

International Workshop on Management of Coastal Dunes and Sandy Beaches

12 to 14 June 2018 – Dunkirk (FR)



Report of Sessions and Excursions



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LIFE+FLANDRE - Flemish And North French Dunes Restoration

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Colophon

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Report of sessions and excursions

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Opening Session



Welcome by **Edmond Abi Aad** (1st vice-president of the University of Littoral-Opal Coast)

A brief introduction is given by **Dries Gorissen** (director of Areas-based operations, Agency for Nature and Forests (ANB), Flemish Region) about the importance of the LIFE programme for the implementation of the Natura 2000 network in Flanders. Amongst the striking figures put forward are the 8 million yearly tourist visits on the Belgian coast alone, stressing the importance of sustainable management of the coast.

François Delcueille (European Commission, DG Environment, LIFE Programme Unit) stresses the importance of the LIFE+FLANDRE workshop, underlining current and upcoming trends. Positive evaluation of LIFE's activities resulted in a significant budget increase after 2020 of 60% or 2 billion euro for biodiversity projects. New tools such as the Standard Action projects and Strategic Integrated projects will be launched. Project beneficiaries will appreciate more flexibility during project implementation. Stimulating synergies with other funds (Interreg, Rural Development) is expected to raise financing opportunities. Feedback on the Future LIFE programme has to be sent to the respective national ministries (national contact points). → [To the presentation](#)

Michéal O' Briain (European Commission, DG Environment, Nature Protection Unit) presents the EU Action Plan for Nature, People and the Economy. He first introduces the Natura 2000 network stressing that already nearly as much as 20% of EU land and 7% of its waters have integrated these protected territories. The mid-term evaluation of the LIFE programme 2014-2020 already lead to constructive feedback on improving managements and showed financial shortages to award all selected projects. A Nature Action Plan (NAP) is formulated containing 15 actions and 100 measures spanning 2017-2019, many of them offer opportunities for the conservation and sustainable use of coastal dunes and beaches. The NAP shall strive towards halting biodiversity erosion towards 2020 while informing post-2020 EU biodiversity policy. Amongst main improvements suggested by the NAP, is an update of article 6 of the 'Habitats' Directive (92/43/EEC). Furthermore, transparency through information sharing is important, which should be translated by a better cooperation across the 9 biogeographic regions of the EU. Local engagements and youth participation call for possible initiatives such as citizen science or even bottom-up engagements. → [To the presentation](#)

François Ruyschaert (Ministry of Ecological and Solidarity Transition, France) presents "The Importance of the LIFE programme in France for public policy supporting biodiversity and sustainable management of the coast". He explains that France's legal biodiversity context follows: the Stratégie Nationale pour la Biodiversité (SNB), the United Nations' Convention on Biodiversity (UNCBD) and the EU's 2020 Biodiversity Strategy. He underlines the creation of France's Biodiversity Agency (AFB) in 2016. Mr Ruyschaert also refers to the sixth massive species extinction currently ongoing: the recent disappearance of 50% of species and 60% of habitats is described as a man-caused extinction called the Anthropocene, with the highest rate of extinction in 65 million year. Amongst the many causes thereof is climate change. → [To the presentation](#)

Dries Gorissen (Agentschap voor Natuur en Bos (ANB), Flemish Region) on "The importance of LIFE for the implementation of NATURA 2000 in Flanders." The presentation first puts LIFE and Natura 2000's funding in perspective comparing these to other local ones of similar project budget sizes (e.g. Flanders' Fisheries, four coastal LIFE projects, and other partnerships such as LIFE+ TOGETHER, standing for the restoration of heath on the Kleine Nete river). Various methodological key principles are put forward as best practice examples, such as leverage multiplier, accelerated realization, visibility, multidisciplinary, capitalizing on results and society involvement (sociological approach). → [To the presentation](#)

John Houston (NEEMO LIFE Monitoring Unit) presents the Natura 2000 Biogeographical Process for the Atlantic Biogeographical Region and an update of the Coastal Dune Roadmap. Coordinated conservation policies, enhanced funding and management are still required. The EU therefore introduced tools such as Prioritized Action Frameworks, LIFE Integrated Projects and the Natura 2000 Biogeographical Process. In 2016 an output of a LIFE platform meeting on coastal dunes was a networking and knowledge exchange Roadmap. Dunes are the EU habitats with the lowest ranking for “favourable conservation status”. The Atlantic biogeographic region, stretching from northwest Portugal to northwest Denmark, includes over half of the EU area of fixed dunes (*2130) and humid dune slacks (2190). Priority is therefore given to coastal dunes in the Atlantic seminars.. A particular concern is the conservation of fixed dunes with herbaceous vegetation or ‘grey dunes’ (*2130) where it is estimated that 53 % (60,000 ha) lie outside of the Natura 2000 network. → [To the presentation](#)

Loïc Gouguet (Office National des Forêts, ONF, France) on “Reconciling coastal dune protection and ecosystem conservation”. ONF’s scope is the protection of forests and sands deploying so-called soft monitoring. The key for successful protection is multifunctionality. “Reasoned” tourism played a favorable role. Recent storms showed that in many cases the dunes were not mobile enough and did not feed the beaches suitably. ONF manages 6500 hectares of non-forested dunes and expects 2500 ha of coastal dunes loss by 2100 due to climate change. Three in-situ experiments are needed to assess the impacts: one on free dune movement, one on grey dunes’ future and one to test relevant interventions. An online guide to the management of dunes and associated beaches exists: <http://www.quae.com/fr/r4895-guide-de-gestion-des-dunes-et-des-plages-associees.html>. → [To the presentation](#)

Jean-Louis Herrier (Agentschap voor Natuur en Bos (ANB), Flemish Region) and **Bénédicte Lemaire** (Département du Nord) presents “Strengthening the Natura 2000 network by cross-border cooperation”. LIFE+ FLANDRE is a cross-border project investing 4 million € in dune restoration and management. This 6,5 years project ends in 2020. The project aims at a permanent cooperation future through working on a non-binding bilateral agreement and a memorandum of understanding, in cooperation with local partners. Increasing public land ownership by the organization was necessary to avoid fragmentation. Field activities include scrub removal, the introduction of grazing management, ponds creation, limiting invasive alien species and monitoring. The mid-term report showed already a positive impact on the biodiversity. Public awareness is risen by exhibitions and an educational programme of proximity. An advisory committee supports the project. → [To the presentation](#)

Question for Loïc Gouguet: You monitored the free evolution of 5 sites. Was the sediment ecology the same or did you notice any difference?

A: The sand grain size differs from place to place. This resulted in different vegetation dynamics.

Q for Jean-Louis Herrier/ Bénédicte Lemaire: Which type of indicators could you use to monitor the socio-economic impact ?

A: Is it the impact of the project on the ecosystem or the economy? The local population is protected against a marine inundation. There is another presentation on this subject (“*The ecosystem goods and services of coastal dunes and their benefits for people and the economy. Illustrated by the socio-economic impacts of the LIFE+ FLANDRE project*” by Leo De Nocker (in parallel session 2)). The economic impact is related to the ecosystem services. The indicators that could be used are the importance on well-being and health of the local population and the state of the dunes: coastal defence against marine intrusions.

Inspiring LIFE projects



Edy Fantinato (Ca' Foscari University of Venice, Italy) presents the LIFE16 NAT/IT/000589 project – “Restoration of dune habitats in Natura 2000 sites of the Veneto coast” – REDUNE: targets and objectives”. The 2 million € project finances measures such as the restoration of natural coastal zonation (Restoration/replacement of habitats 2110/2120; Restoration and/or expansion of 2130, 2250, 2270; Reinforcement of *Stipa veneta*; Control of Invasive Alien Species (IAS) *Oenothera lutea*) and the reduction of negative human impact through fencing and awareness building. In this project, four zones in the North Adriatic coast are included, which are situated near Venice. They include many species that are listed in the habitat directive. It has no Mediterranean climate, it corresponds more to a precipitation regime of the Atlantic climate zones. Many pine species grow here and the area is under threat by tourist activities. Therefore, concrete conservation actions are required, which focus on endangered species. In the context of this project, 10 km of fencing and 1 km of boardwalks are already installed. The formulation of three guidelines are expected upon project completion: engagement of local stakeholders along a new paradigm, UAV monitoring, tour operator and stakeholder involvement.

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Q: You plan to plant trees (*pinus* species), but on which type of dunes are you planning to do this?

A: Plantations were done at the end of the fifties to consolidate the dunes. Now we plan to cut a part of the trees to open up and improve the habitat. We focus now more on shrub species to enrich the habitat. For this we start from existing plantations, in order to transform the area with a monospecific species to a more valuable habitat.

Q: What do you do about invasive alien species?

A: We take into account to what degree it is a threat to the indigenous species. Often this results in a competition to occupy space. This becomes mainly an issue in spring/first week of summertime. No competition for pollination is found.

Gundega Ulme (Carnikava Municipality, Latvia) & **Vilis Zinkevics** (Carnikava Municipality) present "CoHaBit - Coastal Habitat Conservation in Nature Park «Piejūra», Latvia. LIFE15 NAT/LV/000900". Natural Park “Piejūra” is located within the territory of three municipalities - Latvia’s capital, Riga, Carnikava Municipality and Saulkrasti Municipality. The area where the project takes place is strongly impacted by humans as excessive use of dunes habitat is also possible for recreation. This results in problems such as a huge rise in garbage, unauthorized movement of mechanized vehicles, camping and creating of fireplaces in the dunes. As there are several institutions responsible for management of Nature Park “Piejūra” and different landowners, it is hard to balance the needs of nature protection and recreation. For the municipality both of these issues are of major importance. The municipality describes the awareness building challenge from a sociological point of view as a balance with nature protection has to be found. The Nature Management plan and Visitor management plan needs updating to account for the evolving challenges. Coastal dune protection activities include children awareness building, volunteering work and expert meetings. It is important to involve the local society in this project in order to ensure support to project activities and sustainability of the project results.

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Jose Ignacio Alonso Felpete & Elena Fernández Iglesias (Universidad de Oviedo-Indurot) on “Prioritizing the conservation of coastal dunes in Northern Spain”. There are differences within the Atlantic biogeographic region. Northern Spain has 85 river systems, many cliffs and small dune areas. Only 287 ha remain natural with an estimated 38% of original dunes already lost. Most of the 1150 ha remaining are disturbed. Given these trends and dunes retreating between 2006 and 2014, conservation is not sufficient, restoration should be the target. LIFE+ ARCOS aims at protecting northern Spain’s dunes, and focuses 10 areas in 3 regions: Asturias, Cantabria and País Vasco. Given local trends, these dunes should be prioritized while developing coastal dunes protection programs for the Atlantic biogeographic region. There are some problems with pine trees and invasive alien species. Singular actions aimed are non-structural species, seed collection/conservation and the integration of river systems. Some fencing is set-up in order to protect these dunes from people.

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Q: Do you have problems with invasive species?

A: In the North of Spain, they do not invade the dunes but the estuary areas. In the project, we are not focusing on eliminating these species.

Q: How do you see the balance between restoration and conservation?

A: In the North of Spain, we do not have habitats with a few amount of species that characterize the dune. Therefore we cannot talk about conservation. To reach enough ‘wildness’, we need to restore prior to conserve. Therefore, we invest in restoration instead of conservation.

Nadia Sanz Casas, Eric Girard & Etienne Dubaille (Conservatoire du Littoral, France) present “LIFE Adapto: ten approaches to flexible management of the shoreline “. The project spans 2015-2021 with LIFE funding of 6 million € for 2018-2021. Ten demonstrative sites across European France and its overseas territories are studied for the program. It studies nature-based adaptation to climate change and uses an interdisciplinary approach focusing on landscapes with the objective of formulating quality territories creation methods through experience and land purchase.

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Q: In the LIFE Adapto project, there is a budget exceeding 6 million €. What do you expect as output for this project?

A: We aim to find solutions that can work for the 10 sites that are targeted in the project as representative areas. The goal is thus to find methods that can be used in other areas. Therefore, we use an experimental approach. Some restoration work will be included as well in the project. Furthermore, part of the budget will be used for land purchases, in order to allow the Conservatoire du Littoral to become owner of the land.

SESSION 1

Climate change & coastal dynamics



The keynote lecture is given by Professor **Marie-Hélène Ruz**, one of the best French specialists in coastal dynamics, coastal dune geomorphology and dynamics, and aeolian sediment transport. Since 1996, she has been Professor of Physical Geography at the University Littoral-Côte d'Opale in Dunkirk. Prior to that, she spent 6 years in Canada at Laval University in Quebec City. She has published more than 50 articles in major international journals (Marine Geology, Journal of Coastal Research, Journal of Coastal Conservation, Special Publications of the Geological Society of London, Geomorphology, Aeolian Research, Géomorphologie, Relief, Processus, Environnement). Unfortunately, she is unable to join us today. Her lecture is presented in English by Professor Arnaud Héquette on her behalf, under the title "Coastal dunes response to climate change: the geomorphologist's viewpoint".

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Arnaud Héquette reminds us that coastal dunes are found everywhere in the world, in all climatic zones, from the Arctic to the tropics. Coastal dunes play a fundamental role as a stock of sand available for beaches. M-H Ruz stressed that the shoreline's response to sea level rise is not linear. In the short term, the effect of storms is important and climate change should induce greater storminess, but the shoreline's response differs from place to place depending on local environmental conditions. The response is not always coastal erosion. In some cases, there is stability and even an advance of the coastline. One of the most important (but often underestimated) factors to consider is sediment supply. However, human intervention can seriously disrupt the sediment budget. This explains why, in a similar coastal area subject to the same hydro-meteorological conditions, the mobility of the coastline is characterized by contrasting patterns. This is the case along the shoreline east of Dunkirk (see the 2 excursions of the workshop). Moreover, in the context of climate change, many parameters remain unknown: for example what will become of the dune vegetation's further development?

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Q: Will there be changes in sediment inputs in the context of climate change?

A: On the Opal Coast, the sediment supply from the rivers is extremely low, while the offshore stocks (nearshore and offshore) are very important and do not depend on the climate.

Q: Should we pay attention to sand removal from the seabed?

A: "Reasonable" withdrawals in the Channel/North Sea would not lead to any consequences ... but they should not concern industrial needs! When sand is turned into concrete, it is lost for the coastal system, which is not the case for beach nourishments.

The next two presentations concern examples of dune restoration with the purpose of adapting to climate change.

