natural reference conditions or if functional equivalency can indeed ever be reached.

In this presentation we present the findings of monitoring and experimental studies and discuss the implications for other intertidal habitat creation schemes.

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## **CHARACTERIZATION OF THE INTERTIDAL MACROZOOBENTHIC COMMUNITY STRUCTURE WITHIN AN ESTUARINE AREA ('HAVRE') ON THE WESTERN COAST OF COTENTIN (FRANCE)**

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The 'havres' of the Western coast of Cotentin are original ecosystems: their morphologies result from the conjugation between the littoral drift towards south and the presence of a succession of small estuaries along about 80km from North to South. They are under macro tidal influence with a tidal range, which can exceed 10m.

These low-size littoral spaces are thus subjected to a high hydro dynamism, reinforced by a fully western exposure. So the local sedimentary facies are characterized with fine to coarse sand (200 $\mu$ m to 1mm) in comparison with the bay of Seine intertidal sediments, which correspond, rather with very fine and fine sand (100 $\mu$ m to 500 $\mu$ m). The coarse asymmetry, associated with the mega ripples facies, is often significant.

The present study relates to the 'havre' of Regnéville-sur-mer located at the north of Granville. Samplings of sediment and macrozoobenthos were organized along two transects, one in the axis of the estuary, the other perpendicular to this first one, near the mouth. These samplings were carried out in spring 2004, by taking care to associate the stations 'benthos' and the stations 'sediment'.

The local intertidal macrobenthic biocenotics shows in the same time species associations of estuarine transition (*Macoma balthica*, *Hydrobia ulvae*) and of marine sheltered (*Cerastoderma edule*) or exposed environments (*Haustorius arenarius*). In some sandy facies with megaripples, presence of high densities of *Bathyporeia* sp. indicates a favourable area for the food of some waders such as the sanderling (*Calidris alba*).

This study was undertaken at the request of the 'Syndicat Intercommunal de Défense Contre la Mer et d'Aménagement de la Sienne', consecutively to the accelerated erosion of an estuarine shore dune caused by a recent divagation of the flow of the Sienne river.



## THE FLEMISH COAST: LIFE IS BEAUTIFUL!

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Along the quite short Belgian coastline (65km), six Natura 2000 sites have been delimited on land and one at sea. This probably explains why from the 20 Life nature projects that up to now have been or are being executed in the Flemish region no less than four are focused on coastal areas. This paper offers a review of those four coastal Life nature projects and their achievements. The Life nature project 'ICCI' (1997-2001) aimed at re-establishing ecological relations between sea and land, between sandy beaches, mudflats, salt marshes and coastal dunes and between coastal dunes and polders from De Panne to Nieuwpoort and stimulating the policy of purchase of coastal dunes by the Flemish region. Its successor, 'FEYDRA' (2002-2005), has as main goal, the restoration of annex 2 - habitats in several coastal dune sites in Koksijde and Nieuwpoort. 'Salt meadows at the Flemish coast' (1999-2003) and its sequel, 'The Uitkerkse Polder' (2003-2008), strive for the maintenance or restoration of polder meadows with a rich topography by land purchase and an appropriate nature management. The Life nature projects 'ICCI' and 'Salt meadows at the Flemish coast' have achieved complete realisation of their objectives. Both other Life projects that are mentioned above are still being executed, but the prospects look good. Essential elements in this success have been a thorough scientific preparation and a sustained action for public support. The Life nature projects in the coastal zone have not only accomplished their initial program, but also had a favourable influence on the conservation policy of the Flemish government for the coastal zone; prospected the possibilities for a federal conservation policy in the marine environment and stimulated dialogue between conservationists on the one hand, local authorities and drinking water supply companies on the other hand.



## **PURCHASE OF DUNES: THE FIRST STEP TOWARDS NATURE RESTORATION ALONG THE FLEMISH COAST**

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In 1997 of the remaining 3.800 hectares of coastal dunes only 1.022 hectares were owned by the Flemish Region. The other 2.778 hectares were mostly private property of real estate development firms, large landowners, individuals and, to a lesser extent, owned by water collection companies, the Ministry of Defense and a couple of municipalities. The then public owned dunes of the Flemish Region were divided as follows among the different administrations of the Ministry of the Flemish Community: 522 hectares under competence of the Nature Division, 350 hectares under that of the Waterways & Coast Division and 150 hectares under that of the Forestry Division. Most of the areas owned by the Nature Division were already purchased between 1956 and 1990. Lack of personnel, funds and strategic perspective prevented the Flemish Region from pursuing an active policy of land-purchase along the coast. In 1996 an 'Acquisition Plan for the Coastal Dunes' was drawn up by the Group for Applied Ecology of the University of Antwerp under the supervision of the Nature Division. Parliamentary initiatives, following a political debate organized in the framework of the Life nature - project 'ICCI', led to the creation of an 'instrument for the acquisition of coastal dunes' by decision of the Flemish government of 3 February 1998. Since 1998 the 'Instrument for the acquisition of coastal dunes' consists of two staff members who were added to the Nature Division, and a special article on the budget of the Flemish government. This budgetary article received an initial annual endowment of 1.735.255 Euro in 1998, 3.222.616 Euro in 1999 and 4.462.000 Euro for each year between 2000 and 2004. That initial endowment has been reduced to 2.546.000 Euro in 2005. A weakness in this financing system is the impossibility to transfer the eventually remaining budget of one year to the next one, so that no strategic fund can be build up. The active prospecting by the staff of the Acquisition Instrument has allowed the Nature Division to purchase 480 hectares of dunes between 1998 and 2004. Nearly all these acquisitions were realized with agreement of the former owner. In execution of the Decree of 21 October 1997 concerning Nature Conservation and the Natural Environment, the right of pre-emption of the Flemish Region has been introduced in most of the legally protected areas of Flanders. In the coastal zone however this right of pre-emption has not led to spectacular results, because of a very strongly fragmented propriety-structure and high ground-prices due to land speculation. Although the Acquisition Instrument has obtained very good results, a long way still has to be gone before the goal of public ownership of all remaining coastal dunes will be achieved. Essential improvements of the financial and legal instruments for the purchase of dunes should be the creation of a strategic financial fund, an actualization of the since long outdated expropriation act and improvement of the pre-emption for conservation purposes to be able to fend off land speculation.



## **SLEDGEHAMMERS, CRANES AND BULLDOZERS: RESTORING DUNES AND MARSHES BY REMOVING BUILDINGS AND SOIL**

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Flanders has the most urbanised coastline of Europe, north of the Pyrenees and the Alps. During the 20th century seaside resorts grew to one another to finally form one urban agglomeration from the Dutch to the French border, only locally interrupted by some rather small not build upon areas of dunes. Even those remaining and legally protected 'natural areas' include however often buildings, roads and even dredging sludge dumps. In that situation of extreme damage to and fragmentation of the natural environment, management by mowing and grazing is not sufficient to restore it to a satisfactory level. Open space and physical environment have to be restored so that wild species and natural habitats would be given a chance to come back. In this paper an overview of the most important nature restoration works that have been or are currently being carried out by the Nature Division along the Flemish coast from the year 1995 on is given. These works are:

- the demolition of the buildings of the former children-home 'Georges Theunis' to reactivate large scale sand drift (1995) and the removal of a soil dump to recreate a wet dune slack (1997) in the Flemish Nature Reserve 'Ter Yde' at Oostduinkerke;
- the digging off of soil dumps and the excavation of a former raceway to restore decalcified fossil dunes (1998) in the Flemish Nature Reserve 'D' Heye' at Bredene;
- the complete demolition of the former military harbour and the digging off of the dredging spoil-dumps to restore mud flats, salt marshes and sand dunes (1999 - 2003) in the Flemish Nature Reserve 'The Yzer-rivermouth' at Nieuwpoort;
- the demolition of the former 'Swimming Pool' to create a pond, a wet dune-slack, grey and white dunes (2004) in the Flemish Nature Reserve 'Zwin-dunes and polders' at Knokke;
- the demolition of the former sewage treatment plant of Nieuwpoort to restore calcareous marshland and humid dune slack (2004-2005) in the fossil beach-plain of the regional nature domain 'Groenendijk'.

The paper describes how these projects have been conceived, planned, prepared and finally executed and, if the necessary data are already available, compares their results with their initial objectives concerning natural processes and biodiversity. All the concerned sites are included in the candidate - Special Area for Conservation 'Dunes including Yzer-rivermouth and Zwin' that has been proposed in execution of the European Habitat-directive 92/43/EEC and all the above-mentioned projects aimed at an active implementation of this directive.





Although it is financially cheaper to demolish constructions than to restore them, such large-scale demolition- and ground-works are relatively expensive in proportion to the rather limited budgets for nature conservation. The European financial contribution in the frame of the LIFE nature - projects 'Integral Coastal Conservation Initiative' (ICCI) and 'Fossil Estuary of the Yzer-Dunes Restoration Action' (FEYDRA) has been of significant importance to facilitate the dismantlement of the military harbour and the demolition of the sewage treatment plant, both at Nieuwpoort.

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## **INTEGRATED MONITORING OF NATURE RESTORATION ALONG ECOTONES, THE EXAMPLE OF THE YSER ESTUARY**

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Within the framework of Life, one of the larger nature restoration projects in Flanders was realized on the right bank of the estuarine part of the IJzer at the beginning of this century. General aim of the initiative was to restore or create the natural ecological gradients typical for a coastal estuarine ecosystem, which is characterized by salt-fresh gradients, dynamic-stable, wet-dry, mud-sand transitions and other biologically interfering gradients. To do so, several large buildings and roads were removed, an entire tidal port was restructured and some 500.000 m<sup>3</sup> dredging material was removed to restore an intertidal area and several coastal dune(-like) areas. Topographical measures were taken to avoid abrupt transitions along ecological gradients. Before the restoration process started, quite a lot of biological data were available from the area. Together they were a fairly complete source to describe the departure situation. It was decided to start monitoring (2001-2004) from the very beginning of and even during the ongoing restoration process (1999-2003). Monitoring was multidisciplinary (Ghent University, Catholic University of Louvain, Royal Institute of Natural Sciences and Institute of Nature Conservation with facility support of VLIZ), involving monitoring of inanimate parameters such as sedimentation and erosion and ground water fluctuations, and animate parameters, i.e. flora and vegetation, arthropods, benthic fauna and birds. It was decided to include two monitoring levels, a general monitoring of the entire nature reserve (ca. 88 ha) and a detailed monitoring of changes along transects perpendicular to the main ecological gradients.

In this contribution we will present the results of the first three years of monitoring, we will try to integrate the results of the different disciplines and will discuss the advantages and disadvantages of both monitoring methods and the multidisciplinary approach of the monitoring research.



## LARGE HERBIVORES IN COASTAL DUNE MANAGEMENT: DO GRAZERS DO WHAT THEY ARE SUPPOSED TO DO?

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After some decades of rather sparse and marginal nature management (e.g. local shrub-cutting, sod-cutting and haying), the manager of the Flemish nature reserves (Nature Division of AMINAL, Ministry of the Flemish Community) decided to introduce a more coherent and relatively large-scale nature management. Since the mid-nineties, several large areas were cleared from scrubs and in at least six of the larger nature reserves different herbivore species were introduced. On historical grounds and for research reasons, several grazers were introduced (i.e. sheep, donkeys and different horse and cattle breeds). Since the herbivore introductions from 1997 onwards, fundamental research has been done on the foraging behaviour and habitat use, diet selection and preference of some of the introduced herbivores and on their potential contribution to seed dispersal. Above that, several monitoring research programmes were carried out, following the impact of the grazers (cattle, donkeys and horse breeds) on flora, vegetation and different faunal groups and on soil development. Here we will summarize some results of both approaches to get to conclusions on the suitability and usefulness of year round grazing by domestic animals in these low productive, spatially and temporally heterogeneous dune ecosystems.

From the fundamental research we will conclude on questions, such as: do the animals use the system in such a way that it is probable that they enlarge structural diversity, do their diet and habitat preferences indicate that plant communities that are wanted to decrease in dominance will really diminish in favour of more desired communities, is it probable that herbivores contribute significantly to seed dispersal of desired plant species, are there reasons to believe that they induce important nutrient redistribution?

From the seven-year-monitoring period we can conclude whether wanted, dune specific plant and animal species are truly favoured by grazing management and whether nutrient balance and soil profile are significantly influenced. We will comment specifically on the results of research of nature reserves where Highland cattle, Shetland ponies, Haflinger horses, Konik horses and/or donkeys were introduced (Westhoek, Houtsaegerduinen and Ghyvelde (France)). We will show that due to species specific characteristics, not all of them are equally suitable to fulfil the initial management goals.



# **THE CONSERVATION OF SAND DUNES IN THE ATLANTIC BIOGEOGRAPHICAL REGION: THE CONTRIBUTION OF THE LIFE PROGRAMME**

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Since 1992 the EU LIFE programme has supported a series of dune conservation projects within the Atlantic Biogeographical Region. LIFE co-financing has been used to safeguard threatened sites through land purchase, to support the development of the Natura 2000 network, to undertake practical management and to interpret the functions and values of dunes to a wide audience. The additional resources from LIFE have been targeted at specific sites, at national programmes and, through wider networking initiatives, at the community of practitioners. LIFE projects have contributed to the development of European and National policies by acting as case studies and milestones. Dissemination of information is aided by practitioners networks such as the European Union for Coastal Conservation and through the series of conferences and workshops held within the framework of the projects. A further step may be to use the completion of the Natura 2000 network as a catalyst for encouraging a more coordinated approach to networking and for raising some of the key issues affecting dune systems at the European level.





## SPECIES RICHNESS IN SEA-BUCKTHORN SCRUB

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The expansion of Sea-Buckthorn in dunes reduces species richness as well as the cover of mosses and lichens. The decrease in species richness is likely to be due to the shading effect of the scrub. As many regionally rare plants are restricted to dune areas, the spreading of this densely growing scrub might be a serious threat to the phytodiversity of open semi-fixed dunes.



## **SANDY COASTLINE ECOSYSTEM MANAGEMENT - BRIDGING SUSTAINABILITY AND PRODUCTIVITY OF SANDY BEACHES**

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Scientists, resource managers and medical experts today widely accept the idea that human society is dependent upon a healthy environment and that continued environmental degradation threatens the quality of life (Bickham et al. 2000). Although direct links between ecological effects and human health have proven difficult to establish, the use of wildlife species as sentinels of environmental problems is the conceptual basis for this connection (Colborn 1994). Furthermore, considering the principles of sustainable management of marine and coastal areas, defined in the Rio conference of 1992 (Chapter 17, Agenda XXI), the topic of sustainable management has acquired a fundamental role in the country policies all over the world, and must be faced at an international and multidisciplinary level. The intervention through management plans and the use of supporting tools in decision-making acquires particular importance for relatively fragile ecosystems such as sandy beaches.

Exposed sandy beaches are highly hydrodynamic. These ecosystems usually present low biodiversity and high specialization, due to the regime of permanent abiotic changes that governs their functioning. The tiny number of species, however, hide high biomass and production rates along all the trophic web, and the surf zone has been recognized as a nursery for many marine fish species (Brown & McLachlan 1990). The biodiversity of, and the impact of tourism on, sandy beach biodiversity is a subject currently generating great scientific interest in Europe. It is the key topic of the international research programme 'Sandy', which involves scientists from 12 European countries and has recently been funded by the European Commission (e.g. MECO, MEDCORE, COSA, BaltCoast/IKZM-Oder). Part of this concern is expressed in initiatives like the SCOR Working Group 114 on permeable sediments (SCOR 1998; <http://www.scor-wg114.de>). The Importance of Critical Transition Zones (including sandy beaches) was the focus of the SCOPE meeting (Levin et al. 2001). To meet the challenge of progressing Integrated Coastal Zone Management (ICZM) and governance, baseline interdisciplinary research is required (Emeis et al. 2001). The importance of those ecosystems for the countries in different regions (e.g. Europe, South America, South Africa, Australia) has been pointed out in the workshop 'Beaches: what future?' (Florence, 2001; Proceedings in Scapini et al. 2003). This focused on adaptation of communities and populations along the world's coasts and it highlighted the need of common protocols and frequent exchanges between the partners of the research network on beaches (Scapini 2002). It set out to fill important gaps in our knowledge concerning sandy beach biodiversity in Europe, and to link beach biodiversity to tourist impacts, using both a descriptive and an experimental approach.



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# MONITORING BRYOPHYTES AND LICHENS DYNAMICS IN SAND DUNES: EXAMPLE ON THE FRENCH ATLANTIC COAST

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Bryophytes and lichens communities growing on nine non-forested coastal dunes along the Atlantic seaboard of France were studied on the basis of vegetation surveys during three years. Coastal dune systems provide opportunities for the study of plant successions and colonisation processes. The distribution of species and the relationships between bryophytes and lichens versus pedologic factors has been investigated on 1x1m permanent plots and were analysed by multivariate analyses. This study has shown that the different species are distributed in four groups in the different dune habitats. These groups are composed of several mediterraneo-atlantic species which distinguish them from other communities described in bryophytes and lichens successions in Europe. The significative relationships between the four groups and pedologic factors such as pH-water, percentage of total calcium and total nitrogen permit to evaluate the chemical variations of the soil along dune-transect. The knowledge of relationships between the responses of the species and the abiotic variations of the soil determine functional groups. The monitoring of these functional groups is a good tool to understand evolutionary processes of dune-ecosystem and for its management.





# RELEASE FROM NATIVE ROOT HERBIVORES AND BIOTIC RESISTANCE BY SOIL PATHOGENS IN A NEW HABITAT BOTH AFFECT THE ALIEN *AMMOPHILA ARENARIA* IN SOUTH AFRICA

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The European dune pioneer *Ammophila arenaria* (marram grass) was introduced in the 1870's in South Africa and has ever since been used to stabilise Cape coastal dunes and at present the alien grass is still an important drift sand stabiliser. Recently, however, the use of *A. arenaria* has been criticised due to its foreign origin and the proven facts of invasiveness in other parts of the world where the species was also introduced. One of the major explanations of the success of introduced species in recipient communities is their release from natural enemies (Enemy Release Hypothesis - ERH). On the other hand, exotic plant species failure to invade new habitats has been related to biotic resistance from the native communities to be invaded (Biotic Resistance Hypothesis - BRH). In its area of origin the species dominates the foredune plant community of mobile dunes, but it disappears naturally when dunes become stabilised due to growth control by soil-borne pathogens.

We examined ERH and BRH in relation to the invasiveness of the exotic foredune grass *A. arenaria* in South Africa. The role of root herbivores and soil pathogens has rarely been explored in the ERH and BRH view point.

To compare plant-soil feedback from the native habitat in Europe and the new habitat in South Africa, plants were grown in their own soil from both Europe and South Africa, as well as in sterilised and non-sterilised soils from a number of indigenous South African foredune plant species. The results from our study support both ERH and BRH in the case of soil pathogens of the introduced exotic dune grass *A. arenaria* in South African dunes, indicating that ERH and BRH may be active simultaneously. Possibly a number of exotic plant species that do not become highly invasive, such as *A. arenaria* in South Africa, experience both ERH and BRH. The balance between enemy escape versus biotic resistance will determine the invasiveness of a species in a new habitat. In the case of *A. arenaria*, the generalist nematodes and the negative soil feedback apparently originate from the local grasses, whereas the dicots were less important in sharing potential pathogens. Such effects have been demonstrated for aboveground plant pathogens, but not yet for root herbivores and soil pathogens. Our results further suggest that not only the local plant species diversity, but also the type of plant species present will determine the potential for biotic resistance. Therefore, the current debate on invasion resistance of the recipient plant community should also include effects of specific plant species on root herbivores or soil pathogens. The biotic resistance against invasive plant species may depend on plant competition, but also on the presence of plant species that are hosts of potential soil pathogens that may negatively affect the invaders.



# INTEGRAL WATER MANAGEMENT ON THE WADDEN ISLAND VLIELAND

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## Problem:

Vlieland is one of the four Frisian islands. This island amidst the salty waters of the Wadden and the North Sea is a favourite holiday spot. Translated, the island's drinking-water requirement varies strongly in proportion to the number of tourists.

For the drinking water groundwater is used from the freshwater lens beneath the island. The yearly recharge is around 200,000 m<sup>3</sup> per year and this demand is still growing.

