Coastal dune management at selected sites in the Netherlands: South Holland and Zeeland

Report of the study tour of the Netherlands 1-5 March 2010






Charlotte Durkin

Sand Dune and Shingle Network
Occasional Paper No.4

Liverpool Hope University
EST.1844

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Organised by Liverpool Hope University and the University of Amsterdam

Report prepared by Charlotte Durkin

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Published by Liverpool Hope University Press

Foreword

This is the fourth publication in the Sand Dune and Shingle Network Occasional Paper series published through Liverpool Hope University Press. The aim of the Sand Dune and Shingle Network is to support the sustainable management of sand dune and shingle habitats by encouraging an exchange of information and experience and in developing links between different interests. The Network is based within the Department of Geography in the Faculty of Sciences and Social Sciences at Liverpool Hope University, and is supported by the Higher Education Innovation Fund and Natural England.

This publication records a knowledge exchange exercise involving postgraduate students, academics and professionals working in dune conservation. Knowledge transfer is the process by which knowledge, expertise and skills are shared through linkage and exchange between different sectors. It is a key function of the Network and is achieved through the dissemination of good practice via a variety of publications and the organisation of events where key actors may meet and collaborate.

The report arises from a study tour to the Netherlands organised by the Department of Geography and the Network, in partnership with colleagues at the University of Amsterdam's Foundation for Integrated Dune Management. The exact sites visited vary from year to year, but it is an annual excursion to the Netherlands made available to Network members from the UK. Postgraduate students from the MSc in Environmental Management attend the study tour as part of their course. This creates an unusual and productive vertical integration in the university curriculum. The study tour exposes students to professional practice and some of the latest advances in coastal dune management in Europe. For the UK professionals who participate in the study tour, and the Dutch professionals leading site visits, it is a refreshing experience to rub shoulders with early learners in coastal dune management as the deep and often specialist discussions held require framing within the broad concept of dynamic dune management. It is a healthy exercise for all involved to return to this concept and not to be entirely immersed in the fine detail of conservation management.

An outcome from the study tour is the promotion of international exchange of information and understanding on dune management and ecology. This is an action listed in the UK Sand Dune Habitat Action Plan, and this annual study tour makes some contribution to the achievement of it. For the UK professionals an important benefit of the study tour is experiencing coastal dune management on an entirely different spatial scale than that which is possible on most of their sites. We hope that the experience helps UK participants to scale their own site management actions and to work at the landscape level whenever possible, to avoid unnecessary interventions and to realise the potential of natural processes.

We wish to thank all of our Dutch colleagues for their enthusiastic support in organising and delivering the study tours. Further information on the Sand Dune and Shingle network is available at www.hope.ac.uk/coast

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Note:

This is the second occasional paper exploring dune conservation in the Netherlands and there will inevitably be some overlap with the first (Houston and Edmondson, 2010) and future volumes. The authors have tried to limit duplication of material and for this reason, some discussion may appear to be curtailed. For more information on:-

- Nature conservation policy and ideology specifically related to dunes
- Specifics of dune re-mobilisation projects in National Park Zuid-Kennemerland including on frontal dune ridge
- *Prunus serotina* in the Amsterdam Water Works

please see Houston, J.A. and Edmondson, S.E. (2010) Conservation and management of coastal dunes in North Holland: *Report of the Study Tour of the Netherlands, 9-13 February 2009*. Sand Dune and Shingle Network: Occasional Paper No. 2, Liverpool Hope University Press. ISBN: 9781898749042 (available at www.hope.ac.uk/coast).

Acknowledgements

The aim of the study tour was to visit a number of sites in the Netherlands to discuss a range of management activity with a focus on recent large-scale dune restoration projects.

The visit was organised in association with Fred van der Vegte and Cees de Vries of the University of Amsterdam and the Foundation for Integrated Coastal Dune Management. Additional hosts were Luc Geelen (Waternet), Anton van Haperen (Staatsbosbeheer), Gert de Groot (Natuurmonumenten) and Harrie van der Hagen (Dunea).

The report author is solely responsible for any errors in the interpretation of the information.
Special thanks to John Houston and Paul Rooney for editing and guidance and to Marc Jones for proofreading. The layout and design of the report is by Ray Burns of Liverpool Hope University.

Cover photographs clockwise from top left: Grazing at Kennemerland-Zuid, white dunes on Schouwen, cycling through Amsterdam waterworks, interpretation board on Schouwen, the beach near Amsterdam Waterworks, slack at Voorne.

Please Reference as: Durkin, C. (2011) Coastal dune management at selected sites in the Netherlands: South Holland and Zeeland. Report of the study tour of the Netherlands 1-5 March 2010. Sand Dune and Shingle Network Occasional Paper No. 4, Liverpool Hope University Press.

Designed and printed by Liverpool Hope University Reprographics Unit.

ISBN: 978-1-898749-09-7

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Introduction

Coastal dunes in the UK have much in common with those in the Netherlands in terms of habitats and species and similar management problems. The Netherlands and the UK have similar dune areas in terms of size, 48,000 and 56,000 ha respectively (Doody, 2008). However, in the Netherlands dune systems are less fragmented and management units are generally larger than those in the UK. The dunes in the Netherlands are relied upon extensively as sea defences and are important water abstraction areas, filtering and purifying river water. As a result, the dunes provide essential ecosystem services to a greater extent than UK dunes, giving them a value beyond intrinsic biodiversity value. This means that policy making and managing the public interface with the dunes has a different basis in the Netherlands. Nevertheless, there are many important issues which the UK can learn from and use to inform management practice.

Figure1:Map showing locations of each of the five site visits

Geel (2009) of National Park Zuid-Kennemerland provides an overview of the Dutch dune landscape which began to form some 5,500 years ago under the influence of sea, sand and wind. Rising sea levels after the end of the last ice age and offshore sand deposits created a long line of sand banks. Vegetation was able to colonise this new coastal sand area where the organic remains of dead plants and animals had washed up. These sand banks became the beginnings of barrier beaches which would later become what are now called the 'Old Dunes'. Climate patterns altered during the tenth and eleventh centuries when an increase in storminess meant violent storms partially washed away the developing sand dunes. The sediment was first deposited off shore before being brought shorewards again by prevailing westerly winds. This marked the beginning of the 'Young Dunes' when sand drifts began to 'wander' over the 'Old Dunes'. After several hundred years, the climate became milder again and vegetation cover in the dune area increased. In the present day situation, the 'Young Dunes' are the most westerly dune areas which provide the first defence against the sea. The 'Old Dunes' are inland where villages and cities have arisen on top of these former barrier beaches, including Beverwijk, Spaarnwoude, Santpoort, Velsen and Haarlem.

Coastal management policy in the Netherlands

Rijkswaterstaat, as part of The Ministry for Transport, Public Works and Water Management, is responsible for coastal defence while at a regional level provincial authorities and water boards (decentralised government authorities) determine policy in line with national objectives. Consultative Bodies for the Coast act as fora for national and regional stakeholders to discuss coastal defence, and report to Rijkswaterstaat. Rijkswaterstaat is responsible for the primary dune defence ridge as part of their responsibility to maintain sea defences, while other dune areas have a variety of managing authorities. This area of the dunes is off limits to the public and subject to different laws from dunes further inland.

Almost 12 million people (74% of total population) in the Netherlands live in the low elevation coastal zone, the third highest proportion in the world (McGranahan et al, 2007). In comparison, the UK is estimated to have just over a tenth of its population at risk from flooding in or near this zone (CIESEN, 2006). The 1953 floods prompted a more concerted effort to protect people and infrastructure from flooding and the first Delta Committee was established soon after to set a framework for safety standards. Today, the government is concerned with how climate change will affect its future residents, prosperity and landscape.

The first Delta Committee proposed engineering works to protect the South West of the country by closing sea inlets and upgrading existing dykes which could be sealed in the event of another storm surge. This would halt estuarine processes and effectively create a series of freshwater lakes (Heip, 1989). In the immediate aftermath of the floods, the implications for estuarine or marine ecology were considered secondary to the task of protecting coastal populations and infrastructure, as safety was the main concern. When it came to carrying out the works, the last proposed dam closure on the Oosterschelde was challenged by fishermen and ecologists among others (Wesselink, 2007) and subsequently altered to incorporate some estuarine processes (Heip 1989). The imminent threat of disaster is not conducive to integrated coastal management, as concerns over safety will naturally be the highest priority. Today, the government is not prepared to wait for another disaster to spur adaptation and mitigation efforts. A second Delta Committee was established in 2007 and is afforded the luxury of being more holistic in its planning. A new integrated approach to future water safety will consider freshwater supplies, natural and recreational areas and sustainable energy alongside coastal protection. The philosophy underpinning this new period of forward planning is that “a safe Netherlands is a collective social good for which the government is and will remain responsible” (Delta Committee, 2008). Already, a Delta Act is in preparation which will regulate the organisation of the Delta Programme (European Commission, 2009a) and a Water Act will follow whose remit will include prevention and mitigation of flooding and water shortages as well as the protection and improvement of the chemical and ecological quality of water systems (Delta Committee, 2008).

In the second Delta Committee’s initial recommendations (Delta Committee, 2008), two key flood protection policies are identified which attempt to move away from relying solely on hard engineering works. ‘Building with Nature’ refers to the process of beach nourishment which is currently occurring at many locations on the Dutch coast, while ‘Room for the River’ recognises that the changing discharge patterns in the rivers Rhine and Meuse are key to adapting to potential flooding scenarios. Prior to the introduction of the second committee, policy had focused on maintaining the Dutch coastline in a steady state, based on its position in 1990. The new policy recommendations go further and suggest that nourishment programs may actually create more land area on the coastline for nature and recreation, effectively re-defining the coastline (Delta Committee, 2008).

