Humid dune slacks (2190) – The Netherlands

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Conservation status	IUCN: Vulnerable (EUNIS habitat B1.8a) NL: U1 (+)
Protection status	Habitats Directive: Annex I
Area (2007-12)	EU: 235 km^2 NL: 27 km^2
MS where genuine improvement	BE, NL
Other MS	DE, DK, FR, PT, UK, RO, EE, FI, LT, LY, SE, PL, ES, GR

Summary: Humid Dune Slacks have an unfavourable Conservation Status in the majority of EU Member States, principally due to changes in water conditions and natural succession. In the Netherlands these problems are aggravated by desiccation, eutrophication and soil acidification due to nitrogen deposition. Several restoration programmes for the habitat and other dune habitats have been carried out, including through LIFE projects, initiated by various authorities. The main conservation measures taken have been the removal of vegetation, hydrological restoration (e.g. reducing water abstraction, ditch filling), creating wind funnels and the removal of topsoil. These efforts have improved habitat quality, but to ensure a long-term favourable conservation status, further measures will be required to reduce nitrogen emissions and to ensure recolonisation of the habitat's characteristic plant and insect species.

Background

Status and EU occurrence

Humid dune slacks are humid depressions in dune ecosystems. They are extremely rich in biodiversity and contain specialised habitats such as dune-slack pools, pioneer swards, fens, grasslands and reed/sedge/cane-beds (European Commission, 2013). Humid dune slacks often occur together with other dune habitat types: white dunes (H2120), grey dunes (H2130) and dune woods (H2180).

The habitat occurs in coastal areas in 23 EU Member States in five biogeographical regions, but mostly occurs in the Atlantic region. It is listed in the European Red List (as EUNIS habitat B1.8a, Atlantic and Baltic moist and wet dune slacks) as Vulnerable in the EU28 (Janssen *et al*, 2016). Its conservation status is unfavourable-inadequate in the Atlantic, Black Sea and Boreal biogeographic regions, and unfavourable-bad in the Continental and Mediterranean regions (Annex 1). The Netherlands and Belgium have reported genuine positive trends, although the habitat's status remains unfavourable-inadequate in the former Member State and unfavourable-bad in the latter.

Ecological requirements

The presence of natural dynamics in the dune ecosystem is an important prerequisite for the maintenance and formation of dune slacks (Davy *et al*, 2006). Primary dune slacks are formed in accreting conditions, when an area of the upper beach gets enclosed by the development of a new seaward dune ridge. Secondary dune slacks are formed when dry sand is blown away from dune sites and deeper more groundwater influenced sand layers become exposed and become vegetated. As such, reduced dune sand mobility, for example by planting European Marram Grass (*Ammophila arenaria*), scrubs or trees, will lead to a reduction in the formation of secondary slacks. Also other forms of sea defences and shoreline management may limit the opportunities for the spontaneous formation of new primary dune slack.

Dune slack vegetation requires wet or moist conditions which can be fed by precipitation, groundwater and/or surface water. These wet sites are sensitive to water abstraction and drainage, although their sensitivity varies with variation in water source. Most sensitive are the moist dune slacks situated at high elevation in the main dune area, since these slacks depend on scarce input of water from the soil zone where capillary action occurs. Seaward primary dune slacks are relatively insensitive since the water input is of a more ephemeral nature (Davy *et al*, 2006).

Soil and water chemistry is another important ecological factor for dune slacks. The type of plant communities in the dune slacks depend on soil type and source of water inputs, which in turn determines the ecological growing conditions pH, nutrient status and salinity. Changes in water chemistry or air pollution may cause soil acidification and/or eutrophication and species loss. Low nutrient levels which deter the establishment of fast-growing competitors, such as Bushgrass (*Calamagrostis epigejos*), often have higher species diversity.