## Realised activities & results:

As a result of the increasing ecohydrological knowledge of the causes of dehydration, there was a growing realisation that tackling only the groundwater recharge on the island would not lead to the desired (partial) recovery of the hydrological system. It also became clear that other activities and interests were exerting their influence on the hydrological system and, in turn, the groundwater level and quality, and the natural features that are dependent on them. To diminish the resultant dehydration, Vitens set up, with other parties, an integral water management project in 1994. Objective of this project was to restore the island's hydrological conditions as much as possible, on the precondition that an independent and sustainable water production would still be possible on the island. The following solutions / results were found:

- Reduce vaporisation in the coniferous forest by cultivating vegetation in the area
  - Partial transfer of pumpingwells from the centre to the southern coastline of the island.
  - Partial transfer of pumping wells from the first to the second, deeper aquifer.
  - Nature-restore project in dune slack 'Kooisplek'
  - Supplementary hydrological and ecological monitoring in different dune slacks
- 
- The measured hydrological and ecological effects on Vlieland are positive.
  - It shows us that an integral approach has more effect then sectoral solutions.

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# EVOLUTION OF SANDY BEACHES IN ESTONIA AS INDICATOR OF INCREASED STORMINESS IN THE BALTIC SEA REGION

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Warmer winters, increased cyclonic activity and frequent occurrence of extremely strong storms in northern Europe seem to be closely related phenomena caused by climate change. Climatic changes in moderate and high latitudes have led to critical changes in the dynamics and development of coastal areas. In Estonia, the greatest destruction occurs on sandy beaches that are well exposed to waves and is associated with stormy periods when storm surge elevates sea level. Ice-free sea and unfrozen sediments enhance the activity of shore processes.



## STORM SURGES IN THE ODER ESTUARY IN 2002-2003 – NUMERICAL STUDY

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The Oder River forms one of the major estuaries in the southern Baltic Sea. In its downstream reach, the Oder opens first into the Szczecin Lagoon. Then it drains into the Baltic Sea through three straits: the Swina, the Dziwna and the Peenestrom. That shallow, coastal water body is exposed among others to storm surges. Caused by deep low-pressure systems passing the Baltic Sea storm surges are the result of wind activity and changes of atmospheric pressure on the sea surface.

In recent years numerical modelling has become an essential tool to work out the water level forecasts (among others Funkquist, 2001, Kalas et al., 2001). The paper discusses the application of a 3-D operational hydrodynamic model of the Baltic Sea, developed at the Institute of Oceanography, University of Gdansk in studying and forecasting storm surges in the Oder Estuary. The model was based on the coastal ocean circulation model known as POM (the Princeton Ocean Model), which was adapted to the Baltic conditions (Kowalewski, 1997) and for numerical meteorological forecast of ICM (Interdisciplinary Centre of Mathematical and Computational Modelling, Warsaw University). Because of wind-driven back-up in the Oder mouth a simplified operational model of river discharge was developed based on water budget in a stream channel. Linking the Oder discharge model with the Baltic Sea model as one system made it possible to simulate operationally water levels and currents as well as water temperature and salinity in the Oder estuary.

The adequate fit between the predicted and observed water level series from the gauging stations on the Szczecin Lagoon and the Pomeranian Bay (Kowalewska, Kowalewski, 2004) encouraged to apply the model to studying storm surges in 2002 and 2003. The analysis revealed that the highest increases of water level were recorded in the cases of the movement of deep depression with trajectory running close to the coasts of the Southern Baltic Sea (mainly the effect of air pressure) and strong northerly winds (damming up of waters close to the coasts). Overlapping of both factors caused the intensification and prolongation of the storm surge. In that case there was recorded the reverse slope of water free surface. It resulted in intrusion of brackish water from the Pomeranian Bay into the Szczecin Lagoon, reducing river outflow and raising water levels within the whole estuary. Occasionally it resulted in flooding events like in February 2002.





Current 0-60-hour hydrological forecasts via a quick website access (<http://model.ocean.univ.gda.pl>) give potential users an opportunity to predict water level fluctuations, especially storm surges within the Szczecin Lagoon and the Pomeranian Bay. That information can be very important for emergency command centres and services dealing with environmental and flood control of coastal areas as well as with the safety of navigation and harbour operations. It may affect other areas of human life and activities, e.g., sport or recreation.

The application of the model to studying and forecasting storm surges in 2002 and 2003 revealed its high usefulness. In case of high amplitude and significant water level fluctuations the model correctly approximated the changes of water level and reflected properly all the phases of the examined storm surges.

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## **RISE OF GROUNDWATER LEVEL AND VEGETATION DEVELOPMENT IN THE CALCAREOUS DUNES NEAR HAARLEM, THE NETHERLANDS**

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The coastal sand dunes near Haarlem are part of the Nationaal Park Zuid-Kennemerland and are managed by PWN (Water Supply Company of North-Holland), Staatsbosbeheer (State Forestry Service) and Vereniging Natuurmonumenten (Nature Conservancy).

During the past century the dunes have suffered from groundwater depletion by drinking water production and other causes. During the last decades nature managers began to realize the considerable deterioration of groundwater dependent vegetation types in dried-out dune slacks. The need for recovery of the lost ecological values became an important issue. The results of hydrological model studies indicated that inducing a rise in water levels would lead to an increase of wet dune slack surface from 35 to 300 hectares. A plan, the 'Masterplan Regeneratie Duinvalleien Zuid-Kennemerland' was initiated to recover the characteristic ecosystems of dune lakes and wet dune slacks. It was realized that without accompanying management measures the rising water levels would merely lead to an increase in unwanted vegetations with tall grasses and herbs. So in most dune slacks measures like sod cutting, mowing and grazing have been performed, though in some no measures have been taken to get insight in the autonomous developments.

From 1991 to 2001 water extraction from the dunes was gradually stopped. As a result water levels have risen up to one meter and more. In 1998 a research program was initiated to monitor vegetation developments. Although these developments are still going on, the first results are becoming visible. In 2004 many dune slacks show development towards moist or even water vegetation types. In a few dune slacks the groundwater table didn't rise enough to enter the root zone.

In many cases additional measures appeared to be necessary to recover characteristic humid vegetations and to prevent the establishment of vegetations with tall grasses and herbs. Cutting sods to the mineral sand have caused the establishment and increase of pioneer species of humid dune slacks. Mowing also contributed to the recovery of characteristic humid vegetations.

The monitoring results led to some proposals for adjustment of management measures. The research program will be continued to monitor long-term effects.



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## MORPHODYNAMICS OF THE CENTRAL SWINA GATE BARRIER FOREDUNES (POLISH COAST) SINCE 1995 – CASE STUDY

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Majority of Polish coast is being eroded by sea. Accumulation is observed only in a few places. One of them is The Swina Gate Barrier. It is localised on the Wolin and Uznam Islands on the Pomeranian Bay coast. In Polish borders spit has about 16km from morenic plateau in Miedzyzdroje (Wolin Island) to country border in Swinoujście (Uznam Island). It is separated by Swina channel. Today dune ridges coming from different accumulation stages cover all spit. They differ from each other by the morphology, lithology and ridges direction showing following phases of spit increase and development. The youngest dunes growing up since XVIII century. Their heights are not bigger than 7m. Barrier is the biggest on Wolin Island. In west direction - to Swinoujście - number of the younger ridges and distances between them grow. Beach grow near the waterbreakers of Swina channel is the biggest (2m per year). Aeolian accumulation and dune growing is the biggest in middle part of barrier due to strong West and Northeast winds carrying sand accumulated by sea on neighbourhood beaches. Plant habitat that specifies fast accumulation on young dunes or dune fields is characterised by psammophilous plants *Ammophila arenaria*, *Calammophila baltica* and *Elymus arenarius*. Next stages are describing older fixed dunes covered by *Helichryso-Jasionetum* communities with *Helichrysum arenarium*, *Jasione montana*, *Corynephorus canescens* also lichens and mosses. Next stage may be not-forested dunes with abundant *Carex arenaria*, willow shrubs or forested dunes covered by pine trees.

During investigations on beaches of Swina Gate Barrier in 1996 and 1997 author observed continued development of small aeolian forms on the upper beach. Their heights reached from 0.1 to 0.5m. In vegetative season mentioned pioneer dune grasses covered this field. But denser growing (like a green carpet) plant was *Honckenya peploides*, halophilus plant of coastal beaches. This zone was called filed of initial foredune. Mean width of the beach is still about 60-90m. First, closest to the beach dune ridge had abraded seaside slope. Its shape shows influence of sea waves in modelling of this dune ridge (heavy storm surge in 1995 with water level up to 2m over mean). Mentioned pioneer grasses covered this ridge. On its top were accumulated not large sandy tongues (up to 0.2m). On the landward slope accumulation was small or absent provided by existing mosses and lichens fixing the sand. Denser grasses on the upper beach stopped more and more of sand. Highest hillocks and grasses became a bigger obstacle for transported from the beach sand. Accumulation on foredune ridge clearly became smaller. This ridge was slowly stabilised. Small hillocks and shadow dunes have arisen up to 1m between 1998 and 2000. In the end narrowing lowerings among these dunes were filled up by sand. The embryo dunes were connected in one dune ridge localised simultaneously to old foredune. Landward slope of this ridge was step and seaward slope flat. It was built as one ridge consisted from jointed tops of embryo dunes. Ridges of the embryo dunes were transverse to new foredune ridge.





Described ridge reaches up to 1m in year 2000. The bottom of this new lowering was covered by small aeolian hillocks (heights to 0.2m) fixed by pioneer grasses. Among them were deflation gutters filled by organic material. In autumn and winter 2001 few heavy storms caused dune damages. In west and east part of the barrier foredune was destroyed because of lower level. From spring 2002 accumulation processes starting to fill gaps in seaside slope of foredune and gates cutted by storm. Next cold season without storms but with strong winds led to big accumulation on the foredune. The ridge reached up to 2.5m and stopped transportation at the back. The lowerpart between new foredune and old one became stabilised. Slowly mosses and lichens start to colonise it. Only through storm gates sand was transported in land direction. In autumn 2003 one storm surge (with water 1.5m higher than mean) reach foredune ridge and damaged or washed it away – but again in west and east part of barrier. In middle part of barrier foredune ridge became 3m high and dense covered by grasses. It's landward slope started to be area of plants habitats from next succession stage. Since spring of 2004 large number of hillocks 0.3-0.7m high covers upper beach. They are covered by comparable number of grasses from upper beach existed in 1997. In middle part of barrier foredune is now enough stabilised by grasses and enough wide to survive during heaviest storms. It has been builded during last 9 years and so far shaped by several storms reach level as previous one (4 to 5m a.s.l.). The former foredune became structured there between 1986 (measurements from last madden map for this area) and 1995 (my measurements) also during 9 years.

Investigations on natural processes as: dune morphodynamics and plant succession can give us knowledge to proper protection and dune management. These investigations are best to drive on natural coast. Dune coast changes can be observed from relief profiles and vegetation transects across dunes. Other factors as winds and storm surges can be measured and compared with dune environment changes. Also we need information about sand supply dynamics and soil processes that are cause plants succession and dunes stabilisation. Temperature, moisture and salinity of the surface are influencing on plants habitats. Also human impact may play main role especially in present time. These investigations are done several times in the year every season and if it is possible after every main impact of one of the affecting on dunes factors.

Author drives mentioned investigations on Swina Gate Barrier (west Polish coast) since 1996. This work is part of own researches on whole coastal dunes called ANDDY (Anthropogenic-Natural Dunes Dynamics). Since 2003 presented investigations are also sponsored by Polish Committee for Scientific Researches (KBN) and signed under P04E-24-0849 number. In 2004 author is scholarship holder of the Foundation for Polish Science (FNP). For other information about fieldwork area and other investigated areas see web page: [bramaswiny.szc.pl](http://bramaswiny.szc.pl) and [polishdunes.szc.pl](http://polishdunes.szc.pl).

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## **TOURISTS ECOLOGICAL AWARENESS – KEY TO UNDERSTANDING HUMAN BEHAVIOUR IN COASTAL ENVIRONMENT**

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Settlement, tourism and economy development has negative impact in coastal areas, especially in dune environment (Careter 1980). Increasing of tourism, and settlement causes activities of coast protection by sea walls, groins, dykes, nourishment, vegetation planting etc. In present day most of the Polish coastal habitats including dunes are also threatened by human activities. Major impacts of tourism industry in coastal areas are (i) infrastructure with hotels, transport system and garbage, (ii) recreation with human activity, and (iii) coast protection against abrasion. If coastal environment will be damaged or destroyed, tourist will not be arriving. Small value of environment is equal to smaller number of tourists and smaller incoming from tourism industry. People do not think about threats for coastal environment. Tourists and citizens of the coastal villages do not have knowledge about coastal processes and dangers caused by storm and human impact. It is seen in their behaviour: left litter on the beach, trampled dunes, more and more construction for tourism close to the beach. If we want to protect and keep natural environment we should strongly influence on tourism participants to change their knowledge and behaviour in the face of environment. Today when developing tourism endangers environment we should recognise people rest preferences, knowledge and lifestyle to protect and properly use coastal natural values.

A first step in promoting the improvement of the environmental situation is to make information and knowledge about it available (Behaviour and the environment... 2003). The ecological awareness should be understood as defined level of knowledge about threats of life and health resulting from unsuitable relation of man to nature. Awareness consists of knowledge, opinions and imagination, also values and presented norms of the people.

This paper shows data collected on the basis of the questionnaire (22 questions and 200 respondents) carried out with tourists. Used questions were about (i) knowledge about coastal environment and its dynamics, dangers, (ii) opinions on its theme, (iii) its value for tourists, (iv) behaviour presented by tourists in environment. The main research question was on what tourists' ecological awareness depend? These researches were done on beaches of Polish coastal villages in summer 2002-03. The results determine analysis of dependence among social and demographical attributes of tourists, their touristic preferences and their ecological awareness relating to coastal environments. In question about what add attraction to seaside landscape and environment, most of all people answered that it is contact with the sea, rest on beach and microclimate. Only few people answered (below 20%) that these are also: promenades, historic places and museums, recreational infrastructure, park with reservations and luxurious hotels. Tourist, who is observing polluted beach, dunes, sea and villages probably understand



threat flowing for nature from human impact. In question about kinds of preservation of seaside nature over 60% of tourists pointed on: taxes and punishments for poisoning of nature, paths to walk, not roads for cars, sewage treatments, selection of litter and education. Among proposed in questionnaire threats for seaside nature most of all persons pointed: quantity of litters and waste material (79%), absence of sewage treatments (67%) and on more and more great number of tourists (54%). For respondents presence of large number of tourists in little seaside villages is threat for nature (81%). Infrastructure development close to the beach is main problem of tourism development and for coastal protection. In separate question about these investments only 10% of tourists say Yes - it should be build close to the beach (restaurants, hotels), but 65% say No! In question with picture of the natural coast and coast covered by infrastructure (town), 84% of people prefer natural landscape and only 22% prefer this with town buildings. Also 79% of asked tourists prefer to rest in small villages, because of calm, silence and absence of tourists.

In many questions education, pollution and litters were the main problems pointed by asked tourists. But also it is clearly visible, that people do not want a lot of buildings and infrastructure close to the beach. For them bigger value is the natural landscape and environment in which they can really rest. Probably bigger knowledge about coast environment may increase their friendly activity for environment. Local communities and schools should take care for education about seaside environment. Various opinions not true knowledge and not accepted behaviours of tourists should be regulated. Their awareness and attitudes should be changed. In other case natural environment will be soon destroyed. And social costs of protection will rapidly increase.

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## **CLOSING OF COOLING WATER STREAM FROM ELKEM ALUMINIUM LISTA, FARSUND COMMUNITY - ADJUSTMENT IN LANDSCAPE**

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Farsund community is located in the southern part of Norway, with a long coastline to The North Sea (Skagerak). Today there are around 9000 inhabitants in the community. Farsund is the largest farming district in the county of Vest-Agder, and the town has earlier also been the largest maritime town of Norway because of all its shipowners. Today there are three large industrial companies in the community – all located near to each other. In the surroundings there are a lot of small and middle-sized establishments.

Elkem Aluminium Lista was established in the beginning of 1971, and has had – and has today – a central place in the industrial environment in Farsund. The number of employees has been about 800 at the most, but is now about 350. The reduction in manpower takes place because of new technology and changes in working routines. The company is located just outside Farsund town, surrounded by mixed vegetation and other great nature. A new factory making products for the motorcar industry (Alcoa Automotive Castings), buys liquid aluminium from Elkem and is located close to the aluminium plant.

Along the seaside, about 200 m from Elkem, there is a protected zone area. This was effectuated in August 1987 by the State Government. The area is very much used by the inhabitants and tourists for recreation, especially in the summer season.

In this area the cooling water from Elkem is discharged (75m<sup>3</sup>/min.), and up to 1995 this was considered very negative by a lot of people. Smell and visual impression were factors that increased this impression.

Elkem has through the years worked to reduce the PAH and other tar contents in the outlet. Yearly measurements show that the company has succeeded in this. The standard today is below the minimum which the Environmental Authority has imposed.

In August 1995 – after some planning - the work was started in order to close the outlet. The company, the community and the county's environmental department were involved in planning and implementation. There were two alternatives 'above ground level'. And everybody are agreeing that the alternative chosen was very successful considering nature and surroundings.

The solution not chosen was to build an ordinary building – like a wharfside shed.

A main pipeline was built from the lock-chamber out into the sea. This line was open through the winter period. In May 1996 it was covered with sand.





After the shovels had done their work, students from Farsund Junior High School took over the job. Marram was taken gently from the nearby areas. And in two-three days in May the marram was planted in the ground above the pipeline. The marram was planted at about 25x25 cm distance from each other. There were no watering and fertilizing, but the sand was humid when planting. Elkem paid the students for the job – this was a good contribution to their yearly school trip.

After the planting, boughs were put in the area to stop people from walking there – and also for 'binding' the sand. This was very successful. The marram grew fast – and the area today looks quite natural. At a distance it is not easy to see the technical installation in the area. And there is no outside maintenance work necessary. The total cost for the project was: NOK 6,000,000.

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## **CHARACTERIZATION AND PRESERVATION OF SILT-LADEN SOILS IN THE HUMID DEPRESSIONS OF HATAINVILLE'S DUNE MASSIF (MANCHE, FRANCE)**

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The dunes on Cotentin's western coast are a remarkable natural heritage whether from the point of view of geomorphology and landscape or at biological level of flora. Hatainville's dunes thus have become an example for the preservation of a living and diversified dune massif. Because of their extensive resources, the preservation of the humid depressions in Hatainville's dune massif is considered a priority aim in the preservation project by the 'Conservatoire du littoral'. If that wealth is partly related to the topo-geomorphological conditions of the site, it is actually revealed through the nature and properties of the soils, resulting in ecological and floristic diversity.

The soils thus appears as essential studying to understanding the process of floristic growth and the presence of rare or more common plants (Provost, 1975). That is why, for two years now, we have been focusing research on the relationship between soil and vegetation in the humid depressions. If the relationship between the texture of the soils with the sand basis is generally observed, the significant presence of silt in many pedological profiles is truly typical of soils in humid depressions (Le Gouée et al., 2005). Those silt-laden soils thus appear as a particularly interesting natural heritage as they are closely linked with the presence of hygrophile vegetable communities among which, for example, *Apium repens*, a species mentioned in Annex II of 'Directive Habitat'.

A close analysis both on the site and in laboratories has made it possible to describe the silt soils very accurately, to define the origine of these soils, to confirm the importance of their hydric properties for hygrophile communities, and to work out a precise map of the humid depressions characterized by that type of soil on the site.

Actions for the protection of diversity and ecological resources are associated with the tradition of extensive pasture which contributes to preservation of Hatainville's dune massif. Yet, the watering places which the humid depressions can be are not numerous enough. The high density of cattle around the pools leads to an intensive trampling of the soil which seriously endangers its edaphic and ecological balance. The preservation of silt-laden soils as natural heritage thus goes together with the creation of artificial pools accessible to cattle.

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## **MANAGING THE FLEMISH DUNES: FROM ECO-GARDENING TO MECHANICAL DISTURBANCES CREATED BY BULLDOZERS**

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The 'Conseil Général du Département du Nord' is the manager of 480 hectares of Flemish dunes located at the far North of France. These spaces, initially preserved by the action of the 'Communauté Urbaine de Dunkerque' are now the property of the 'Conservatoire de l'Espace Littoral et des Rivages Lacustres'.

Characterised by an aelian dynamism and by the winter flooding of their damp depressions, these systems had represented a very high patrimonial richness before man, by his activities (the pumping of the aquifers, the parcelling out of dune massifs, the fixation of sand by plantations, the destruction of rabbits), reduced to nothing the natural expression of perturbations (storms, floods, important sandbanks) and made dune massifs become wastelands and low marshes and dry lawns disappear.

The first step for preservation was the in extremis safeguard and the maintenance by scateurs (1989) then by motor scythes (1992) of micro-habitats with a high richness over a 2 hectares total surface lost in very important pre-forested systems.

Rapidly, the objectives of preservation obliged us to put into practice the restoration of natural environments by stripping and clearing the ground (1994 and 1997). But these operations of a large scale (10 hectares) were always based on a 'fixist' and 'museographical' approach to the environment (the maintenance of a representative sample of habitats).