In responding to climate change, the Netherlands has opted to plan for the higher end of the emissions scenarios, after considering local effects of subsidence and thermal expansion, to ensure that defences will withstand the worst case scenarios of sea level rise. It is interesting to consider that the potential cost of planning for the worst case scenario is not considered prohibitive. Indeed, the recommendations from the Delta Committee are expected to cost between €1.2bn and €1.5bn per year until 2050 and €0.9bn to €1.5bn after that. In addition, if the option of building out the coast through beach

nourishment is implemented there will be an additional cost of €0.1bn – €0.3bn on top of this. For many Dutch people, climate change is seen more as a threat to prosperity than to safety (Kabat et al., 2009) but the Delta Committee tries to promote the opportunity to build a more prosperous society based on sustainability and innovation. It can be difficult for people to think beyond the span of their own lifetime, and governments often produce vote winning policies based on short term prosperity. However, the scale of the threat to the country has mobilised leaders into concrete action despite the high cost. The potential cost of a single dyke failure has been estimated at between €10bn and €50bn while the cost of doing nothing could run to €3.7trillion across the country, dwarfing the annual investment needed (Kabat et al., 2009). The most urgent action identified by the Delta Committee was to immediately prioritise upgrade works to existing dykes and levees. An audit in 2006 found that between 24% and 56% of defences did not meet even the current standards (between 1 in 1,250 and 1 in 10,000 flooding probability), before the Delta Committee had suggested raising these standards by a factor of 10 (Kabat et al., 2009).

Dune nourishment at Voorne.

Some of the concepts and actions proposed in the Netherlands are difficult to reconcile with a traditional interpretation of sustainable development. The terms 'future proof' and 'climate proof' are continually used rather than 'adaptation' and 'mitigation', terms which imply less certainty. Wesselink (2007 p. 242) describes the "taboo" in discussing the risk of flooding in the Netherlands where the dominant paradigm is that defences are strong and safety is guaranteed, whereas in the past there seems to have been a greater acceptance of nature's invincibility (Rijkswaterstaat, 1977). The predictions that have been made regarding the effects of climate change are all based on probabilities, modelling, uncertainty and risk. Nations around the world are using the best guidance currently available and doing what they can with the resources they have to adapt their societies to coming changes. The Netherlands will do the same and is already diverting resources from natural gas reserves and securing loans to pay for their ambitions. The route which policy makers have taken so far using expensive technological fixes to manage flood risk has created a "political lock-in" (Wesselink, 2007, p. 242) requiring more and more resources to maintain safety standards which politicians use to reassure the public. There is no certainty, however, that the measures taken will be sufficient or sustainable as economic and climatic conditions change. Beach nourishment, for example, involves dredging and transporting sand from offshore to beaches at a cost of €8m/year in one location on the island of Voorne. Rising oil prices may make this prohibitively expensive in future, or the value of homes and commercial assets may fall to a level which is not worth protecting. The committee has recommended that the ecological, economic and energy requirements involved in beach nourishment be investigated in order to assess the sustainability of this particular aspect.

The idea of market involvement in meeting the costs of 'future proofing' the Netherlands has been presented as a way of co-investing in sustainable planning and development. The idea is that businesses are involved in securing their own future economic security as 65% of the country's GNP is generated in the coastal zone, including the internationally important transport links of Rotterdam and Schiphol. The committee is eager to ensure that the burden of responsibility and the costs are borne by society as a whole, and most importantly those who derive greatest benefit from the Netherlands' strong economic standing. Future development in known flood risk areas will be granted on a cost benefit analysis basis which will see those who benefit from the development bear the associated cost, such as flood defence upgrades, although it is not clear for how long the responsibility will remain with the developer (Delta Committee, 2008).

Nature conservation management policy in the Netherlands

The Netherlands is a small country with a high population density, intensive agriculture and thriving industry. This makes biodiversity conservation a challenge and, in line with the rest of Europe, biodiversity loss continues (van Veen et al., 2008). The Netherlands is internationally important for some species such as migratory birds and habitats including dunes, heaths and aquatic habitats (MinLNV, 2006a). The number of species on the red list has increased over the past decade and many have become extinct over the last century (van Veen et al., 2008). This is symptomatic of widespread habitat decline and degraded environmental conditions. Nature has tended to be isolated in the Netherlands, taking second place to economic activities and being ignored in favour of heavily engineered solutions to problems. Now, the importance of nature is being recognised and the Netherlands is working hard to create a connected landscape where biodiversity can thrive in spite of economic activities.

Participation

The Dutch philosophy around people and nature says that participation and consultation should lead to increased public support for projects and decisions (Turnhout et al., 2010). This belief has informed many aspects of nature conservation policy. Where the 1990 nature policy plan was seen as a top-down prescriptive approach, the current plan seeks to involve the views of individuals to achieve a wider acceptance of the plan. The overarching theory is that if nature meets the demands that humans place on it and is seen as relevant and usable in the public realm, people will take responsibility for it and contribute to its protection and management (Turnhout et al., 2010). While this may be true, allowing everybody to have a say inevitably dilutes the conservation agenda and allows the focus to be shifted onto other concerns such as the economy. For example, during the process of designating sites as Special Protection Areas to comply with the EU Birds Directive (79/409/EEC of 2 April 1979), five thousand objections were raised to the draft list, mainly economical in concern (van der Touwen and van den Top, 1999).

Legal Protection

There are many acts and laws in place governing nature conservation management in the Netherlands. The Flora and Fauna Act (2002) protects around 500 species while the Nature Conservation Act of 1998 seeks to protect important habitat areas (MinLNV, 2011). Both were developed during the adoption of the Habitats Directive (92/43/EEC of 21 May 1992) and Birds Directive and can be seen as the Netherlands' interpretation of these directives. The Netherlands' attempt to re-interpret what was required in this way contributed to long delays in implementation and judicial proceedings against the country (Bennett and Lighthart, 2001). The Nature Conservation Act was amended in 2005 to more adequately protect areas designated under the Birds and Habitats Directives, with a permit system introduced to regulate economic activities within the areas (MinLNV, 2011).

With regard to European directives, notably the Bird Directive and Habitats Directive, the Dutch are seen to show a pioneering spirit in developing new policy but are then reticent in implementing it (Bennett and Lighthart, 2001). For example, many Dutch policy makers were involved in the formulation of the Habitats Directive, drawing on their experience of using ecological networks in their country to embed this thinking in the directive which later gave rise to the Natura 2000 network. However, the Netherlands were one of the slowest to implement the directives and incurred judicial proceedings as a result of their non-compliance (Bennett and Lighthart, 2001).

National Ecological Network – formerly Ecological Main Structure

Introduced in 1990, the National Ecological Network (NEN) was seen as a way to limit housing and industrial development taking place in sensitive nature areas (MinLNV, 2005). The idea is of larger nature areas connected by green corridors which allow for the movement of wildlife between resource areas. In conservation theory this helps to conserve species by increasing the exchange of genetic material and allowing populations to migrate if their primary habitat becomes depleted. The NEN includes Natura 2000 areas, and in the future it is intended that it will link up to networks in other countries and become part of the Pan-European Ecological Network (PEEN). There is a target of 728,500 ha to be realised by 2020 which will comprise 20% of the total land area in the Netherlands. An additional target of six million ha has been set for waterscapes in the Netherlands (MinLNV, 2005).

Natura 2000

The Netherlands has 162 sites within the Natura 2000 network covering around one million hectares, two thirds of which are open water (MinLNV, 2006a). The Netherlands is considered to be of very high importance for certain habitat types including sand drifts and species of breeding and non breeding birds as it is on the Palearctic flyway (MinLNV, 2006b). There are a number of guiding principles which underpin how the Netherlands approaches Natura 2000 sites and actions, as set out in the targets document (MinLNV, 2006a). Targets for improvement should be practically and financially feasible requiring minimum input from, and having minimum consequences for, the public and economic sectors. Severely threatened habitats and species are prioritised, whereas those where improvement is not realistically expected attract little effort and expenditure. The sites that are part of the network are expected to be sustainable by incorporating natural dynamics and being adaptable to climate change. In terms of managing these sites, maintenance or improvement targets are set depending on the sites' condition. The ecological state of the sites is monitored nationally and reported to the EU, to see if they meet expected conditions or are improving. Where sites are in particularly bad condition, a 'sense of urgency' status is applied to the site which means irreparable damage is likely in ten years if no action is taken. Thirty one core tasks have been assigned this status including tasks for grey dunes (MinLNV, 2006a), a priority habitat in the Habitats Directive. The Natura 2000 network of sites is part of the NEN so is subject to the same protection, but there are laws which govern it as a separate entity too. This is because of the flexibility which exists within the NEN to allow economic development, which if it were to take place on a Natura 2000 site, may contravene European law.

National Parks and National Landscapes

These are single areas comprising at least 1,000 hectares, with many integrated into the Natura 2000 network or the NEN. National Parks are designated for their significance to nature conservation but are seen as equally important to encouraging participation and engagement with nature. The MinLNV (Ministry for Agriculture, Nature and Food Quality) (2005, p.9) states that National Parks "bridge the gap between nature as an abstract concept and nature as a phenomenon" echoing the idea that people's use of nature encourages greater protection of the resource.