Julie Creer works for Natural Resources Wales as their Coastal Ecologist. She has had this role for 4 years. Previously she was a Natura 2000 monitoring ecologist for the Countryside Council for Wales (now part of NRW) for 13 years. She talks about "the restoration of sand drift dynamics in Wales; from preservation to conservation". Dune mobility and dune stability drivers were discussed and current climatic conditions are actively encouraging dune stability and the loss of bare sand between 1940 and 2018, 86% of the bare sand surface became vegetated. Some species typical of early succession dunes have disappeared (*Meesia uliginosa* and *Bryum calophyllum*); *Liparis loeselii* was on the verge of extinction; Coleoptera such as *Broscus cephalotes* is now restricted to the coastal margin even though it was once present in the inner dunes. NRW considers 10 to 15% of bare sand surface to be the minimum required to preserve natural dune heritage. According to Houston and Dargie (2010),

climate change is unlikely to reverse dune stabilization. On 3 Welsh dune sites, experiments of dune slack rejuvenation and frontal dune remobilization have made it possible for us to reactivate natural processes and restore pioneer habitats and species. Following dune slack scraping, the population of *Liparis loeselii* has gone from 44 plants in 2014 to 1016 plants in 2017 and the results of invertebrate monitoring are good. Encouraging public access can also contribute to the reactivation of aeolian dynamics.

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Q: After decades of public channelization in protected areas, this is a radical change... but the trouble caused by dogs often force us to continue with the process of public channelization.

A: Each site is a specific case.

Q: How long do you think the new dune mobility will last?

A: I am unable to answer that as it depends on so many environmental factors, however, we are monitoring our sites and the dune mobility depends on how well we harness the wind.

Q: On your poster you indicated that you wish to reintroduce rabbits.

A: Yes, our plan is to release rabbits in prepared areas after they have been vaccinated.

Luc Geelen works for Waternet, the water company of the municipality of Amsterdam. Waternet manages 34 km² of dune reserve in the "The Amsterdam Dunes". Luc works at the nature management department of the company and he introduced us to a LIFE+ dune restoration project (LIFE11NAT/NL/000776). Every year, more than 1,000,000 people visit the Zandvoort dunes. Some of this dune area is open to those who purchase a ticket. Large scale restoration measures were needed to reverse the long term effects of dehydration, eutrophication and encroachment of the invasive alien species, *Prunus serotina*. Sod cutting allows to export the organic matter, the whole root system and seedbank of *Prunus serotina*. Grazing with a herd of sheep was introduced as aftercare management. Creating blowout features and mosaic management had a positive effect on fixed dune grasslands. 70 ponds are restored as well, with a positive response of *large white-faced darter* (*Leucorrhinia dubia*, a dragonfly) and *natterjack toad* (*Epidalea calamita*). In 2008, 200 ha were covered with *Prunus serotina*, compared to 2.5 ha in 2016. A large population of *fallow deer* prevent the optimal development of scrubbed dunes. The scheme below summarizes the conceptual model of stability and mobility in the Dutch dunes, + and – indicate trends in last decades:

Stability: temperature +, rainfall +, beach nourishment +, fragmentation +, plantation +, nutrients +, soil development +, vegetation succession +,

Mobility: storm activity -, coastal erosion-, summer droughts ?, plants diseases ?, recreation +/-, wood gathering--, rabbits --, overgrazing -

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Q: Is grazing a permanent or temporary management?

A: We re-introduced Cattle and Sheep grazing in 1985. We now stopped grazing because of the increasing population of fallow deer (more than one animal per ha) which causes an overgrazed situation.

Hon Chim Chiu is the fourth speaker of this session. He is a lecturer at the Department of Geography of Hong Kong Baptist University. As a physical geographer, he specializes in modern and relict shoreline systems. His current research focuses on the geomorphological response to extreme events along urban coasts. His talk concerns "Beach recovery processes in urban beach systems: a study in Hong Kong after an extreme storm event".

It concerns the effects of several typhoons, especially the Hato Typhoon that struck Hong Kong in August 2017 (strong winds at 130 km/h to 193 km/h - with high spring tide). The sea level rose to 3.57m (with an extra 1m due to the cumulative effects of the typhoon and a high equinox tide). However, on all the different types of beaches, the topographic monitoring revealed a sand replenishment of the upper beach (around one meter) during the following winter, a result in contradiction with the literature affirmations. The dune vegetation plays an important part in the process of replenishment. A dune forming in winter on two studied beaches proves that the most artificial urban beaches are able to recover and that it is important to consider natural processes in order to manage urban coasts. But we do not know what the effects of climate change will be if storms are more strong and frequent.

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Q: What is the source of sediments?

A: Mainly the active erosion of nearby cliffs.

Q: Do you find foredunes? - **A:** No

Q: Can the sea reach the wooded dune in a normal climate? - **A:** No

SESSION 2

Ecosystem services
from dunes and beaches

Leo de Nocker (VITO) & Katrien Van der Biest (UA): *“The ecosystem goods and services (EGS) of coastal dunes and their benefits for people and the economy.”* The ECOPLAN toolbox allows to fine-tune coastal ecosystems’ EGS. Estimating EGS includes EGS identification, EGS quantification and EGS valuation in monetary terms. Impacts are best evaluated by identifying threats and opportunities and by highlighting the importance of the EGS at stake. EGS are quantified monetarily by multiplying the EGS indicator by its monetary value. Services concerned (and their indicators) are climate regulation (weighted carbon offset), water quality regulation (nitrate ground leakage), water provisioning (volumes), recreation (visitors), flood prevention (sand deposition) and air quality (atmospheric particulate matter - PM). Ecosystem service value is higher in wet and young nature types, which motivates measures to restore slacks and marram grass. Flooding protection results in high monetary values. Restoration make dunes more resilient to sea level rise. Economic values of dunes before restoration range between 6000 and 20 000 €/ha/year. Benefits after restoration remain to be evaluated. In general, the increase in EGS economic value within Natura 2000 habitats after restoration is limited. To conclude, the expected effects of restoration on monetary values of ecosystem services would be relatively small. → [To the presentation](#)

Katrien Van der Biest et al. on *“Ecosystem vision for the Belgian coastal zone”*. The Belgian coast has a high biodiversity and faces evolving challenges. Both are calling for a (new) long-term vision. Ecosystems function through ecosystem services (ES), biodiversity and their interaction. A rationale for ecosystem vision is developed, followed by a selection of key processes. Habitats and ES are selected through their underlying ecological and anthropogenic processes. Services are summarized through an impact score of the intensity of the relationship between ecological and anthropogenic processes. This summary prioritises ecological processes based on a stakeholders census and a scientific consultation. A priority score is designed. Multiplying impact by priority score and summing the product per process yields weighted sums for ES and habitat. Plotted in a graph, the results produce guidance for the definition of key targets (11) and clusters some processes. These targets are presented in the face of two coastal defence strategies namely, to “retreat the (coastal) line”, or to “advance the line”. Clear representation of how processes support multiple benefits allows to find common ground between seemingly disconnected goals and supports the development of multifunctional, nature-based alternatives. Stakeholder involvement allows for a shared vision based on ecosystem functioning knowledge. → [To the presentation](#)

Myrthe Fonck: *“Nature conservation and drinking water production: mutual benefits of an ecosystem service”* (PWN, Netherlands). PWN exploits two coastal dunes reserves for producing drinking water for a million households close to Amsterdam. Dunes’ fresh water lenses, lying on saltwater and replenished with about 1 m/year (change in water level), are exploited benefiting from the ES (ecosystem service) “direct filtration”. Growing extraction following growing demands lead to dehydration and salinization. Nowadays, we make use of water from the IJssel lake that we infiltrate in the dune system for biological purification. So the dunes are only used as a step in the purification process, there is almost no net extraction of groundwater. However the dune groundwater is still an important storage of fresh water, that can be used in case of emergencies (for example pollution of the IJssel lake). For society, dunes improve biological stability, guarantee availability, protect sources, buffer these in times of crisis and offer natural quality consumers appreciate. For nature, dunes get protected from urbanization and mass recreation, are guaranteed a sustainable co-existence, infiltration areas are appreciated by visitors and birds and funding of nature conservation is continuous. Co-existence of both interests is successful thanks to the ecological optimization of infiltration areas which cover only 5% of reserves, the absence of work on installations during breeding season, a nature conservation plan, ranger patrols and avoiding ground water extraction as

much as possible. Future challenges as climate change are ever more pressurizing strategic reserves, new pollutants such as micro-plastics are increasingly challenging purification techniques and whether the wetting of inner dunes is a threat or opportunity is not yet clearly defined. → [To the presentation](#)

Daphné Thoon MDK Coastal Division of Vlaanderen MOW: coastal safety) "*Ecosystem services provided by coastal dunes and sandy beaches: Coastal Safety – case studies in Flanders*". Flanders' coast is densely populated with 85% of the polders below storm water level. The type of coastal defence measure depends on the location: harbours, dunes and beaches. The last storm surge that caused major floodings was the storm surge of 1953. After 1953 Coastal defence measures were taken, however they were always on a small, local scale. The Coastal Safety Masterplan, which has been approved by the Flemish Government in 2011, was the first plan that considered the flood risk in a larger scale: the entire coast of Flanders. In 2007 the first studies of the Coastal Safety Masterplan were started: Safety was assessed, and risks calculated. The safety norm that is being used aims for zero victims in case of a one-thousand-year storm surge event. Coastal defence measures were proposed for each weak coastal link that has been identified during those studies. The measures can be divided in 2 types: 'soft' measures, such as beach nourishments, and 'hard' measures such as sea and quay walls, storm wall, reinforcement of locks and weirs, storm surge barrier and stilling wave basins. The cost of the measures of the Coastal safety Masterplan is estimated on 300 million €. The design of the defence measures takes into consideration a sea level rise of at least 30 cm till 2050. A part of the proposed measures such as beach nourishments and the construction of storm walls are already implemented. The other measures are being designed or constructed at the moment. Topobathymetry monitoring occurs twice a year and a detailed safety assessment occurs every six years. The last safety assessment (2015) showed that breaching of dunes or seawalls is prevented by the measures of the Coastal Safety Masterplan that were taken. Beaches and dunes have also other functions besides providing flood protection: in a specific area of Oostende, Mariakerke and Raversijde, new dunes with Marram grass in boxes of brushwood will be created to reduce excessive eolian sand transport. In the town of Middelkerke a new green flood defence system in front of the existing seawall is being designed. This will also create an added recreational value. → [To the presentation](#)

Question for Leo de Nocker and Katrien Van der Biest: Do dunes' ES require jurisdictional protection?

A: In Belgium, dunes are protected legally under the Flemish law. Whether other national/regional laws provide for such legal protection remains to be answered per project case. All the while, some deem that reinforcing dunes' legal protection does not constitute a genuine opportunity.

Questions for Daphné Toon and Peter Van Besien

Q: Is there an interest to strategically retreat the tramway between La Panne and Oostende to avoid having to manage the sand drift on the rails?

A: There would be no interest to do so.

Q: What's the life expectancy of buildings considered? Would it be an option – over time – to move the tramway behind the houses and let nature recreate the dunes.

A: The life expectancy of houses is 50 years on average, but there are many exceptions. Moving the tramway would be difficult: there are many stakeholders (on a small area along the coastline), rather than a political discussion.

Q: The solutions that are proposed at the moment are short term. How can we discuss with stakeholders to let them see the importance of long term solutions.

A: Coastal safety is foreseen till 2050. If there are larger deviations, big issues will arise. No plans are foreseen at the moment to protect the coast in a sustainable way for 2100.

Q: What is a wasting basin?

A: It is an additional warding of the seawall which is lower than the sea wall itself. It breaks water before walls are hit. It is made of concrete. In French, it is called: “Basin de dissipation des vagues”.

Questions for Leo de Nocker and Katrien Van der Biest:

Q: Are there values usable to estimate dunes' EGS?

A: Local conditions (e.g. soil conditions) should be considered while quantifying dunes' ES' values in other locations. A tool has been developed to be used in spatial planning. The numbers are expressed in euro/ha/year.

Q: Does it imply that high land reclamation and tourism would be profitable?

A: Tourism and land growth are not considered in the model developed at the University of Antwerp. Attracting people has limits, which means that this variable is not a direct multiplier. Some interventions are interesting to have more effect, others are less interesting.

Q: Would it be interesting to build a hotel in the context of these calculations?

A: You could look how to use 20 000 ha to maximize its profits, but you have to be careful to do this. You need to talk to local stakeholders as they are not always aware of nature in the local area. Furthermore, politicians do not recognize importance of nature in tourism

Q: When quantifying the EGS – especially when considering the socio-ecological cycle – do you have any example where quantification has led to an alternative management of an area?

A: Yes, for example with work that has been done at the river Scheldt: land (which was previously agricultural) has been given back to the river. Mainly the tool is interesting to be used as an eye opener. However, we need to look at the bigger picture (policies); we cannot solve everything with EGS.

Q: How did the value of the ES of carbon offsetting by dunes get estimated?

A: It corresponds to social costs not to any carbon credit market value such as those of the European ETS. Our value of 200 euro/ton is at least 10 times higher than the ETS market value. This is not a real market; it is linked to the costs we as a society would have to make sure that the temperature would not increase more than 2 degrees (alternative to isolating houses, etc.).

Question for Myrthe Fonck: Dunes are still present in the Netherlands because these are used for drinking water. How long back does the long-term vision date? How did it emerge?

A: The combination of functions such as coastal protection was already important historically. So, the long-term vision is relatively old and probably first emerged from coastal safety considerations.

SESSION 3

Spatial fragmentation and ecological connectivity



Theo Van der Sluis and Thomas Haynes (Wageningen Environmental Research, Nature Bureau/Biogeographical Process); *Ecological networks for improved landscape connectivity – examples for coastal dunes*. In the past, human impact was limited. Urbanization and transport infrastructures development result in reduced and fragmented habitats. As natural areas are fragmented, the populations of some species are reduced to isolated small groups and biodiversity decreases. The connectivity depends on the mobility of a species and the type of the available habitat and its configuration in the landscape. Within a coherent ecological network, corridors are very important because they facilitate biological processes such as dispersal, migration or the regular movement of animals. During the development of corridors, it is important to take into account the individual requirements of species. It is also necessary to have connectivity between habitats of the same type (forest with forest, wetland with wetland...). The different species require ecological networks at different scales (small network or large area). The concept of ecological networks was officially recognized in Europe as an important approach for biodiversity conservation in the Pan-European Biological and Landscape Diversity Strategy (PEBLDS). The PEBLDS was endorsed in 1995 by 55 States and called for the development of the Pan-European Ecological Network (PEEN). The Habitat Directive of the European Union (1992) acknowledges in Article 10 the importance of landscape elements that enhance connectivity (corridors). Whilst building the EU ecological network Natura 2000, the Directive encourages member states to include those landscape elements in their land-use planning and development policies.

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Q: Which type of connectivity for the coastal dunes (isolation, fragmentation)? What are the opportunities?

A: There are two different scales of connection that depend on the size of the species and their habitats. On one side at micro scale, there is a local network and there is a good mapping (UAV are useful). At a macro scale, connectivity works as a stepping stone approach (for sand pipers for instance).

Q: Which connectivity alongside the coast? What about natural processes, sand drift from one dune site to another ?