The management which consists of stopping certain pioneer and post-pioneer stages of vegetation can in fact correspond to a counter-natural step as these dune systems make the proof of a very high dynamism and permanent evolution.

Today the management of dune space is done by bulldozers: First the pre-forested vegetation is totally destroyed (16 hectares in 2004) leaving systems of bare sand freely evolving and accepting their spontaneous wastelanding over more than 50% of their surfaces.

The return to uncontrolled vegetal dynamism is only accepted if perturbations are periodically created in order to regularly produce the starting or reappearance conditions of the different series of vegetation.

The last stage of our managing operations would consist, with a middle-term effect, in reducing the stability of the edging dune row and in favouring the development of wind passages with their devastation or saving effects on the dune we intend to preserve.



## **PRESERVING THE BEACH DEPOSITS (HIGH-WATER DRIFTLINES) AND THE EMBRYO DUNES ON THE COASTLINE OF THE NORTH DEPARTMENT (FRANCE)**

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The management experiences presented here have been realised since 1994 owing to the 'Conseil Général' of the North district on the upper beaches of the 'Perroquet' and 'Marchand' dunes owned by the 'Conservatoire du Littoral' situated on the Bray-Dunes and Zuydcoote municipalities.

This experience aims at the restoring of the habitats on the sea frontline of the border dune.

The subject is the space that starts from the annual halo-nitrophile strip on the upper beach, goes on with the embryonic dune and finishes with the quick white dune dominated by the 'oyats'.

The requirements of beach cleanness, especially as regards to seaside tourism, have lead to the destruction of these patrimonial importance habitats by the regular and complete mechanical raking of the 'estran' (the strip of the beach included between the low and high tide).

The first step consisted in limiting this mechanical raking to the rights of sea-side resorts. At the same time, the upper strip of the beach along the dune 'massif' is managed softly by a selective manual picking up of the biggest trashes.

These simple operations are now principally realised by the 'Syndicat Intercommunal des Dunes de Flandres', a public structure whose one of the missions is to clean up the beached.

This change of cleaning process rapidly produced the emergence of noticeable habitats that didn't exist before. It concerns water marks mingled with sand (*Beto maritimae* – *Atriplicetum laciniatae*) and embryonic dunes with sand couch grass (*Elymo arenarii* – *Agropyretum junceiformis*).

To a reduced extent, these methods of management lead to a reinforcement of the white dune with oyat and Sand Elyme (*Elymo arenarii* – *Amophiletum arenariae*) and the white dune which is warmer with oyat and dune Euphorbe (*Euphorbio paraliadis* – *Amophiletum arenariae*).

Some of these habitats are listed as part of the Guideline 'Habitat' and are listed as vulnerable or endangered after the red book of the littoral terrestrial phytocoenoses according to the definitions proposed by the International Union for Nature Preservation.

The stop of systematic mechanical raking and the structuring of embryonic dune has afforded the ponctual nidification of the kentish and of little ringing plover.

A photographic following up and a regular following up the indicatory species are being realised.





Moreover, the obstacles kept on the upper strip of the beach afford the start of a process of sand accumulation and built the embryonic dune.

According to the sedimentary context, this type of operation assists the fertilisation of the upper beach and reduces the retreat phenomenon of the coastline. The sedimentary following up is realised by the dynamic geomorphology laboratory of the 'Université Littoral Côte d'Opale' (Mylène Ruz).

The cost of operations is much reduced, money is even saved with the reduction of the number of interventions. It was difficult to convince our partners about modifying their cleaning habits.

This successful experience over a 1,5 km distance of beach, facing preserved dune massifs, shows the large potentialities of spontaneous restoration of these natural environments.

The extreme simplicity of this method and its very small cost, except employees, allow us to envisage and adapt it all along the European coastline.

As a consequence of the positive results obtained in the previous phase, the following years were marked by similar actions implemented by different partners (municipalities, regional authorities, etc.) and different species of birds and plants were observed on the beach.

The French Nature Reserve created the vegetation and dune management plan, which is open, participative, flexible and can be adapted to the specific characteristics of the site. The plan is based on the principle of the least intervention, i.e. the least possible intervention to maintain the natural state of the site. The plan is based on the principle of the least intervention, i.e. the least possible intervention to maintain the natural state of the site.

The management plan is based on the principle of the least intervention, i.e. the least possible intervention to maintain the natural state of the site. The plan is based on the principle of the least intervention, i.e. the least possible intervention to maintain the natural state of the site.

The partial success of the large-scale removal of invasive species and exotic tree species was a part of the LIFE nature project 'Large Coastal Conservation Initiative' (LIFE-NAT/97/2001) and the LIFE nature project 'Forest Ecology of the Yvelines' (LIFE-NAT/01/2001).

The project (which) was carried out in the two largest (a surface area of more than 200 hectares) dune areas of the French Coast: the French Nature Reserve 'De Wijkhoek' at De Binnendijk and the French Nature Reserve 'De Yde' at Yde (Drenthe). These two nature reserves are part of the Natura2000 network.

The project gives a detailed, historic overview of the different large-scale removal and control methods used. The different removals are listed as a map on the website of the project and are clearly described. Much attention is given to the practical aspects that were important for the nature managers and the public.



## **INVASIVE SCRUBS AND TREES IN THE COASTAL DUNES OF FLANDERS (BELGIUM): AN OVERVIEW OF MANAGEMENT GOALS, ACTIONS AND RESULTS**

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Before the management responsibility of the Nature Reserves had been handed over to the Flemish Nature Division in 1995, the management policy of the dune-nature reserves was mainly oriented to the spontaneous evolution of vegetation towards scrub and woodland.

As a consequence of this passive attitude, most of the Nature Reserves along the coast were encroached by scrubs: mainly sea-buckthorn (*Hippophae rhamnoides*), wild privet (*Ligustrum vulgare*) and different species and cultivars of exotic poplars (*Populus div. spp.*); open dune habitats became very rare.

The Flemish Nature Division wanted the restoration and maintenance of the natural, open, herbaceous habitats that are typical for lime-rich coastal dunes, especially dry grey dune-habitats (with calcicole dune-grasslands), wet dune-slacks, and calcareous grasslands. In other words: the restoration and maintenance of the habitat directive types 2130 'Fixed dunes with herbaceous vegetation (grey dunes)', 2170 'Dunes with *Salix repens* ssp. *Argentea* (*Salicion arenariae*)' and 2190 'Humid dune slacks'.

The habitat directive also protects the scrubs with Sea Buckthorn (habitat type 2160 'Dunes with *Hippophae rhamnoides*') because they are also a major component of the vegetation of coastal sand dunes. Therefore, before removing scrubs and exotic trees, the Flemish Nature Division had management plans made for the Flemish Nature Reserves. So it could be decided in a scientific well-considered way, which scrubs should be removed and which should stay.

The practical execution of the large-scale removals of invasive scrubs and exotic tree-species were a part of the LIFE-nature project 'Integral Coastal Conservation Initiative' (ICCI, 1997 -2001) and the LIFE-nature project Fossil Estuary of the Yzer Dunes Restoration Action (FEYDRA, 2002-2005).

They were (mainly) executed in the two largest (a superficies of more than 200 hectares) dune -sites of the Flemish Coast: the Flemish Nature Reserve 'De Westhoek' at De Panne and the Flemish Nature Reserve 'Ter Yde' at Koksijde (Oostduinkerke). These two Nature Reserves are part of the Natura2000 -network.

The poster gives a detailed, historic overview of the different large-scale removals and describes which methods were used. The different removals are located on a map and the results of the removals are shortly discussed. Much attention is given to the practical experiences that were acquired and suggestions for other nature -managers are made.



The removal of shrubs and trees as a measure of management of the coastal dunes in Flanders can have several goals in relation to the maintenance of biodiversity:

- the removal of thickets of indigenous but invasive shrub-species such as Sea-Buckthorn (*Hippophae rhamnoides*), Wild Privet (*Ligustrum vulgare*) and ... Willow (*Salix cinerea*) to the restore and maintain the habitats white dunes and sand-drift, 2130 'Fixed dunes with herbaceous vegetation (grey dunes)', 2170 'Dunes with *Salix repens* ssp. *Argentea* (*Salicion arenariae*)' and 2190 'Humid dune slacks';
- the removal of artificial plantations of exotic tree-species such as White poplar (*Populus alba*), Ontariopopulieren that are often expanding by vegetative regeneration, to restore the above mentioned habitats that are typical for the open dune-landscape;
- the removal of (semi-) exotic tree- (*Sycamore* (*Acer pseudoplatanus*), Amerikaanse vogelkers (*Prunus serotina*) ...) and shrub-species from thickets and woods that are mainly constituted of indigenous species to maintain the habitats 2160 'Dunes with *Hippophae rhamnoides*' and duinbossen
- the removal of woodland constituted by indigenous (*Alnus glutinosa*) as well as semi-exotic tree-species (*Alnus incana*, *Acer pseudoplatanus*) to restore 2190 'Humid dune slacks'.

When the measure aims at restoring dynamic pioneer conditions or even large-scale landscape dynamics such as sand drift, the use of heavy machinery is appropriate.

When the aim is to restore habitats that had a historical presence on the site on which the measure is taken, carefulness is essential to preserve the soils and seed-banks on which depends the restoration of habitats such as calcareous grasslands ('De Westhoek', 'orchideeënpanne 'Ter Yde', 'Hannecartbos'). If historical knowledge points out that there is a chance to restore such habitats that need quite a long time to develop into maturity, taking the rarity of these habitats along the Flemish coast into account, this restoration benefits preference above the restoration of dynamic conditions.



## CONSERVATION OF DUNE SYSTEMS: CONTRIBUTIONS FROM MORPHO-DYNAMICS AND VEGETATION ECOLOGY

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Coastal zones, in which dune-systems are included, are extremely dynamic and sensitive systems which undergo natural and regular geomorphological changes that reflect on the conservation status of both geoforms and plant communities.

Recent studies have been performed in order to correlate geoforms (as the landscape supporting framework) and associated vegetation complexes. Evidence shows that a close relationship exists between dune vegetation and coastal geoforms, which supports the theory that they can be the background for bioindication models of erosion and stability in the coastal zone.

In this paper, we discuss results from recent case-studies and identify the main indicators of coastal processes and of coastal zone dynamics; we also refer to some methods usually applied in this kind of studies. GIS technology is proposed as the ideal tool to store and analyze all kinds of ecological data from coastal areas, in order to address planning and management issues. Thus, we stress that coastal planning and management require integrated studies, including the knowledge from several scientific areas.

### Theory

Coastal areas are highly dynamic systems that are suffering fast and significant changes. The most important phenomenon taking place on littoral areas is *inland beach migration*, including the formations of cliffs and thinning of beaches (Granja & Carvalho, 1998; Carvalho, 1999; Carvalho & Granja, 2002; Granja & Carvalho, 2000; Granja *et al.*, 2000). Destruction of coastal geoforms is induced mostly by natural causes, related to global climate changes, and reinforced by anthropogenic processes (Araújo *et al.*, 2002; Carvalho & Granja, 1997; Granja *et al.*, 2000).

Natural vegetation reflects geomorphological changes and is thought to be an important (bio) indicator of coastal transformations. Several recent studies identified a straight relationship between plant species/communities and the conservation status of dune systems (Araújo *et al.*, 2002; Carvalho *et al.*, 2002; Favennec, 2002; Jones *et*





al., 2004). Other authors have proposed the use of Phytosociology (vegetation science) for identifying indicators of landscape planning and conservation (e.g. Loidi, 1994), and the overlapping use of several data sources, namely geomorphological and botanical, in order to achieve a more global and efficient evaluation of coastal stability (Loidi, 1994).

In this paper we discuss the relationship between geofoms and sand dune vegetation, as well as its contribution as a diagnosis tool for conservation purposes. We also present case-studies related to this subject.

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## THE ROLE OF HYDROGEOLOGICAL RESEARCH IN THE REALIZATION OF A COMBINED PUMPING AND DEEP INFILTRATION SYSTEM AT THE EXCAVATION 'DUINENABDIJ'

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The archaeological site of the medieval abbey 'O.-L.-V. Ten Duinen' is situated in the dunes of Koksijde. Because of its low topographic level and the occurrence of a shallow semi-permeable layer, the excavation suffered from high water levels during the winter periods. Since the former draining was ineffective, a new drainage system was needed to preserve the archaeological relics. Furthermore, the conservation of the ecologically valuable dunes surrounding the site was a second objective in the realization of the system. A profound knowledge about the hydrogeological characteristics of the concerning aquifer was indispensable to plan this system. A study of relevant literature provided a first insight in the hydrogeological constitution of the groundwater reservoir. The aquifer is composed of Quaternary sediments existing of three permeable layers, which are separated by two semi-permeable layers. Underneath, the aquifer is bounded by a Palaeogene layer that could be considered impermeable in the scope of this study. The former draining of the uppermost permeable layer caused a worse infiltration of water which largely explained its ineffectiveness. Thus, in order to achieve a better infiltration through this layer one should drain the middle permeable layer. However, this pumping would not only cause a descent of the water table at the excavation, but would also affect the surrounding dunes. Therefore, it would be necessary to deeply infiltrate the pumped water in the two undermost permeable layers at the borders of the site. Modelling this system of combined pumping and deep infiltration, given the specific hydrogeological constitution, revealed the importance of an accurate knowledge of the hydraulic parameters of the concerning hydrogeological layers, particularly the hydraulic resistance of the two semi-permeable layers. Estimations of the parameters based on the interpretation of pumping tests executed in the vicinity of the study area were not reliable, because of the heterogeneous nature of Quaternary deposits in the Belgian coastal plain. The performance of a pumping test at the excavation was therefore inevitable. Moreover, in order to achieve a reliable deduction of the hydraulic resistance of both semi-permeable layers, it was necessary to execute a double pumping test affecting the two undermost permeable layers. The results of this test were simultaneously interpreted by means of an inverse numerical model and this interpretation resulted in reliable parameter values. The model simulating the system of combined pumping and deep infiltration based on the deduced parameter values gave a profound insight in the system's effectiveness: not only the excavation would be drained properly, also the surrounding valuable dunes would be protected. This study thus illustrated the important role of field tests (e.g. pumping tests) and mathematical modelling in the planning of hydrogeological interventions in ecologically valuable areas.



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## NEW PERSPECTIVES FOR FISH IN THE SCHELDT ESTUARY

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The Sigmoplan aims at protecting the watershed of the river Scheldt (Belgium) from flooding. The plan comprises the construction of dykes and retention areas or controlled floodplain areas along the tidal Scheldt and its major tributaries. Several smaller floodplains are already in use while a large 600 ha floodplain (Kruibeke Basel Rupelmonde) is under construction. Using different life history characteristics of estuarine fish species, we predict future changes to the species composition of the estuary and outline implications for future management. Once a functional floodplain has been established, the southern part of the floodplain area will develop into a spawning and nursery ground for eurytopic fish species. The northern part will be exposed to reduced tides, creating mudflats and marshes, which will serve as nursery grounds for reophylic and eurytopic species. We expect that the floodplain will autonomously develop into a fish nursery as long as permanent aquatic habitats are provided: small ponds and creeks are refugia to which juvenile fishes withdraw once the flood water is drained to the main river channel. The increased availability of spawning and nursery habitat is predicted to result in a notable increase of the total fish density in the oligohaline and freshwater parts of the estuary. The addition of inundated areas to the stream corridor particularly favours reophylic fish species such as ide (*Leuciscus idus*), a species that is now virtually absent in the Scheldt estuary. Measures that support the recovery of the ide population may therefore be successful. However, not all species are likely to increase in abundance. Anadromous fish such as *Lampetra fluviatilis* and salmonid species will not benefit from increased habitat diversity since their distribution is limited to the main river channel.





# HYDROLOGICAL CONDITIONS FOR THE SURVIVAL/REMANING OF A UNIQUE SOUTHERN BALTIC MARSH AS A HABITAT OF ENDANGERED FAUNA AND FLORA SPECIES

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The accumulation coasts of the South Baltic Sea are characterized by diverse environmental conditions, cause by different genesis of physical and biochemical processes. In this special region where interaction of salt-water with fresh water occurs, essential the differences in local hydrological conditions. Accumulation South Baltic Sea is famous for separate, extensive branches of great rivers, direct mouths of rivers from postglacial lake areas, estuaries, coastal lakes (inner-dune, trough, deltaic) and numerous wetlands. Quoted types of objects differ from one another by an area, depth and connection with sea.

Current environmental condition of this coast is a result of both a natural development and a human activity, as well as a water circulation.

From several years The Department of Hydrology of Gdansk University researches conducts the in order to define the hydrological conditions, which must exist if these unique environments are to remain. One of the objects of our interest is a unique on the polish stretch of coast - marsh, located near Reda river mouth and Puck Bay (Gdansk Bay - South Baltic Sea).

This object is very attractive as regards environment, landscape and tourism. This is an area of landscape protection (Seaside Landscape Park), proposed for the system of Baltic Sea Protected Area (BSPA). This is also a mainstay of European rank.

In 1988, in order to preserve take into account avifauna breed and avifauna flying (*Calidris alpina schinzii*, *Motacilla citreola*) as well as moisture salt meadow so-called *Juncetum gerardi* (*Plantago maritime*, *Epipacis palustris*), 'Beka reserve' has been established.

Marsh is a low-situated zone in humid times swamped by the soil - water.

From hydrological point of view, uniqueness of this marsh is a result of the fact that the marsh is situated on a coast with a half - closed sea, where tides not exist. Fluctuations of water level induced by wind set-ups are the factors, which cause cyclic swamp.

All therehydrological conditionings result in biotope environmental (halofile plants, flying fowl, periodic settled and breded flow) variability. They cause sea - water intrusions from Puck Bay. They create numerous pools. Simultaneously from the higher parts there is a confluence of fresh water. The hydraulic gradient is minimal. That is why the phreatic waters are low. The effects of this fact are the spatial and temporal differences in physical and chemical water composition. They decide about the



remaining or extinction of unique habitats of endangered flora and fauna species in the South Baltic Sea.

Very essential for a preserving this area is human activity. The positive action is an annual mowing of reed during the springtime. This makes the reed weaker. A grazing of different species of animals also positively influences the salty plant. The animals that are grazed are: cows, sheep and horses. Also the number of animals changes. The best animals of for grazing are the cows, whereas the worst are the sheep. That is because the sheep eat plants when they grow about several millimeters the ground.

The negative fact is that in this place there is no above proper supervisor over the land improvement system very. Often the channels are overgrown and this results in a decrease off and capacity hydrological rank to. Simultaneously uncontrolled tourism, especially during birds breeding time is another negative form of human activity. Also illegal cottage building in the outline of reserve, results in disturbance of water circulation.

To recapitulate, the hydrological processes and human influence very closely shape the biotope environment of the present marsh. The effect of this liaison between nature and human activity is the 'Beka reserve' which, should be propagated as a unique marsh on the scale of southern coast of Baltic Sea.



# **MULTI-TECHNIQUE SURVEYS OF FINE SEDIMENT TRANSPORT AND DEPOSITION IN A MANAGED ESTUARY: THE AUTHIE ESTUARY, NORTHERN FRANCE**

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Estuaries are highly dynamic environments of great socio-economic and ecological importance due to their position at the interface between marine and continental environments. This location commonly entails an adequate supply of coarse (sand) and fine (mud) particles from both marine and continental sources. A good knowledge of the sediment distribution pattern in time and space is important because estuarine accretion eventually leads to the evolution of intertidal habitats towards supratidal ones, while erosion may induce risks of damage to infrastructures. Erosion and accretion patterns may also determine the distribution of pollutants in estuaries. Moreover, by providing space, resources and habitat for wildlife, the loci of fine sedimentation are of critical ecological significance.

Estuarine management and eventual habitat restoration need preliminary studies, pertinent surveys and tools to understand the behaviour of sediment stocks. It is difficult to evaluate qualitative and quantitative aspects of sediment dynamics, as a result of overall mixing inside the estuarine system and recycling of materials. This issue is also complicated by the nature of the materials in movement and their physical properties, as well as by variations in the energetic forces driving estuarine dynamics (wind, waves, tide, river discharge). One way of maximising data collection with a view of improving the understanding of estuaries is by diversifying the range of methodological procedures and techniques in order to attempt matching the diversity of estuarine parameters.

This communication presents an overview of a range of simple and high-technology techniques (acoustic, electromagnetic and optical instruments) and scientific methods used in a small, human-managed, highly dynamic, temperate macrotidal estuary to quantify the movement and deposition of sediment in space and time. The advantages of each technique and its limitations are exposed and perspectives for improvement evoked. It is shown that this multi-technique approach is relevant to a better understanding of processes, rhythms and sedimentation rates, while the data acquired are of importance to reliable modelling. Permanent feedback from high-resolution field monitoring is still a necessary pre-requisite in forecasting the evolution of estuarine systems.