National Landscapes are areas where economic activities are not formally controlled; living and working are important but equally so is the landscape value. Sites were designated on the basis of cultural, historical or natural values and a good balance is sought within the landscapes between ecology, economy, liveability and beauty (MinLNV, 2005).

Species Protection Plans

One of the goals of nature policy for 2020 is to create the conditions required to support all species and populations which existed in the Netherlands in 1982 (MinLNV, 2005). It is unclear why this date has been chosen and its arbitrary nature echoes the 1990 baseline used for coastal protection. Species Protection Plans work in conjunction with the Flora and Fauna Act and Red Lists describing concrete actions which must be taken to preserve a species which has become threatened (MinLNV, 2005). A new approach is being developed which will influence how individual species are protected in the future. The emphasis will shift to protecting the habitat and living conditions of certain species and groups of species, mirroring a similar change recently seen in England (Webb et al., 2010).

LIFE projects

This source of funding from the European Commission has been and continues to be of enormous value in achieving some of the objectives for nature conservation in the Netherlands. It provides funds for conservation projects which help to realise the Natura 2000 network of sites. Initially, the EC had been unwilling to fund LIFE projects in the Netherlands following the legal proceedings against the country regarding the Habitats Directives (Bennett and Lighthart, 2001). Now there are many projects completed and ongoing which benefit from the fund, including large scale dune restoration projects by Staatsbosbeheer, Natuurmonumenten and others (MinLNV, 2006b). The LIFE Dunes project helped to restore islands in the Wadden Sea, parts of the mainland coast and Schouwen in Zeeland, benefiting an area of 4,700 ha (Staatsbosbeheer, 2010).

Learning from practice through field visits

Management of the Dutch coast requires a good understanding and integration of the main functions of the coastal dune belt for coast defence, nature conservation, water abstraction and recreation. These functions are inter-related and are addressed in integrated management plans for coastal areas.

The 2010 study tour visited a number of sites in the provinces of South Holland and Zeeland to learn from several different management bodies who were addressing the complexities of multiple-use management in a densely populated country. The focus was on aspects of nature conservation and large scale dune restoration projects. All the sites visited are part of the Dutch Natura 2000 network of protected sites established under the EU Habitats Directive. In the Directive the main sand dune habitats present in the Dutch dunes are;

2110: Embryonic shifting dunes

2120: Shifting dunes along the shoreline with *Ammophila arenaria*

2130: Fixed coastal dunes with herbaceous vegetation

2150: Atlantic decalcified fixed dunes

2160: Dunes with *Hippophae rhamnoides*

2170: Dunes with *Salix repens*

2180: Wooded dunes of the Atlantic, Continental and Boreal region

2190: Humid dune slacks

(European Commission, 2009b)

The visits were to;

- Kennemerland-Zuid National Park
- Amsterdam Waterworks Dunes
- The islands of Schouwen, Goeree and Voorne
- Dune Waterworks of The Hague (Meijendel)

At each site discussions were held with site managers and recent conservation actions were seen in the field. The range of issues included the re-juvenation and re-mobilisation of dune habitats, the problems of invasive alien species, habitat restoration, coastal defence policy and public attitudes to management. The remainder of this report provides a summary of the issues discussed in the field. Those statements that are not formally referenced are the statements and opinions of our hosts and guides.

Visit to Kennemerland-Zuid National Park

Guides: Fred van der Vegte and Cees de Vries (University of Amsterdam and Foundation for Integrated Dune Management)

The 3,800 hectare dune area primarily consists of young calcareous dunes. In parts of the site, management is focussing on re-mobilising the dune system. The aim is to re-instate the natural geomorphic processes which controlled succession and habitat creation before stabilisation processes began. A variety of anthropogenic factors such as afforestation and nitrogen deposition have encouraged the dunes to stabilise and the remobilisation projects are undertaken as compensation for some of these factors. The area has been utilised for drinking water extraction since 1850, with an extraction volume of 14 million m^3 per year up to 1999 (Bakker, 2005).

Each year two million people visit the park. The area is co-owned and managed by a number of organisations including:

- Provincial Water Company PWN Noord-Holland,
- 'Natuurmonumenten' the Society for the Conservation of Natural Monuments,

- 'Staatsbosbeheer' the State Forest Service,
- the municipalities of Velsen, Bloemendaal, Haarlem and Zandvoort,
- the Society for Nature and Environment Education IVN Noord-Holland,
- the District Water Board Rijnland,
- the province of Noord-Holland and the State

There are also a number of private land owners involved. The park is managed as a single unitary area with close co-operation between partners, evident in the adherence to uniform signage and admission rules.

Techniques

Re-mobilisation projects in Kennemerland have been taking place since 1998 (Arens, 2004) attempting to intervene at a higher level of dune processes in order to have the greatest effect. The project at Kennemerland is investigating whether permanent rejuvenation at the landscape scale is possible by restoring the natural process of dune mobility (Arens, 2004). A variety of factors have contributed to the dunes becoming more vegetated and stable over time. One of the reasons is plantations of non-native species such as stands of pine *Pinus* spp which artificially stabilised dunes when large scale sand-blow was a problem in the 1920s and 1930s. The removal of these pine plantations has been assisted by the trees' intolerance to local salt deposition of around 70g/m^2/year. A belt of deciduous trees previously protected the conifers in one part of the site, but this is now thinning and dying off exposing the pines to salt spray. The removal of trees and scrub has been combined with regular deployment of management interventions to ensure they do not re-establish through self seeding. Where trees have spread in to scrub land, horses nibble the bark and prevent them flourishing.

Clockwise from top left: Turf stripping activity to level of dune water table; rejuvenation of dune and dune slack habitat; re-mobilisation of parabolic dune; 'hedgehog' dune formed by Salix repens.

Removing conifers can be a controversial management activity as visitors value the trees as well as the dune landscape, and are often unaware that conifers are not a natural part of dune vegetation. The stumps of felled trees are removed by horses which also contributes to public engagement efforts.

Visitors have enjoyed watching this process and it gives managers an opportunity to discuss their plans and why certain actions are being implemented.

The process of scrub removal in the park was evident as some root structures were still visible. The results of remobilisation efforts were also evident in some places as small hummocks of blown sand in what had once been a flat landscape. Removal of vegetation is often accompanied by humus or turf stripping of around 20-30cm, removing nutrients and allowing bare sand to move in response to the wind. This technique works well in dune slacks which may have become over-vegetated. Turf stripping removes nutrients while the action of wind and sand-blow scour out depressions creating new slacks. A large-scale restoration project was initiated in autumn 1999, with the aim of restoring the typical vegetation of oligotrophic wet dune slacks, and characteristic species are now locally abundant (Bakker, 2005). It is still too early to say whether large-scale destabilisation measures in the case of artificially fixed coastal dunes result in durable aeolian activity and landscape rejuvenation (Arens, 2006).

Sustainability

There are a number of issues which may affect the success of this project and ultimately determine how sustainable it is. During the 1980s nitrogen deposition began altering growing conditions in the Netherlands but it was 10-15 years before people realised there was a problem. The amount of nitrogen deposited encouraged nutrient build up and created ideal conditions for scrub encroachment with the loss of many grey dune species.

Compounding the issue, climate change over the past century has increased the length of the growing season, giving scrub a greater chance to establish and grow in semi fixed dune habitats, negating the possibility of erosion and blow outs. The stabilising effect of scrub vegetation is difficult to reverse with natural system processes alone, and management intervention is often needed later on. This came in the form of both practical measures and in what is referred to as 'external management' which means trying to influence policy on a regional and international level to enhance efforts on a local level. Progress was made with EU policies from 1999 limiting the release of nitrogen and sulphur dioxides which have ensured that nitrogen deposition will decrease to a manageable level over the next decade.

The destabilising efforts all take place inland from the frontal dune ridge which effectively isolates the dune system from the dynamic processes of the sea and beach. However, there are plans to work with the sea defence ridge in the future. The safety aspect of breaching dune ridges may hamper the destabilisation efforts here, although permission for breaching has been granted on Goeree (see later section). Offshore and onshore winds plus salt spray and sand supply all have a role in maintaining blowing sand, instigating blow outs and keeping scrub at bay so it is difficult to see long term aeolian processes being reactivated without an interface between sea and dunes.

Conflicts

The main obstacle to enacting large scale processes in this 5km of dunes was cited as "emotions" by the former park Director, Fred van der Vegte. The coast, and more importantly the protective dunes, are obviously tied up in people's feelings and fears about inundation from the sea, meaning attempts to 'destabilise' the dunes can be seen as reckless. Taking time to engage with people by inviting them for tours, coffee mornings and information days was seen to be helpful in reassuring those worried by actions being taken. In addition, an art competition invited artists to create impressions of what a more open site might look like in the future.

The remobilisation process involved the removal of a large area of forest which uncovered remnants of a farm dating from the 6th/7th century prompting archaeologists to suggest stabilising the blow out to protect the remains. Coastal change can lead to the loss of archaeological remains and may have implications for features valued by geoconservation. Today there is a perception that ever wider interests have to be considered when managing for a specific purpose. The National Park at Kennemerland was originally designated for research, education and nature conservation but a more modern designation may have to consider a greater variety of issues.