Pressures and threats

According to the Member State Article 17 reports for 2007-12 (ETC-BD/EEA, undated), the two most frequently reported and highly important pressures were changes in water bodies conditions (24 times mentioned) and vegetation succession/biocenotic evolution (18 times). The same factors were reported as highly important threats: vegetation succession/biocenotic evolution (21 times) and changes in water bodies conditions (16 times). These two pressures are also the most important ones in the Netherlands. According to the Dutch report[1], the main pressures are (ground)water abstractions/changes and changes in species composition and succession. Dune slacks in the Netherlands have suffered from desiccation, acidification, eutrophication and enhanced vegetation succession. Various factors have influenced the vegetation changes. Vegetation change by soil acidification and eutrophication has for example been increased by air-pollution by atmospheric deposition of nitrogen, and accelerated by the decimation of the European Rabbit (*Oryctolagus cuniculus*) population by myxomatosis and viral haemorrhagic disease (Kuipers *et al*, 2016).

Drivers of improvements: actors, actions and their implementation approaches

Organisers, partners, supporters and other stakeholders

Various parties have been involved in actions with respect to humid dune slacks in the Netherlands. National programs for improving the quality of nature management are SNL ('Subsidieregeling Natuur en Landschap'), PAS ('Integrated Approach to Nitrogen'; De Heer *et al*, 2017) and OBN ('Ontwikkeling en Beheer Natuurkwaliteit') a knowledge network for restoration and management of nature where policy makers, site managers and scientists cooperate in the management and restoration of natural areas.

Plans for restoration of dune slacks have been made by various land owners / nature management organisations (PWN, Waternet, Natuurmonumenten and Staatsbosbeheer) in combination with various national or regional authorities (provinces, regional water authorities). In several cases universities have assisted. As listed in Annex 2, several LIFE projects have contributed to the conservation and restoration of the habitat. The Amsterdam Dune project was initiated by the water company Waternet. Other LIFE projects were coordinated by the nature protection organisations Landschap Noord-Holland (Revitalising Noordduinen), Natuurmonumenten (Dutch Dune Revival) and staatsbosbeheer (Dutch Coastal Dunes) or the national authorities of Rijkswaterstaat (SAMARES). The main partners in these projects were national and regional authorities, such as the Ministry of Economic Affairs, as well as provinces and regional water authorities, nature protection organisations and water companies.

Contributions / relevance of strategic plans

No relevant strategic plans are known to have made a significant contribution to the habitat's improvement.

Measures taken and their effectiveness

According to the national Article 17 report 100% of the habitat is considered to be within the Natura 2000 site network in the Netherlands. The report also lists the following measures as being important for the conservation of the habitat in the Atlantic biogeographic region. These measures aim to maintain the open slacks, counteract one-way vegetation succession and to restore degraded slacks and improve natural dune dynamics.

[1] http://cdr.eionet.europa.eu/Converters/run_conversion?file=/nl/eu/art17/envukhtvg/NL_habitats_reports_2013-12-10T13-34-58.xml&conv=350&source=remote#2190ATL

Application of conservation measures for *habitat* for 2008-2012 in the Netherlands (Atlantic)

Measure	Type	Ranking	Inside / outside N2k	Broad evaluation
2.1 – Maintaining grassland and other open habitats		High	Both	Maintain
4.4 – Restoring coastal areas		Medium	Both	Enhance

Source: MS-BIOGEO Article 17 report 2013 available at https://bd.eionet.europa.eu/article17/reports2012/

At various areas (i.e. islands of Texel, Terschelling, at Hollands Duin and the Kop van Schouwen, Amsterdamse Waterleiding Duinen, Voornes Duin, Duinen Goeree & Kwade Hoek and Kennemerland-Zuid), over 140 hectares of trees and bushes were removed from wet dune slacks to create more space for young dune slack vegetation (LIFE database). Alongside removing the dense vegetation, soil hydrology was improved and various sites were re-wetted by for example changing water abstraction, filling or rerouting ditches, or removing topsoil. Often the nutrient enriched topsoil was removed to recreate favourable nutrient-poor conditions for target plant communities.