## **THE GEMEL EXPERIENCE: AN ASSOCIATION AS A LINK BETWEEN ESTUARINE ENVIRONMENT, SCIENTIFIC RESEARCH AND STAKEHOLDERS**

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At the beginning of the 1970's, French oceanographic research on tidal shores was declining to the advantage of other fields of marine scientific investigation, creating a lag in organized data acquisition. At the same time, the teaching of oceanography was limited to a few universities. In 1981, young researchers without employment created the GEMEL, an association encouraging mutual help in order to found and promote their research on estuaries facing an increasing request for tidal flat studies, as a result of the development of shore management. One of the first pluridisciplinary research teams on estuarine environment was built on this social and scientific basis.

After more than twenty years of activity and presence on the western French coast, the GEMEL offers now a certain experience and maturity. The GEMEL has its place in the civil society as a link between estuarine environments, scientific research, stakeholders and citizens. The association is funded by members' contributions, governmental grants, and participations in research programs at local and European levels (from COST 647 to MOREST, steering of regional PICCEL) and involves in a no lucrative idea of these different actions. Its functions are to study (working to order or not), acquire structured data pools, propose practical training, provide information and finally widely communicate about estuaries to a large public with a range of supports (international symposium organization, local exhibitions, web...).

The associative structure presents a high flexibility that can facilitate the setting up of projects and an efficient communication: between each member in one side, exchanges and so enhancement of the expertises, and with institutions (IFREMER, French Water Agency, universities...) and stakeholders in the other hand. The originality of the association is to deal at the same time with fundamental research and practical applications. In this way, the GEMEL works essentially on methodology and inter calibration of ecological survey tools issues, provides objective expert's reports but is also able to initialize or continue monitoring of areas in a long term perspective (long data series of few chosen parameters in the bay of the Somme and Veys for example). Such data are very rare but nonetheless reveal actually their utility face to an increasing pollution risk and to study communities' dynamics in the frame of global change. It seems to be primordial to distinguish natural and anthropogenic trends in observed evolutions to give keys for a rational and integrated management of such sensible sites like estuaries.

This communication will give some examples of initiatives of the GEMEL to show its independent and special position in the network of the environmental decision scheme, from study to management by monitoring phase. It will equally set the association in a context of environmental education emergence and debates on the future of French research.





## **SCHELDEFONDS VZW**

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The Scheldefonds is a unique cooperation between governments, companies and environmental organisations from Flanders and the Netherlands. Its main goal is to underline the economic as well as the ecological importance of the Scheldt estuary, by combining forces.

Sustainable development of the estuary demands a global approach, meaning that all further activities should contribute to the economic, ecological and social function of the area. All the values of the river need to be equally respected. To realise these objectives, people dependent on the River Scheldt need insight in this mutual dependency and measurements that are necessary to preserve the different functions of the river for the future. The Scheldefonds contributes to this objective by informing people and raising awareness. Therefore different activities are organised.

Scheldekran: The Scheldekran is a joint publication of the Scheldefonds and the Schelde InformatieCentrum. This newspaper appears once a year and is distributed for free. With this newspaper we want to reach all people who work or live near the river. Through different topics such as nature, culture, fisheries, economics and safety the diversity of the Scheldt estuary is shown. The newspaper is available in town halls, libraries and touristic information centres of municipalities near the Scheldt in Flanders and the Netherlands. 100.000 copies are distributed.

Scheldeschorrenproject: This is an educational project about the mud flats of the tidal River Scheldt. Three adjacent mudflats are situated near a popular cycling route. The Scheldefonds would like to build a hide for bird watching in this unique and valuable area. People passing by will be able to enjoy the hide not only for bird-watching, but also as an observation-post to enjoy the landscape.

On a regular base the Scheldefonds organises lectures, workshops and other activities about the River Scheldt.

The Scheldefonds is a non-profit organisation where members pay a yearly membership fee as support. Members get reductions on application money and publication fees for the Scheldekran. Every year the Scheldefonds also organises a field trip for the members.

Website: [www.scheldefonds.org](http://www.scheldefonds.org)



## **THE OPENING TO THE FRENCH PUBLIC OF 'NATURAL' SITES OF COASTAL DUNES: THE CHOICE BETWEEN 'OVER-VISITING' AND 'OVER-PROTECTION' OF A SHARED NATURAL HERITAGE**

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This paper proposes some thoughts on the stakes of opening to the visiting public natural sites with particular reference to coastal dunes.

In France the visiting public readily enjoys access to sites and particularly those situated along the coasts where this social activity forms part of the vocation of the Conservatoire du Littoral, the Office National des Forêts and the Conseils Généraux (Departments)(Meur-Férec, 1997). At ground level the diversity of each site together with the variable policies adopted by owners and managers, together with their differing geographical locations and social and economic pressures, produces an infinite variety of particular situations. The range of the degree of liberty of access to coastal sites varies greatly from the extremes of severely protected 'réserve biologique domaniale' only open to guided tours to free access peri-urban sea-side parks. Although most coastal zones readily admit the public, the inherent damage caused to sand dunes by 'over-visiting' is sometimes badly accepted in scientific and ecological circles as constituting a real menace to our shared natural heritage (Dauvin, 2002).

In terms of risk we have to consider stakes of opening, or closing sites to the public. The reasons are multiple and the protection of the bio-diversity for future generations is certainly one of them (the protection of human lives against the risk of sea water flooding is of course another prime aspect but, fortunately, this is a limited risk along the coasts of France). However, one can also consider the amenities acquired through site visits and the awareness of ecological issues that hopefully will be transmitted to future generations. To what degree the opening of sites will conciliate the major issues of conservation of the biodiversity / public access?

These questions lead on to a reflection concerning the evolution on the relation between Man and Nature (Kalaora, 1998, Miossec 1998). The coastal dune environment has moved on over recent centuries from the 'frightening desert' (Brémontier, 1797) to a precious spatial resource destined often for short term unbridled economic development, and becomes sometimes today a 'sanctuary' precluding public access. In a reaction against development excess the current thought in sites management tends to privilege the conservation of the ecosystems in the name of biodiversity. However the best interests of Humanity as a whole cannot only be translated into terms of biodiversity, which is, after all, only one of several factors of good husbandry concerned by the protection of our shared heritage of Nature. The access accorded to a public, as a function of the nature of the sites, well-informed,



marshalled, limited in number and reasonably behaved can also through an acquired awareness of our heritage become a guarantee of sustainable preservation.

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## **SUSTAINABLE ESTUARY MANAGEMENT FOR THE 21<sup>ST</sup> CENTURY**

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The response of estuaries to sea level rise and hundreds of years of aggressive land-take for agriculture and commerce has profound implications for nature conservation. Salt marshes and mudflats are eroding, whilst the natural process of landward transgression of habitats is attenuated by physical barriers such as sea walls. In south-east England this has led to a loss of 25% of saltmarsh habitat in the past 25 years. At the same time, sea level rise means that ageing flood defences are less effective and will need to be re-built to meet the challenge of increased flood risk through diminished crest heights and increased storminess. A morphological solution is needed.

If the UK is to maintain its Natura 2000 series in favourable condition (let alone Biodiversity targets) there needs to be an accelerated programme of managed realignment. However, thought needs to be given to the way in which managed realignment might also contribute to improved flood management and to long-term management of the flood defence budget. An important consideration is the morphological response of estuaries to sea level rise that has happened since the Flandrian transgression.

Ideally, accommodation space for sea level rise should be provided throughout estuaries so that the changes occur along their entire length, allowing upstream transgression of the saline wedge, and lateral transgression of inter-tidal habitat. However, residential and commercial developments impose constraints and a designed approach is needed, taking account of natural responses to physical barriers.

In developing Conservation Objectives for SAC Habitat 1130 'Estuaries', English Nature used the O'Brien Rule relating tidal prism to cross sectional area of the mouth as the foundation for evaluation of changes. This rule can be applied further to assist in developing a broad-scale approach to sustainable estuary management. Importantly, managed realignment increases the tidal prism at a particular location and consideration needs to be given to downstream effects on tidal current speeds, especially ebb currents. In the case of many estuaries, the width of the mouth of an estuary will be the limiting factor for sustainable use of managed realignment, and therefore consideration needs to be given to the cost-effectiveness of deliberately widening 'pinch-points', especially at the mouth.

Using these principles, English Nature advocate a radical new approach to estuary management that seeks to establish longer-term morphological stability, around which land-based spatial planning may be developed. We think there is considerable scope to restore a number of English estuaries to a form that is more consistent with the local geography, and which in the long-term will minimise flood management costs. Using examples from Essex and Suffolk, we highlight the need for early investment to address the fundamental impediments that would otherwise make such an approach impossible.





## **MANAGEMENT PLANS IN PERSPECTIVE OF ARTICLE 6.1 OF THE HABITATS DIRECTIVE: A COMMON INTEREST BINDING FISHERS, ECOLOGISTS, HUNTERS, PORT PLANNERS AND RECREATIONISTS**

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In the perspective of Natura 2000 requirements, throughout Europe, and particularly in the coastal zones, restoration measures for dune ecosystems are being planned. These measures are being initiated in order to strengthen the ecological structure and function of the designated areas under the Birds Directive (BD) and the Habitats Directive (HD). On the other hand, the same types of projects also ask for quite rigorous interventions in existing systems – e.g., the moving of large quantities of soils or the change of the systems of water management – with consequences for protected species and sometimes also for functions bordering these areas. Just these consequences sometimes cause the delay of the development of restoration measures, as they involve several dilemmas regarding restoration, e.g., whether a dunes restoration project for example may negatively affect an animal species. The general provisions of Article 5BD providing protection for all birds species, Article 12HD for animal species and Article 13HD for plant species and the provided derogations under Article 9BD and Article 16HB are here of great relevance. This presentation will describe the existing dilemmas as well as the solutions developed. It will also deal with the issue of the respective stakeholder consultation in view of the ‘conflicting’ interests and with the different interest groups. Finally, using an undertaken project in a dune area in the Netherlands as a case study, some recommendations will be presented on how to deal with such matters that may be helpful for other restoration projects.



# **EUROSION: COASTAL EROSION MEASURES, KNOWLEDGE AND RESULTS ACQUIRED THROUGH 60 STUDIES**

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Coastal erosion is usually the result of a combination of factors - both natural and human induced - that operate on different scales. Most important natural factors are: winds and storms, near shore currents, relative sea level rise (a combination of vertical land movement and sea level rise) and slope processes. However, where erosion occurs in populated areas, it can cause social and economic problems; it can also damage sensitive and rare habitats. Furthermore, coastal erosion is often aggravated by human activities. The outstanding amount of knowledge accumulated over the past 50 years, the persisting problem of coastal erosion, the increasing number of actors involved at all levels, as well as the conclusions of the recent EC funded ICZM demonstration program which highlighted the need for a Europe wide coherent strategy to address coastal issues, have motivated the Directorate General Environment of the European Commission to design and fund the EUROSION project.

## **Natural and Human Coastal Erosion Factors**

EUROSION reviewed natural and human-induced factors responsible for coastal erosion has been undertaken in about 60 case studies representative of European coastal diversity.

## **The European Scope**

Besides the technical oriented analysis at local scale an assessment at European level has been made to qualify and quantify actual state and the developments during the last decades taking the main coastal functions into consideration. To achieve this EUROSION developed a EU (including the new member states) covering database with 19 thematic GIS layers.

## **Coastal Erosion Management and Information**

The role of information in monitoring, assessing and decision making affecting the state of the coast has been described. A difference between different vertical levels of information need and usage can be distinguished; all have been considered and placed into context. The three levels are:

1. European level information including EU level databases showing the main parameters such as trends in land use management and coastal processes and the indicators used to assess these;
2. National level information (including legislation, policy plans);
3. Sub-national to local information concerned with spatial planning, infrastructure development and mitigation measures etc.

The character of information varies (within and) among the above levels, at European and Regional Sea level information mainly relates to visible and quantifiable (measurable) parameters. CoastBase technologies are applied to maintain the



accessibility and re-usability of this huge pillar of important information. Actually the relation with CoastWatch is studied to improve information fluxes and use of remote sensing.

### Concluding Coastal Erosion Conclusions

The nature of erosion occurrence is complex, seldom one activity can be pinpointed as the factor causing erosion, multiple drivers are contributing which prevents clear 'cause effect' relationships and implementation of related 'polluter pays' principles. Providing more transparency in this process is essential to establish some accountability and description of roles.

Contributing to this are small-scale developments in coastal zones not requiring environmental impact assessments (EIA) but occurring in increasing numbers causing a mayor impact difficultly to compensate or avoid. The fact that in huge parts of Europe at regional level planning and spatial zoning (among others based upon risk maps) are not included in policymaking and policy enforcement makes this development even more difficult to prevent from occurring. Adding to this the EUROSION study outcome that when EIA procedures are required, this is often seen as an administrative burden, not an opportunity to come to sustainable, committed solutions. Risk mapping depends largely on scientific information and knowledge, which is interpreted, visualised and communicated to involved stakeholders.

Planning, mapping and communication are key findings to be more explicitly addressed to all involved.



## **COLONISATION PATTERNS IN RELATION TO SEED DYNAMICS IN A RECONSTRUCTED BRACKISH MARSH ALONG THE RIVER SCHELDT (BELGIUM)**

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Estuaries are widely recognized for their very high biological values. Especially the salinity gradient causes communities to change completely from the marine, over the brackish to the fresh water tidal zones. However few estuaries still exist with a full salinity gradient, hence brackish and fresh water tidal marshes are among the most threatened habitats. On the other hand estuaries are subject to major anthropogenic stress as many large cities and harbours are situated near estuaries. This is particularly true for the Scheldt estuary. This is one of the few European estuaries with a full salinity gradient but it is subjected to major changes due to the dredging of the fairway to the harbour of Antwerp and reclamation of marshes for industrial development. As the EC Habitat directive now protects these marshes, losses need to be compensated. This paper describes the restoration of a former marsh as part of a compensation scheme.

The Ketenisse polder is situated on the left bank of the river Scheldt. The site was raised in the sixties with sand. This was removed between June and September 2002 up to about 20 cm below high water level to promote marsh development. Conductivity of the water varies between 1000 and 23000  $\mu\text{S}/\text{cm}$ . The main research questions were:

1. What is the germination, growth and senescence of plants in relation to inundation frequency, height and sediment type
2. To what extent are these colonisation patterns determined by the input of seeds

The vegetation dynamics in the study area are digitally recorded along six trajectories distributed over the project area, perpendicular to the river Scheldt and later analysed using image analysis. On the first transect, a clear zonation developed after one year. In areas that were flooded less than once a month, grasses and thistles emerged. In lower regions a mix of different chenopodiaceae can be found, and in more frequently flooded areas, *Scirpus maritimus* is abundant. On the transect in the area that was created last, the same vegetation pattern developed in a remarkably shorter time span and a broader spacial scale.

The first step in the seed dynamics & distribution research was the analysis of germination requirements for seeds in the brackish area along the river Scheldt. Four parameters and their combinations were tested: sandy soil vs peaty soil, waterlogged vs non-waterlogged conditions, brackish water vs fresh water and cold treatment vs. direct germination. Storage for one month in a cooling chamber improved the germination in most treatments. Combined with this cold treatment, fresh water caused more plants to germinate, especially in a peaty substrate under waterlogged conditions.





Using a standardised seed trap technique, seeds are collected every 10 cm inundation depth along the monitored transects and analysed according to inundation frequency, sedimentation/erosion patterns and current vegetation. In contrary to the vegetation pattern, the number of viable seeds deposited on the soil increases with inundation depth and frequency. Large differences in seed abundance can be found both within a transect and between transects. Variations of this pattern over a tidal cycle and also monthly fluctuations over a year will be analysed. Up to now, this shows an abundance of viable seeds in February, decreasing over the following months.

Although a lot of work remains to be done to quantitatively model and/or predict colonisation dynamics in brackish marshes, the preliminary results of this research can already be used in future restoration projects. Different aspects like inclination, depth, substrate and even timing of restoration projects can be evaluated to improve colonisation.



## **EU BIODIVERSITY POLICY CONTEXT FOR THE CONSERVATION OF ESTUARIES AND DUNES**

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Europe's estuaries and sand dune systems have suffered serious losses and degradation over the past century due to land and water use changes and coastal development pressures. EU biodiversity policy aims to halt the loss of these and other habitats of European conservation concern by 2010. The main legal instrument to achieve this is Council Directive 92/43/EEC on the conservation of natural habitat and of wild fauna and flora, commonly known as the Habitats Directive. This identifies estuaries and different types of sand dunes as habitat types of Community importance. The designation and management of Special Areas of Conservation is the key mechanism under the directive to achieve the favourable conservation status of these habitat types. The focus of action has initially been on establishing this network of sites, using commonly agreed habitat definitions and site selection criteria, with a view to ensuring sufficient representation of estuaries and sand dunes in the NATURA 2000 network. This process is advanced and lists of sites for different Biogeographical Regions covered by the Habitats Directive are being established. Increasingly, the focus is on putting in place effective management and monitoring systems. There is already a considerable amount of experience on management and restoration of sand dunes and estuaries in the EU, especially from projects supported under the LIFE programme. The European Commission has proposed that EU rural and regional development funds be used to co-finance management measures for the NATURA 2000 network. New monitoring arrangements should also provide a unified source of information at the EU scale on estuaries and sand dunes. There will be a need to address other threats to these habitat types in Europe, especially the predicted negative effects of climate change, in the context of the wider debate on EU biodiversity policy.



## COASTAL DUNES AND THEIR MANAGEMENT

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This paper presents the data of the coastal dunes of Lithuania in the period 1966-2003. The coastal dunes keep the sand blown by wind and protect the plain behind the dune during storms and hurricanes from the overflow of the Baltic Sea waves as well. Besides, the coastal dune is an asylum for rare species of plants. The coastal dune is significant not only in ecological, but in social (recreational) aspect as well.

Storms and hurricanes, prevailing western wind and anthropogenic activities from the destructive influence on the coastal dunes. During the storm and hurricanes due to the flow of the sea the western (wind ward) slope of the coastal dune found itself almost totally in the zone of action of the wave factors. After each hurricane the situation of the Lithuanian shore becomes more complicated and forces us to look for ways and means to soften the influence of waves on the coastal dune. During the hurricanes the western slope of the coastal dune fell into zone under the influence of wave factor. The waves raised by the hurricane are so intensive that during some hours the coastal dune range harrowed up to 10 meters and more.

In the other segments of the coastal dune – range where the height is about 2 – 3 – meters the waves raised by the hurricane overflowed into the plain behind the dune.

In 1966 – 1999 the dune – range of the Lithuanian shore narrowed average 33 meters and the territory of dune – rare diminished over 250 ha. In this period the sea waves washed off about 15 million cubic meters of sand. In dune – range of some kilometers the only element of relief of the dune to remain was the eastern (wind lee) slope. The other elements of the relief – the western (wind ward) slope and the top of the coastal dune – range were washed away by the waves and the sand was floated in to the Baltic Sea.

The erosion of the coastal dunes of Lithuania may be stopped by the implementation of a precisely drawn up and irreproachably implemented plan of measures for controlling the factors having influence on the seashore. The survival of the coastal dunes, especially its western slope during storms and hurricanes depends on the nourishment width and inclination angle of the beach. On the inclination angle length and projective cover of plants of the western (wind ward) slope height, and projective cover of plants of the dune top. On the width, inclination angle and projective cover of plant, of the eastern (wind lee) slope. Can be and unforeseen circumstances.

Keywords: coastal dunes, erosion, urgent measures ensure of dune stability.

Alfonso M. C. ... and A. ...

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The paper presents the data of the coastal dunes of Lisbon in the period 1950-2000. The coastal dunes have been divided into two main groups: the dunes of the ... and the dunes of the ... Besides the coastal dunes, an analysis for vegetation ... The coastal dunes are significant not only in ecological, but in social (recreational) terms as well.

Stones and hummocks, revealing weathering and soil development, are the distinctive features of the coastal dunes. During the dunes' evolution, due to the flow of the sea, the dunes (and their slope) change. After the dunes' formation, the vegetation is the result of the action of the sea and the wind. In the coastal dunes, the vegetation is the result of the action of the sea and the wind. The dunes are the result of the action of the sea and the wind. The dunes are the result of the action of the sea and the wind.

In the other segments of the coastal dunes - large dunes - the vegetation is the result of the action of the sea and the wind.

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Keywords: coastal dunes, vegetation, erosion, regeneration, Lisbon.