Visit to Amsterdam Waterworks

Guide: Luc Geelen

One of the few paved paths in the Amsterdam waterworks

This site is integral to the network of nature reserves and ecological corridors envisioned by the government's Nature Policy Plan. It is part of the Natura 2000 network and is a Special Area of Conservation under the Habitats Directive. The site also has enormous commercial value as it supplies water to one million people in Amsterdam and beyond (Waternet, 2010), having done so since the mid 19th century (Bekelaar & Geelen, 1999). During the first decade of the 20th century there were signs that the drinking water resource had been over-exploited as dune slacks dried out. It wasn't until the 1940s that water companies realised the consequences of abstracting water above the natural re-charge rate as saline intrusion into the groundwater became a possibility (Verstrael, 1996). Infiltration with water from the Rhine began in 1957 (Engelen & Roebert, 1974) leading to problems of eutrophication of slacks which further damaged the habitats. During the early period of drinking water production nature conservation was of secondary importance, but as its practice ensured good quality drinking water it came to be seen as equally important (Beekelaar & Geelen, 1999).

In the management plan covering 2000-2010 (Beekelaar & Geelen, 1999) managers discussed objectives for nature conservation and whether natural processes or high biodiversity was of greater importance. In the end, the area was divided into three sections to achieve different results. In the South and West areas there was more potential for reactivating natural processes and simultaneously restoring dune slacks. Initially, mowing, grazing and top soil removal was undertaken to kick start the dunes' dynamic nature, after which patience was the only ingredient (Beekelaar & Geelen, 1999). Ongoing experimentation and monitoring is taking place to determine the best options for species management in the dune slacks. A combination of mowing, sod cutting and grazing as well as control slacks (where no actions are taken) were evident on site and will inform future management decisions. The management plan recognises the fact that connectivity between the sea, beach and dunes is key to activating and maintaining dynamics. This connectivity is currently prevented by strict management of the frontal dune ridge for sea defence. However, some leniency is beginning to be shown and it may be possible through partnership working with the Regional Water Board to create blow outs and breaches which would contribute to greater connection between the dunes and marine processes. The small scale of the eastern area precluded the development of significant dynamic processes so creating an area of high biodiversity was favoured. The authors of the management plan (Beekelaar & Geelen, 1999) acknowledge that in the Netherlands promoting high biodiversity requires continued management intervention, similar to the situation in the UK. In contrast to the remobilisation project, where it is hoped the natural dune dynamics will reinvigorate the system and it will become self sustaining, this area will need ongoing management.

In terms of recreation management, as a privately funded area the Amsterdam Waterworks Dunes is not obliged to follow the same principles as nature reserves where government policy dictates that management must be adjusted to suit the needs of the visiting public. However, with six million people within 50 km of the dunes, managers appreciate the necessity of balancing nature conservation with recreation. The objective is to allow access but to limit the extent of paved paths. Thus footpaths are maintained near the entrance to allow access even during rainy weather, whereas further in to the site, the Amsterdam Waterworks is the only site in the Netherlands where unmaintained paths are permitted (Beekelaar and Geelen, 1999).

Today, managing for water production is combined with nature conservation, recreation and sea defence and also considers the livelihoods of bulb growers in the polder areas. It is a delicate balancing act which must provide enough water for consumption, ensure that ground water tables are maintained at a level needed for slack biodiversity and that bulb fields are not inundated. The restoration project 'de Zilk' started in 2006 with the aim of restoring slacks in the dune area without compromising water production or bulb growing (Waternet, 2010). Hydrological modelling and an environmental impact assessment were completed along with a consultation process which resulted in six short-term and three long-term scenarios for dune restoration. The final scenario resulted in dune slacks being created near to the dune water works by raising the water level there. The canal bringing river water from the Rhine was maintained in part, but the water table was lowered in the bulb area. Monitoring systems are now in place to inform future modelling of the site as readjustments will be necessary in response to weather and climatic changes (Waternet, 2010).

Clockwise from top left: Operational infiltration canal; organic material exposed in a remobilised area; young wet slack habitat; the burial of the former Van Limburg Stirum canal and remobilisation of dunes.

The water purification process produces drinking water so pure it contains less phosphorus than rain water, and *Charophytes* spp have been found in reservoirs. The Dutch use no chlorine or fluoride in the water and the system of reed beds, bacteria and sand-carbon filtration breaks down metals and trace elements leading to an excellent water quality. Although the primary ecosystem service and hence value of this site is drinking water, the dunes still fulfil a vital sea defence role.

The linear foredunes are outside the management jurisdiction of the site and are managed by Rijkswaterstaat (see chapter two). They are an entirely artificial construction, being essentially sand dykes. There is strictly no entry onto these dunes, something which is fully respected by Dutch visitors owing to the country's history of inundation and reliance on artificial defence structures.

The frontal dunes along most of the Dutch mainland coast are maintained as uniformly straight and tall sand dykes.

Prunus serotina *on part of the Amsterdam Waterworks*

Alien Species

The issue of alien species on the Amsterdam Waterworks must be approached differently from other sites due to it being a sensitive drinking water catchment. Bird Cherry *Prunus serotina* was introduced to improve woodland soils during the 19th century in be a major threat to biodiversity in the dunes (Weeda, 2010). It colonises both open outer dunes and inner dune woodland, and on poor soils found on dunes it impedes natural regeneration of less competitive species (Muys et al. 1993). The use of herbicides is not an option (and in fact is rarely employed in the Netherlands) meaning a more patient approach to management is needed. The trees are coppiced to stumps and then the area is grazed for between 6 and 15 years by sheep and cattle.

The Delta Region

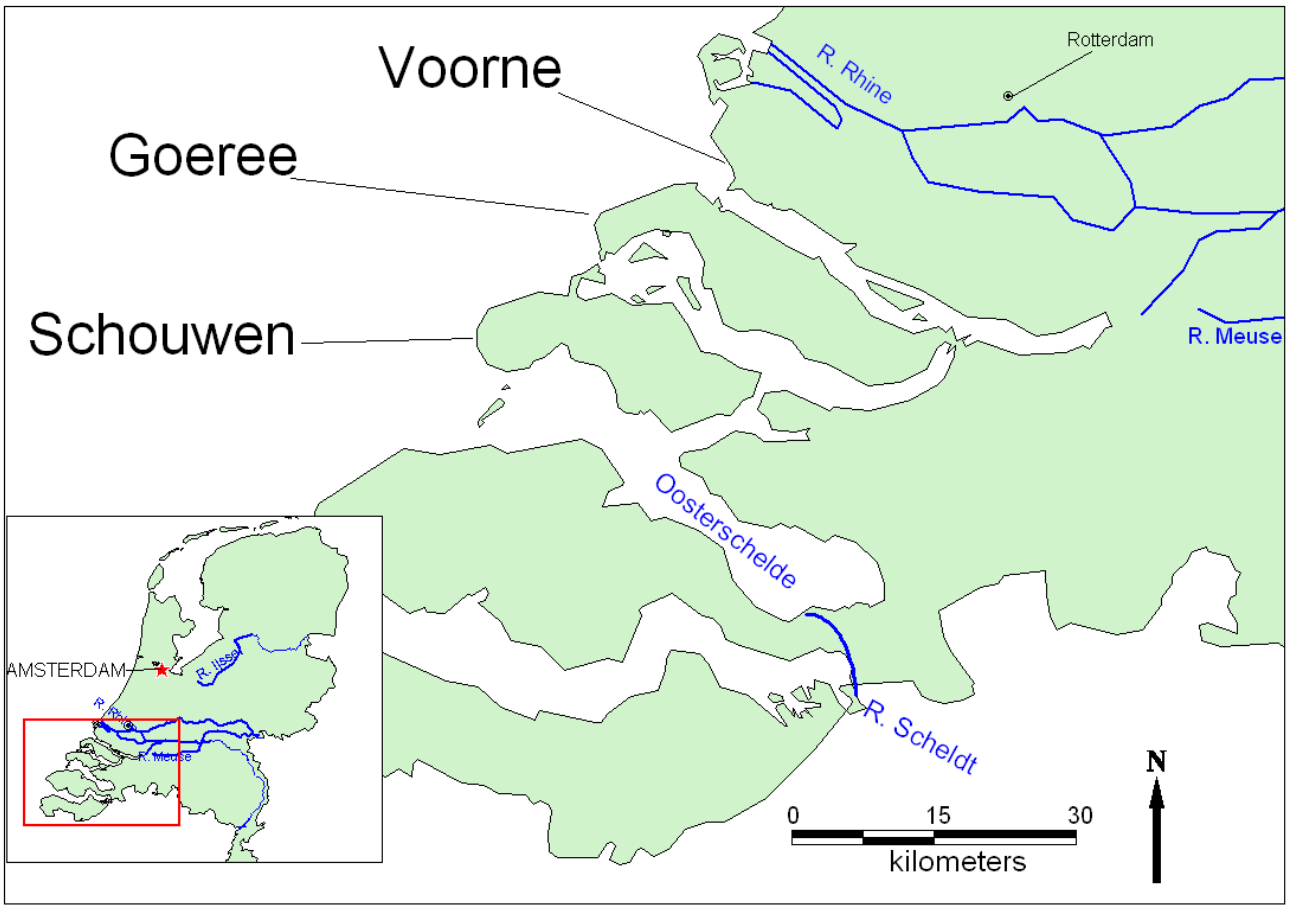

Figure 2: Map of Zeeland showing discharge of the River Scheldt

On the islands of Schouwen, Goeree and Voorne land is managed by a variety of conservation agencies. Staatsbosbeheer is the national forestry service and is responsible for many different habitats in the Netherlands (only one quarter of their area is actually woodland). Natuurmonumenten is an NGO, similar to the National Trust in England and Wales, which manages a variety of habitat types for recreation and conservation. The islands making up the Delta region in the South West of the Netherlands were one of the worst hit areas in the 1953 floods. One of the second Delta Committee's recommendations relevant to the South West is that the Oosterschelde (Eastern Scheldt), which discharges to the south of Schouwen, should have its tidal dynamics restored once the dyke is no longer adequate (post 2050). In the meantime, the loss of intertidal habitat in this area, where the net transport of sand is seaward, will be compensated by beach nourishment programmes.