A: Focus of the studies is concentrated much more on the species than on dynamics and processes.

Thomas Haynes (Wageningen Environmental Research, Nature Bureau/Biogeographical Process, Nature Bureau); *Use of drones for mapping*. It is interesting to use UAV technology in studies about dunes and connectivity for different reasons: small and fragmented conservation sites, desire to restore large areas to a wild state, increase awareness of ecosystem services, connecting people and wild life, climate change adaptation. In recent years, the availability of UAV technology (Unmanned Aerial Vehicles) has increased (UAV used for larger areas, UAV stable to take photography). The UAV technology provides data of high precision, geo-referenced photos, with automation, speed, cost effective. Different UAV exist for various applications. Numerous projects have already used UAV technology: classification of sand dune vegetation, coastal dune mapping (Ex: Dunster Beach, Somerset, UK).

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Q: Is there a risk of disturbing the birds?

A: It may be a problem during nesting season, essentially with loud drones.

Jean-Louis Herrier et al. (Agency of Nature and Forest of the Flemish government), *Possibilities to restore ecological connections between dune sites in the spatially fragmented coastal dune belt of Flanders*. Flanders coast is highly urbanized. A comparison between two topographic maps 1860/2006 (Oostduinkerke, Belgium) shows the transformation from a desert to an urbanized coast due to the development of seaside resorts. Therefore, the dune system (included in the Natura 2000 network) is spatially fragmented. For instance, young dunes are cut through by a camping site between the “Dune du Perroquet” and the Belgian Nature Reserve “De Westhoek” (excursion guide). Built-up areas, canal and roads impede migration of wild animal and plant species from one isolated dune site to another. The populations of non-flying animal species and plant species with seeds not dispersed by wind or by birds, have gotten isolated. So there is a high risk of local extinction. Restoring connectivity is difficult even in green suburban areas. There are gardens with cultivated plants and among them invasive alien species. Beaches can be used as corridors by some animal species (e.g. Natterjack toad) but beaches in front of seaside resorts are kept clean by mechanical cleaning into a bare surface which also impedes embryonic dunes development and could also prevent wild animal migration. The transition zone between dunes and polders is also a possible corridor but it is intensively used by farming. A technical obstacle for the restoration of the habitat “grey dunes” from arable fields and meadows that have been strongly fertilized are the high levels of phosphates in the soils. Several methods to get rid of the phosphates are still being subjected to scientific experiments. The first step to realize ecological connection between the different dune sites (part of Natura 2000) is to change the status of the necessary lands from agricultural or military area (when obsolete) into nature area, through spatial planning processes. The delimitation of Special Areas of Conservation should include not only areas where target species and habitats are present but also areas where these species and habitats can be developed in order to obtain a coherent and robust network.

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Q: Can we explain the problems of phosphates by domestic waste waters?

A: No, the concerned areas are no water courses but cultivated fields and dry meadows that do not get inundated by (polluted) water courses. The high level of phosphates is due to intensive fertilization of agricultural lands.

Q: Are there any solution to get rid of phosphates? Is it possible to use the phyto-remediation techniques?

A: It is possible to dig, but we cannot dig deeply because we don’t want a wetland or a polder. The aim is to obtain a grey dune. It is possible to cultivate maize without fertilizer. Maize impoverishes the soil but it takes a long time. To put in nitrogen is necessary during some years. If you don’t put nitrogen in you don’t get rid of the phosphates. The problem is that we don’t know if it works and how much time is necessary.

Benjamin Blondel (Syndicat Mixte Baie de Somme - Grand Littoral Picard); *Remarkable landscapes and natural habitats restoration in the Marquenterre coastal dunes, Northern France*. The Marquenterre is one of the largest dune fields of the Northern French coast (3,000 ha). It offers a mosaic of open or half open habitats. (Humid dune slacks, dune grasslands, thickets of Sea-buckthorn, 200 ponds...). This natural heritage is decreasing, especially since 1950 due to the fixation of the dunes, the disappearance of rabbits, lower groundwater level, forestation dynamics and the closing of environments. In 1840, there were much more humid dune slacks. At the end of the twentieth century, Sea-buckthorn (*Hippophae rhamnoides*) was dominant. For the last 20 years, projects of restoration of grasslands, dry zones and humid slacks were implemented. The Syndicat mixte Baie de Somme- Grand littoral Picard (SMBS-GLP) is in charge of the management. Actions were planned on a larger and larger scale (humid slacks and grasslands). After the works, the results show reappearance of remarkable plant communities and many species (flora: *Centaureum littorale*, *Potamogeton gramineus* and fauna : *Caprimulgus europaeus*, *Epidalea calamita*) of high value. Since 2012, soil

stripping was implemented, sometimes till bare sand, in the dune slacks. In one year (2012-2013) results were visible with new plant communities development. In the grasslands, rabbit populations reinforcement operations began. In the dry zones, after 2 years (2012-2014), high value plant communities with *Tortula ruraliformis* have developed, as well as thermophilic insect populations increased. The results are very good in the dune slacks with a good structure, a good cover of vegetation. A new project for 3 years aims to develop open habitats on 80 ha (30 ha of wetlands and 50 ha of dry grasslands) with deforestation, shrub clearing, soil stripping of dune slacks. After 2 woodchipper passages, the maintenance will be done by grazing (horses, cows or sheep according to the topography and the humidity).

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Q: Is there a patrimonial valorization of grazing by horses?

A: There is collaboration with a local equestrian center. It is a show case for a regional race (Henson)

Q: What is the impact of animal excrement? How counteract the addition of nitrogen?

A: There is no impact observed at the moment. In some areas, there is an exporting mowing to avoid nitrogen enrichment of the soils.

Q: Is there a problem with trampling?

A: It remains localized. Globally the result is positive. It is an advantage for insects and animals are not necessarily present all around the year.

Q: Is all the area managed with grazing? Are there control areas?

A: There are various possibilities. There are areas with mixed grazing, areas without grazing but with mowing and areas without grazing but with rabbits.

Els Ameloot and Carole Ampe (Vlaamse Landmaatschappij); *Grey blockhouses in grey dunes: Schuddebeurze (Flanders)*. Schuddebeurze is located east of Nieuwpoort, at 3 km of distance from the present-day coastline, and is part of the Flemish coastal dunes. During the last century this area has been extremely urbanized. Only a part of Schuddebeurze escaped from construction development, ca. 40 ha are now preserved as a nature reserve. But there is a high degree of fragmentation in Schuddebeurze and only small parts of dune remain of “la minuscule bruyère de Westende” described by Massart in 1912. A nature development project (Agency of Nature and Forests and Flemish Land Agency) was approved in 2016 and a restoration plan has been submitted to the Flemish Minister of environment for approval (2018). In this Natura 2000 site, the main aims are the restoration/redevelopment of the acidic dune grasslands (grey dunes), dune heath and dune slacks. The acidic type of grey dunes (habitat 2130) represent 18 ha (conservation goal: to increase to 39 ha), the dune heath (2150) surface less than 1 ha (goal: extension to 1 ha), the dune slacks (2190) surface less than 1 ha (goal: extension to 2 ha). Measures will be taken for threatened species: for instance, increasing the number of individuals of the Great Crested Newt (from 20 to 50 adults). Another challenge of the project is the integration of natural and cultural heritage (bunker complex). The WWII Field Battery Bamburg is a part of the Atlantic Wall and during the First World War Schuddebeurze lay at the front line. A viewing platform, consolidation works of bunkers and trenches are planned. These cultural heritage consolidation and visitor management measures, as well as some nature development measures, are planned (co-funding) within the Project “Vedette” (Interreg V France-Wallonie-Vlaanderen). The main points of this project are the development of a trans-boundary vision on recreation, an optimization of natural areas, raising awareness in target groups and showcasing good management practices.

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Q: What are the measures to redevelop the heath of Westende and the acidic dunes?

A: Mainly sod cutting and removal of the top soil (25-30 cm) to get rid of phosphates and nitrogen. It depends on the depth of nutrient enrichment.

Christine Dobroniak (Grand Port Maritime de Dunkerque); *The Natural heritage Master Plan (SDPN), a forward looking vision to protect port biodiversity (Dunkirk, France)*. Dunkirk is the third largest port in France. To conciliate economic development and environmental preservation the PA2D (Sustainable Development and Action Plan) was approved in 2014. In a Strategic Plan for the port district (2014-2018) 5 major guidelines were defined. Two of them concern the preservation of biodiversity and the strengthening of links between the stakeholders and the port. The project of Natural Heritage Master Plan (SDPN) was launched in 2011. "Dunkerque-Port" decided to move from a passive or accepted biodiversity to the management of the natural heritage. First, inventories were done (protected plant species, remarkable species of fauna, habitats) to produce a global and synthetic index of ecological value. Along the French North coast, there are small areas of high ecological interest (Natura 2000 zones, nature reserves, coastal areas of the "Conservatoire du Littoral") but without connection between them. Maps of high stakes and forthcoming development programs were realized and combined through a Geographical Information System. So it was possible to structure the port's green and blue belt. Nature sanctuaries have been defined as well as ecological corridors connecting them. It is a long-term vision for areas dedicated to nature, recreating nature areas by means of environmental engineering either from environments of strategic significance, with high potential which are protected and managed, or from degraded environments which have to be restored. The managers are the "Conseil Général du Nord" and the "Communauté Urbaine de Dunkerque".

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Q: Have you superposed aerial photos (particularly old ones) with the projects? Subsistence of former sandy substratum can be useful for drawing the corridors.

A: We did not work on the historical aspect, only on the habitat one.

Q: To develop corridors, older photos are interesting.

A: Here we are in a polder zone

Q: Did you work on specific species before the conception of corridors?

A: The studies were more on the habitats, on the landscape mosaic than on the species.

SESSION 4

Climate change & atmospheric nitrogen
deposition versus biodiversity

Mark van Til (Waternet); *Nitrogen deposition and grass encroachment in calcareous and acidic Grey Dunes (H2130) in NW Europe*. The areas receiving most nitrogen deposition, caused by traffic, industry and agriculture, are situated in the Benelux, North-western France, Denmark, Brittany and the North of Italy. Maximum deposition was reached in the Netherlands in 1990. Although nitrogen deposition is decreasing, the prediction is that in 2030 the critical load for grey dunes will still be exceeded in many Dutch coastal dune areas. It became clear that there is also a role for Ammonium evaporation due to the degradation of seaweed on beaches and tidal areas, especially in polluted water (North sea). The most important effect of nitrogen deposition is grass encroachment, which especially occurs in acidic dune grassland and can be explained by differences between calcareous and acidic grey dunes. Grass encroachment leads to a decline of characteristic grey dune species. Fortunately nitrogen is not accumulated in high amounts in the organic top soil. However, apart from eutrophication, nitrogen deposition causes an acceleration of soil acidification, which on the longer term makes also calcareous dune grasslands more vulnerable for grass encroachment. Governments should continue their efforts to diminish nitrogen deposition. Coastal dune managers should focus on decreasing the accumulation of organic matter (by using “grazing” as management tool) and increasing soil calcium content and pH (more aeolian activity).

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Mark van Til (Waternet); *Experiences with reactivation of blowouts in the Amsterdam dunes*. After a long period of stabilization until the second half of the 20th Century, aeolian dynamics have spontaneously increased in Dutch mainland calcareous dunes between 2000 and 2014. The most important reasons are the temporary explosive growth of rabbit populations, more favorable meteorological conditions due to longer drought periods and more heavy showers, causing an increase of rainwater erosion, especially on southern slopes. Blowouts affect a surrounding area of 2 to 10 times the area of the deflation zone. Close to the blowout strong sand accumulation causes a rejuvenation of soil and vegetation. Further away shallow sand accumulation contributes to base enrichment in old dune grasslands. The effects of blowouts are still significant 10 to 25 years after stabilization. In decalcified and acidic dunes there is hardly any spontaneous recovery of small scale aeolian activity, mainly caused by more severe exceedance of the critical load for nitrogen deposition, more grass encroachment and lower rabbit numbers. In those areas dune managers should promote aeolian activity by reactivating stabilized dunes and the creation of new blowouts, as was illustrated with recent examples of the Amsterdam dunes.

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Q: How do you choose the spot where to reactivate the aeolian dynamics.

A: The exposition to the prevailing wind direction is an important factor. South(-western) slopes are favorable because of sensibility for rainwater erosion. Wind obstacles in the vegetation (trees, shrubs) should be removed. Select sites for blowout reactivation where grey dunes are situated behind and will be affected by sand accumulation.

Q: Do you think blowout reactivation is a remedy against nitrogen deposition?

A: Negative effects of nitrogen deposition can definitely be tackled by promoting aeolian activity. However, acidification is still accelerated, by which vegetation succession and grass encroachment is enhanced. Besides blowouts generally do not cover a very large proportion of coastal dune areas. So, governments should continue efforts in order to diminish nitrogen emission.

Dries Bonte (department of Biology of Ghent University); *Linking the spatial organization of marram grass to dune functioning*. The study concerns the project INTERREG 2 Seas ENDURE, in a region where 70 million persons can be impacted by coastal erosion. The use of coastal dune to prevent the coastal area from marine erosion marks a change of mentality. Marram grass (*Ammophila arenaria*) is a keystone species for dune development and its biology is well documented. If the sand supply stops, the proliferation of nematodes (roundworms) affects the roots of Marram grass which can no more flower and tends to wither. The combination of positive and negative feedbacks from respectively (ceasing) Aeolian dynamics on marram grass vitality is anticipated to generate a self-organization of the grass' cover with bare sand and vegetation jointly occurring in a stable equilibrium. The ENDURE project is seeking to map this spatial organization as an indicator of foredune resilience. The authors additionally demonstrate the home-field advantage of marram grass. This implies that local genotype performs best in for instance plantations.

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Q: how do you think this equilibrium will depend on the local conditions.

A: it is expected to be driven by the net- sand influxes from the beach and local disturbance (recreation). This will be researched in the project.

Marijn Nijssen et al. (Bargeveen Foundation of the Radboud University Nijmegen); *Soil calcium levels determine effectiveness of mitigating N-deposition for fauna in coastal dunes*. Apart from chemical stress in water and wet soils, all effects of increased nitrogen deposition on fauna are indirect: cooler and moister microclimate, loss in reproductive habitat, changes in food plant quantity and quality. The Northern Wheatear (*Oenanthe oenanthe*) needs a territory of 1.5 to 4 ha with at least 1.1 ha of open vegetation to forage. 50% of preys are caught on 16% of the territory: *Anomalia dubia* on bare sand; *Phylan gibbus* in more vegetated habitat; *Melanotus punctolineatus* in scrub areas. In calcareous dunes, the invertebrate biomass is higher than in acidic dunes. Aeolian dynamics has more positive effect on invertebrate fauna in calcareous dunes. The effects of grazing have no impact on the availability of nitrogen in calcareous dunes but they have impact on microclimate diversity (patchwork of hot and cold spots). In calcareous dunes flowering is more frequent and abundant than in acidic dunes and grazing increases this trend.