## **THE HUMID ZONES OF THE DUNES IN NORTHERN FRANCE: AREAS OF EXCEPTION WITH MULTIPLE ISSUES AT STAKE**

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The North-West coast of France is mainly covered with dunes of variable extent whose value as part of the national heritage is nowadays fully recognized. To people visiting them, these dunes offer a variety of landscapes including humid zones well-loved by those familiar with them and of the greatest interest to naturalists. They can be considered as exceptional areas in that they provide privileged sites for endangered plant and animal species. The survival of these species depends on management practices respecting the quality of the environment. Today a management policy of conservation is being implemented and, thanks to regulation and the use of technical means adapted to the situation, it has become possible to preserve or restore biodiversity in the species or the landscapes.

The policy of conservation of the peaty depressions has gradually developed in France over the last ten years. It began in the Nord-Pas-de-Calais region, then spread to Upper and Lower Normandy. As in the Netherlands, innovatory practices such as reactivating the dynamics of the dune have encouraged the reappearance of groups of plants typical of humid zones. Today the exchange of experiments and knowledge contributes further towards precisely-targeted and effective intervention. The technicians' know-how is instrumental in the setting-up of different protocols of intervention and monitoring, and also in acquiring a better understanding of the response mechanisms of the peat environments to the experiments and management modes applied to them.

If this policy of conservation is approved by actors in the protection of the coast, it is not always understood by those who have a different conception of how to enhance the value of these areas. Conflicts arise or continue due to conceptions and representations of the multiple issues at stake which diverge in their aims. For an understanding of the reality of these issues, a historical framework is necessary to follow the evolution of Man's relation to Nature and the changing ways of thinking over the centuries and during the past few decades. Old maps and written accounts throw light on the occupation of space and on the way it has developed. Not only does a historical perspective show changes in the uses land has been put to, it also reveals the ambivalence of Man and coastal societies where the all-important question of how to enhance the value of these exceptional areas is concerned. Finally, the humid zones must be placed in a wider geographical context, that of the dune system affected by its own dynamics, and also in the broader context of the coastal and inland areas, where the systems of logic and functioning must be envisaged and confronted with those of the humid zones. Telling examples of present issues will be taken from the North of France (Nord-Pas-de-Calais, Picardy, Lower Normandy regions) and will be compared with foreign sites (Great Britain, the Netherlands) where similar problems are posed.

# THE HUMAN ZONE OF THE DUNES IN NORTHERN BRANIC: AREAS OF EXCEPTION WITH MULTIPLE ISSUES AT STAKE

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The field of human dunes is a complex one, involving a wide range of issues. In this paper, we focus on the human zone of the dunes in northern Branic, a region of the north-eastern coast of the Gulf of St. Lawrence. This area is characterized by a unique combination of geological, geomorphological, and environmental factors. The human zone is defined by the presence of human settlements and infrastructure, which have developed in response to the natural environment. The human zone is also characterized by a high degree of vulnerability to natural hazards, such as coastal erosion and sea level rise. This paper discusses the challenges of managing the human zone of the dunes in northern Branic, and proposes a framework for integrated coastal zone management.

The policy of coastal zone management in the north-eastern coast of the Gulf of St. Lawrence is a complex one, involving a wide range of issues. In this paper, we focus on the human zone of the dunes in northern Branic, a region of the north-eastern coast of the Gulf of St. Lawrence. This area is characterized by a unique combination of geological, geomorphological, and environmental factors. The human zone is defined by the presence of human settlements and infrastructure, which have developed in response to the natural environment. The human zone is also characterized by a high degree of vulnerability to natural hazards, such as coastal erosion and sea level rise. This paper discusses the challenges of managing the human zone of the dunes in northern Branic, and proposes a framework for integrated coastal zone management.

If the policy of coastal zone management in the north-eastern coast of the Gulf of St. Lawrence is a complex one, involving a wide range of issues, then the human zone of the dunes in northern Branic is a particularly challenging one. This is because the human zone is characterized by a high degree of vulnerability to natural hazards, such as coastal erosion and sea level rise. This paper discusses the challenges of managing the human zone of the dunes in northern Branic, and proposes a framework for integrated coastal zone management. The human zone is defined by the presence of human settlements and infrastructure, which have developed in response to the natural environment. The human zone is also characterized by a high degree of vulnerability to natural hazards, such as coastal erosion and sea level rise. This paper discusses the challenges of managing the human zone of the dunes in northern Branic, and proposes a framework for integrated coastal zone management.





## GRAZING MANAGEMENT ON SAND DUNES

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Many dune systems in temperate Europe today are characterised by increased stability, spread of scrub and coarse grasses and the loss of early successional vegetation. This is viewed with concern by the UK nature conservation agencies. Livestock grazing is widely used as a management tool in an attempt to counteract the associated loss of species diversity and maintain a range of successional phases.

This case study is a contribution towards a better understanding of the long-term effects of grazing management on dunes, analysing vegetation data gained prior to and after up to 16 years of livestock grazing. The aim is to test if grazing management was successful in counteracting scrub encroachment and loss of species diversity.

The study was conducted at Newborough Warren, UK. Until the early 1950s, the dune system was predominantly mobile, however today the dunes are largely stable, with semi-fixed and fixed dune grassland and mature slacks representing the dominant vegetation types. Livestock grazing by cattle, ponies and sheep was introduced in 1987. A series of permanent monitoring quadrats (2x2m) was set up by the Countryside Council for Wales and re-surveyed at regular intervals, most recently in 2003.

The quadrat data were initially separated by Twinspan analysis into wet slack and dry dune habitats, and these habitats were analysed separately. Species diversity increased in both the wet and the dry habitats. Data for all years of survey were analysed by Detrended Correspondence Analysis for both habitats. These ordinations show marked changes in the vegetation composition since 1987 for the dry habitats, where grazing was related to the second ordination axis. In the wet habitats, however, grazing does not appear to be as clearly related to any axis. This suggests that the impact of grazing is more pronounced on dry dune grasslands than in wet slacks, where other environmental variables may be more important determinants of species composition.

Future analyses will explore changes in the plant community and sub-community post-grazing.



## REMOTE SENSING OF COASTAL VEGETATION IN THE NETHERLANDS AND BELGIUM

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Vegetation maps are essential tools for planning and evaluation in nature conservation. This paper explores the past, present and future of vegetation mapping in coastal dunes and salt marshes along the Dutch and Belgian coast.

In general, vegetation maps are based on remotely sensed images. The earliest aerial photographs known from the Belgian and Dutch coast date from WW 1. After WW 2, black and white and false colour aerial photographs were taken on a more regular basis in function of cartography or coastal defence. More recently, also multi- to hyperspectral digital scanners are applied in airborne remote sensing.

Until 1980 vegetation maps of coastal areas were only made sporadically. They were hand-made and based on monochrome aerial photographs (e.g. van Dorp et al. 1985). In the 1980s the Belgian coastal defence administration and the Survey Department of the Dutch Ministry of Transport, Public Works and Water Management started programmes for vegetation mapping of the (fore)dunes.

Gradually (vector-) GIS application became current and in the Netherlands, the first steps towards digital image interpretation were taken (Droesen 1999, Janssen 2001). Currently, research projects are going on in Belgium and The Netherlands to explore in depth the possibilities of image interpretation for vegetation mapping.

Remotely sensed images are either analogue (photo film or print) or digital. The latter type can be characterised by four types of resolution (Lillesand and Kiefer 1994). Spatial resolution is expressed as the size of one image pixel measured on the ground. The number of bands is denoted as spectral resolution while the storage precision of the information is called radiometric resolution. Finally the temporal resolution reflects the frequency by which images of the same area are acquired. As quality indicators, these resolutions have several technical or financial limitations such as the trade off between spatial and spectral resolution or the high cost of multi-temporal images. Also the way the images are obtained (digitised photographs versus scanners) determines technical properties such as georeferencing accuracy.





Interpretation possibilities are quite different for analogue or digital images. Image quality and easy use of stereo-pairs (3D view) are advantages of the former, georeferencing, objectivity and digital image processing of the latter. The success of computerisation of image processing depends on the classification algorithms, the image's spectral and spatial resolution and georeferencing accuracy. The latter is of paramount importance when relating images to GPS referenced ground truth.

Image processing can either be pixel or object oriented. Performance of per pixel classification is favoured by high spectral resolution as provided by hyperspectral images. Object based algorithms require a good spectral resolution as they include feature's texture parameters. The spectral signature of vegetation is mainly influenced by its structure rather than its composition. Therefore we cannot expect remote sensing to replace botanical fieldwork but both methods can reinforce each other.

The applicability of remote sensing for vegetation mapping depends on the aim of the end product. Present techniques and knowledge must enable us to develop operational systems for accurate recurrent mapping of several vegetation classes, mainly based on structure properties. This information can be very useful for evaluation of seawall strength for coastal defence or for example grazing management. Future research should focus on optimising image properties (spectral bands versus spatial resolution) and classification techniques such as object based classification or wavelet analysis. Also additional ground measurements of vegetation reflection can reveal possibilities and limitations for more advanced applications of remote sensing in nature conservation.

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# **THE GEOMORPHOLOGICAL IMPACT OF THE JANUARY 2005 HURRICANE STRENGTH STORM ON THE ATLANTIC COASTLINE OF THE OUTER HEBRIDES**

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In January 2005 the Atlantic Coast of the Outer Hebrides was struck by winds in excess of 100 knots. Hurricane force winds set-up exceptionally high destructive waves.

Elevated sea levels caused extensive flooding. In addition to property damage there was also loss of life by drowning. Storms and erosion are frequent in the Outer Hebrides but the severity of this event called into question the level of awareness of coastline vulnerability in specific localities. In addition, the debate on possible rise in sea level and increased storminess re-emerged not only in a theoretical context but also with a sense of application to real life problems.

The coastlines affected were all low-lying machair landforms with extensive sand and occasional shingle beaches. Machair is a type of calcareous sand dune system of great antiquity (in excess of 6 to 8000 years old). It is especially important for archaeological and conversational sites. For more than forty years geomorphological and archaeological research has demonstrated systematic erosion and reworking of the machair coastline, albeit with pronounced local differences. As a result of this research the hurricane impact of 2005 can be seen as an extreme event within a long-standing pattern. Nevertheless the strength of this event underlines the power of the Atlantic storm environment and possible impacts on both economic and cultural assets which are likely to need enhanced protection.

THE GEOPHYSICAL IMPACT OF THE LATEST 2002 MURRAY  
STRENGTH STORM ON THE ATLANTIC COASTLINE OF THE OUTER  
HEBRIDES

William R. ...

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In January 2002 the Atlantic Coast of the Outer Hebrides ...  
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## DEVELOPING A EUROPEAN COASTAL DUNE MANAGEMENT NETWORK

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An informal network of European sand dune conservation managers and researchers has existed since a conference in Leiden, the Netherlands in 1987. At the European Symposium 'Coastal Dunes of the Atlantic Biogeographical Region' held in Southport, England, during 1998, the sand dune community met again and reaffirmed its presence. This event identified the benefits of sharing experience of conservation practice through a European network of common interest in coastal dune management. To this purpose and with the support of the EUCC-The Coastal Union, a first step was taken to develop a European Coastal Dune Management Network at the Littoral 2004 conference, Aberdeen, Scotland during September 2004. The developing network aims to promote sustainable use and share experience of conservation practice in coastal dune management amongst a distinctive and yet diverse community. The Dunes and Estuaries 2005 conference provides an opportunity to develop the Network as a platform that will benefit European coastal dune management.

Paul Harvey

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An informal network of European coastal dune management managers and researchers has been developing since the late 1980s. The network was initiated in 1987 at the European Symposium Coastal Dunes of the Atlantic Biogeographical Region held in Southampton, England. Since 1988 the network has been expanding and currently has 15 members. The network has been established to provide a forum for the exchange of information and to promote research in coastal dune management. The network has been instrumental in the development of the European Coastal Dune Management Network in the late 1990s. The network has been instrumental in the development of the European Coastal Dune Management Network in the late 1990s. The network has been instrumental in the development of the European Coastal Dune Management Network in the late 1990s.

# MANAGED REALIGNMENT IN NORTHERN EUROPE – A COMPARATIVE STUDY OF ENGLAND AND GERMANY

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The coastal management measure 'managed realignment' (to create intertidal habitat) has aroused increasing interest over the past decade. This doctoral research project has so far concentrated on a comparative study of England's and Germany's approaches to managed realignment, to determine similarities and differences, and make predictions on its future use. Qualitative interviews were undertaken with key experts; supported by an extensive literature review and communication with coastal practitioners. All interviewees perceived managed realignment as a positive development, although the likelihood of its increased future use was judged differently. Some 36 schemes exist. Motivation for English, and to a certain extent on Baltic Sea schemes, seems more driven by long-term, multi-causal factors than on Germany's North Sea coast, where managed realignment has to date only been motivated by habitat mitigation needs. However, there are signs that on this coast, conservation could be an important driver for its increased use in the 21<sup>st</sup> century. Thus managed realignment is now firmly on the agenda in both countries, reflecting a radical departure from the recent past. However, take-up is likely to differ notably both between and within these countries.





## COASTAL DUNE EVOLUTION ON A SHORELINE SUBJECT TO STRONG HUMAN PRESSURE: THE DUNKIRK AREA, NORTHERN FRANCE

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The extreme northern coast of France from Dunkirk to the Belgian border is bounded by coastal dunes that have been massively transformed by urban and port development. The only stretch of preserved dune barrier, less than 12 km long, is located east of the port of Dunkirk. The foredune ridge was seriously damaged at the beginning of the 20<sup>th</sup> century by urban development and almost completely destroyed during World War II. In the 1980s, the foredune, 15 to 20 m high, was affected by breaches and blowouts, and by erosional scarps cut during storm events. The dunes are presently in a state of meso-scale (decades) stability. This stability is attributed in part to human intervention. In the early 1990s, active restoration was carried out by the Departmental Authority of the North (Conseil Général du Nord) in charge of the management of these coastal dunes. Sand fences and brushwood barriers were erected in order to encourage sand accumulation in the most sensitive areas, and *Ammophila arenaria* was planted on bare sandy surfaces. In order to promote the recovery of natural habitats, these rehabilitation measures have involved, since 1994, manual collection of detritus and debris accumulating at the high tide lines. These measures have resulted in incipient foredune development along accreting sectors. Collaborative work involving beach and foredune surveys carried by the *Coastal Geomorphology and Shoreline Management Unit* of the Université du Littoral Côte d'Opale and the Conseil Général du Nord over the past years has enabled better insight into beach and foredune sediment dynamics. Aeolian sand transport measurements allow for quantification of sand exchanges within the dune front. The influence of sand fences and brushwood barriers on incipient foredune growth is presently studied along an experimental sector. These surveys highlight the current stability of this coast. Much of the foredune stoss side is now stabilised by vegetation and only episodic dune scarping occurs during winter, with recovery in summer. Near the Belgian border, accumulation prevails and is emphasized by incipient foredune development. There is, however, a need to address more precisely the exact role of human interventions in the present status of shoreline stability. The restoration practices mentioned above have significantly encouraged foredune stability and incipient foredune development. However, no major storm events have occurred since 1990 and a context of net sediment supply from foreshore to dune has certainly been a factor in enhancing shoreline stability and dune development.



## **SUPPORTING DUNE MANAGEMENT BY QUANTITATIVE ESTIMATION OF EVAPOTRANSPIRATION**

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A previous research project dealt with the determination of the evapotranspiration in dune ecosystems in order to support shrub encroachment as a management option for nature conservation. From this project it became clear that the Leaf-Area-Index (LAI) is a very important input parameter to dynamic vegetation models used for the determination of the overall evapotranspiration (Sevenant et al. 2002) and carbon sequestration in dune ecosystems. In contrast to this importance it is very difficult to obtain reliable and straightforward values of LAI in different vegetation types at a certain moment during the season, but also of its seasonal evolution.

Different methods exist to determine the LAI. Many methods have thoroughly been tested in forest (e.g. Mussche et al. 2001) and agricultural crops. However, in dune ecosystems a limited comparison of methods was only reported by Sevenant et al. (2002). These authors found in their study conducted in 'De Westhoek' nature reserve (De Panne, Belgium) different LAI values with different methods but for the same vegetation types and moments during the growing season.

Therefore, a new experiment was conducted in 'De Westhoek' nature reserve (De Panne, Belgium) during the 2004 growing season, with as overall objectives (1) direct determination of the LAI of the major vegetation types, and its seasonal evolution; (2) indirect determination of the LAI based on several optical methods for the major vegetation types and taking into account the seasonal evolution; (3) indirect determination of the LAI based on airborne images (one flight at the beginning of summer) for a large area of the nature reserve including all major vegetation types; (4) comparison of the different techniques for LAI determination and finally (5) the use of the obtained information on LAI to estimate evapotranspiration in this ecosystem on a spatially integrated basis visualised in maps.

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## **INVESTMENTS AS A LEVER FOR SUSTAINABLE EQUILIBRIUM BETWEEN ECOLOGY AND RECREATION AT THE BELGIAN COAST**

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Flanders' tradition in coastal tourism dates from the beginning of last century. It was however not until after World War II and the introduction of paid leave that coastal tourism had its explosive growth. At present the coastal region represents half of the economic sector of tourism in Flanders. Notwithstanding its still increasing numbers of employment in coastal tourism (Westtoer, 2004), the region is faced with an obsolescence of its tourist product, a strong seasonal employment and an ongoing deterioration of its existing nature. In order to alter these trends into a more sustainable form of coastal tourism, an investment plan was set out with a budget of € 12,5 million. Several projects could profit from this 'Coastal Action Plan' on the conditions that each initiative was to the benefit of the coast as a whole and provided that each initiative optimally supported the quality and image of the coast as a holiday destination. Many of the above projects were additionally subsidised by 'Toerisme Vlaanderen' and the European Regional Development Fund programme 'Objective 2, Coast Fisheries'. This latter programme aims at revitalising the littoral region by reinforcing the economic & tourist structures and by enhancing the environment. A special emphasis in the programme goes to the reconvention of former fishing activities towards new forms of tourism such as eco-tourism, all weather infrastructure, culture tourism...

In the general perception of the coast as a region, the natural elements such as sea, beach, dunes, estuaries and polders are essential. Ironically these elements which provide the attractive character, are threatened by their own popularity. Several initiatives were undertaken by the Flemish government to foresee in the necessary protective measures such as the Dunes decree and the recent proposal of a Polder decree. In order to achieve a more pro-active policy in coastal protection, special attention within the above action plan and other policy areas was given to nature restoration projects which integrated sustainable means of enclosing these natural values for the recreant.

This paper assesses the pitfalls and successes of this policy outset from 1999-2004. In search of an optimal balance between bio-diversity and added recreational value, it tries to distillate conclusions from experience gained from the several projects incorporating the evolution of the societal opinions towards the initiatives taken. Study cases within this paper include the Nature.CoastManager, one out of eight managers appointed to create a more coherent coastal policy in different areas.

The recruitment of the first Nature.CoastManager was an initiative of the Flemish representative of NGO Birdlife International, 'Natuurpunt' and the Minister of Tourism, Renaat Landuyt. With the specific task to search for synergies between recreation and

# INVESTMENT AS A LEVER FOR ENVIRONMENTAL CONSERVATION BETWEEN ECOLOGY AND PROTECTION AT THE REGIONAL LEVEL

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Abstract: This paper discusses the role of investment in environmental conservation at the regional level. It argues that investment in infrastructure and services can play a key role in improving the quality of the environment and in creating jobs. The paper also discusses the importance of public-private partnerships in this regard. The paper concludes that investment in infrastructure and services is a key to sustainable development and to the creation of a high-quality environment. The paper also discusses the importance of public-private partnerships in this regard. The paper concludes that investment in infrastructure and services is a key to sustainable development and to the creation of a high-quality environment.

In the general perception of the public and private sectors, the environment is a natural resource which should be protected and preserved. However, the environment is also a natural resource which should be developed and improved. The paper discusses the role of investment in environmental conservation at the regional level. It argues that investment in infrastructure and services can play a key role in improving the quality of the environment and in creating jobs. The paper also discusses the importance of public-private partnerships in this regard. The paper concludes that investment in infrastructure and services is a key to sustainable development and to the creation of a high-quality environment.

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The conclusion of the paper is that investment in infrastructure and services is a key to sustainable development and to the creation of a high-quality environment. The paper also discusses the importance of public-private partnerships in this regard. The paper concludes that investment in infrastructure and services is a key to sustainable development and to the creation of a high-quality environment.

nature conservation, the manager sets out to create new partnerships and innovative projects. The paper will report on the experiences of the first working year.

Other study cases will include a first evaluation of the newly created coastal cycling route and its connection to the cycling junction network and the various points of natural interest. The different experiences by which nature compensations in the light of the Habitats- and Birds Directive are enclosed to sustainable tourism will also be discussed. The final case is the execution of the design for the estuary of Nieuwpoort which scope was to implement all sectors into an integrated plan, thus attaining win-win situations between culture, housing, yacht - port enlargement, employment, nature restoration and recreation.