Visit to Schouwen

Guide: Anton van Haperen, Staatsbosbeheer

In contrast to the more urban areas, the island of Schouwen presents a different set of conflicts which dune managers must consider. There is understandably a strict planning zonation system in the Netherlands which separates the functions of rural and urban areas. The two are, however, intrinsically linked through the demands each places on the other. The urban demand for green space and a better quality of life is balanced by the rural demand for services and employment. A recent EU project 'Building new relationships in rural areas under urban pressure' (European Commission, 2010) sought to help rural residents to find ways of providing landscape and nature related services in return for payment by developing new relationships with urban areas. The Groene Hart is an area of green space similar to the UK's green belt with restrictive planning laws but which is nevertheless under pressure from economic development. The Deltaworks following the 1953 floods served to better connect Zeeland and its islands with the rest of the Netherlands. The burgeoning urban population

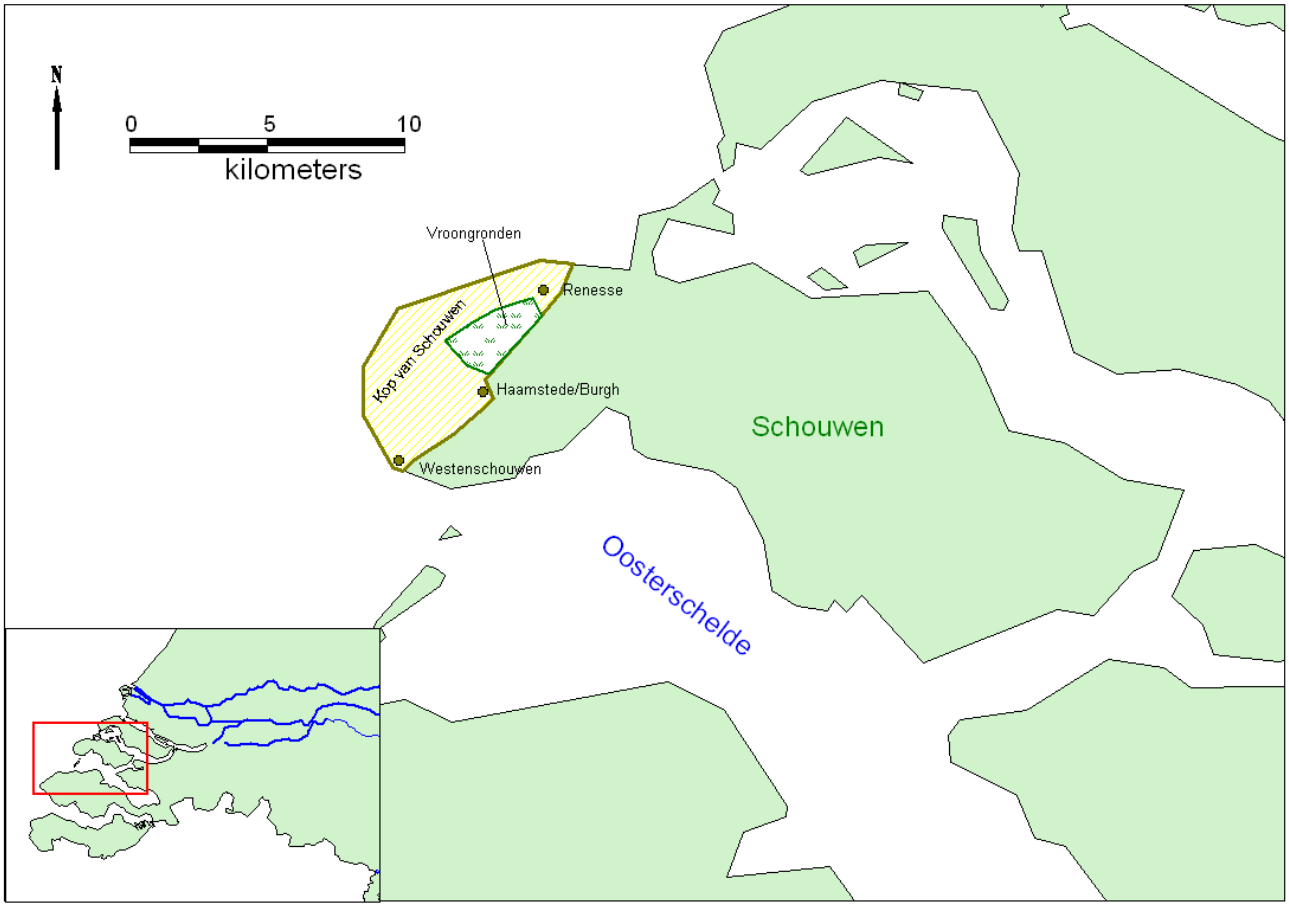

Figure 3: Map of the Island of Schouwen showing the location of site visits

of the Netherlands is now beginning to assess this area of relative rurality and what it could provide. Eight percent of houses in the Haamstede/Burgh region in the west are second homes and there is a strong dependency on the seasonal tourism industry for employment as agriculture has intensified and reduced employment to just 4% of the population (Overbeek & Vader, 2003).

On Schouwen there is a concerted effort by provincial and central government to enhance the tourism, recreation and nature conservation functions of the island as the traditional occupation in agriculture becomes less economically viable. The island areas are heavily used in summer as recreation and tourism areas, and fiscal investment is beginning to develop and expand this economic base. A new road has been constructed with a car park from where public transport provision takes visitors to the beach and camping areas from further inland. This approach has allowed the use of other areas for nature reserves by focusing traffic on fewer roads and easing congestion. It is hoped that in time, visitors will begin to see nature reserves as valuable recreational spaces in addition to the traditional resorts, although this will have to be carefully managed. This island has had to constantly adapt to the changing social and environmental conditions which influence it. A shift away from agriculture to tourism is being facilitated by fiscal stimulus while in some areas, nature takes a greater precedence and residents are learning to accept the new surroundings this will create.

On Schouwen, Staatsbosbeheer has been working hard to create nature areas and continuing large scale efforts to enhance the natural areas already in existence. The Kop van Schouwen covers the western part of the island encompassing a total of 3,000 acres between the towns of Renesse and Westenschouwen. It is managed by a variety of partners but the state forestry service Staatsbosbeheer owns the majority of the land (Staatsbosbeheer, 2010a).

Using LIFE-Nature funding, Staatsbosbeheer along with other partners undertook various management activities to assist dune restoration. In 2005 the first project on the Kop van Schouwen was launched

and sod cutting of 150 ha of dune land was undertaken to remove nutrients and encourage sand blow. Wet dune valleys were given a similar treatment to allow original slack vegetation to recover. In addition, encroaching scrub vegetation such as small dune reed *Calamagrostis epigeios* and creeping willow *Salix repens* have been cut and removed. The grazing area for cattle and Shetland ponies has recently been extended.

Left: Dune slack vegetation benefits from the removal of nutrients. Right: Shetland ponies grazing to control scrub and tall grasses.

Mobile dunes at Kwade Hoek

Only a century ago blowing sand was evident in Westerschouwen as sheep and rabbits consumed all the vegetation and erosion was given free rein. Pine plantations were used to stabilise the dunes and Staatsbosbeheer is now working to transform these plantations. During the winter of 2007/2008 birch stands were removed in several locations to restore the view of the polder from the dunes, thus connecting the landscapes in the mind of the visitor. There are coniferous plantations on Schouwen, but they are not as extensive as in other locations in the Netherlands because German occupation during World War II stopped the planting which began in 1920. Scattered throughout the coniferous plantations are deciduous seed sources and young deciduous trees. The conifers have been thinned allowing deciduous trees to germinate spontaneously along with plants and shrubs. This results in a healthy, balanced forest representing possible future climax vegetation. The aim is to create a more natural transition between dunes and forest (Staatsbosbeheer, 2010b). Along the coastal strip - the transition from beach to forest - indentations in the forest have been made to restore the dynamic influence of the dunes on the forest, encouraging sand blow. Already, the sand is "lying in wait" (Staatsbosbeheer, 2010b p. 24) at one of these notches and will soon drift into the woods.

The Vroongronden is a dry and wet transition zone between the dunes and the polders which was cultivated farmland until the 18th century. Today it is a nature reserve in part, and the government are negotiating the conversion of surrounding remnant agricultural land into nature reserves through an 'ecological infrastructure programme'. The provincial road running through the site has been converted into a bicycle path and a campsite in the area has been moved, which initially faced some opposition from locals. When the road was in use, access was restricted onto the surrounding fields. Now as a bicycle path, the wire fencing has been removed, allowing people to picnic and interact with the landscape.

High water table in the inner dunes

The area has an interesting hydrological regime which affects vegetation on a seasonal basis. The substrate is acidic and further acidifying (pH <3) as rain water leaches calcium out of the sand. However, the underlying ground water is buffered against acidification as it is in contact with carboniferous soils comprising the bedrock. In winter, raised water tables bring the buffering ions into contact with the acidifying sands, but in summer, the only plants able to grow here are acidophiles. The removal of the road and its associated ditches has allowed the water table to remain somewhat higher, promoting the development of more diverse vegetation communities. In drier areas, bioturbation by ants, moles and worms allows the same buffering effect to influence the vegetation (Van Haperen, 2010). There is a close moss and herb layer atop the dunes and managers feel rare lichens could grow here if the dunes were more dynamic. Blow outs are being stimulated locally to allow more calcareous sand to blow into the inner dune grasslands and restore some of the dynamics previously seen on Schouwen (Van Haperen, 2010).