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SESSION 5

Integrating nature development in coastal defence



Sierd De Vries (Faculty of Civil Engineering and Geosciences (CiTG), TU Delft). *Natural dune development and coastal defence, lessons learned at the Sand Motor mega nourishment*. The Sand Motor is situated at National park Hollandse Duinen and is the result of a mega nourishment. The main aim of the Sand Motor is to buffer erosion. Next to that it's a recreation zone and a place where nature develops. The Sand Motor does not develop as expected. There is little accumulation of sand into the dunes in comparison to other areas. Also the development of the vegetation is lagging behind. Question for discussion: Can coastal dunes be a template for nature-based engineering solutions?

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Q: You showed us monitoring from along the shore? Do you also do monitoring from sea to dune?

A: we did a lot of research on how the sediment mobilized, but it does not really mobilize. The intertidal zone is very small, so there's a small sediment supply.

Q: Are there a lot of shells in the sand?

A: Yes, they influence the size of the grains. The fine grains are mobilized after nourishment, they interact with the Aeolian system.

Q: Where does the sand come from? How is the impact on the marine habitats?

A: The sand comes from off-shore. Ecological development receives attention and is facilitated. This is proven after research done in the dredging pit.

Marieke Kuipers (PWN) **et al.** *Restoration of dynamic coastal foredunes in the Netherlands*. The highly dynamic foredunes are most interesting for research and coastal defence. PWN is making stable dunes more dynamic in different ways. At several places PWN creates blow-outs to create more dynamics and diversity and a corridor from the foredunes to the inner dunes. Another technique is to take the topsoil and vegetation away. Through this techniques coastal defence and building nature go hand in hand.

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Q: Is the state of the coastlines in front of the foredunes everywhere the same, equally vulnerable?

A: There's an increasing erosive coast in most of the cases and embryonic dunes develop because of the nourishments. The notches influence the wind if there is enough tunnelling. There has to be a balance.

Q: Would you consider to close the notches to have a better developed, less eroding coast?

A: I have no idea on the expected impacts. The Waterboard uses notches on the most weak points to strengthen the dunes.

Pieter Rauwoens (Leuven University, Department of Civil Engineering, TC Construction) **et al.** *Coastal safety in 2100: It's hard to teach engineering students the soft way*. Master students (58) civil engineering got the assignment to design a coastal defence in Blankenberge (Belgium). The first ideas were hard engineering solutions and not sustainable. After feedback from field experts, the students came up with new and softer solutions.

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Q: How long did the students work on this project?

A: They were supposed to work 90 hours/project in a period of 3 months.

Q: There was an idea of a hybrid dune above the promenade, how high is the promenade?

A: The promenade itself is at 9 metres.

Q: What did the teachers learn?

A: I learnt that we should facilitate a change in mindsets from hard engineering to soft solutions.

Q: Were they aware that the harbour of Zeebrugge is close to Blankenberge, and this harbour is a sand-sediment trap?

A: Yes, but this part was not considered in the project. There is a widening of the beach expected there. You would expect safety is no problem in Blankenberge because of this process. But it is checked and it can be problematic.

Anne-Lise Montreuil (Vrije Universiteit Brussel - VUB, Dep. of Hydrology and Hydraulic Engineering) **et al.** *Improved Understanding of Coastal Morphological Processes along the Belgian Coast*. The aim of the exercise is to determine the resilience of the Belgian beach. Two different study sites have been included: Groenendijk (natural beach) and Mariakerke (developed beach). Conclusions are that there is an opposite long-term morphological evolution for natural (positive trend) and developed/artificially nourished (negative trend) beaches, and there is a linkage between beach and shoreface sediment.

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Q: When you did beach nourishment, where did you put the sand and at which depth off-shore?

A: There were two nourishments, one at the beach and one at the shoreface, at 3 metres depth.

Q: Do you also monitor where the sand is going? Is it going to the dunes and do you study the dunes as well?

A: We monitor the foredunes, but the innerdunes are not studied. At Mariakerke the beach is separated from the dunes by the dyke and the tramtracks, it's not the case at Groenendijk.

Wietse Van De Lageweg (AnteaGroup Belgium) **et al.** *Alternative nourishment methods for the Belgian coast protection*. Antea Group is suggesting a mega-nourishment as solution for the Belgian coast, based on existing examples and literature study. It has advantages for coastal defence, nature development and recreation.

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Q: Can you elaborate on the volume change over time?

A: One average profile is used and the volume is estimated

Q: Are there other possible solutions described in the literature?

A: That's a concern I share. This model is highly simplified, I would like to integrate studies on beach-dune connection.

Q: From which volume do we talk about meganourishment?

A: Small nourishment: 1-1,5 million m³, medium: 5-6 million m³, large: 10 million m³

Q: The current research is done for a limited amount of cases?

A: Yes, this is indeed one of the big concerns. We are looking for more. The model we use now corresponds best with what we do now, but we need a more complete and complex one.

Sebastian DAN (Flanders Hydraulics Research) **et al.** *Preliminary results of a comprehensive monitoring program at the Belgian coast.* The Belgian coast has a complex morphology. The monitoring programme measured waves, marine currents and suspended sediment concentration at 8 different places along the coast. The research is ongoing and there should be results in 2019.

→ [To the presentation](#)

Q: How could we stimulate the formation of new dunes? Is there room for development from an engineering perspective?

A: This question was not answered.

SESSION 6

Management planning and monitoring

Session 6 offered six communications on the European dunes monitoring and management planning : from the Zwin to the Belgian and French Flanders cross-border dunes, Merlimont's Picardy dunes, and the Atlantic dunes of Truc Vert. The different approaches showed are divided between biomonitoring - from the pollen to the large herbivores- and geomorphological monitoring by drones of the evolution of the different changes, distortions or steadiness of the dune and the beach.

European and regional biodiversity policy, particularly in Belgium and France, supported by LIFE projects, cross-border or simply regional, comes at different scales by multiple organizations which collaborate with each other. The various organizations which have developed and treated the monitoring plans, presented in this session, are Academic laboratories (Universities of Venice, Dunkirk, Lille, Bordeaux) in collaboration with national structures (Research Institute for Nature and Forest, French National Forest Office, National Botanical Conservatory of Bailleul). As coastal dunes are fragile environments and wind, marine and biological processes cover a wide range of spatio-temporal scales, following their evolution requires a deployment of soft methods to characterize morphology and texture on relatively thin spatial scales.

Geomorphological monitoring of dune systems

Coastal dunes systems on the lower European coasts - the sedimentary supply of coastal transits and prevailing sea winds allow the accumulation of sand on the beaches - moderating marine erosion; they have generally been fixed (wooden fence, marram grass plantations, trees) in order to optimize the role of natural dike. The artificial fixation of the dune sometimes has seriously deteriorated fragile ecosystems, habitat restoration work is considered everywhere. But new issues have emerged after years of planning and monitoring. Managers and researchers suggest that the resilience of dunes to extreme events is diminished because of the reduction of the beach-dune natural exchanges.

Like the systems of Aquitaine and North regions, the dune massif of Merlimont has for several decades been the subject of geomorphological monitoring; the latter has also been the subject of a heritage classification under geomorphological title. Analysis of historical aerial photographs and recent maps of vegetation reveal radical changes in the landscape over the past century with mobile dune fixation and hydrological changes (see Session 3). Two papers dealt in particular with obtaining and monitoring high-resolution geomorphological data through drones. These are the sites of the Truc Vert peninsula and the Dunkirk coastline.

The stereophotogrammetry of drone images developed in the EPOC laboratory (*Environnements et Paléoenvironnements Océaniques et Continentaux*) is applied in combination with *in situ* measurements of vegetation dynamics. The sites and methods of experimentation are defined in consultation with the Observatoire de la Côte Aquitaine and the Office National des Forêts. Foresters will experiment with different methods of management of the dune, from active management (wooden fence, vegetation, etc.) to a soft management (*let do* - see paper L. Gouguet). The database thus collected on the response of the dune to different modes of management and to the different forcings (wind and sea) should help understand the resilience of the system to natural (storms) and anthropogenic disturbances.

The dune in the experiment is located in Aquitaine and stretches for 4 km length and 500 m width. Eight wide breaches were dug every 500 m in order to boost the sedimentary exchanges. **Q. Laporte-Fauret** explains the flight plan of the drone: *two flights with two starting points, images taken every two seconds and the photographs are gathered in a cloud of points thanks to the software. A survey of the data is carried out every three months (except during winter period) and just after the storms. If it is possible to fly, measuring the impact of each storm is important. On the field, there are GPS-based benchmarks every 250 m. The georeferencing on a map is done with an accuracy of 5 cm and there are 36 reference points.*

Airborne UAV photogrammetry complements short-term LiDAR data and reduced areas with high resolution. The high spatial resolution and the high precision assure it a real success. Experimentation on the Dunkirk coast clearly shows the embryonic dunes and the dynamics of the coastal dune.

Several questions concern the degree of precision due to the presence of vegetation. **O. Cohen** explains that since it is a digital surface model, it is not possible to see underneath this dense vegetation, whatever the vegetal cover is. Taking into account the seasonal variations of vegetation it may indeed be possible to study altitudinal variations, providing that they don't go past the margin of error of the method (no wind and vegetation movement which could disturb the measurements). It could be possible and probably easier to use suitable infrared sensors which only cost a few thousands euros (*circa* 6000 €). The vegetation's thickness engenders a problem but in this case of study, the subject was mainly the overall geomorphological issue. On bare sand areas, the measurement accuracy is about 3 cm.

The managers' point of view: ecological monitoring methods

The matter of defining the environments and so of the assimilation of the monitoring choice (Cf. Corine biotope code, etc.) has been raised several times during conferences but also on the field. For example, **F. Duhamel** asks : *How do you include the acidiphile grasslands in the 2150 (Cf. Atlantic decalcified fixed dunes (Calluno-Ulicetea), for example the Cabour domain Dune)? In France, it is taken into account only when there is really presence of heather (Calluna vulgaris).*

S. Provoost : *We have a harder reading of the code, which is already strict enough and quite absurd ; it mentions that all the grassland are included in the 2130 and that the presence or the missing of Calluna really makes a difference. It's absurd because it's about only one species ; the heather in the dunes involves a huge range of vegetation but we only use it in a strict interpretation of the 2130 grasslands (Cf. Fixed coastal dunes with herbaceous vegetation (grey dunes) - even if it is highly decalcified we need Calluna ; the presence of Calluna is essential to classify a vegetation as habitat 2150 !* In addition to the definition of vegetations, the spatial and temporal scales of monitoring require a clarification. **S. Provoost** explains, for example, that different quadrats (see protocols) are used: 1 x 1m in France and 3 x 3m in Belgium. A species-area relationship was investigated for herbaceous vegetation and scrub in Belgian dunes. Saturation of the curves was observed at about 10 m², supporting the choice for the use of 3x3 m² vegetation monitoring plots. Both in France and Belgium the decimal Londo cover scale is used for estimation of plant abundance within the plots.

Issues related to grey dune management practices including mowing are discussed. **F. Veillé** for the dunes of the Merlimont's Biological Reserve (managed by ONF) explains that the mowing is done in November because of the fragility of moss (*Tortula ruralis*) which then presents itself as a felt and would thus be less likely to be damaged than when it is dry (in summer). The experience of the Netherlands is underlined with a good success of a summer mowing while the plants have more energy. The question of comparison in an equivalent rainfall context is then recalled. **F. Veillé** plans to add a test with a summer mowing season and continue indicating that after a restoration, the area is maintained for five years, exhausting the soil and then, more intermittently. **F. Duhamel** emphasizes the preference for a summer mowing by taking into account all ecological interests. Indeed, from the point of view of fauna, it is not always interesting to mow in summer, a delayed mowing appears more relevant in the case of Merlimont; however, it may be interesting to shorten the periodicity of the mowing regime to make the soil more poor.

New bio-indication techniques in the dune

In the Zwin Nature Reserve (Belgium), cattle, horses and sheep, like in the Franco-Belgian dunes (cattle at Merlimont) are used for grazing dunes, salt marshes and ecotone with the polder. As at Merlimont, the management objectives are long-term with restoration and maintenance of a mosaic of open and semi-open habitats. Here too, it is a question of selecting the management practices that make it possible, in addition to the diversity of environments and species, to benefit smaller herbaceous species and thorny shrubs. Grazing of the intertidal zone (to reduce the dominance of

Festuca, Agrostis, Elymus athericus) has yielded promising results in the restoration of pioneer vegetation.

One of the difficulties is to know precisely the behavior of herbivores. Data using GPS collars recording the position of animals over a year (seasonally for cattle) allowed calculation of grazer density in 5 x 5 m cells and derived from this preferences for each vegetation type using Jacob's index (= a score from -1 to + 1 indicating a range from avoidance (< -0,1) over indifference (-0,1 to +0,1) to preference (> 0,1 that is based on grazer presence in a certain vegetation type and the availability of this type). **J. Van Uytvanck** said that the GPS solution is cost-effective and efficient despite some technical difficulties with horses that do not keep the detection device.

On a completely different scale of experimentation, in the context of a crisis of biodiversity, the study of pollinators-plants networks has become a research issue over the past ten years (see SPIOLL and SAPOLL in France). Plants-pollinators networks show interactions with a clear spatial pattern with plant species contributing differently to the organization of pollination interactions occurring non-randomly from the beach to the interior of the dune belt and mobile dunes ensure the stability of pollination interactions.

E. Fantinato answered the questions: *We have a lot of pollinating insects into the frontal dune; can this data be used as justification for clearing? Removing the shrubs from the frontal dune so that pollinators can fly in habitats with reduced vegetation is possible. Especially since some species such as bumblebees can fly up to 1 or 1.5 km but many important pollinators such as wasps and wild bees hardly exceed a radius of 500 to 600 m. Physical barriers such as scrub can limit the mobility of some pollinator groups. It is important that more open dune habitats communicate with each other.*

Conclusion

Both field trips and session 6 were complementary. Monitoring - periodic data collection processes - such as the management methods chosen are distributed according to the techniques used and the costs in a seasonal calendar. They consist out of repeated punctual interventions over twenty years (Merlimont and Zwin). The spatial scale deploys according to tools and protocols. More and more precise studies of coastal dunes with an interdisciplinary approach at the crossroads of geomorphology and ecology bring a set of exchanges and questions. Optimization of techniques and costs have been widely discussed. The geomorphological monitoring of the dune has gained in precision and perspective with the use of drones. New ways of bio-indication are being put into place. The long-term grazing experiments (Zwin, Franco-Belgian cross border system, Merlimont) make it possible to evaluate and control more precisely the management of the habitats that one wishes to maintain or restore. Finally, research on plants-pollinators networks brings new perspectives of management of habitats, biotic exchanges linked to pollination and thus more attentive glances towards certain taxa.