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<http://www.onssrszls.fgov.be/onssrsz/index.htm>





## **RABBITS (*ORYCTOLAGUS CUNICULUS* L.) IN COASTAL DUNE GRASSLANDS**

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The 'wild' rabbit (*Oryctolagus cuniculus* L.), although non-native, has become one of the most important free-living herbivores in our coastal dune grasslands. We describe a field experiment to assess the impact of this small grazer on the dune grassland vegetation.

The study was carried out in two coastal dune grasslands in Belgium (in the IJzermonding in Nieuwpoort and in the Doornpanne in Oostduinkerke). To counteract the increasing dominance of grasses and shrubs in this type of grasslands, large herbivores were introduced in both nature reserves (sheep in the IJzermonding, Shetland Ponies in the Doornpanne). An experimental approach was used to assess the impact of these large herbivores, of the wild rabbits, and of the interaction between rabbits and large herbivores, using exclosures with three treatments (5 exclosures in the IJzermonding and 3 in the Doornpanne). In one treatment all kinds of herbivores can graze. In the other two treatments large herbivores only and large herbivores and rabbits are excluded respectively. After two years, we examined several characteristics of the vegetation (such as species richness, the presence of particular plant species, the vegetation height and the dominance of grasses). Rabbit pellets in the plots were counted every four weeks, because they can be used as a measure for the abundance of the rabbits in the vegetation.

When the rabbits were numerous (IJzermonding), they seemed to be very effective in reducing vegetation height and diminishing the cover of dominant grass species. Their impact was almost as strong as the impact of the large grazers. Furthermore, the digging of the rabbits, created some uncovered soil, which is positive for the germination of plant species that have no chance in a high and dense vegetation. In Doornpanne, there was only little activity of rabbits. The vegetation had grown high and dense in the plots, except for these plots where the large grazers were able to graze. Nevertheless, the large herbivores were not able to compensate for the digging of the rabbits, so there was hardly any uncovered soil in the plots. From this experiment we conclude that the impact of rabbits can be impressive when they're numerous: rabbits play an important role in the ecosystem of a dune grassland. If the dune manager wants a mosaic of nutrient-rich and nutrient-poor patches of vegetation (shifting mosaics), rabbits can contribute in this process. The recent decrease in the number of rabbits, especially due to VHS (Viral Haemorrhagic Syndrome), should not be ignored in this context. If the number of rabbits in our dune areas keeps declining, introducing large herbivores will be even more important than before.



## **MAINTENANCE OF THE FAVOURABLE CONSERVATION STATUS IN TWO SPECIAL PROTECTION AREAS IN CO-HABITATION WITH DEVELOPMENT OF THE ANTWERP HARBOUR**

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Nature restoration and development is an important issue in the growing Antwerp Harbour on the left bank of the river Schelde, since it is mainly located in the Special Protection Area (SPA) of both the Habitat and Bird directives. This situation leads to a constant pressure of economic activities on maintaining natural values of the SPA, and vice versa a constant pressure of nature priorities on the economic expansion of the harbour region. With the digging of the Deurganckdock this stress field became very pronounced, because part of the breeding area of some Annex I species was destroyed. According to the European Commission nature compensations had to be implied in the project. The development of these nature compensations is coupled to the building permit for the Deurganckdock and is followed up very strictly. A key word in the further management of the region is 'co-habitation', the aim of the Flemish Government to maintain equilibrium between both industrial and ecological needs.

For the planning of the compensations an addendum to the Environmental Impact Assessment of the losses of birds was made, together with the amount of different habitats these birds need for optimal survival in the SPA. From this a matrix was drawn up pointing out how much of different habitat types is needed, where it has to be created, and who is responsible for a certain phase in the project. This is now an important tool for the established Management Committee. The Management Committee coordinates all necessary actions in the process from planning till realisation. It is composed of members of all co-actors, governmental and non-governmental.

Parallel to the planning and development process, a long term monitoring program is set up to follow closely the evolution of the nature values in the SPA in relation to the harbour expansion and realisation of the compensations. This monitoring is carried out by the Institute of Nature Conservation. It includes census of breeding and wintering birds for which the region is important (national and international), as well as assessment of the availability and quality of different habitat types and hydrology of the region. Also some other animal species (insects, natterjack toad, bats) are taken into account for their indicative value or because they are listed as Annex IV species in the Habitat directive.

Apart from long term follow up, the data also can be an important aid in planning and in the realisation process of the compensations, and thereafter in the management of the area, which can be adjusted according to the results. The monitoring also results in a yearly report which forms part of the yearly reporting to the European Commission by the Management Committee. Next to monitoring data it describes the general status of the SPA and points out the needs for specific future actions concerning management or development.

# MAINTENANCE OF THE FAVORABLE COMPETITIVE STATUS IN THE SPECIAL PROTECTION AREAS IN CO-OPERATION WITH DEVELOPMENT OF THE AUSTRIAN HARBORS

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Abstract: The paper discusses the importance of the special protection areas in the development of the Austrian harbors. It is shown that the special protection areas are not only a source of income but also a source of investment. The paper discusses the importance of the special protection areas in the development of the Austrian harbors. It is shown that the special protection areas are not only a source of income but also a source of investment.

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From the long-term view, the special protection areas in the Austrian harbors are a source of income and investment. They are not only a source of income but also a source of investment. The paper discusses the importance of the special protection areas in the development of the Austrian harbors. It is shown that the special protection areas are not only a source of income but also a source of investment. The paper discusses the importance of the special protection areas in the development of the Austrian harbors. It is shown that the special protection areas are not only a source of income but also a source of investment.

## HOW MAY BEACH NOURISHMENT AFFECT THE SANDY BEACH ECOSYSTEM? THE CASE OF BELGIAN BEACHES

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Nourishment of beaches is mainly used as a measure for coastal conservation. An amount of sand is deposited on the beach to serve as a protective buffer for the hinterland. In some cases nourishment can also be applied to restore natural values of beaches. Plans exist to do so for the beach in front of the Flemish nature reserve 'IJzermonding' at Lombardsijde (Westende). In order to provide potential nesting grounds for seabirds (mainly Snowy Plover *Charadrius alexandrinus* and Little Tern *Sterna albifrons*), a larger dry beach is to be created by means of nourishment. Beach nourishment is considered to be a 'soft' measure, in contrast with 'hard' measures such as the construction of groins or dykes. Nevertheless a serious (short term) ecological impact of the deposition of a layer of sand with a thickness of 1.5-2m can be expected on the beach ecosystem.

A study was conducted by a consortium of experts with as main objectives (1) to provide an integrated overview of the Belgian beach ecosystem and all its components, (2) to conduct a first evaluation on what is known on the ecological impact of beach nourishment and (3) to identify gaps in the scientific knowledge on both matters.

Although sandy beaches are often considered of less biological value, they are the habitat of a number of beach specific organisms and play an important role in providing food and serving as breeding grounds, resting area and nursery for several plants and animals. An integrated overview of the Belgian sandy beach ecosystem has been made, divided into three altitudinal zones: the supralittoral, the littoral and the infralittoral zone. Besides sedimentology and hydrodynamics, five ecosystem components were taken into account: microphytobenthos, vascular plants, terrestrial arthropods, zoobenthos and avifauna.



A review of prior studies indicates that the impact of nourishment is rather case-specific and that it is difficult to draw general conclusions (Nelson, 1993). Nevertheless it seems very likely that potential recovery from the impact of nourishment will be limited to two essential, species specific pathways: (1) survival by resident organisms and (2) recolonisation by immigrating individuals, the latter depending on both the dispersal capacities and habitat demands of the organisms. Considering the current practice of beach nourishment, the first option is non-existent. The large quantity of deposited sand excludes survival for all organisms (Löffler & Coosen, 1995; Essink, 1999; Greene, 2002). Thus the restoration of the natural values of a replenished beach will largely depend on post hoc recolonisation (Menn, 2002).

Further research is needed to explore possibilities for reducing detrimental ecological effects. Specific studies are needed towards the survival options, the dispersal abilities and habitat demands of the species present on Belgian beaches. These should allow for management guidelines to be drawn in terms of preferable nourishment sediment characteristics, timing and practice of the deposition of the sand.

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## **HARBOURING NATURE: PORT DEVELOPMENT AND DYNAMIC BIRDS PROVIDE CLUES FOR CONSERVATION**

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During the twentieth century, many coastal areas in Europe have changed dramatically because of coastal protection works, human expansion drift and booming beach tourism. As a result the natural area of suitable nesting habitat of many coastal birds has decreased enormously and a large number of species are now listed as threatened. Some species were able to exploit new opportunities offered by human activities, but most coastal birds are now confined to islands, protected areas or artificial sites (nature development projects, restored coastal habitats and even floating rafts). Protection of local reserves, as well as further development and management of breeding sites is considered vital in maintaining the populations of threatened coastal breeders. The rationale behind nature restoration and development is often solely based on offering suitable habitat to the birds, while its success is mainly judged from the evolution in the number of birds present. As more and more information becomes available on the reproductive performance of coastal birds, it becomes clear that in some protected areas long-term reproductive success is below self-sustaining levels. Apparently we humans are able to create artificial nesting habitats that are highly attractive from the birds' perspective but are in fact pitfalls for the population on the long term. In contrast, the harbour of Zeebrugge, Belgium, is an excellent example of an artificial nesting habitat of high quality in terms of attraction as well as reproduction. Here, vast sandy areas were raised in a former marine habitat 1980s. The works mimicked natural dynamic processes and coastal breeding birds instantly reacted. Within 20 years, the area has developed from open sea to a breeding site of major international importance. Peak numbers of some threatened coastal birds by far exceed the 1% of their total biogeographical populations. At present, Zeebrugge harbours 4% of the total northwest European Common Tern population making it the largest colony in Europe. It is also one of the most productive populations that act as a major source of recruits for the biogeographical population as a whole. On the one hand, the success of the bird populations is based on the ongoing creation of suitable nesting habitats and management measures, like removal of the vegetation and covering areas with shell fragments. On the other hand, feeding conditions are very good because the harbour itself functions as a major source for small prey fish of which the availability is facilitated by the heavy shipping traffic and the sheltered conditions of the feeding areas. Further development of the harbour, the arrival of the fox and competition for nesting habitat with large gulls are major threats for the bird population. Further steps are now being considered to protect this valuable breeding site.



# BREEDING BIRDS OF DUTCH COASTS AND DUNES: ACTION PLAN FOR BIRDS AND PEOPLE!

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## 1. Coastal breeders under pressure

The coastline is a key feature in the Dutch landscape. From the Wadden Sea to the Schelde estuary, the Netherlands has some 300 km of sandy beaches and dunes. A rare feature in Europe. In natural situations the dynamics of wind and water are the driving-forces shaping such coastal landscapes. Depending on wind and tides sand is deposited and removed, and creeks, gullies and dune slacks are temporarily filled with water. The vegetation reflects the highly dynamic nature of the system and succession stages alternate in space and time.

Unfortunately, the Dutch coastline is no longer an undisturbed habitat. Our dunes are artificially fixed so that the hinterlands are better protected against the sea. Our beaches are packed with sun-worshippers and kite-surfers. Our dunes crowded with recreational walkers and cyclists. As a result of the lack of natural dynamics and a high degree of human disturbance, many areas have become unsuitable for the typical breeding birds of dunes and beaches. Many of these species are now listed on the Dutch Red List of breeding birds (2004).

## 2. Action plan

To counter the negative developments, Vogelbescherming Nederland is developing an action plan for 2005 –2009. The plan is aimed at typical coastal breeders like Little Tern (*Sterna albifrons*), Common Tern (*S. hirundo*), Sandwich Tern (*S. sandvicensis*), Artic Tern (*S. paradisaea*), Ringed Plover (*Charadrius hiaticula*), Kentish Plover (*C. alexandrinus*) and Red-breasted Merganser (*Mergus serrator*). As well as typical dune breeding species like Northern Wheatear (*Oenanthe oenanthe*), Short-eared Owl (*Asio Flammeus*), Hen Harrier (*Circus cyaneus*) and Red-backed Shrike (*Lanius collurio*).

The action plan for breeding birds of coasts and dunes sets out to:

1. create more opportunities for natural dynamical processes, and
2. decrease human disturbance of breeding birds while enhancing the possibilities for people to enjoy nature and birds.

In its first phase, the action plan focuses on research to identify effective conservation measures. In 2005, Vogelbescherming initiated research on species whose decline is little understood.

### *Northern Wheatear*

Northern Wheatears nest in deserted rabbit holes. They prefer open, very short vegetation in or near sand dunes. Their breeding numbers have declined dramatically during the last twenty-five years (-70%) and the decline is still ongoing. The main reason for the species' decline is the decreasing quality of dune habitats. The overall lack of open, pioneer-like situations due to artificial dune fixation, eutrofication and the decreasing rabbit population, is one of the main problems of this species in the Netherlands.



Therefore, large-scale habitat restoration is needed for the conservation of the Dutch population of Northern Wheatears. Vogelbescherming Nederland conducts research on the actual breeding numbers, the main breeding areas and the effectiveness of specific conservation measures, amongst which the possibilities to (temporarily) increase the breeding success of Northern Wheatears in the Dutch coastal zone with artificial burrows is being studied.

#### *Hen Harrie*

In the Netherlands, Hen Harriers mainly breed on the islands in the Wadden Sea. During the last ten years, the breeding population on these islands was halved to sixty pairs. Important preys are young rabbits, mice and small birds. The exact causes of the decline are unknown, but changes in management and disturbance are probably important factors. Restoration of natural processes, so that pioneer stages of vegetation succession will appear again, will probably positively affect the Dutch breeding population of Hen Harriers.

Vogelbescherming Nederland conducts research on the nesting ecology of Hen Harriers breeding on the Dutch Wadden islands. The research focuses on the causes of decline and on conservation measures.

#### *Ringed Plover*

Besides research on conservation measures, Vogelbescherming can carry out conservation measures that have already proved to be effective. Ringed Plovers breed on bare beaches covered with shells. Their breeding population has declined dramatically. Natural development of the dynamic breeding habitat hardly occurs anymore along the Dutch coast. It is quite easy to create this habitat by removing the top-layer of the soil, including vegetation. Vogelbescherming provided funds to make such measures possible along the coast of Lake Oostvoorne, in the south of the Netherlands.

### 3. Conclusions: future actions

In the second phase of the action plan much attention will be given to increase the awareness and support of land managers, policymakers and the general public for conservation measures. A series of local restoration projects will be used to set examples and enrapture managers and policymakers to work together and to stimulate that conservation measures are replicated elsewhere. Facilitating the general public to enjoy birds and nature is essential for the success of nature conservation in intensively used areas. Therefore, the action plan sets out to improve the Dutch coast for both birds and people.

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The first part of the paper is devoted to the description of the study population and the study area. The study area is located in the north-western part of the island of Crete, Greece. The population consists of 1000 individuals, 500 of which are birds and 500 are plants. The study was conducted in 2000 and 2001.

The second part of the paper describes the methodology used in the study. The methodology includes the collection of data on the population and the study area. The data were collected using a combination of field observations and interviews with local residents. The data were then analyzed using statistical methods.

The third part of the paper presents the results of the study. The results show that the population is highly diverse and that the study area is a rich source of biodiversity. The study also found that the population is declining and that the study area is being degraded.

The fourth part of the paper discusses the implications of the study. The study has important implications for the conservation of biodiversity in the study area. The study also has implications for the management of the study area. The study suggests that the population should be protected and that the study area should be managed in a way that maintains its biodiversity.

### 3. Conclusions and future work

In the second phase of the study, we investigated the population and the study area. We found that the population is highly diverse and that the study area is a rich source of biodiversity. We also found that the population is declining and that the study area is being degraded. These findings have important implications for the conservation of biodiversity in the study area.

### 4. Bibliography

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# DYNAMIC DUNE MANAGEMENT IN PRACTICE – REMOBILIZATION OF COASTAL DUNES IN THE NATIONAL PARK ZUID-KENNEMERLAND IN THE NETHERLANDS

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Dutch Dunes completely stabilized in 19th & 20th century due to stopping of over-exploitation, systematic stabilization programmes, air pollution and rabbit diseases. In order to achieve enduring dune dynamics, new thinking led to the notion that remobilization of entire, formerly mobile but artificially stabilized dunes, is probably the way forward. Some experiments are going on at the moment. The first results are shown here. A great effort is needed to build consensus for such controversial projects.





## **ECOLOGICAL ASPECTS OF VEGETATION REMOVAL FROM THE COASTAL SAND DUNES OF ISRAEL**

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Coastal sand dunes are known to be: (i) free of vegetation and active (ii) partly vegetated and active (iii) fully vegetated and fixed. Some of the dunes are vegetated naturally, while others were artificially stabilised for the purpose of controlling sand movement or because of biological invasion of alien species. The vegetation that covers two parabolic coastal sand dunes south of Ashdod, Israel, was removed as part of a study of dunes management. This inventive and not so well known method of management was used, despite the common idea that active sand dunes are undesirable nuisances which are threats to arable land and infrastructure elements. The aims of the research are: (i) to study the geomorphological and dynamic responses of the dunes to removal of vegetation (ii) to monitor the rate of vegetation recovery, its pattern and effect on dune morphology and dynamics. Coastal dunes provide us with examples of dynamic natural processes and the nature of the ecosystems that they support depends on this dynamism. Re-mobility of stabilised dunes is an important technique of ecological restoration. The parabolic dunes of the research area were formed during the last 30 years and are characterised by phytogenic mounds, known as nebkhas, composed of windborne sand that was trapped within or around shrub canopies. The nebkhas were formed, mostly on the crest of the dunes, because the crest is the area of no erosion and no deposition.

Two methods of vegetation removal were used. First, removal of above ground biomass by hand, with no disturbance to the dune shape. By this method the nebkha mounds were sticking out at the dune crest. These exposed nebkhas turned the dune into a bluff body (a non-streamlined shape) that produces considerable resistance to the wind. The wind reacts to the projecting mounds as an erosion force. After one year the nebkhas were not eroded. Artificial sand mounds near the nebkhas eroded quickly after a couple of storms. The resistance of the nebkhas to the wind is due to the web of roots. A second method was the flattening of the nebkhas by a tractor that reinstated the form of active transverse dune. In both methods the roots of the shrubs started to sprout and grow, particularly in the dune that was exposed by the first method.



# THE CHOICE BETWEEN KEEPING OUT CHRONIC POLLUTION VERSUS ACUTE MORTALITY DUE TO EMERSION: THE CASE OF THE TRICOLOR OIL POLLUTION PREVENTION IN THE ZWIN NATURE RESERVE (BELGIUM)

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As a result of the impending Tricolor oil pollution in the Southern Bight of the North Sea at the end of January 2003, the Zwin nature reserve was blocked from the North Sea by use of a sand barrier. This method of protection has an important consequence for tidal flat ecosystems: the absence of the tide. To estimate the effects of the tideless situation on the ecological very important bottom-life of tidal flats, macrobenthic samples were collected starting just before, two times during (after 12 and 21 days of emersion), and frequently, after the removal of the sand barrier, during one year. This study shows a high resistance of all macrobenthic species to a medium-term emersion during winter. Two ecological patterns could be distinguished during the emersion: (1) immigration into the emersed intertidal zone of *Talitrus saltator* and *Orchestia gammarellus*, (2) decreasing densities of polychaete species which were very abundant before the construction of the sand barrier. However both patterns were not significant. In view of the high survival of the macrobenthos to a medium-term emersion and the fact that a pollution in the nature reserve was inhibited, the choice to protect the reserve from the impending oil pollution by use of a sand barrier, may be positively evaluated.



## TIDAL WETLAND RESTORATION AT KETENISSE POLDER (SCHELDT ESTUARY, BELGIUM): DEVELOPMENTS IN THE FIRST YEAR

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Ketenisse polder is a former intertidal brackish marsh (30ha) situated in the mesohaline part of the Schelde estuary. In the 19<sup>th</sup> century its central part was embanked as a polder. In the mid 1980's the area was almost completely raised above intertidal level when it was used as a dumping site for the excavated soil from the Liefkenshoek tunnel. In 2002 it was restored as compensation for the construction of the North Sea container terminal on an intertidal mud flat in 1994-1995. The rubble of the summer dike and the dumped material were removed and the area was levelled with a weak slope below mean high water level creating the optimal starting conditions for new intertidal mudflats and marshes. The morphological and ecological developments of the restored site are monitored in a multidisciplinary project. Here we present the results of the first monitoring year after restoration of the tidal regime.