Visit to Goeree and Voorne

Guide: Gert de Groot, Natuurmonumenten

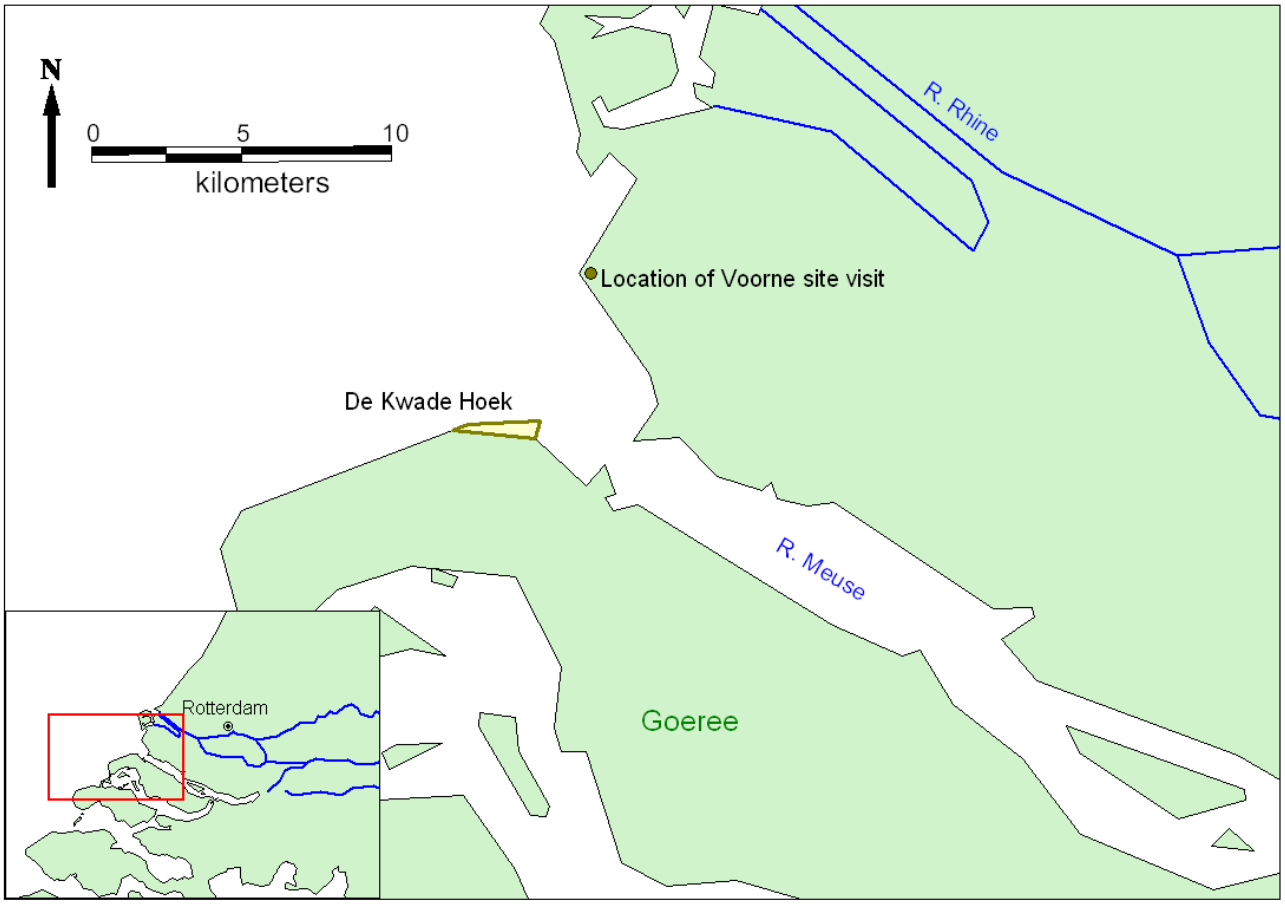

Figure 4: Map showing site visit locations on Goeree and Voorne

In the Delta Coast region Natuurmonumenten manage a variety of habitats including mudflats, sand dunes and estuarine areas. At Kwade Hoek on the island of Goeree coastal management policies

can accept a more natural approach to coastal processes. The creation of artificial breaches has encouraged seawater to break through part of a spit in one project. This is obviously an exception to the general Dutch policy which dictates that the 1990 coastline is maintained. The process is part of a wider policy in the Kwade Hoek area where less active management is inviting nature's processes to take over. Natuurmonumenten consider that the sea is still the dominant force here and they are enabling the currents and waves to instigate dune building by allowing water to come further inland than before. They have also breached a dyke in strategic places to restore some natural dynamics. This helps to reverse succession to scrub by introducing salt water and spray to the environment (Natuurmonumenten, 2010).

The area of scrub clearance on the left will be prevented from reverting to scrub because of the interaction between the sea and dunes through natural and artificial tidal breaches (right).

Left: Vegetation stripped from frontal dunes at Kwade Hoek to encourage sand drift. Right: Wet slacks at Voorne cleared of woodland and scrub.

Developing or accreting beach plains can be a great asset in reinstating dynamism within a dune area as blowing sand helps to invigorate primary dune building processes which also encourage the development of botanically rich primary dune slacks. The depositional nature of the Kwade Hoek area means beach plains are expanding and creating ideal conditions to kick start dynamic dune building. The experimental attitude of management here makes it the perfect site to observe this process and learn lessons for other sites.

This laissez-faire attitude is a stark contrast to the activities taking place on Voorne further north where a 'dynamic preservation' scheme nourishes the beach with sand dredged offshore to build out the coastline. Here, different current and wave regimes make erosion the dominant process and so suppletion is necessary. There is no record of large scale sand drift at Voorne in the past so restoring dynamics may not be a sustainable option here. Scrub management is the primary task as it is overly dominant to species-rich grasslands and grey dunes – a 90%/10% split, whereas 60%/40% is the realistic target. The techniques of fencing and grazing with cattle plus mechanical scrub clearance are taking place to achieve this target. In the Middle Ages, cattle were introduced to commercial

rabbit warrens as they were known to improve feeding conditions by removing the tougher shrubby vegetation and leaving shorter grasses for the rabbits to graze. Traditional rabbit grazing encourages grassland of the highest conservation value. What habitat management is trying to preserve is a landscape which was developed in co-evolution with rabbits. The devastation of the rabbit population through myxomatosis and now rabbit haemorrhagic disease virus (RHDV) is certainly a factor in the increased precedence of scrub and rank grasses. Grazing with herd animals is helpful in reducing the biomass of scrub, but without a sufficient rabbit population it is difficult to promote the short sward grasses where rare perennial species thrive.

Left: Beach and dune nourishment taking place on Voorne. Right: Rabbit droppings amongst the short sward mosses and grasses which are encouraged by rabbit grazing.

Visit to The Hague Waterworks (Meijendel dunes)