To the presentations

1. [PROVOOST | Monitoring of ecological dune restoration in Northern France and Belgium](#)
2. [LAPORTE-FAURET | Morphological and ecological monitoring of a beach-dune system in response to the experimental set up of transverse blowouts: Truc Vert, Nouvelle-Aquitaine, France](#)
3. [VEILLÉ | The dune grasslands of the Opal Coast Biological Reserve. Monitoring and management methods to ensure long-term conservation](#)
4. [FANTINATO | Functional conservation of coastal dune systems: the pollination network perspective.](#)
5. [VAN UYTVANCK | GPS-data of large herbivore habitat use support management practice in the Zwin nature reserve](#)
6. [COHEN | Mapping coastal dunes morphology and habitats evolution using UAV and ultra-high spatial resolution photogrammetry](#)

Workshop on Atlantic Dune Roadmap

The aim of the Roadmap¹ for knowledge exchange and networking for the period 2016-2020 is to help support the conservation of dune habitats in the Atlantic Biogeographical Region. The Roadmap is both a living document and a record of activity. It identifies actions, develops ideas and highlights issues best addressed between several member states. Networking activities occurring between the high-level seminars, such as the LIFE+FLANDRE workshop, are the most important to keep the Roadmap process going. Although common issues are identified, progress is currently hampered by the lack of an active network of European coastal dune managers to disseminate good practice. National and cross-border networking is necessary and the process depends on the initiative of host agencies, such as through LIFE projects, to organize meetings.

The roadmap stresses that communication is essential between nature conservationists and coastal defense authorities. There also needs to be more communication and engagement with the public to explain the dynamic nature of coastal dunes. Funds other than LIFE will be needed to support networking and communication. Integration and discussions between disciplines is essential through gatherings such as this. The “coastal dune community” should meet regularly, especially in the field to exchange experience. In this respect the excursion of June 13th was probably the most important day of the workshop.

The Natura 2000 communication platform has not been used very well to date. The European Commission will continue to support the platform and using the platform better should be an aim of a European dune network. More effort is required to publish and disseminate evidence-based conservation practice as part of a program of knowledge exchange. The roadmap to date has focused on EU habitats: it should be able to include other aspects such as coastal defense, natural processes, so called ‘regionally important’ species and habitats and cultural landscape heritage.

John Houston will update the roadmap reflecting this session’s view, and the updated roadmap will be published on the Biogeographic Process website. **Stakeholders, including participants of this workshop and readers of its proceedings are requested to provide feedback on the document to John.Houston@neemo.eu by 14/09/2018.**

1

<http://ec.europa.eu/environment/nature/natura2000/platform/documents/Roadmap%20for%20dunes%20of%20the%20Atlantic%20Region-%20V2-%20LIFE%20FLANDRE%20Conference.pdf>

Excursion 1

De Westhoek – Dune du Perroquet – Fossil
dunes of Ghyvelde and Adinkerke

Excursion Ghyvelde - Bray-Dunes

----- itinéraire



Itinerary of the visit to the fossil dune de Ghyvelde – Cabour Domain – Westhoek nature reserve and Dune du Perroquet

A: Rue de la Frontière at Ghyvelde

STOP 1: stop at the exit of the 'Fossil Dune'

- Introduction to the structures CD59/CDL, general introduction to the site
- Example of partnership with the firm ENEDIS/CDKL/CD59 for the burial of the high-voltage line to enhance the landscape
- The dune is managed by the Nord Department. It covers 205 hectares acquired at the end of the 1980s. This territory was ceded to the Conservatoire du Littoral in successive phases until 2005, notably through expropriations.
- The dune, which is about 5000 years old, is decalcified and is located at about 3 km from the present coastline favouring original vegetation.
- Previously, a medium and high voltage line crossed the landscape. This was recently buried by ERDF along the road, thus reducing bird mortality and improving the landscape, classified as national heritage. The site is also included in the N2000 network (FR 3100475 Dunes Flandriennes décalcifiées de Ghyvelde). The Moères area, located further south, was drained in 1626 by the archdukes of the time, Albert and Isabella, representing the King of Spain. Before the drainage, it was a vast natural brackish lake which is today an agricultural expanse crossed by canals, desiccating the dunes. The fossil dune belt extends into Belgium. There is a cross border continuity of this Franco-Belgian territory. Tourism is frequent, especially in summertime. The fossil dunes are accessible, in France along a hiking path around their edges, in Belgium along a loop-shaped walking trail within the Domain Cabour. On the French side, an artificial lake is present on the site and guided tours are possible on request. Agriculture is practised around the sites that are managed by the Département du Nord and the Agency for Nature and Forests. Pastures were historically practiced in the dunes.
- An enclosure (inside the protected area) is present in order to protect *Gagea bohemica*, discovered about twenty years ago. Without this, it would be threatened by the grazing of the herbivores (horses and sheep) introduced for maintenance purposes, and the many rabbits living on the site. The follow-up is realised on a yearly basis by departmental guards. 10 to 25 feet are geolocated by GPS, which corresponds to 20-30 flowers. These are small plants that flower from late January to early March and especially in February. The flower is also sometimes found outside the enclosure. However, the origin of this population of the Bohemian Gage remains unknown and its presence is unique for the region. *Calamagrostis epigejos* is a competitive colonizing grass species that is favourably controlled by pastures. The vegetation is acidiphilous: *Festuca filiformis* - *Galietum maritimi*. There would be hardly 4-5 plant species / m², but they are very specific for the concerned type of habitat.
- The Moères south of the fossil dunes were once swampy (brackish lake). The reclamation has drained these areas. The (planted) pines that grew around the year 1900 on the fossil dune have disappeared. Pheasants, woodcocks, rabbits etc. are still hunted there. This required keeping open spaces in the landscape. The end of the pastoral use provoked the encroachment by the *calamagrostis epigejos*, followed by the invasion by the sycamore maple. Today, the site is mostly managed again by grazing by Haflinger horses and sheep. This limits site management to management of these herds. An area of 150 ha is grazed by 20 sheep and 4 Haflinger ponies (Austrian breed). These herds are halved during periods of high rabbit populations. The rabbits were introduced in the 13th and 14th centuries, the site being used from this introduction on as a warren. The number of rabbits has fluctuated since the global outbreaks of myxomatosis and viral

haemorrhagic disease in the 1980s. In general, this fluctuation has mainly resulted in an overall decrease in populations. The fossil dunes are cut off from the present coastal dune massif by a road and a canal and cultivated fields. The populations of dune species in the Fossil Dune therefore do not have direct access to the so-called young dunes (border dunes).

- The woods present (poplars, sycamore maples...) were planted there. An author (Cécile Baeteman) questions the age of the dunes on the basis of sediment core samples. But part of the controversy is probably rather semantic. For a geomorphologist, a sandy shore barrier is probably not to be considered as a dune strictly speaking. The present day coastal dunes also rest on ancient dunes. These actual coastal dunes and the inner dunes present an archaeology dating from the Iron and Gallo-Roman Age. A series of "fossil" shore barriers is present and marine calcium is still present at depth in the soil of the fossil dune beyond one meter.

STOP 2: stop internal area of the 'Fossil Dune'

- Management of the dune by grazing.
- Exceptional species and grasslands dominated by mosses and lichens.
- Measures foreseen for the management of the habitat 2130*.
- The location at this stop used to be a swamp, but it became a dry area because of agriculture.
- Afforestation makes the grey dunes disappear. The fight against it is difficult. The Direction Départementale des territoires (et de la Mer) (DDTM) requires that one hectare of cleared forest be compensated by reforestation of four hectares. The 2016 Biodiversity Act provides for an exception to this rule for Natura 2000 sites. But this decree is blocked at the national level. Poplars will naturally decline. Oaks take the place of poplars when they decline. On the Dune of the Cabour estate in Belgium many poplars were still planted on an experimental basis in the 1980s. These poplars were cut in the years 2010-2012. Strapping operations are also carried out on sycamore maples. An exchange of technical knowledge is taking place with Belgium. The clearing of sycamore seed trees prevents their dispersion. Poplars cast shadows and enrich the soil with their leaves, contributing to the retreat of open areas and habitat type "2130* Grey Dune". Their deep roots not only re-calcify the soil, they also eutrophy it.
- The white poplar reproduces vegetative via root shoots, so invading the dune grasslands. The hybrid black poplar does not reproduce itself in the forest environment. In the long term, the system evolves, according to the foresters present, towards an oak grove, even if the maples throw competitive shadows. Light, soil-friendly Haflinger ponies and hardy sheep ("Bruyères" (meaning "Heaths") / "Vlaams heideschaap" breed) graze on the acidophilic dune grass. Two grazing agreements are signed between the association of "Shepherds of Flanders", the association "Nature Horses" and the Département du Nord. On the seafront-dunes, grazing is practiced more by goats than sheep. The animals are dewormed and quarantined because of the persistence of toxicity (about one month). Males are castrated. Calving takes place naturally on site.

Q: When was this area bought?

A: The first plots were bought during the years 1980, but land purchase is still going on to realize a spatially coherent public domain. The site is accessible to the public thanks to a pedestrian route that surrounds it.

Q: When were the trees cut?

A: The pine trees that stood here at the beginning of the 20th Century were cut during the second World War to be placed as “Rommel’s stakes” on the beach (military defence of the German occupant against eventual landings by the allies). In the dunes there are bunkers from the WWII, which now serve as shelter for bats. Recently, some poplar trees (that had been planted after WW II) were cut to restore open spaces. However, there is a strong regulation regarding cutting trees: if you cut 1 ha, you need to replant 4 ha. The larger shrubs (including sycamores) under the poplar trees were not cut, and as a result, there is now an invasion of *sycamore maple seedlings*.

Q: How is grazing managed?

A: The number of grazers is adapted depending on the number of rabbits. The number of animals thus varies throughout the year. The animals belong to an association of breeders

Q: There are some rare plants in the area (*Gagea bohemica*), which are protected by a fence. Why is this?

A: Because they are so rare, they have to be protected as such from the grazers.

Q: Isn’t there a risk the flower will disappear, because of the fence?

A: No information available yet, this will be evaluated

Comment: The only individual plant of *Calluna vulgaris* that was (still ?) present in the “Dune fossile de Ghyvelde” has disappeared as a consequence of (too intensive) grazing, but there is hope the species will reappear from its seed bank.

STOP 3: stop with panoramic view of the ‘Fossil Dune’ Ghyvelde

- ‘Secondary’ dynamic of the ‘Old’ dune
- Wild rabbits issues



Rabbit burrows in the fossil dunes

- (Pre-)history of the fossil dune belt, archaeological finds (Gallo-roman & middle-ages)
- Transition zone between “Ancient” dunes belt and polder plain:
 - French side: former dune meadows quite recently turned into asparagus fields
 - Belgian side: mainly meadows, but too strongly fertilized
- 40 ha with many rabbits + 25 sheep + 4 horses (Haflinger)
- From here, observers can see north on the Dune du Perroquet and the Westhoek dunes.
- Light-coloured sheep with very abundant fur were favoured (‘les Bruyères’, meaning “Heathlands”). Initially, Boulonnais sheep had been grazed but they needed shelter in winter.
- The Natterjack toad, the alpine newt and the green frog are present in the pond of the site. Still other species are observed in the lake.
- Christophe Blondel identifies other rather calcareous plant species on the site, including sea buckthorn, privet, Characeae and glyceria in a pond.
- The dune here is semi-mobile. It is adjacent to a landscape of plains.
- Asparagus agriculture recently took the place of the old dune grasslands in the intermediate zone between a fossil dune and the polders. The asparagus fields near the dune, with its high density of rabbits, were damaged. To prevent this, rabbit fences have been installed.

Q: Why are there so many rabbits?

A: They were introduced for hunting in 1990. These rabbits are protected against diseases, which killed the rabbits near the coast, north of the canal Dunkirk-Veurne. Therefore, there has been no decline in the local rabbit population.

STOP 4: stop Cabour domain (Belgian part of the fossil dunes belt)



Eric Cosyns (Wvi) explains the management choices for the Cabour Domain

- Introduction to the Belgian (Flemish) management structures (ANB): the Cabour Domain is owned by the water supply company I.W.V.A. and managed on the basis of a convention by the ANB.
- Introduction about the development of the 'Old' dune belt and the actual dune belt and the central 'polders' plain.
- Panoramic view of the landscape, the actual coastal dunes, fragmentation and intensification of agriculture in the transition zone between 'fossil' dunes and polder.
- Cabour domain is separated from the Dune fossile de Ghyvelde by the Maerestraat. This road is an obstacle for the migration of unwinged organisms and complicates the nature management.
- Unification of the Belgian and French domains in a single grazing block is made difficult by the physical presence of the road and also by veterinary regulations of both countries.
- Management measures (2010-2011): felling of poplars and conifers to restore acidophilic grey dunes and restoration of pools. Note that tree felling is not allowed in France – unless an area 4 times as large is replanted elsewhere, while in the Flemish region of Belgium an exemption from the obligation to compensate is applicable to deforestation planned and executed to achieve the conservation objectives of the European Habitats Directive.
- Historic desiccation of the dune belt caused by the reclamation and drainage of the Moëres.
- What are the consequences of the increased deposition of atmospheric nitrogen in environments that have a lower content of lime? Encroachment with nitrophilous grasses.
- The Cabour Domain, owned by the IWVA (Intercommunal company of production and supply of water) since 1924, is located on the Belgian part of the fossil dunes belt. After 2006, a management agreement with the ANB entrusts the management of the site to the latter. A management plan drawn up by the West-Flemish intercommunal group (Wvi) commissioned by the ANB and ratified by ministerial decree since 2008 establishes a nature reserve there. Cabour was a shipowner from Dunkerque who established circa 1900 a castle on this estate he had acquired in Belgium. It became a military hospital during the First World War, just 18 km from the Yser-front. The Belgian army then already exploited the phreatic groundwater here. This exploitation is now over because the resource was limited and its exploitation entailed risks of salinization. Eric Cosyns, biologist at Wvi wrote the management plan 12-13 years ago. Shrubs and woods were then dominant and acidophilic grasslands were mainly present in the centre of the site.
- Old woods around the site of the castle are preserved (ashes, oaks, indigenous bluebells). Until the 1970s-1990s, experimental poplar cultivars were planted on the grey dunes, which was threatened by these artificial plantations as well as by the spontaneous expansion of sycamore maples. Today, the surface area of shrubs and woods of Canadian poplars or other more recent non-indigenous species has been greatly reduced.
- *Calamagrostis epigejos* sometimes dominates locally. Critical areas for the restoration and preservation of acidophilic grasslands and for increasing open landscape area and improving connectivity are identified as priorities for clearing. The pastures of the eastern part are preserved. Sheep (30-40 for 35-40 ha) are selected for their consumption of *Calamagrostis epigejos* and shrubs. In the north of the Cabour estate, calcareous soils are present. During the Second World War, the Germans disturbed the soil, bringing limestone up to the previously decalcified areas. But there are still decalcified areas, especially south of the site. "Scottish Blackface" and "Hebridean" sheep and Shetland ponies are deployed for the grazing management. The vegetation consists of acidophilic grasslands with mosses (+/- 10 species) and lichens (+/- 13 species).