Sedimentation and erosion were monitored at 20 sites situated along 6 transects perpendicular to the shoreline. Sedimentation as well as erosion between 0 and 30 cm were observed in the first year. Seasonal topographic measurements along transects, spanning the intertidal zone, revealed similar sedimentation/erosion rates. Median grain size showed large variation particularly at those sites situated in downstream part of the area where the sediment was rather sandy. Organic carbon content of the sediment varied between 0.5 and 15%. Chlorophyll a concentrations were negatively correlated with median grain size and tended to increase from the low water line to the shore. They were slightly lower than at nearby intertidal areas but displayed similar seasonal variability with a maximum in spring. The macrobenthos community was dominated by Oligochaetes (*Tubificoides heterochaetus* and *Amphicaeta sannio*), which were present in 73% of all samples and attained an average density of about  $40 \cdot 10^3$  ind.  $m^{-2}$ . Other macrobenthos species found were nematods and copepods. Macrobenthic densities and community structure differed from those on nearby intertidal areas. The vegetation was monitored on macro scale at a series of permanent quadrants and by means of detailed vegetation mapping. The large surface of tidal mudflat and *Vaucheria*, a pioneer on tidal marshes, were indicator of initial succession stages. With increasing altitude, and consequently decreasing inundation frequency and time, *Scirpus maritimus* and transitional vegetations to *Chenopodiaceae*-vegetations established. The *Chenopodiaceae*-vegetations were relicts of earlier vegetations before



the tidal restoration, and will probably disappear. 16 breeding bird species were recorded in the first season, the most common species being the Pied Avocet (*Recurvirostra avosetta*). The most common waterbirds were Common Shelduck (*Tadorna tadorna*), Greylag Goose (*Anser anser*), Curlew (*Numenius arquata*) and Lapwing (*Vanellus vanellus*), typical species for the mesohaline part of the estuary. Our monitoring results suggest that one year after the managed realignment, Ketenisse polder has the potential to develop towards a normal functioning intertidal area.

In July 2002 the management of Water Company of the Yeuve Region (WVYR) started with the production of drinking water by the means of wastewater effluent. The new treatment plant, located in the polder, started by following treatment steps: pre-treatment (40%), primary treatment, aeration (80%) and chlorination (10%). The Tropicana were designed to produce 2 Mm<sup>3</sup>/day of water of minimum quality, that is 40% of the current drinking water demand. The flow chart is shown below.



Fig. 2. Water treatment process.

The whole project was designed to create a sustainable environment, managing the existing water resources. Because of the presence of salt-water north and south of the polder, the drinking water production capacity was limited and by the end of the 1990's the WVYR was unable to fulfill the increasing demand of drinking water. Significant portions of the water mentioned above had not been used for that intention. The production capacity could be increased and all the natural groundwater resources could substantially be restored.

Water treatment technologies advanced, but the water quality standards were not. Wastewater effluent could be used as the source for the production of drinking water.

The present flow chart shows the results of both cases in the design of wastewater treatment plant for the production of drinking water.





# SUSTAINABLE GROUNDWATER MANAGEMENT OF A DUNE AQUIFER BY RE-USE OF WASTEWATER EFFLUENT IN FLANDERS, BELGIUM

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In July 2002 the Intermunicipal Water Company of the Veurne Region (I.W.V.A.) started with the production of infiltration water by the reuse of wastewater effluent. This new treatment plant, called 'Torreele', contains the following treatment steps: prescreening, microfiltration (MF), cartridge filtration, reverse osmosis (RO) and ultraviolet irradiation (UV). The 'Torreele' plant is designed to produce 2,500,000 m<sup>3</sup>/year of infiltration water; this is 40 % of the current drinking-water demand. The flow chart is shown below.

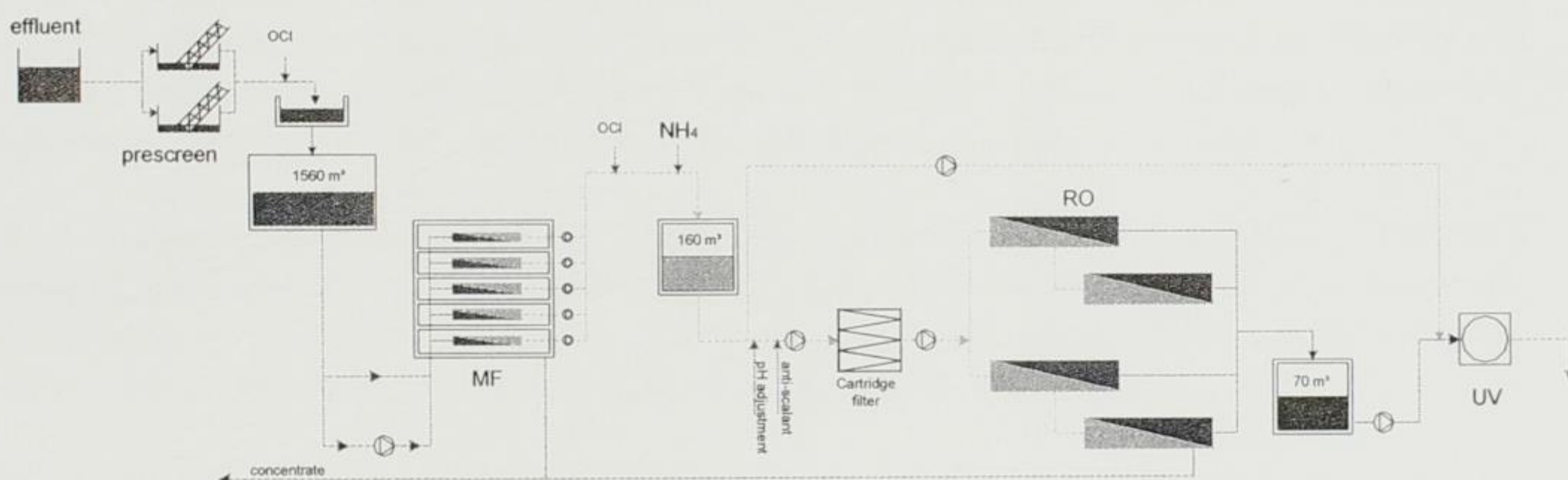


Fig. 1: Flow chart of the 'Torreele' plant

The whole project was developed to create a sustainable groundwater management of the existing dune water catchment. Because of the presence of salt-water north and south of these dunes, the drinking-water production capacity was limited<sup>1</sup> and by the end of the 1980' s the I.W.V.A. was unable to further satisfy the increasing demand of drinking water. Artificial recharge of the sandy unconfined dune aquifer was chosen as the best alternative: the production capacity could be increased and still the natural groundwater extraction could substantially be lowered.

Pilot tests using membrane filtration techniques showed that, although stringent quality standards were set, wastewater effluent could be used as the source for the production of infiltration water.

This presentation will describe the results of infiltration in the dunes, a period that will cover over 3 years at the time of presentation.

<sup>1</sup> Increased production could cause saline water intrusion into the dune aquifer

# SUSTAINABLE GROUNDWATER MANAGEMENT OF A QUANTICUM BY RE-USE OF WASTEWATER EFFLUENT IN FARMHOUSE WELLS

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In July 2002 the Municipal Water Company of the Western Region (WVW) started with the production of infiltration water by the means of a new infiltration treatment plant called 'Tonsels'. During the following treatment stage consisting of microfiltration (MF), activated sludge filtration (AS) and ultra-filtration (UF). The Tonsels plant is designed to produce 2,500,000 m<sup>3</sup> of infiltration water, this is 40% of the current drinking-water demand. The flow chart is shown below.



Fig. 1. Flow chart of the Tonsels plant

The whole project was developed to create a sustainable groundwater management of the existing drinking water distribution network of the Western Region and to reduce the drinking water production capacity. The existing drinking water production capacity was limited, and by the end of the 1980's the WVW was unable to further increase the drinking water supply. A detailed analysis of the water resources and the drinking water distribution network was conducted. The best alternative for the drinking water supply was identified as the infiltration of groundwater. A detailed study was conducted to assess the feasibility of this alternative.

Pilot tests were conducted to assess the feasibility of this alternative. The results of the pilot tests showed that the infiltration of groundwater is a viable alternative for the drinking water supply. The pilot tests also showed that the infiltration of groundwater is a sustainable alternative for the drinking water supply.

The infiltration will reduce the need of infiltration in the future. A pilot test will cover over 3 years of the time consumption.

1. This work was supported by the Flemish Government, the Walloon Government and the Brussels Government.

The infiltration water recharges the sandy unconfined dune aquifer; the residence time of the recharged water in the aquifer is minimum 40 days.

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## **NATURE DEVELOPMENT AND MANAGEMENT IN INNER COASTAL DUNES ALONG THE BELGIAN COAST**

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Dunes along the Belgian coast are characterized by a high dispersion. Especially the borderline areas between dunes and polder and middle-old dunes are threatened by urbanization and agriculture among other factors.

Despite these threats, still many areas have high scientific value. Two specific cases are presented, D'Heye (Bredene), a middle-old dune complex with important relict acidic dune vegetations and the Belvédère (Koksijde), a dune-polder vegetation area with one of the few remaining fronts with blowing sand along the Belgian coast.

In both cases first a vegetation study was undertaken and combined with hydrological and other abiotic data to form the basis of the management plans and to identify the required habitat types. Reconciliation was sought with other land uses, including agriculture, recreation and tourism and possibly drinking water extraction.

Initial management proposed removing of constructions and garbage. This was followed by sod-cutting of potentially floristically valuable zones and restoration or construction of puddles. During the first years areas were mown followed by extensive grazing. Now both areas are under extensive grazing management.

The poster will give an overview of the works undertaken in both areas, including an assessment of the results obtained.

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## **RESTORATION AND MANAGEMENT PLAN OF 'HET ZWIN', A SALT WATER MARSH ON THE BELGIAN COAST**

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'Het Zwin' (Knokke-Heist) is an internationally reknown nature reserve and is one of the few salt water marshes on the Western-European coast. With its size of approximately 150ha, largely located in Belgium, it has a very high biological value.

The nature reserve is threatened by many factors, including silting up with sand from the North Sea. This abiotic factor has caused a decrease of the ecological value due to the less frequent inundation with seawater and even threatens the further existence of the salt-water marshes as a whole.

In order to salvage this area, a management plan was developed, taking into account all different functions of the nature reserve.

Recent studies of vegetation, fauna and abiotic factors served as a guideline to develop a global vision for the nature reserve. Several possibilities were investigated, including an offshore sand fall, shoveling of areas of the marsh surface, restoration of natural tidal influence, tube systems and creation of salt marshes in current polder land and others.

After an evaluation of the different possibilities and their impact, a management plan is presented aimed at the restoration and conservation of the valuable salt marshes.

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## **OOSTHOEKDUINEN: A SATISFACTORY AGREEMENT BETWEEN NATURE DEVELOPMENT AND RECREATION - A NATURE RESTORATION PROJECT BY THE FLEMISH GOVERNMENT**

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The nature development project 'Oosthoekduinen' includes the Oosthoekduinen s.s., the Calmeynbos and the Krakeelduinen. The area is situated at De Panne and covers 190ha. This area is legally protected in several ways : protected landscape, 'green area' on the zoning plans drawn up under the 'Law of the organization of town and country planning', Special Protection Areas in application of Bird directive (79/409/EEC) and Habitat Directive (92/43/EEC), and partly under the Decree for protection of the dunes (BS 31/8/1993).

This protection status contrasts with the continuous growing recreational pressure on the area. To accommodate those apparently opposing interests, the Nature Division of the Ministry of the Flemish Community commissioned the FLA to develop and execute a nature restoration project in this area.

The project aims at the restoration and development of

- open dune habitats of dune grassland and moss dune ('grey dunes'),
- dune shrub communities,
- dune pond and pools,
- moist to wet polder grassland and low productive natural grassland,
- introduction of ecological forest management,
- zoning of recreation.

Degradation of the grey dunes, a priority habitat protected by the Habitat Directive is caused by a lack of nature management and too much treading by recreation. A grazing area was established to maintain the dune grassland vegetation.

The Krakeelduinen forms a mosaic of dune shrubs, dune grassland and moss dunes. To maintain the dune shrub vegetation invasive plant species such as Ontario poplar (*Populus canadensis*), Grey poplar (*Populus canescens*) and Sycamore (*Acer pseudoplatanus*) were removed. The cutting down of the planted poplar lanes was the first step towards the restoration of the parabolic dune landscape.

The Calmeynbos is originally a diverse afforestation from around 1900. Nowadays about 60% of the initially planted taxa are still present. Their regeneration however, is difficult except for the Sycamore. The purpose of the project is to introduce ecological forest management. Therefore coniferous plantations are replaced by deciduous trees,



forest structure is improved, regeneration of indigenous tree species like Common ash (*Fraxinus excelsior*) and elm (*Ulmus spec.*) is facilitated by clearing more competitive species and the proportion of dead wood is increased.

In the former military zone, all military infrastructure such as store houses, concrete platforms, watch-towers are removed except for one blockhouse which will be restored as a hibernation shelter for bats.

Before the start of the project, the dune - polder transition zone was in intensive agricultural use. This zone was acquired by the Nature Division of the Ministry of the Flemish Community and has now the statute of Flemish Nature Reserve 'Duinzoom'. The restoration of the dune-polder zone was established by locally removing the nutrient rich surface horizon, increasing microrelief on former arable land, reprofiling the banks of the watercourse 'Langgeleed' and other ditches, enlarging existing pools and digging new ones. Part of the area is managed by mowing, the other part by permanent grazing.

To channel the recreational activities, agreements were made with neighbours and users (e.g. the scouting, mountain bike and horse riding clubs). Therefore trails were established for walkers, mountain bikers and horse riders. In conflicting situations where walkers, mountain bikers and horse riders interfered too much the paths were separated or rerouted altogether.

The effectiveness of these measures will be monitored during 10 years. Lessons that will be learned from this monitoring will be of value in future management projects.



## **THE ABBEY OF THE DUNES (KOKSIJDE) AND NOORDDUINEN: THE ENVIRONMENTAL LINK RESTORED**

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The site of the Abbey of the Dunes is situated in a dune area of 115ha. The Abbey of the Dunes (Duinenabdij) at Koksijde was founded in the 12th century and abandoned around 1600. In 1949 excavations started on the site, the discoveries were consolidated with the techniques available at the time and put on display for the public. During the same period, part of the abbey disappeared under a newly constructed road (Van Buggenhoutlaan). This road severed the historical link between the abbey site and the dunes. An archaeological park and a very attractive and modern museum was constructed. However, by lack of new investments, the exhibition became outdated, the ruins of the abbey and the park fell into decay and eventually the museum closed its doors in 1998.

Since 1999 the municipality of Koksijde aimed at upgrading the abbey site and requested the Flemish Land Agency (FLA) to participate in the restoration of the Abbey of the Dunes site. Within the FLA a multi-disciplinary team was established to study the Abbey of the Dunes. Because of its spatial position, bordering on the Noordduinen and caught between the urbanization of Koksijde-Dorp, Koksijde-Bad and St-Idesbald, it was soon decided to involve the wider environment of the Abbey of the Dunes in the project. This approach would ensure a consolidation of the fragmented dune area and an integration of the abbey in its original landscape.

An inventory was made for the different aspects such as environment (fauna and flora, hydrology, pedology and geomorphology), recreation, archaeology and cultural-historical landscape elements, an analysis of bottlenecks and a view was formulated. Next a comprehensive strategy was determined in which the different goals were integrated.

The first phase of the project aimed at a cultural-historical valorisation of the entire former abbey site. The project 'I rise from beneath the sand' focussing on the museum and the incorporation of the ruins in an open-air museum, was launched by the municipality and forms the subject of a land use planning project realized in partnership by the FLA.

The second phase concerns defragmentation by the removal of the Van Buggenhoutlaan. This measure is supported by the municipality council and awaits approval of the Minister. The breaking up of the road forms subject of a multi-modal traffic study which had to simulate the future traffic flows. From the study it was clear that most of the traffic could be deviated along the Ter Duinenlaan. Because this road

THE ABBEY OF THE DUNES (DUNES) AND WOODCROFT: THE ENVIRONMENTAL LINK RESTORED

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The site of the Abbey of the Dunes is situated in the north-west of the island of Jersey, in the Channel Islands. The site is a Scheduled Ancient Monument and is listed as a Grade I site. The site is a Scheduled Ancient Monument and is listed as a Grade I site. The site is a Scheduled Ancient Monument and is listed as a Grade I site. The site is a Scheduled Ancient Monument and is listed as a Grade I site. The site is a Scheduled Ancient Monument and is listed as a Grade I site.

Since 1999 the ownership of the site has passed to the Jersey Heritage Trust. The Trust has a vision for the site as a place where the history and culture of Jersey can be shared with the public. The Trust has a vision for the site as a place where the history and culture of Jersey can be shared with the public. The Trust has a vision for the site as a place where the history and culture of Jersey can be shared with the public.

An interim study was carried out in 2000 to assess the current state of the site and to identify the key issues for the future. The study identified the need for a comprehensive environmental assessment of the site and for the development of a management plan for the site. The study identified the need for a comprehensive environmental assessment of the site and for the development of a management plan for the site.

The first phase of the project aimed to establish a baseline understanding of the site and to identify the key issues for the future. The project team carried out a series of surveys and assessments of the site and identified the key issues for the future. The project team carried out a series of surveys and assessments of the site and identified the key issues for the future.

The second phase of the project involved the development of a management plan for the site. The plan sets out the objectives for the site and the measures to be taken to achieve these objectives. The plan sets out the objectives for the site and the measures to be taken to achieve these objectives.

runs through residential area it is necessary to rebuilt the road. After this realization the Van Buggenhoutlaan can be broken up and the excavations of the dune abbey and extension of the park can proceed.

The third project comprises nature restoration of the Noordduinen. The policy of the Ministry of the Flemish Community, Nature division is the conservation and restoration of the specific environmental dune environments and to stimulate its biodiversity. The project aims to strengthen the nature values especially the moss dunes and dune grasslands which are priority habitats under the Habitat Directive. The main actions include removal of shrubs and exotic plant species, introduction of a grazing regime, strengthening of small landscape elements e.g. making drinking pools and restoration of wooded banks bordering former fishermen's fields and channelling of recreation.

of the coast between Dunkirk and the Belgian border inland some dunes including dune blowouts and benches and heathland over the dunes. This coast is presently in a state of stability (since 1997), dune restoration has been encouraged by the 'Conseil Général de Nord' (Department of authoring) and the 'Conservatoire de Littoral'. The restoration scheme has focused on a large blowout in Lillersducker, and has involved the use of longshore oriented sand fences, crosswise oriented brushwood barriers and the planting of *Amorpha canescens*. The mentioned sector reported in this study is a part of the rehabilitation zone, and covers the upper beach, and the dune foot and crest. From September 1999 to October 2007, nine very high resolution topographic surveys were realized over a 2500m<sup>2</sup> area using an electronic total station (Leica TC600). An average of 700 data points were collected each time (i.e. 1 point per m<sup>2</sup>). This dataset was used to create two Digital Elevation Models (contour maps and 3D models). Nine cross-sections were constructed with maps generated following subtraction of one DEM from the next one, and the last map by comparing the last and the last DEMs. These maps show regular dune growth in the fence-equipped area (dune foot and crest), and sometimes minor retrogradation or erosion on the upper beach. However, these maps do not give a clear synthesis of the morphological change and do not allow for assessment of the efficiency of the dune rehabilitation measures. The DEMs were therefore divided into three sub-zones (upper beach, dune foot and crest) using the 5 and 7.5m contours (related to French elevation datum) as limits. Calculations of global and partial volumes were carried out and then statistically analysed: mean volumes, flow trends, standard deviations and variance coefficients were computed. The results confirm the trends detected from analysis of the comparison maps and provide further information. They highlight regular volume growth on the dune foot and crest, and a strong heterogeneity of the efficiency of the fence and brushwood barriers. In contrast, the upper beach is stable or slightly eroded on the whole, but exhibits much higher variability than the two other zones. The upper beach is subject to strong phases of erosion or accretion.

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and through external means, it now was to be left to the will of the individual.  
Von Bismarck's plan was to bring up and the settlement of the law after the  
revision of the law was made.