Guide: Harrie van der Hagen, Dunea

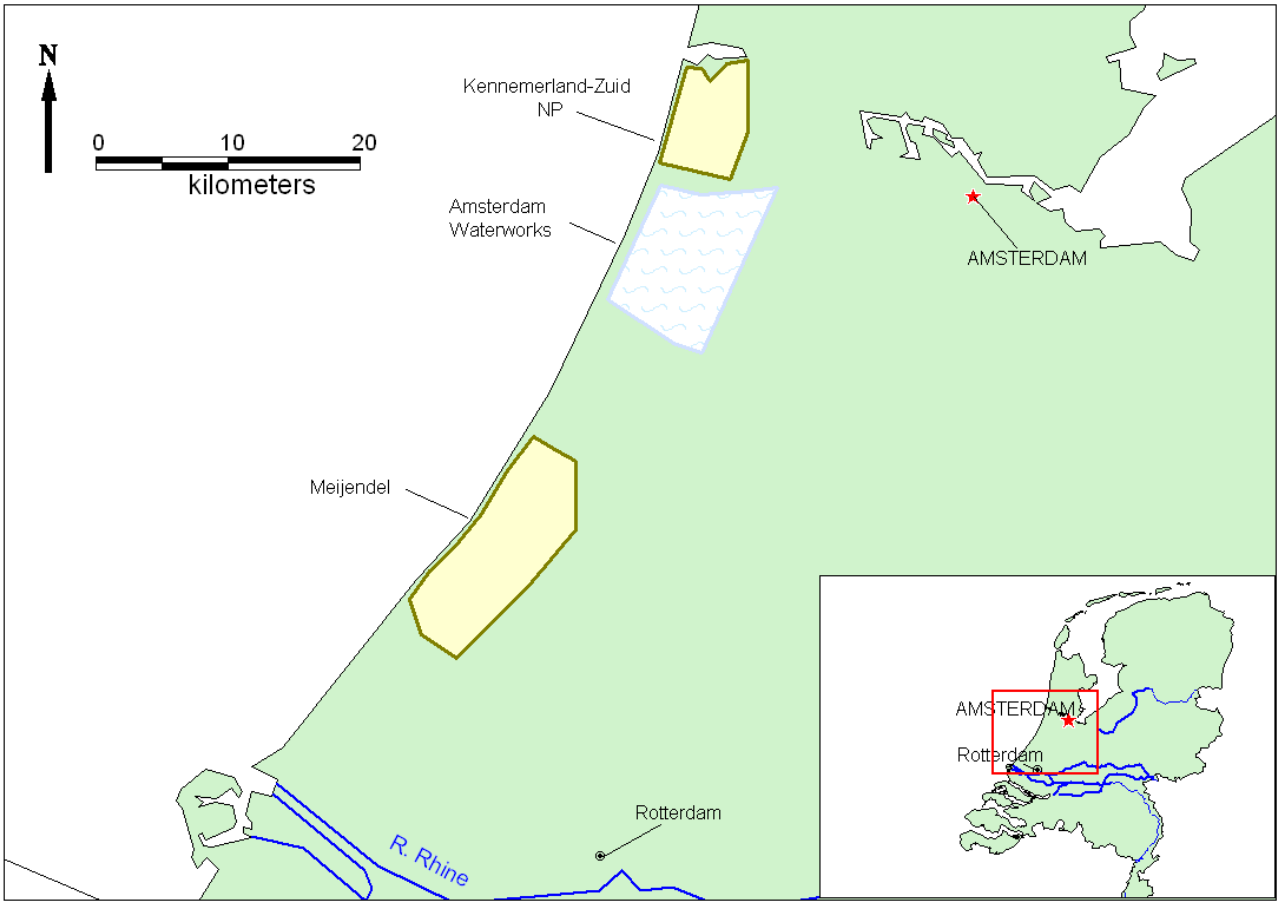

Figure 5: Map showing the location of Meijendel dunes

Older drainage canals are now used for the collection of water from the infiltration system.

The Meijendel dunes cover an area of approximately 2,000 ha (Bakker and Kramer, 1993) and are located in a densely populated region with over a million visits yearly (Van der Meulen et al., 2004). The area is part of the National Ecological Network (Van der Meulen et al., 2004) and is managed for drinking water production and recreation, as well as nature conservation, meaning there are inevitably compromises between these interests. Small scale human activities have long been a part of the landscape as evidenced by remnants of settlements and records of agriculture dating back to 1820 (Bakker and Kramer, 1993). Later, commercial pressures on the resource such as water abstraction, afforestation, recreation and substantial house building on dune areas began to alter the very character of the landscape. Water abstraction created similar problems to those experienced at the Amsterdam Waterworks Dunes. A canal delivered drinking water to The Hague, drying up wet slacks which at that time covered a third of the area. Later, infiltration of Rhine water began and from 1976 water was taken from the less polluted Meuse. Infiltration was heralded as the ideal solution with seemingly unlimited supplies of freshwater to raise groundwater tables and re-wet the slacks. However, there was no return of dune slack vegetation (Bakker and Kramer, 1993).

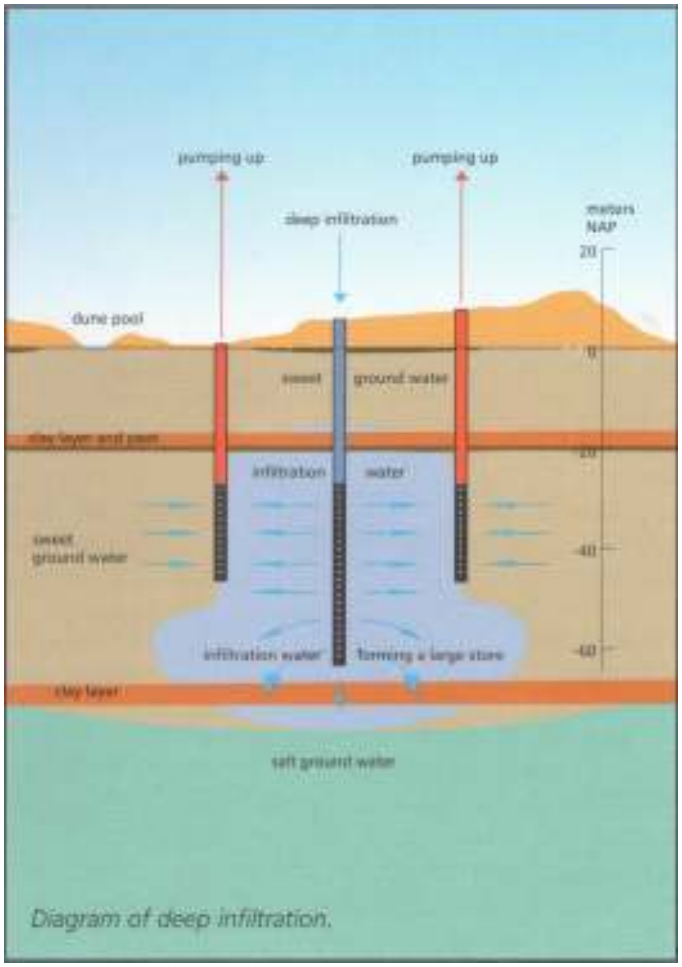

Figure 6: Diagram of deep well infiltration © Dunea

Today, 'deep well infiltration' pumps pump precipitation quality water in and extract it at the same deep level, leaving groundwater and slacks unaffected. Management is encouraging the return of characteristic vegetation, but the landscape managers are striving to recreate existed under very different conditions when geomorphological and hydrological processes were still driving dune formation. Wet slacks are still comparatively rare and sand mobility is low (Van der Meulen et al., 2004) because humans have influenced and altered the geomorphology and hydrology. Remobilisation of areas including the foredune is desirable, and finding a way to deliver drinking water production over a smaller area would provide the space needed for mobility and an increase in natural values. It is clear this is an area which provides many ecosystem services, and in this respect the nature management which takes place can be seen as an activity which compensates for the decrease in natural values and processes caused by other (human) activities. The drinking water company Dunea meets the cost of this compensation which amounts to around 4% of the income earned from selling drinking water (Van der Meulen et al., 2004).

There are 3.5 million people living within 25km of Meijendel (Van der Meulen et al., 2004), meaning recreation must be carefully managed. The main problem is that cars can be taken almost to the centre of the site where a restaurant and horse riding base create overcrowding with people, horses, cars and dogs. Strict zoning of recreation allows managers to balance the needs of the nearby urban population with the need to conserve nature and produce drinking water. One third of the area is open to anyone, one third is open to permit holders and one third has no access to visitors, being a strict nature reserve (Bakker and Kramer, 1993). In this way, those who seek peace and solitude can access quieter areas away from those enjoying casual recreation. Better opportunities for combining nature conservation with recreation have been realised through zoning which allows visitors who enjoy natural landscapes to access them, while others utilise facilities and paths in the main recreation areas. Whereas previously drinking water production areas have been off limits to visitors, some areas are now part of the recreation landscape. This approach has worked well because visitors appreciate the artificial recharge lakes used for infiltration, and while they are excellent habitats for birds, where 100 species breed, they do not benefit characteristic dune species. Having nature conservation activities take place in a core area is compatible with visitor preferences. Wet boggy ground associated with dune slacks and blowing sand may be considered a nuisance for visitors and so keeping the functions separate is perhaps the best way of ensuring maximum value from both.

Left: The Meijendel dunes lies within a dense metropolitan area. Right: One of the infiltration ponds, a landscape feature visitors enjoy.

Left: Part of 50 ha remobilisation area to rejuvenate the landscape. Right: without mowing and grazing the young rejuvenated slacks would quickly be invaded by sea buckthorn and birch.

In terms of vegetation, the proportion of wood and scrub has increased in the vegetation cover during the last few decades, with Marram *Ammophila arenaria* and Small Dune Reed *Calamagrostis epigeios* dominating (Bakker and Kramer, 1993). The Meijendel dunes are known for stands of tall scrub. Sea Buckthorn *Hippophae rhamnoides* reaches 1-2m high and Hawthorn *Crataegus monogyna* with Dog Rose *Rosa canina* and Honeysuckle *Lonicera periclymenum* reaching up to 4-6m in places creating habitats favoured by breeding Nightingales *Luscinia megarhynchos*. Sea Buckthorn colonises the leeward face of fore dunes and its nitrogen fixing properties enable Elder *Sambucus nigra* to colonise here as well (Bakker and Kramer, 1993). Tall grassland of Calamagrostis and Ammophila dominate over shorter sward species in parabolic dune valleys. This is a relic agricultural landscape, so typical farm woodland tree species are also present including Poplar *Populus nigra*, Beech *Fagus sylvatica, Elm Ulmus glabra, Oak Quercus robur, Pine Pinus sylvestris/nigra*, with Birch *Betula* spp seemingly the only natural climax species (Bakker and Kramer, 1993). Grazing using mainly ponies and cattle to influence scrub development began in 1990 at a density of 1 animal per 15 ha (Bakker and Kramer, 1993). It is thought that the grazing may not be able to significantly influence the proportion of scrub and woodland, but transition zones between grassland and scrub will be made more complex creating a greater diversity of habitats to support more characteristic species.

Conclusion

Over five days of site visits a variety of issues were encountered and the complexities of sustainable dune management were examined. The sites had differing priorities including sea defence, drinking water production and recreation. Each of these demands had to be balanced with nature conservation and in some cases restoration of the dynamic nature of the coast. It is difficult to predict with any certainty what the future dune landscape of the Netherlands will look like given the variables of population, climate change and economic uncertainty. The current objective is, where possible, to create sustainable coasts which are able to respond freely to future changes through their dynamic nature. Investment in the coast over the coming years is designed to prevent another flood disaster and to ‘future proof’ the Netherlands. The Dutch have overcome so many obstacles to build a prosperous country in the most unlikely of places, but the next challenge of sand and sea now awaits them.