- *Senecio jacobaea* is observed with fluctuating populations, as a consequence of deforestation. The Maerestraat divides the fossil dune parallel to the border. It would be preferable to unite the two dune estates into a single grazing entity. The municipal administrations resist. Horse trails follow the road. Without these equestrian tracks, the connection of the two parts of the fossil dune belt is possible. However, there is a legal obstacle, in this case the question of under which national veterinary legislation animals from a possible cross-border site should be treated.
- Herbivores are numerous, including rabbits, which are the most effective at maintaining acidophilic lawns. The *Hypnum cupreciform* foam is also present. The installation of deep trenches by the Germans locally caused the soil to be turned and the limestone to rise, favouring calcareous grasslands locally. The site has already not been grazed by sheep for two years, since the action of rabbits is sufficient. The eventual return of the sheep is still unforeseen. Some species are protected in exclosures such as—*Ulex europaeus* of the habitat 2150*, where *Calluna vulgaris* is still lacking what makes that the habitat is classified in 2130* as a 'grey dune' rather than 2150* as a 'decalcified Atlantic dune'.

Q: What kind of grazing is applied?

A: In 2012-2015, grazing by sheep pushed back common *Agrostis* and poplar sprouts. However, at the moment, there are enough rabbits, so the sheep are not necessary, but when rabbit population would drop, sheep will have to be reintroduced. The image of the vegetation gives an indication of the rabbit population. Grazing has an influence on the height of the grass, which is an indication of the grazing pressure.

Q: What kind of vegetation do you have here?

A: There is a mosaic in the vegetation. Mostly it is known for its mosses and lichens. In this area we have decalcified dunes resulting in mosses + 1 species of grass. The missing species are *Teesdalia* and *Calluna vulgaris*. The latter would have been present 10 years ago on French side.

Q: Is *Calluna* necessary?

A: Yes for the vegetation to be classified as habitat “2150* Atlantic decalcified dunes (*Calluno-Ulicetea*)”. The restoration of this place went very fast.

Q: Wouldn't it be better to close the road between the Belgian and French site?

A: It would indeed be beneficial for a better integration of cross border project area. The road should therefore not be removed completely. It can still be used for hikers and cyclists. Cattle grids should be placed at the entrance/exit of the site.

Q: Where is the water level situated?

A: Currently, the water level is lower than 2m. There are no humid dune slacks, probably because of the drainage of the polders (especially the very low “Moëres”) and long-time water extraction.

STOP 5: stop Zwartten Hoek

- ‘Landscape of covered foreshore plain’ (‘polders’) between the present day coastal dunes of the Westhoek and the so called ‘fossil’ dune belt of Cabour
- Insufficient connectivity of the Natura 2000 network. Necessity to strengthen the connectivity by the creation of an ecological connection between the present day coastal dunes and the ‘Old’ dunes (so called ‘fossil dunes’) by the development of natural habitats in the central plain, e.g. for Great crested newt (*Triturus cristatus*).
- Difficulty for the development of natural habitats: the high phosphate content of the soils of some formerly agricultural grounds

- To the north of the "Old" dune range, we find ourselves on a landscape slope which consists of a fringe of land of Aeolian sand dune sediments deposited above marine sediments (sand or clay). This inner fringe of the dunes is called "duinzoom" in Dutch. Groundwater from ancient dunes seeps and may resurface in places. This provides opportunities for the creation of pools. But the drainage of Moëres, very low lands located south of the belt of old dunes, dessicates the dunes because of agriculture and is adverse to these efforts to restore wetlands. On the Belgian Flemish side, the dune decree protects dune land used by agriculture. This Flemish legal protection status is called "agricultural area of importance for the dunes". In addition, a large part of these inner fringes of the dunes are included in the Special Area of Conservation under the European Habitat Directive. However, land is still mostly private. Acquisition attempts by ANB are made.
- Further on, we enter the polder plain and the soils consist of an overlay of clay on sand or clay on clay. In the early Middle Ages, this area consisted of intertidal mudflats and intertidal salt meadows. The connection with the sea has been interrupted since the 11th century. The traditional polder landscape was a "scenic" landscape, with many ditches, rows of pollard trees and thorny hedges that served as "ecological corridors" until the early 20th century. After the Second World War, agriculture was intensified and linear elements of the landscape largely disappeared. The dunes have been progressively fragmented by urbanization. Large infrastructures interrupt the connection between the two dune belts (called "Old" and "Young": Rail, canal Dunkirk-Veurne (already present since the 17th century), highways, urbanization. The 450 ha block of dunes of the Westhoek and Krakeelpanne-Calmeynbos, located between the camping of Le Perroquet and the road that connects Adinkerke to De Panne are not enough to form a really robust natural entity. The whole dune site remains fragile.
- A recreational bridge over the Dunkerque-Furnes canal financed by an INTERREG European project reconnects the two parts (north and south) of the plain. On the Belgian side, the canal bank has been very locally redeveloped to accommodate aquatic fauna and stones have been laid out on the bank to allow large mammals to get out of the water. Deer can pass now. The development of freshwater marshes and reed beds in the polder plain is an idea to consider. Natterjack toads are present in recently dug pools. Local soil diversity promotes habitat diversity.
- An old potato field was transformed by the ANB into wet grassland by removing the top layer of soil. The resulting vegetation consists mainly of a mosaic of mesophilic and alkaline lowland grasslands with *Carex flacca*, *Carex viridula*, *Blackstonia*, *Dactylorhiza incarnata* and *Ophrys apifera*. This site is an outpost for the ecological connection between the Cabour domain and the Westhoek reserve for various species. A 35 cm layer of clay was removed in places to strip lime-rich sand. The site is sometimes completely submerged in winter. The earth that has been dug has been deposited in the form of slopes surrounding the meadow so that the birds are not disturbed by the many passers-by (hikers, riders, cyclists...). Bird species that nest in the meadow and these slopes: Northern Lapwing, Grey Partridge, Eurasian skylark, Meadow Pipit, Stonechat ...

Q: How were the works carried out?

A: The soil profile is very variable, which made it difficult to plan works. The site-managers had to stay permanently next to the crane operator in order to give him instructions according to the type of soil layers that were being uncovered.. It was an experimental project.

Q: What is the reaction of the general public when it got known this site would be reorganised?

A: Initially, people did not like it, but no negative reactions were noted when the works were done. However, thistles have to be mowed.

B: Café du Perroquet

STOP 6: stop at the panoramic platform near the central, formerly mobile dune

- General introduction to the site 'De Westhoek' nature reserve
- Accelerated fixation of the sand by the spontaneous development of the vegetation under the influence of climate change and the increased atmospheric nitrogen deposition
- Discussion about the causes of the spontaneous fixation and the opportunity to restore the dune dynamics
- Camping site 'du Perroquet' (on adjacent French territory): habitat fragmentation, obstacle for the migration of organisms, obstacle for the Aeolian sand drift as consequences of the presence of a camp site that crosses the whole dune site from polders to foredunes. The camping site as a source of I.A.S.
- The Westhoek is a 350 ha estate belonging to the Flemish region. In 1957, the Westhoek and the "Hautes Fagnes" in Wallonia became Belgium's first national nature reserves. Previously 650 ha of dunes belonged to the Bortier family who relegated their estate to Brussels businessmen. Already in 1935, this site was protected as a cultural landscape, but this protection was only partial and still allowed part of the site to be urbanised. After the Belgian state had acquired 335 ha of the Westhoek dunes, IWVA purchased 98 ha adjacent to the state reserve. In the 1970s and 1990s, a large area of dunes was sacrificed to the highly contested Westhoek (suburban) allotment. The current landscape of the high dunes, called "Young", began to form with a large influx of sediment during the Little Ice Age (from the 14th century on). These high dunes formed over a much older dune base. Archaeological sites dating back to the Iron Age, the Gallo-Roman and the High Middle Ages have been discovered. Archaeological layers have even been exposed by wind action. In the 1970s, the base of the dune was reinforced with remains of demolished bunkers, on which a layer of concrete was then poured.
- South of the Westhoek, natural and spontaneous aspen forests are classified under habitat 2180, further on sycamore maple and Canadian poplar were successively planted and fought. A place called "Pietje Mol" is an ancient small cultivated field surrounded by slopes planted with alders that have grown and are now part of a wooded dune.
- The initially open dune landscape has begun to become encroached by scrub following the abandonment of traditional agro-pastoral use. Only the large central mobile dune was spared until the 1990s from the invasion by sea buckthorn, privet and willows. Until 1996, management was limited to the maintenance by mowing of a few parts of dune slacks with a total area of only 2 ha. The first management plan for the Westhoek Nature Reserve dates from 1996 (almost 30 years after the creation of the Nature Reserve). Between 1997 and 2001 30 ha were cleared from scrub and poplar plantations as part of the Integral Coastal Conservation Initiative LIFE project and grazing management by large herbivores, Highland cows, Shetland ponies and Konik, was introduced, all in order to restore the "2130* grey dunes" and "2190 humid dune slack" habitats. Ponds were then also dug as aquatic environments for the crested newt, the Natterjack toad, dragon flies, Characeae algae etc.



Fresh water pool with Characeae algae in the Westhoek nature reserve

- Since the beginning of the 21st century the large central mobile dune of the Westhoek, which still included more than 80 ha of bare sand during the 1990s, was quickly invaded and finally fixed spontaneously by Marram grass and Sea Buckthorn. The shortening of winters, the increase in precipitation observed in 2001 (considered today as a moment of changeover of the system) favoured the germination and the survival of the germs of Marram. The deposition of atmospheric nitrogen in turn stimulates plant growth.
- The high dune of the Perroquet (in French territory), still mobile in the early 1990s and moving towards the Westhoek, was artificially fixed by the plantation (by the operator of the campsite) of Ontario poplars and Marram grass in order to prevent the silting of the road which crosses all the dune massif to connect the northern and southern parts of the campsite "Le Perroquet".
- An area of 9 ha of the recently encroached large central dune will be cleared in order to restore the 2120 "white dune" habitat and especially the Aeolian sand drift. Several invertebrate species, including the Maritime Tiger Beetle, are linked to this environment. A scientific and geomorphological monitoring of the evolution of the dune after clearing will take place. The white dune is the matrix of the dune landscape. It is in non-vegetated dunes that humid dune slacks are formed by sand drift under the influence of the wind. The fixation of dunes also implies their decalcification in the medium or long term. Hence the question of the importance of blowouts in the dunes. Should the dune systems be reactivated by digging artificial blowouts in order to ensure a recalcification of the landscape by the wind spray of sand containing limeor should it be accepted that dunes age and decalcify? Essentially, the conservation of the calcareous character of dune habitats on the current site is desirable. The Dutch have historically mainly fixed their dunes and have since this century dug gaps in them in order to restore the mobility of dunes under the effect of wind .

- Sea buckthorns are declining after about 40 years due to nematode parasitism. Nitrophilic *calamagrostis epigejos* fills the openings in the scrub, resulting in a loss of biodiversity.
- As soon as a wet slack has formed by the drift of sand by the wind until reaching the groundwater table, the creeping willow colonizes the wet soil of the slack. The prevailing wind during storms is from the northwest and it is during these storms that sand drift is at its maximum and blowouts form. Sometimes the wind is from the southeast, in which case sand is deposited on the creeping willows in the slacks and their direct surroundings. This causes the formation of micro-reliefs, called mini dunes or ridges. This geomorphology also favours the increase of biodiversity.

Q: Is budget foreseen for aftercare management after the removal of vegetation ?

A: This is not included yet, it will be studied what needs to be done.

Q: Are there suggestions on how to reactivate mobile dunes ?

Suggestions and remarks made during the discussion:

- > the reactivation needs to start from remnants of the former mobile dune;
- > there could be need of creating a larger number of small scale blowouts;
- > there could be a lack of wind coming from the NW;
- > the shape of the dune is not so important, but the focus needs to be on reactivating the head of the (parabolic) dune;
- > the area of 9 ha from which the vegetation would be removed is most probably too limited to restore durably the dynamic habitat 2120 'white dunes'; will the area be increased in the future ? (**A:** An eventual increase depends of the further results of the operation. The managers hope that the remobilized sand dune will move to the south east and cover the vegetation that it encounters on its "way").
- > Why is the to be remobilized area not located more to the east of the central dune (as dominant wind direction during storms is north west) ? (**A:** Because a location more to the east would be too close to the urban area of De Panne ...)

Conclusion: A study of the "best practices" of similar projects (e.g. in the Netherlands, Wales ...) will be carried out to provide the most appropriate and effective way to reactivate the sand drift.

Q: How will you remove the vegetation?

A: Vegetation will have to be removed till 2 m deep, to also remove the roots. In this area however, the vegetation is rather young and no organic soils were formed yet, so maybe digging less deep could also be sufficient. Attention has to be paid to the after care management after removing the vegetation. Previous projects have showed that taking out unwanted vegetation by hand by volunteers turned out to be unsustainable in the medium term.

Q: Would it be an option to begin with a small scale restoration?

A: The whole central dune (80 ha) would indeed be a (too) huge project. It might be a better option to focus on a smaller area (9 ha) that can be contained & managed afterwards. After 3 years, an evaluation can be done to see how well this approach worked and possibly extent it to a larger scale.

Q: What is the management after the vegetation removal (débroussaillage). Is grazing an option?

A: This depends on the results – vegetation development is monitored and the aftercare will be adapted to the monitored regrowth.

STOP 7: stop at the large dune slack in the northern part of the Westhoek



François Delcueillerie (EC) et Jean-Louis Herrier (ANB) contemplate the results of scrub clearing under LIFE ICCI (1997-2001), followed by 20 years of recurrent management

- Removal of scrub in the northern part of the Westhoek in the frame of the LIFE project ICCI (1997-2001): results after 20 years of recurrent management by grazing and periodically mowing the regrowth of bushes + methods of scientific monitoring of the management by INBO (Research Institute on Nature and Forests of the Flemish region).
- Monitoring results mowing vs. grazing: both have advantages and disadvantages. All species remain with grazing, but there is less abundant flowering
 - Shrubs are not controlled by grazers or you have to introduce a too high grazing pressure (that would be harmful for e.g. orchids, viviparous lizard and several species of invertebrates)
- Sam Provost from INBO presents the database of the permanent inventory of coastal nature reserves PINK (Permanente Inventarisatie van Natuurreservaten aan de kust,). This inventory consists of a scientific follow-up of the management carried out and its results.