The first step was to bring up the revision of the law. The bill of the  
Ministry of the Interior (Prussia) which contained the proposed law and  
of the specific amendments that were made had a right to be discussed. The  
project was to strengthen the law which was already in force and to give  
provisions which were more liberal than the existing law. The new law  
included a number of articles which were to be added to the existing law.  
strengthening it and making it more liberal. The law was to be made  
of wood and to be made in a way which was to be made in a way

## ASSESSING COASTAL DUNE REHABILITATION USING VERY HIGH RESOLUTION DIGITAL ELEVATION MODELS: AN EXAMPLE FROM LEFFRINCKOUCKE, NORTHERN FRANCE

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The northern shores of France are bounded by large beaches associated with a coastal barrier comprising two or three sub-shore parallel dunes. Until the early 1990s, much of the coast between Dunkirk and the Belgian border suffered severe erosion involving dune blowouts and breaches and bluffs cut into the dunes. This coast is presently in a state of stability. Since 1997, dune restoration has been undertaken by the 'Conseil Général du Nord' (Departmental authorities) and the 'Conservatoire du Littoral'. This restoration scheme has focused on a large blowout in Leffrinckoucke, and has involved the use of longshore oriented sand fences, cross-shore oriented brushwood barriers and the planting of *Ammophila arenaria*. The monitored sector reported in this study is a part of the rehabilitation zone, and comprises the upper beach, and the dune front and crest. From September 1999 to October 2001, nine very high resolution topographic surveys were realized over a 25x30m sector using an electronic total station (Leica TC600). An average of 708 data points were collected each time (i.e.  $\approx 1$  point per  $m^2$ ). This dataset was used to create nine Digital Elevation Models (contours maps and 3D models). Nine comparison maps were computed: eight maps generated following subtraction of one DEM from the next one, and the last map by comparing the first and the last DEMs. These maps show regular dune growth in the fence-equipped area (dune front and crest), and sometimes minor accumulation or erosion on the upper beach. However, these maps do not give a clear synthesis of the morphological changes and do not allow for assessment of the efficiency of the dune rehabilitation measures. The DEMs were therefore divided into three sub-zones (upper beach, dune front and crest) using the 5 and 7.5m contours (relative to French elevation datum) as limits. Calculations of global and partial volumes were carried out and then statistically synthesized: mean volumes, time trends, standard deviations and variation coefficients were computed. The results confirm the trends detected from analysis of the comparison maps and provide further information. They highlight regular volume growth on the dune front and crest, thus enabling better assessment of the efficiency of the fences and brushwood barriers. In contrast, the upper beach is stable or in mild erosion on the whole, but exhibits much higher variability than the two others zones. The upper beach is subject to active phases of erosion or accretion.

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## LIFE-NATURE ALONG EUROPEAN COASTS

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Since 1992, LIFE-Nature has been funding nature conservation projects across the European territory of the EC Member states. The current article briefly explains the rationale of the LIFE-Nature programme, its relationship to the implementation of the Birds and Habitats Directives and provides an overview of the types of actions funded. Given that LIFE-Nature is a limited fund compared to the needs of the Natura 2000 network, funding is only available for the most relevant actions at the European level.

year 1970 heavy storms had broken through the two-dune ridge of the Dune du Parnasse. The consequence was that during spring tides the sea water could penetrate through the breach into a new dune. This phenomenon is called a 'breach', as these days the water could during spring tides also get over the fore-dunes of the Belgian 'Waddell', but at the end of the year 1970 a concrete dike was built in front of the fore-dune to prevent further marine erosion. Similarly to the dunes are a rare phenomenon along the continental coast of northwestern Europe. They usually harbour a highly specialised bird-life and other biotopes. The management plan for the Natura 2000 site was approved in 1994, prescribing to create a couple of 'islands' by locally removing the concrete dike. The feasibility of this action was the perspective of recent works had already been demonstrated by a study executed in 1995 by a technical engineering consultant. At the coastal defence-policy of the French Regional Authority has since long evolved to a more dynamic approach, the Coastal Division agreed to execute the prescriptions of the management plan. Before that time an ordinance on the biological system of natural areas was however added to an Environmental Impact Assessment, as that for the creation of two islands an EA had to be drawn. After the approval of the EA by the competent authority and a construction licence had been delivered, the works were carried out between the 22nd January and the 20th June 2004. The works consisted of:

- \* lowering the height of the dike and the fore-dune to partly the fore-dunes themselves to a level that is lower than the spring tide level;
- \* strengthening the dike at two locations that would be exposed to a wave pressure to penetrate the dike area further into a concrete structure. This reinforcement was carried out with the sand that was excavated from the dike area and the fore-dune;
- \* removing the concrete dike at two locations over a distance of 20 metres and 15 metres to allow the sea water to penetrate the dune area;
- \* building two bridges over the breaches in the dike to allow visitors to remove their walk uninterrupted.



## **WINDOWS IN THE DUNES - THE CREATION OF SEA INLETS IN THE NATURE RESERVE DE WESTHOEK IN DE PANNE**

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The Flemish Nature Reserve 'De Westhoek' constitutes together with the French state-domain 'La Dune du Perroquet' a trans-border coastal dune area with a superficies of 700 hectares, situated between De Panne (Belgium) and Braydunes (France). From high-tide mark to polders, the range of dunes has a width of nearly 2 kilometres. In the years 1950 heavy storms had beaten a breach through the fore-dunes of 'La Dune du Perroquet'. The consequence was that during spring tides the seawater could penetrate through the breach into a dune-slack. This phenomenon is called a 'sea-inlet'. In those days the seawater could during storm tides also top over the fore-dunes of the Belgian 'Westhoek', but at the end of the years 1970 a concrete dike was built in front of the fore-dunes to prevent further marine erosion. Sea-inlets in the dunes are a rare phenomenon along the continental coasts of northwestern Europe. They usually harbour a highly specialised bird-life and salt-tolerant flora. The management-plan for the Nature Reserve 'De Westhoek', that was approved in 1996, prescribes to create a couple of sea-inlets by locally removing the concrete dike. The feasibility of this action from the perspective of coastal safety had already been demonstrated by a study executed in 1995 by a hydraulic engineering consultant. As the coastal defence-policy of the Flemish Regional Authority has since long evolved to a more dynamic approach, the Coastal Division agreed to execute the prescription of the management plan. Projects that have an influence on the hydrological system of natural areas are however subjected to an Environmental Impact Assessment, so that for the creation of two sea-inlets an EIA had to be drawn. After the approval of the EIA by the competent authority and a construction license had been delivered, the works were carried out between the 22nd January and the 20th June 2004. The works consisted of:

- lowering the bottom of two deflation zones behind the fore-dunes and partly the fore-dunes themselves to a level that is lower than the spring tide level;
- strengthening the dunes that surround those lowered deflation zones to prevent the sea-water to penetrate the dune-area further than is considered desirable; this reinforcement was carried out with the sand that was excavated from the deflation zones and the fore-dunes;
- removing the concrete dike at two locations over a distance of 20 metres and 15 metres to allow the seawater to penetrate the deflation zones;
- building two bridges over the breaches in the dike to allow strollers to continue their walk uninterrupted.





The two new sea-inlets have a total superficies of approximately 3 hectares. The deflation zones where the sea-inlets were created consisted originally of sandy plains that were thickly strewn with debris from demolished blockhouses and had a scarce Marram-gras (*Ammophila arenaria*) vegetation. The creation of sea-inlets should allow the development of the natural habitats of the annex I of the European Habitat-directive '1310 (15.11) *Salicornia* and other annuals colonising mud and sand' and '2110 (16.211) Embryonic shifting dunes', and also offer breeding opportunity to at least Kentish Plover (*Charadrius alexandrinus*) and Great Ringed Plover (*Charadrius hiaticula*). The results and effects of the sea-inlets on the quality of the groundwater is meticulously being monitored.

Future activities in European coastal habitats, research and nature habitat development research is concerned with the effects of major field in the future due to expanding environmental changes of integration in the European Union Regional Policy. The European Union Regional Policy, as stipulated, providing the European Union Environmental Action Program will be integrated in the coastal management and nature management. The results indicated coastal zone management process integration with the European Union Regional Policy functions must therefore be considered that further to that sustainable development transition and change, future research in European coastal habitat development.

The ways to state and law, to address the problems of the future integration in European coastal habitats, research and nature development, in order to provide an integrated environmental responsibility in the coastal zone management under the European regional integration it is necessary to form new European coastal zone policy concepts. An integrated and project activities through the built of ideas in coastal management development, responsibility in the coastal zone management strategies, multi-level development perspective in the European Union integration.

The overall objective of the European Union Environmental Action Program for integrated coastal zone management sustainable development is to provide the European Commission with a package of documents environmental issues in the European Regional Policy.

The main objectives of the European Union Environmental Action Program development of an integrated coastal zone management, research, habitat management, and the quality of environment includes the research and policy of coastal management. The environmental impact of the research use, the development of the Policy and European coastal management projects, for example, to develop and management of the coastal zone (2010), and etc.

One of the ways to the analysis of a nature and nature, research and nature development in the European coastal habitats problems, with relevant levels, second, to determine responsibility of environmental responsibility, that including the environmental issues in the European Regional Policy, hence, preparing the model of study to address the problems of the future integration, research and nature development in the European coastal zone habitats management strategies in the future.

According to the European Regional Policy, as stipulated, providing the European Union Environmental Action Program, which aims to provide an integrated coastal zone



# THE ROLE OF THE EU REGIONAL POLICY ON THE ETHICAL RESPONSIBILITY FOR THE DEVELOPMENT OF RECREATION AND TOURISM AND CONSERVATION OF EUROPEAN COASTAL HABITATS

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Nature restoration in European coastal habitats, recreation and tourism business development research is consistent set to become a major field in the future due to impending environmental changes of integration in the European Union Regional Policy. The European Union Regional Policy, its principles, priorities, the European Union Environmental Action Program will be integrated on the coastal management sustainable management. The results indicated coastal zone management process integration into the European Union Regional Policy Programs must therefore be connected over the idea so that sustainable development recreation and tourism, nature restoration in European coastal habitats development.

*The ways to study problems, to solution this problems of the nature restoration in European coastal habitats, recreation and tourism development. In order to provide an integrated socioeconomic responsibility in the coastal areas management under the European economic integration it is necessary to formulate their integrated responsibility conception. As an empirical and practical evidence suggests the bulk of ideas in model integrated socioeconomic responsibility in the coastal areas management strategies, management development perspectives in the European Union integration.*

The overall objective of the European Union Environmental Systems for integrated coastal zone management sustainable development is to provide the European Commission with a package of documents environmental issues in the European Regional Policy.

The ways to study region are *three different conceptual frames*: regional development at as a political process, as an economic process (perhaps progress), and as a spatial process also includes the use and problems of natural resources and the environmental impact of the resource use, the definitions of the Baltic Sea Region in major cooperative projects, for example, 'Vision and Strategies around the Baltic Sea 2010', end etc.

*One of the ways is the analysis of o nature restoration, recreation and tourism development in the European coastal habitats problems, their solution levels; second, to determinate propositions of socioeconomic responsibility; third, estimating the environmental issues in the European Regional Policy; fourth, preparing the model of study to solution this problems of the nature restoration, recreation and tourism development in the European coastal areas habitats management strategies in the future.*

According to the European Regional Policy, its principles, priorities, the European Union Environmental Action Programme, which shown its point for integrated coastal areas



habitats management sustainable development, was in fact valid provide that integrated responsibility management of coastal recreation and tourism business destinations can be reduced through an implementation of the European Union Environmental management systems, and Situation ethic algorithm, developed by ourselves.

According to Situational ethic algorithm, the basic tenet underlying situation ethics is that circumstances alter cases. Complex significant ethical decisions are made based on the situation at given moment in time. The factors of a Situational ethics algorithm includes: goals, methods, motives, consequences. As the consequences of decision become more complex and unpredictable, the Situation ethics becomes necessity in the recreation and tourism business, nature restoration in European coastal development management strategies in future.

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## **TIDSEED: INTERTIDAL SEDIMENT CHARACTERIZATION USING HYMAP IMAGERY**

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With one of the largest wading bird populations in western Europe, and several rare habitat types such as tidal marshes, the Scheldt estuary is internationally known for its nature. On the other hand, the estuary is also a site of heavy industry, and is an important commercial shipping route. These two contrasting worlds make it difficult for coastal zone managers to make planning decisions that affect the whole ecosystem.

Obtaining accurate data on the basic biological, chemical and physical processes in intertidal sediments is expensive and difficult: the accessibility of the site is limited, and estuaries are characterized by a wide spatial heterogeneity. Remote sensing methods can produce detailed information on ecological functions in a cost-effective manner.

Hyperspectral HyMAP imagery is combined with intensive ground truthing to quantify the most important biological and physical parameters such as pigment content, sediment grain size and water content.

To achieve these goals a consortium consisting of five research institutes with complementary skills in remote sensing, marine (and coastal zone) ecology and sediment mechanics, joined forces in the TIDSEED project financed by the Belgian Science Policy Office in the framework of the STEREO research program.





## LAI DETERMINATION IN DUNE VEGETATION: A COMPARISON OF DIFFERENT TECHNIQUES

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Research was conducted in the nature reserve De Westhoek (De Panne, Belgium) during the 2004 growing season. The main objectives of this research are (i) the direct determination of the leaf-area-index (LAI) in different vegetation types by destructive measurements, (ii) the indirect determination by different non-destructive optical methods (including digital hemispherical photography and airborne remote sensing), (iii) comparing the applied methods to estimate LAI, and (iv) producing a map of the horizontal LAI distribution in the research area. The destructive LAI determination was conducted in herbaceous vegetation, and in shrub vegetation (*Salix repens*, *Hippophae rhamnoides* and *Ligustrum vulgare*). It was found that the LAI of herbaceous vegetation ranges between 0.87 and 4.60, with a mean LAI value of  $2.11 \pm 0.34$ . The LAI of shrub vegetation ranges between 2.25 and 3.58. A mean LAI value for the shrub vegetations is  $3.03 \pm 0.19$ . All formerly mentioned values are based on destructive measurements. Ground-based optical determination of LAI was only conducted in the shrub vegetation, by means of the SunScan (Delta-T Devices Ltd, Cambridge, UK). The indirect LAI determination, with a mean value of  $5.67 \pm 0.50$ , systematically overestimated direct LAI. Another applied optical method is digital hemispherical photography (Nikon Coolpix 5000 camera). The software used to analyze the hemispherical photographs is CAN\_EYE (INRA-Avignon, France). First results also indicate a systematic overestimation. Airborne remote sensing data are used to establish a relationship between direct LAI and some vegetation indices such as the Normalized Difference Vegetation Index (NDVI). False colour digital orthophotos and hyperspectral (32 bands) data are used. Based on the above established relationship a map of the horizontal LAI distribution in the nature reserve De Westhoek will be produced. First results already revealed a (quasi) linear relationship between direct LAI and NDVI derived from false colour orthophotos ( $R^2 = 0.65$ ).



## MONITORING DUNE DYNAMICS IN 'DE KERF' (NL) 1997-2003

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In the Netherlands 'De Kerf' was initiated as a pilot project for dynamic coastal management. Within this pilot project five years of monitoring and evaluation was applied. The monitoring of the geomorphological development and of the vegetation and flora was sufficient for recording significant changes in ecotopes. The monitoring of macrofungi and Carabidae confirmed these results. The monitoring of reptiles and birds gave only qualitative information.

The project focused on coastal areas in the Netherlands, in particular on coastal areas with a high degree of biodiversity, such as the coastal dunes of the Dutch coast. The project was initiated in 1997 and lasted until 2003. The project was initiated as a pilot project for dynamic coastal management. The project aimed at monitoring and evaluating the development of coastal dunes and the impact of coastal management on the dunes. The project was initiated as a pilot project for dynamic coastal management. The project aimed at monitoring and evaluating the development of coastal dunes and the impact of coastal management on the dunes.

There were four key elements in the project, which will be discussed. One of the main objectives was the development of a coastal habitat management plan (CHMP) and creating Natura 2000 areas. The project was initiated as a pilot project for dynamic coastal management. The project aimed at monitoring and evaluating the development of coastal dunes and the impact of coastal management on the dunes. The project was initiated as a pilot project for dynamic coastal management. The project aimed at monitoring and evaluating the development of coastal dunes and the impact of coastal management on the dunes.

The project learned from production of the CHMP the lessons learned and to develop guidelines, which has now been incorporated into Dutch policy on coastal management.

The paper will present information about the coastal project and outcomes, the CHMP changes, and other specific elements of the study including the lessons learned. The project was initiated as a pilot project for dynamic coastal management. The project aimed at monitoring and evaluating the development of coastal dunes and the impact of coastal management on the dunes. The project was initiated as a pilot project for dynamic coastal management. The project aimed at monitoring and evaluating the development of coastal dunes and the impact of coastal management on the dunes.



## **THE UK LIFE PROJECT ON SHORELINE MANAGEMENT: 'LIVING WITH THE SEA'**

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Climate change and sea level rise is posing ever-greater challenges to the sustainable management of our coasts.

'Living with the Sea' was a 4-year partnership project benefiting from European Commission LIFE Nature funding. The UK partners were English Nature, the Environment Agency, the Department for Environment, Food and Rural Affairs (Defra), and the Natural Environment Research Council.

The project focused on coastal areas of England, in particular on coastlines with complexes of sites designated under European Habitats and Birds Directives. Research has indicated that climate change and sea level rise will drive significant habitat change on these coastlines, with implications for how we deliver flood risk management. The project ended in July 2003, and its recommendations, management tools and vision are feeding into both conservation, and flood and coastal management policy and practice in the UK.

There were four key elements to the project, which will be described. One of the most far reaching was the development of seven Coastal Habitat Management Plans (CHaMPs) covering Natura 2000 site complexes on the eastern and southern coasts of England. These evaluate the impacts of sea level rise and flood and coastal defence works on the Natura 2000 sites, over the next 30 to 100 years. They ensure that the flood management options are compatible with our obligations arising under the Habitats and Birds Directives. CHaMPs now have to be produced in the UK prior to the development of the second generation Shoreline Management Plans (SMPs), as required by Defra High Level Target 11 for flood and coastal defence. SMPs set out the flood and coastal risk management policies for the UK coastline and are reviewed every 5 to 10 years.

The lessons learned from production of the CHaMPs have been used to refine project guidance, which has now been incorporated into Defra guidance on SMP development.

This paper will provide information about the overall project aims and successes, the CHaMP concept, and other specific elements of the study including the review of how we have incorporated the Habitats and Birds Directives into UK law. The paper will also consider the recommendations arising from this visionary project in the wider context of how we need to manage our coastlines, the communities, natural features and wider land use, so that we can survive climate change and sea level rise in the long term. We must anticipate change, plan for it and provide space within our coastal zones; zones that will become more extensive and influential with the continued rise in sea levels and pressures to find new development opportunities.



# NATURE RESTORATION IN THE HARBOUR OF ROTTERDAM, THE NETHERLANDS

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The Rotterdam harbour system is not only well suited for containers. The unique properties and the many quiet locations offer opportunities for rare estuarian species. The New Waterway is the only open connection of the Rhine and Meuse rivers and the North Sea with tidal action and a gradual transition from salt to fresh water. It is a crucial link for migratory fish species, among them the Twaite shad (*Alosa fallax*), the Lampern (*Lampetra fluviatilis*) and the Sea trout (*Salmo trutta*). Shallow and sheltered parts in the harbour serve as stepping-stones for these species. The harbour infrastructure serves as an ideal hard substrate for species like the Plumose anemone (*Metridium senile*).

The Rotterdam harbour system is also an important breeding area for shore birds. Especially the Maasvlakte, the latest port development build into the sea, is ideal for foraging in the nearby coastal waters for the likes of terns and seagulls. Contrary to its image, the port of Rotterdam has many quiet and undisturbed spots, probably more than the rest of the highly touristic Dutch coast.

## Nature restoration

The Rhine-Meuse estuary is potentially one of the most important wetland areas in the Netherlands, but it has been subjected to excessive influence from human activities, given the growth of the Rotterdam harbour over the last century. This caused heavy pollution of the estuary. Since the late seventies however, water quality has improved. Therefore, habitat rehabilitation has become viable. In this industrial area, small and sometimes temporary measures can have a relatively large effect.

Experiences within the port of Rotterdam have shown that even completely artificial areas can be colonized by species within a few years, especially by opportunistic and mobile species like most shore birds. For instance, a test with floating pontoons in the sludge depot 'Slufter' can probably allow terns (*Sterna hirundo*) to breed without disturbance. These birds will forage in nearby coastal waters.

For aquatic fauna, sheltered areas are being developed to function as resting places during migration. These stepping-stones can also be important for species such as the Scurvygrass (*Cochlearia danica*). One of the locations, the 'Gors Rozenburg' boasts sizable fields of the rare softstem bulrush (*Scirpus tabernaemontani*).

## EU directives

Current EU Bird and Habitat directives are important to protect the present natural values. But these legislations seem to have a detrimental effect on the willingness of port authorities and enterprises to award lots as 'temporary nature'. Afraid as they are that once protected flora and fauna species settle, economic development of the area will be hampered. This can even culminate in ensuring – sometimes forcefully – that species will not settle. Perhaps a more flexible policy for opportunistic species could have a positive impact on nature restoration in industrial environments.