References

Arens, S. M. and Geelen, L. (2006) Dune landscape rejuvenation by intended destabilisation in the Amsterdam Water Supply Dunes. *Journal of Coastal Research*, **22**: (5) 1094-1107.

Arens, S.M. (2004) Mobility of a remobilised parabolic dune in Kennemerland, the Netherlands. *Geomorphology*, **59**: 175–188.

Bakker, C., de Graaf, H. F., Ernst, W. H. and van Bodegom, P. M. (2005) Does the seed bank contribute to the restoration of species-rich vegetation in wet dune slacks? *Applied Vegetation Science* **8**: 39-48.

Bakker, T. and Kramer, R. (1993) Coastline special: Meijendel, a dune area in a densely populated part of the Netherlands. Coastline **3**: 14–24.

Beekelaar, W. and Geelen, L. (1999) Management plan 2000 – 2010; new issues in the Amsterdam Waterwork Dunes. In: Rabski, K. (ed) *Connecting Science and Management in the Coastal Zone. Proceedings of the 7th EUCC International Conference Coastlines '99*. EUCC, Poland.

CIESIN (Center for International Earth Science Information Network), Columbia University, (2006) Low Elevation Coastal Zone (LECZ) Urban-Rural Estimates, Global Rural-Urban Mapping Project (GRUMP), Alpha Version. Palisades, NY: Socioeconomic Data and Applications Center (SEDAC), Columbia University. [online]
Available at http://sedac.ciesin.columbia.edu/gpw/lecz. [Accessed 12/09/10]

Delta Committee (2008) *Working together with water. A living land builds for its future: Findings of the Deltacommissie 2008 summary and conclusions*. [online]
Available at: http://www.deltacommissie.com/en/advies [Accessed 05/08/10].

Doody, J.P. (ed) (2008) Sand Dune Inventory of Europe, 2nd Edition. National Coastal Consultants and EUCC - The Coastal Union, in association with the IGU Coastal Commission.
DOSBOUW (De Oosterschelde Stormvloedkering Bouwcombinatie) (1987) *The Storm Surge Barrier in the Eastern Scheldt*. DOSBOUW, Netherlands.

European Commission (2010) *Building Rurban Relationships*. [online] Available at: http://ec.europa.eu/research/agriculture/projects/qlrt_2001_01696_en.htm [Accessed 11/08/10].

European Commission (2009a) *The economics of climate change adaptation in EU coastal areas – Country Overview and Assessment, the Netherlands. Luxembourg: Office for Official Publications of the European Communities*. [online] Available at: http://ec.europa.eu/maritimeaffairs/climate_change/netherlands_en.pdf [Accessed 30/08/10].

European Commission (2009b) *Atlantic Region Reference List*. [online] Available at: http://ec.europa.eu/environment/nature/natura2000/sites_hab/biogeog_regions/index_en.htm#atlantic [Accessed 25/01/10].

Geel, L. (2009) *National Park Zuid Kennemerland*. [online] Available at:
http://www.np-zuidkennemerland.nl/documents/documents/ab6ad2.pdf [Accessed 30/08/10].

Houston, J.A. and Edmondson, S.E. (2010) *Report of the Study Tour of the Netherlands, 9-13 February 2009*. Sand Dune and Shingle Network: Occasional Paper No. 2 Liverpool Hope University Press.

Kabat, P., Fresco L.O., Stive M.J.F., Veerman C.P., Van Alphen J.S.J., Parmet B.W.A.H., Hazeleger W. & Katsman C.A. (2009) Dutch Coasts in Transition. *Nature Geoscience*, **2**: (7) 450-452.

Isle of Wight Council (2005) *A Case Study Documenting Coastal Monitoring and Modelling Techniques in the Netherlands*. [online] Available at:
http://www.interreg-messina.org/documents/Component%202/MESSINA%20-%20Component%202%20-%20Case-Study%20-%20Netherlands.pdf [Accessed 11/10/10].

McGranahan, G., Balk, D. and Anderson, B. (2007) The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment and Urbanization*, **19**: (1) 17-37.

MinLNV (Ministry of Agriculture, Nature and Food Quality) (2011) *Nature Conservation in the Netherlands*. [online] Available at: http://english.minlnv.nl/portal/page?_pageid=116,1640408&_dad=portal&_schema=PORTAL&p_document_id=111079&p_node_id=10076648&p_mode= [Accessed, 30/09/10].

MinLNV (2006a) *Natura 2000 targets document Summary*. [online] Available at: http://english.minlnv.nl/portal/page?_pageid=116,1640360&_dad=portal&_schema=PORTAL&p_file_id=19683 [Accessed 09/12/10].

MinLNV (2006b) *15 Years of Life-Nature Europe's contribution to Natura 2000 in the Netherlands*. [online] Available at: http://english.minlnv.nl/portal/page?_pageid=116,1640360&_dad=portal&_schema=PORTAL&p_file_id=18430 [Accessed, 30/09/10].

MinLNV (2005) *Nature Conservation in the Netherlands*. [online] Available at: http://english.minlnv.nl/portal/page?_pageid=116,1640360&_dad=portal&_schema=PORTAL&p_file_id=21686 [Accessed, 30/09/10].

Muys, B., Maddelein, D. and Lust, N. (1993) Ecology, practice and policy of black cherry *Prunus serotina* (Ehrh.) management in Belgium. In: Gjerstad, D. H. (ed) *Procedures of the International Conference on Forest Vegetation Management-Ecology, practice and policy*, Auburn University 86-93.

Natuurmonumenten (2010) *De Kwade Hoek*. [online] Available at: http://www.natuurmonumenten.nl/content/natuurgebied/duinen-van-goeree/de-kwade-hoek [Accessed 21/08/10].

Overbeek, G. and Vader, J. (2003) Urban pressure and rural land use. XX *Congress of the European Society for Rural Sociology.* Sligo, Ireland 18-22 August 2003.

Rijkswaterstaat (2007) *Because the Dutch Love their Coast*. Rijkswaterstaat, The Hague. [online] Available at: http://www.rijkswaterstaat.nl/images/Engelstalige%20brochure%20Because%20the%20Dutch%20love%20their%20coast_tcm174-187935.pdf [Accessed 30/06/10].

Rijkswaterstaat (1977) *The Netherlands, a Wet Country Short of Water*. Rijkswaterstaat, The Hague.

Staatsbosbeheer (2010a) *Schouwen Duiveland*. [online] Available at: http://www.staatsbosbeheer.nl/Natuurgebieden/Schouwen%20Duiveland.aspx [Accessed 12/08/10].

Staatsbosbeheer (2010b). *LIFE Dunes Report on five years of dune restoration in the Netherlands.* Groningen: Staatsbosbeheer. [online] Available at: http://www.staatsbosbeheer.nl/Nieuws%20en%20achtergronden/Dossiers/LIFE%20Nature/~/media/00%20PDF/Actueel/Dossiers/LIFE/Publieksrapport_EN.ashx [Accessed 18/01/11] .

Taal, M., Mulder, J., Cleveringa, J. and Dunsbergen, D. (2006) *15 years of coastal management in the Netherlands, Policy; Implementation and Knowledge Framework*, Rijkswaterstaat, National Institute for Coastal and Marine Management/RIKZ. [online]
Available at: http://www.safecoast.org/editor/databank/File/15%20YEARS%20OF%20

COASTAL%20MANAGEMENT%20IN%20THE%20NETHERLANDS.pdf [Accessed 30/08/10].
Turnhout, E., Van Bommel, S. and Aarts, N. (2010) How participation creates citizens: participatory governance as performative practice. *Ecology and Society*, **15**: (4) 26.

Van der Meulen, F., Bakker, T. and Houston, J. A. (2004) The Costs of Our Coasts: Examples of Dynamic Dune Management from Western Europe. In: Martinez. M. L. and Psuty, N. P. (eds) *Coastal Dunes, Ecology and Conservation*. 259 – 277.

Van Haperen, A. (2010) Ecology and management of the inner dunes in the Southwest Netherlands. In: Dewulf, E., van Nieuwenhuyse, H. And Herrier, J. -L. (eds) *International workshop on the Management of Dune Polder and Dune Marshland Transition Zones 1st, Knokke-Heist, Belgium, 7th October 2010*.

Van Veen, M.P., ten Brink, B.J.E., Braat, L.C. and Melman, Th.C.P. (2008) *Halting biodiversity loss in the Netherlands: Evaluation of progress*. PBL (Netherlands Environmental Assessment Agency). [online] Available at:
http://www.pbl.nl/en/publications/2008/Halting-biodiversity-loss-in-the-Netherlands
[Accessed 12/01/11].

Verstrael T.J. (1996) Research on breeding birds in Dutch dune areas. *Landscape and Urban Planning*, **34**: (3-4) 301-313.

Webb, J.R., Drewitt, A.L., and Measures, G.H. (2010) *Managing for species: Integrating the needs of England's priority species into habitat management. Part 1 Report. Natural England Research Reports, Number 024*. Natural England, London.
Available at: http://naturalengland.etraderstores.com/NaturalEnglandShop/NERR024 [Accessed 17/01/11].

Weeda E.J. (2010) The role of archaeophytes and neophytes in the Dutch coastal dunes. *Journal Coast Conservation*, **14**: 75–79.

Wesselink, A.J. (2007) Flood safety in the Netherlands: The Dutch response to Hurricane Katrina. *Technology in Society*, **29**: (20) 239-247.

Waternet (2010). *Project Zilk*. [online] Available at: http://www.waternet.nl/werk_in_uitvoering/projecten_van/de_projecten/project_de_zilk [Accessed 19/08/10].

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