Sam Provoost (INBO) describes the scientific monitoring of the management of the coastal dunes in Belgian Flanders

- The mowing method is compared to the grazing method. Mowed areas have more flowering plants (among other different orchid species). By the late 1980s, almost all of these species that are now abundantly present again had declined sharply or even disappeared: The Musk orchid (*Herminium monorchis*), the Dune Gentian (*Gentianella uliginosa*) etc. as consequence of encroachment by Sea-Buckthorn (*Hippophaë rhamnoides*), Wild privet (*Ligustrum vulgare*), Grey willow (*Salix cinerea*) etc. During the 1980's, mowing was carried out on a very small surface area that was scattered over several relict spots, and mainly for scientific purposes. Since the second half of the 1990's, the scientific actions included the establishment of:
 - Topological mapping
 - Phytosociological survey: 50 / 50 metres since 1998 within the frame of the LIFE ICCI project (1997-2001). After 1997, 300 permanent quadrates were monitored along the entire Belgian coast, recorded in the PINK database.
 - Point and very precise mapping of plant species. Unfortunately, recently there has been no funding for monitoring of the fauna.
- The combination of mechanical management with grazing by herbivores aims to change the landscape. Larger open spaces are needed to support durably the vegetation typical of coastal dunes. More than 100 piezometers are installed in the Westhoek to monitor the phreatic groundwater regime and locate areas with high potential for habitat restoration and maintenance "2190 humid duneslacks". Mapping is important to locate priority areas.
- Among the results of this research, it appears that mowing is not necessary to increase habitat biodiversity, but that it is periodically and locally necessary to contain the regrowth of thorn bushes, which grazing by large herbivores is not enough to prevent.



Mowing (left side of the fence) versus grazing (right side of the fence)

Q: Which type of cattle do you use for grazing?

A: We have 5 Shetland ponies , 8 Scottish Highland cows and 16 Konik horses. They graze in a large enclosed grazing area of 137 ha and are present the whole year round.

Q: Why do you have horses and cattle?

A: They have different grazing patterns that are complementary to each other to obtain the desired vegetation structure.

Q: What would happen if you put the grazers on the mowed area?

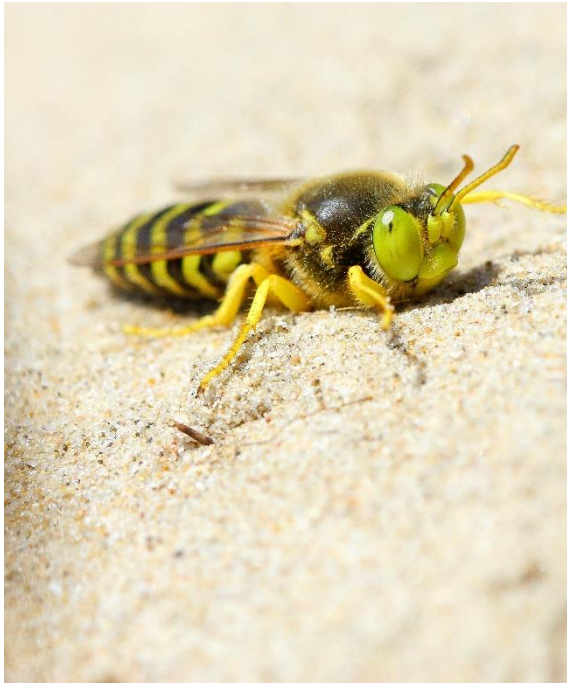
A: This area would evolve to the same situation as that in the grazing area, which would result in a loss of diversity in the vegetation structure, vegetation aspect (less flowering) and landscape . Therefore, we also maintain on several locations within the reserve management by (exclusively) mowing over a surface area of 5,43 ha, which also allows us to continuously compare the effects and results of the two management methods.

Q: How often do you mow?

A: The area is mown rather late, which is good for certain plant species : end September/November. The mowed materials are removed from the site.

Q: Do you do insect monitoring?

A: There is some monitoring of invertebrates but this is, since a number of years, very basic. For vegetation the monitoring is more extensive: the basic typology (structure) is monitored. This is based on species composition and on samples. More detailed monitoring is done for about 250 target species of plants . For these, we map each individual. Unfortunately, there are no enough financial means available anymore for monitoring insects. Some typical species are monitored. The Sand wasp *Bembix rostrata* is important and is monitored as it indicates the transition between open terrain and thickets. This is thus an indicator species for the grazing pressure.



Bembix rostrate



Herminium monorchis

Q: Do you work with volunteers in this area?

A: Not so much.

Q: Do you have problems with Sea Buckthorn?

A: The Sea Buckthorn (*Hippophaë rhamnoides*) is along the Flemish coast an indigenous pioneer shrub species. It needs calcareous soils and light. It has the ability to fix atmospheric nitrogen into the soil and to rapidly expand vegetatively via root shoots. In a stabilized scrub environment the Sea-Buckthorn individual loses quite rapidly (after a couple of decades) its vitality as a consequence of root parasites (nematodes). In the 19th and early 20th Century Sea-Buckthorn was regularly cut to be used as brushwood to stop sand drift and as firewood, which kept it under control. But abandonment in the second half of the 20th Century allowed Sea-Buckthorn to spontaneously expand into the white dunes, grey dunes and humid dune slack, finally resulting in a complete encroachment of the dune landscape. We have to remove Sea-Buckthorn scrub and to reduce the expansion of Sea-Buckthorn in order to respectively restore and maintain humid dune slacks and grey dunes, but the Sea-Buckthorn scrub is also a target habitat of the European "Habitat" directive (2160). The Sea-Buckthorn thickets are important as nesting habitat for numerous passerine bird species that are also declining.

Q: which bird species are nesting in the scrub ?

A: Among others: nightingale (*Luscinia megarhynchos*), turtle dove (*Streptopelia turtur*), willow warbler (*Phylloscopus trochilus*), lesser whitethroat (*Sylvia curruca*), Cetti's warbler (*Cettia cetti*), common grasshopper warbler (*Locustella naevia*), Common linnet (*Linaria cannabina*) ...

STOP 8: stop at the entrance/exit of the Westhoek Nature Reserve to the beach



Lieven Dekoninck (ANB) outlines the history of the concrete dune foot reinforcement of the Westhoek nature reserve and the alternation of erosion and growth phases of the beach and seafront dunes

- There is a large population of the Sea Holly, a protected plant species in Belgium. In the western part of the Westhoek, the concrete dike has been buried under the sand for a few years. The Maritime Services and Coast agency of the (Belgian) Flemish government has planted brushwood in front of the concrete reinforcement of the dune base (called "dyke" by some) to capture the sand carried on the beach by the wind. These rows of brushwood made up of poplar branches have taken root and have become shrubs, whose leaves cause eutrophication of the vegetation in the seafront dunes. Photos from the 1960s and 1970s show three large natural breaches in the seafront dunes of the Westhoek. In 1978, the base of the dune was reinforced with concrete poured over the debris collected from demolished bunkers (from the Second World War). The structure is not considered a dike strictly speaking. According to Yvonne Battiau, the Germans did not establish anti-tank walls on the Belgian side, which suggests that at that time there were high seafront dunes. After many years of consultation and scientific studies concerning the protection of the hinterland against marine flooding, two breaches were drilled across the concrete reinforcement of the dune foot in 2004. These 2 breaches worked for a while, letting the sea into the dunes by very high tides. In the dune depressions flooded by sea water, halophilic vegetation developed with among others *Suaeda maritima*, *Salicornia*, *Cakile maritima*, etc. The Ringed Plover then nested in these "sea inlets". But, following the spontaneous advance of the Westhoek coastline, the breaches were quickly filled by silting. The most easterly breach is sometimes still in connection with the tide but its silting is underway. This breach was last submerged in 2013, during the storm known as St-Nicolas. Consultations between the Agence Nature et Forêts and the Maritime Services and Coast Agency resulted in an agreement to demolish the wall if it came to surface naturally. However, such an outcrop could still be decades away.

- Since 1875, the coastal line has changed little. Some beach areas have become bigger, others have regressed. Dune bases sometimes regressed locally by several hundred metres and then regained ground. In short, these developments are cyclical and express a certain resilience. This calls for caution in the face of hasty or even catastrophic conclusions in the face of short-term changes.

Q: Are there other experiences in other countries (on “sluifers”/sea inlets in the dunes)?

A: In Wales, the experience shows that it is better to work with natural processes, than to restore artificially inlets. In Texel (NL) there is very limited sand and sediment transportation inland. In Spihoo (Germany) there is limited sand supply in the inlet. In Western Denmark there is more erosion (at 2 km from place of intervention) after the removal of a dyke.

- The beach has a macro-tidal tidal range with an intertidal zone nearly 450 metres wide and 6 m of difference in height. Camping du Perroquet was won on the sea by trapping sand. This illustrates the silting potential of the area whose formation was artificially accelerated. This is an anthropogenic acceleration of natural process. A micro cliff is observed.
- In front of the Dune du Perroquet, there is a natural transition between the foreshore and the dunes. Flood marks can be observed towards the embryonic dunes (Habitats Directive code : 2110). The bunkers serve as geomorphological landmarks. There are French structures of the First World War built in 1917, then those, German, of the Atlantic Wall of the Second World War. Between 2002 and 2018, the almost complete silting of a bunker observed shows a sea entrance into the dune, followed by a local advance of the coast. The same phenomenon would be observed elsewhere in France, at Le Touquet. There is embryonic dune vegetation (Sand Couch, *Elytrigia juncea boreoatlantica*/*Elymus farctus*). Cleft Chestnut fences and plantations of Marram are effective to support the accumulation of wind-blown sands. However, on the bunker, the accumulation of sand is natural on more than 5 meters of height. When the opportunity for natural beach and dune growth occurs (as is the case in front of the Dune du Perroquet), it is better to let free the spontaneous formation of embryonic dunes by the accumulation of sand on the natural foreshore floodmark vegetation (among others *Cakile maritima* and *Elymus farctus*).

STOP 9: stop on the beach in front of the Dune du Perroquet



*Beach with floodmark. On the back-ground: embryonic dunes with *Elymus farctus* and Sea-front dunes with *Ammophila arenaria* (Dune du Perroquet). On the horizon: Bray-Dunes*

- Recent evolution of the foredune; Dynalit-transect of the evolution of the beach/dune transition
- Former 'breach' through the foredunes (seafront-dunes) of the Dune du Perroquet
- Cross-border aspect: Camping "Le Perroquet" (on French territory): presence of a camping site on foredunes in a context of climate change and sea level rise, strategic retreat required? In fact all along the coast of the Dune du Perroquet the shoreline has not retreated since the WWII. It has even advanced significantly. But sustainable coastal zone management and safety of people require that the worst case scenario for the future be taken into account.
- Foredunes receive more sand from the beach
- In World War II, a French bunker dating from World War I located on the beach and was used as target for shooting exercises by the Germans. Several German bunkers that were part of the Atlantic Wall are now concealed by sand. An anti-tank wall (3m wide, 5m high) was built on the beach in front of the dunes. This is now in the dunes, but created a sand barrier, resulting in high dunes formed behind it. This wall now serves as a benchmark to assess the mobility of the coastline.
- Dynalit is a French national program. Profiles are followed frequently. A database that is more than 10 years old constitutes a metadata database. The information was georeferenced by kinematic differential GPS. The bicycle wheel method is also deployed there: a point is marked every meter or decimeter of difference in height. Embryonic dunes with gentle slopes are observed. The dune is higher and wider in front of the blockhouse where there was an anti-tank wall.

- In the 1980s, the authorities cleaned the beaches mechanically. These mechanical cleanings removed both the natural materials brought by the tides (algae, etc.) and the artificial plastic and metal detritus. There was therefore no flood mark left and this prevented the appearance of flood mark vegetation and the formation of embryonic dunes. Since the end of the 1990s, discussions led by the Département du Nord have motivated the manual and selective cleaning of beaches in front of natural sites, allowing the natural development of vegetation and dunes on these beaches. Mechanisation of the garbage collection is now only done in front of the seaside resorts. Outside these sites bins or tide bins have been installed. The Syndicat Intercommunal des Dunes (management) empties the bins.

Q: Is there enough sand for the future?

A: There is a huge supply. The prevailing wind is easterly from west to southwest. Furthermore, there is a strong current when the tide rises. Nearshore there are many sand banks which contribute to the natural beach nourishment. Then the wind moves the beach sand to the foredune. Because nothing prevents sand exchanges between beach and dune, the system is highly resilient. The dunes are not threatened. During spring tides coinciding with storms, small sand cliffs may appear at the base of the dune, but they are rapidly concealed by sand blown from the beach. Most of the storms take place during winter.

Q: Is the beach cleaned?

A: If you clean the beach with a machine, you also remove the natural flood mark and thwart the natural development of vegetation and embryonic dunes. If you look at the foredunes at this stop you can see new vegetation (*Cakile maritima* and *Elymus farctus*) and embryonic dunes, thanks to the fact that here the beach is not cleaned with machines. The organic matter from the floodmark plays a fundamental part. The pioneer vegetation is absent at locations where machines cleaned the beach. Until 20 years ago, the beach was mechanically cleaned, resulting in no embryonic dune development.

Q: What is the beach profile here?

A: There is a 6m height difference (tidal range) between low tide and high tide. There is a ridges & runnels profile creating an alternation between dry and wet sand. The runnels form wet corridors between the ridges. The waves break on the ridges. The runnels & ridges system moves more or less quickly on the foreshore. Runnels are thus lower wet places between ridges. The waves break on ridges.

Q: Is any sand bypassing the harbour?

A: No. In the harbour of Dunkirk the channels need to be dredged and the sand is used to nourish the beaches closest by (Malo-les Bains). Just a negligible quantity of sand from the port can arrive here despite the longshore current.

Comment: The dunes are guarded by patrollers on horses. They take care of guarding the external grazing areas + monitoring. The surveillance is organised by an association.

STOP 10: stop at the LIFE IA1-1 zone

- Evolution of the dynamics of the Dune du Perroquet with historical aerial photos.
- Mechanical removal of scrub executed in the frame of the cross border LIFE+ FLANDRE project during the winter 2017/2018 aiming at the restoration for the priority habitat '2130* grey dunes' and 2120 white dunes.
 - If the aim is to sustainably restore the grey dunes, more interventions will be needed and/or very intensive mowing as aftercare

- The works were done with heavy machines, about 3 months ago, but the entrance road is now almost not visible anymore.
- The vegetation was pulled out, stacked in huge piles and without being chopped, exported outside the area with trucks. This took about 3 days. The works in total took 20 days for the whole area. About 2.000m³ were exported.
 - Burning the vegetation is forbidden by law
- The cost of the works that were executed on the 3 dune domains (Dewulf, Marchand and du Perroquet) is estimated at 940.000 € (total LIFE budget 1.393. 000 € for the actions of the Département du Nord)
- There are still some (French and German) bunkers buried in the sand from WWI and WWII. They serve as benchmarks to monitor the dune development.
- Of the 250 ha covered by the Dune du Perroquet, 184 ha are owned by the Conservatoire du Littoral and 66 ha are privately or publicly owned, which the Conservatoire du Littoral is trying to acquire especially within the context of the LIFE+Nature FLANDRE. The management of the dunes belonging to the Conservatoire du Littoral is entrusted to the Département du Nord. It is one of the most mobile and wild sites. The Dune of the Perroquet is included in the Natura 2000 site " FR 3100474 Dunes de la plaine maritime flamande (of the Flemish maritime plain)", most of which is located at sea. Common and Grey seals grey are observed on sandbanks. The Crested Newt, the Natterjack Toad and Dune pansy (*Viola curtisii*) are observed in the dunes. Within the framework of the LIFE+ FLANDRE project 34 ha will be cleared of scrub in order to restore the habitats "2130 grey dune" and "2190 humid dune slacks" of which 15 ha have already been completed, the creation of 7 ha of new grazing areas and the creation of 5 new ponds. This work, commissioned and directed by the Département du Nord, was subcontracted to private companies and social reintegration workshops.
- A dune slack which was in the early 1990s still a sea entrance with halophilic vegetation has, after spontaneous silting of the breach in the dune, evolved by desalination towards an alkaline low-marsh environment. This dune slack (formerly called "the Breach") is mown annually. Among the flora, are now found there: *Salix repens*, *Pyrolia rotundifolia* L., *Parnassia palustris*, *Epipactis palustris* etc.
- Work of the LIFE project is being undertaken here (zone IA1-1), from 1 to 20/2018 bush clearing took place with a crawler shovel. 29 semi-trailers were needed to evacuate the 1800 m³ of cuttings. Grubbing-up combined with scraping is also undertaken. The objective is to reconstitute the natural grey dune. On the cleared ground *Euphorbia paralias*, *Viola curtisii*, etc. can already be observed. A study of flora and vegetation was carried out by the Conservatoire botanique national de Bailleul (CbNB) (before the works) and will be recorded again in 2019 (one year after the works). The cost of the mechanical works amounts to 336,000 € to removal of the vegetation on 16 hectares and the creation of 10 ponds.



Bénédicte Lemaire describes recent removals of scrub in the 'Dune du Perroquet'

Q: How do you decide where to remove the vegetation?

A: The goal is 'natural habitat restoration'. In this, the profile of the dunes is not touched. Different zones were selected: grey dunes, places with soils containing seed banks. Other seeds (e.g. of orchids) will be brought by the wind. A mosaic was used to start. The wind is not an issue to cover the small plants here.

Q: What will be the follow-up management? Grazing? Mowing?

A: That will depend on the results of the vegetation monitoring (in cooperation with the Conservatoire Botanique National de Bailleul)

ADDITIONAL STOPS A BETWEEN STOP 10 and 9

- Coast: 2 hunting seasons
 - Nov- end Feb: pheasants, wood cock, common wood pigeon
 - March: rabbits were introduced within a fence
 - Trees/shrubs/sands: important in fossil dunes
- Dune slack 1995: the sea came into the dunes, now the breach through the seafront-dunes is filled by natural silting and the foredune became higher
- Transition salt water to fresh water: not only fresh water, but remains of salt water are still visible
- Nature conservation in the Département du Nord (CD59) is financed by a 1,5% tax on new buildings.

STOP 11: stop at dune slack 6

- This dune slack ("panne") is already visible on maps of 1938; the management by the Département started in 1991. Up to the 19th Century, slacks like these were grazed by fisherman's cattle.

- Monitoring of the species that are typical for humid dune slacks (habitat 2190) following the works executed 15 years ago, structure of the vegetation, species
- Presentation of the methodology and the results of the follow-up of the quadrats by the CBNBL (Conservatoire Botanique National de Bailleul) during 15 years.
- The mowing maintenance method requires 6 people working for 8 days (ECOFLANDRES integration association). Cutting off sods on 5 metres around the periphery of the dune slack was carried out in 2004. Piezometers are set up to monitor the level of the phreatic groundwater level. The flowering of *Parnassia palustris*, *Salix repens*, *Pyrola rotundifolia* L., *Dactylorhiza praetermissa*, *Dactylorhiza incarnata*, *Herminium monorchis*, etc. is observed.... The bitter gentian (*Gentianella amarella*) was discovered there in 1991. The result is one of the richest humid dune slacks in Nord-Pas-de-Calais. The evolution of the flora and vegetation according to the management techniques (mowing or grazing) of this slack are monitored by the CBNB using quadrats and control plots.
- Like the evolution of vegetation in Merlimont, clematis also invades sea buckthorns here. Although invasive to the detriment of humid dune slacks and grey dunes, Sea Buckthorn offers a favourable habitat for many birds (nightingale, turtle-dove, willow warbler... in summer and woodcock (*Scolopax rusticola*), redwing (*Turdus iliacus*) and fieldfare (*Turdus pilaris*) in winter). Clematis is a toxic ranunculaceae species with no special avifauna habitat. Hence the question of the measures to be taken. A management plan for seafront dunes includes pulling out the plants, but this action is difficult to implement because the area to be treated is very large. Merlimont, it was found that after a certain time, the clematis manages to kill the sea-buckthorn on which, it fixes itself, these disappear and the clematis is found on the ground, forming a carpet which can make several tens of centimetres of thickness...

Q: Do you completely remove the vegetation?

A: The vegetation is mowed and then moved into the sides of the cleared area, usually nothing is removed from the site because this is very expensive. The LIFE+ FLANDRE project allowed to export the cut or mowed material from the site.

Q: How is the site managed; do you use volunteers?

A: We have a partnership with students who do about 15 days of work each year. We use mowing as management, without a tractor. It is done with a brush cutter

Q: How is the site monitored?

A: Scientific monitoring is very expensive, but there are budgets foreseen for research

Q: Why do you keep mowing?

A: It is a continuous battle against the Sea Buckthorn – the yearly mowing takes 2 weeks. We like to keep the pioneer stadium in order to maintain a high biodiversity.

Q: Why no grazing? Ideally, by sheep or goat

A: Because these are vegetations that do not necessarily tolerate grazing.

C: Welcome signboard of the Dune du Perroquet

Travaux de restauration écologique de la dune du Perroquet



Programme européen
LIFE + Nature "FLANDRE"



Conservatoire
du littoral

AGENTSCHAP
NATUUR & BOS



Vlaanderen
is natuur



Objectif des travaux LIFE + Nature "FLANDRE" :

- restaurer les habitats naturels « dune blanche » et « dune grise » des paysages dunaires ouverts d'intérêt européen (NATURA 2000)
- entretenir les surfaces restaurées par du pâturage
- recréer des zones humides favorables à la reproduction des espèces d'amphibiens protégées d'intérêt européen (Triton crêté, Crapaud calamite)

Nature des travaux :

- débroussaillage manuel ou mécanique (coupe, arrachage des souches, broyage et exportation des copeaux) ;
- pose de clôtures ;
- restauration de lisières ;
- creusement de mares.

Doel van de werken in kader van het LIFE + Natuurproject "FLANDRE" :

- herstel van de natuurlijke habitats van Europees belang (NATURA 2000) "witte duinen" en "grijze duinen" van open duinlandschappen
- onderhoud van de herstelde zones door begrazing
- herstel van vochtige milieus voor de voortplanting van beschermde amfibieënsoorten van Europees belang (Kamsalamander en Rugstreeppad)

Aard van het werk:

- manuele of mechanische verwijdering van struikgewas (kappen, uittrekken van stronken, verhakseln en uitvoeren van houtsnippers)
- plaatsen van omheiningen ;
- herstel van zoomruigten ;
- graven van poelen.

Goals of conservation actions of the LIFE + Nature project "FLANDRE" :

- restoration of natural habitats of European Community importance "white dunes" and "grey dunes" associated to open dune landscape
- management of newly restored surfaces by grazing
- restoration of humid areas to allow the reproduction of protected species of amphibians (Great Crested Newt, Natterjack Toad)

Nature of conservation actions :

- manual or automatic clearing of scrub (cutting shrubs and trees, pulling out of stumps, shredding and exportation of the cuttings);
- placing of fences ;
- restoration of tall-herbs fringes ;
- digging of ponds.

Maîtrise d'ouvrage :

Département du Nord
Direction adjointe Ruralité
Environnement

Maîtrise d'œuvre :



Entreprises :



Coordinateur sécurité :



Montant des travaux :

431 970 € TTC

Lot 4 avec le soutien financier de l'Union Européenne
LIFE+12NAT/BE/000631 "FLANDRE"

Renseignements :

03.59.73.57.43

Excursion 2

Dewulf Dune



Itinerary of the excursion through the 'Dune Dewulf' on 14 June 2018

STOP 1: Dewulf Dune entrance on the Maritime Hospital side



Dune Dewulf: the Hippophaë scrub invaded by indigenous climbing plant Clematis vitalba

The Dewulf dune covers 275 hectares, it is the nearest dune of Flanders to Dunkerque. The site includes some embryonic dunes, white dunes, grey dunes and wooded dunes. Tourism is more local and linear throughout the year. The vegetation is more uniform and shrubby (80% coverage). This leads to the implementation of maintenance and/or restoration work over a larger area than in other dune sites. Clematis is very present there.

In the 1970s and 1980s Marram grass was planted by the municipality of Dunkerque to stabilize the dune. This, among other things, is to limit the silting of the industrial site located to the south of the site. Management was transferred to the Conservatoire du Littoral 15 years ago. Photogrammetry of the site indicates historical erosion in the vicinity of the site. Operation Dynamo (second world war) took place partly on its beaches. Many wrecks still lie on the bottom of the sea, some of which are visible at low tide. These wrecks form artificial reefs. Sometimes explosives are still found. The seafront-dune has a cliff profile.

STOP 2: beach and boundary

A large German bunker from World War II collapsed under its own weight in recent years. Other structures testify well to the natural evolution because the blockhouses were built in a way adapted to the profile of the dunes. One example indicates that a silting phase was followed by an erosion phase.

In 1986, the dune was lower. In 2005, it was very steep. Measures are taken to stimulate silting, such as the installation of cleft chestnut pale fences and the planting of Marram grass. A long period without storm then spreads from 1994 until 2010. Then, high water levels undermine the dune.

A better understanding of the geomorphological evolution of dunes depends on better monitoring of beach evolution like the intertidal zone. The monitoring of the latter is a technical challenge given the turbulent conditions caused by the waves.



STOP 3: Nature development zone

This stop is one of the largest work areas of the LIFE+ Nature “FLANDRE” project (3ha). It was covered with shrubs and trees. Clearing work has restored dune conditions there. The operations were carried out mechanically using hydraulic crawler excavators and dump trucks, entering the dunes from the beach. After the work was completed, the wharf road from beach to dunes was removed and the morphology of the site was restored to its original state. The method used was the pulling out of the bushes (including their roots), followed by removal of organic debris by semi-trailer. The sand is of Aeolian origin and rich in lime (mollusc shell fragments).



An area of the 'Dune Dewulf' that was recently cleared from scrub. On the background the industrial site of the 'Usine des dunes'



Aerial photograph of the same area that was cleared from scrub

STOP 4: nature development zone

The dune slack visited where scrub removal was carried out in winter 2016/2017 is rich in iron oxides. A flow of it is possible from the surrounding dune heights. *Juncus articulatus* and *Carex flacca* are

observed, among others. There is also a microfilm of bacteria in the pools and slacks whose colours suggest the presence of iron.

The water table is between 20 to 40 cm deep. Local hydrology may explain the presence of iron. There is often more iron in winter. Iron fixes phosphates, which causes a decrease in available phosphate.

STOP 5: panoramic view of Dewulf Dune



Asparagus prostratus

Along the trail, a prostrate asparagus individual is observed. Prostrate asparagus, by some authors considered as a species (*Asparagus prostratus*), by others as a subspecies (*Asparagus officinalis* ssp. *prostratus*), is an endemic taxon of the NW-European coasts. It is an open dune plant species that is threatened by the encroachment by scrub of the dune landscape, but also by the possible hybridisation with cultivated asparagus (*Asparagus officinalis* ssp. *officinalis*), which is commonly naturalized in the dunes. The dune slack was cleared of scrub about 1.5 year ago (winter 2016-2017). Measures have been taken to extend the vegetation associated with the open dune landscape. A first maintenance mowing was carried out in January 2018.

Areas are fenced to allow grazing by Haflinger ponies, sheep and goats. Pools were excavated. The bottom of the dune slack is wet and under the influence of the water table. Indeed, there is more precipitation than evaporation, which allows the formation of a fresh water lens in the dune massif. Fresh water does not mix with salt water, which is heavier. Salt water is therefore expelled from the dune by fresh water, sometimes down to the base of the quaternary permeable layers (e. g. in the large dune ranges of the Belgian West Coast). The hydrological system of most Flemish dunes has no surface runoff and the groundwater level broadly follows the variations in precipitation/evaporation during the year. This results in relatively high groundwater levels in late winter and relatively low groundwater levels in late summer. Tidal regularity reduces groundwater variations, resulting in more moderate fluctuations towards the edge of the dunes system adjacent to the beach. Local variations in

vegetation (bare sand, herbaceous vegetation, thickets, wood, etc.) and thus local variations in evapotranspiration as well as the permeability of the underlying stratigraphic layers can nevertheless strongly influence the absolute level and the annual or periodic fluctuations of the phreatic groundwater level from one place to another. Therefore, there is no general hydrological system of dunes and to know the hydrological conditions of a specific site (in order to make substantiated management decisions), it is necessary to have temporarily a dense measurement network: many piezometers must be placed and measured.

The hydrology of the “Dune Dewulf” is, for example, very different from that of the “Dune du Perroquet”. The structure of the “Dune Dewulfs” hydrological system appears to be quite “classical”, with the highest levels in the centre of the site and fairly small differences in levels, whereas in the “Dune du Perroquet”, on the contrary, the highest levels are found towards the inner edge of the dune massif, with a clear gradient towards the middle of the massif. This may be due to the presence of underlying layers of peat or clay that are not very permeable.

A global hydrological diagnosis is therefore necessary when a dune slack has to be restored.

During the twentieth century, the water table of many dune systems seems to have been lowered, partly by drainage, but also because of scrub encroachment and afforestation (increased evapotranspiration). But at the moment, apart from local external influences (pumping, etc.), the groundwater tables seem to have stabilized or even raised. The increased rainfall since the 1980s causes more frequent and longer-lasting floods in the dune slacks, which can threaten the most vulnerable species. The most durable situations seems to be in the slacks closest to the sea (tidal stabilizing influence) and in complexes of slacks with a groundwater level that vary greatly over short distances (for example, some areas of the “Dune du Perroquet”, “de Westhoek” nature reserve ...). Dune slacks on such strong gradients do not flood uniformly, and do not dry out too much during dry periods. This leads to an increased floral diversity.