The Dutch Dune Revival LIFE project, with a budget of €6 million, was initiated by Natuurmonumenten (the NGO responsible for management of a majority of nature areas in the Netherlands) and the province of North Holland. Utrecht University did research on the effects interventions and PWN, (Amsterdam Dunes Water Supply) monitored the changes. The main target was to (re)create a more dynamic landscape with original vegetation and drifting dunes. To achieve this, a number of slots were dug from the seaside inwards (100m wide, up to 900m length, with a depth increasing to 9m above sea level (for safety reasons). These acted as funnels for the wind. As the top soil was removed, a large amount of sand started to drift and covered habitats nearby, which created low-nutrient conditions and reduced the acidification and the succession in neighbouring grey dunes. In total, the project conducted habitat restoration on nearly 190 ha of white dune, grey dune and dune slack habitats. The interventions were quite drastic and might easily be (mis)judged as harmful for nature and people. Therefore, at the start of project much attention was paid to communicating with the local inhabitants, who were concerned with their safety, as dunes provide shelter from the sea and inundations (LIFE projects database).

The Amsterdam Dune LIFE project aimed to expand and improve in quality the habitats of 'fixed coastal dunes with herbaceous vegetation' (2130), 'dunes with Hippophae rhamnoide' (2160) and 'humid dune slacks' (2190), which in turn also improves several species protected by the Habitats Directive, such Narrow-mouthed Whorl Snail (*Vertigo angustior*), Large White-faced darter (*Leucorrhinia pectoralis*), and the Fen Orchid (*Liparis loeselii*). The measures affected an area of 350 ha and included mowing of grass, removal of trees and bushes (in particular dense cherry stands), sod cutting and blowouts were dug out. The most important follow up measures include the reduction of invasive species and the prevention of unnatural water fluctuations (LIFE project database).

The LIFE project Revitalising Noordduinen aimed to revitalise the grey dunes in the Noordduinen, by removing hardened surfaces, introducing anti-desiccation measures, counteracting the negative effects of eutrophication and reconverting an agricultural area into a humid dune slack, combating the invasive alien species Japanese Rose (*Rosa rugosa*) and improving access to the area (LIFE projects database).

The main objective of the project Dutch Coastal Dunes LIFE project was to create favourable conservation conditions through a set of related measures carried out on 4,700 ha of dunes covering eight Natura 2000 sites. The project focused on restoration of around 1,100 ha of wet and humid dune areas, primarily through restoration of natural hydrology, sod cutting and the removal of shrubs. The most important follow up measures are focused on the public support of the local inhabitants and stakeholders, education, monitoring and the continuation of conservation measures (LIFE projects database).

The aim of the SAMARES LIFE project was the restoration of salt marsh areas and had humid dune slacks as one of the target habitats. However, due to capacity problems, higher costs of the measures and indications that the measures would not lead to the achievement of objectives, the project was terminated (LIFE projects database).

An important finding was that hydrological restoration alone, by means of removing groundwater extraction wells, without additional sod-cutting, have sometimes led to a steady state of already existing low-quality communities from *the Caricion davallianae* and even partially to an undesired increased succession with grass

and shrub encroachment (Van der Hagen *et al*, 2008). In those cases, target pioneer communities did not return as expected. Sod-cutting therefore often seems necessary to counteract progressive succession and restore open habitats and pioneer communities

Funding sources (current and long-term) and costs (one-off and ongoing)

Measures have been funded by EU LIFE programme, programmes of national ministries and regional authorities (provinces, water boards) and land owners/NGO's. Furthermore, important national programs for funding were SNL, PAS and OBN (see above). The LIFE programme funds were of particular importance, with about half their costs met by the EU. The Amsterdam Dune project had a budget of €2.5 million and was co-funded by Waternet (35%) and the province of North Holland (18%). The Dutch Dune Revival project had a budget of €6.7 million, and was co-funded by the provinces of the North and South Holland for 45% and for 5% by Natuurmonumenten and PWS. The project of Revitalising Noordduinen had a budget of €1.5 million and was co-funded by the province of North Holland (45%), the Ministry of Economic Affairs (3%) and Landschap Noord-Holland (2%). The project Dutch Coastal Dunes had a budget of €5.8 million and was co-funded by the partners of the project. (LIFE projects database)

The Netherland's Prioritized Action Framework (PAF) for Natura 2000 in 2014-2020 does not mention wet dune slacks as a prioritised habitat. However, other dune habitats (H2130, H2140 and 2150) are prioritised (MinEz, 2016). The PAS policy instrument mentioned above is presented as the main tool to reduce nitrogen deposition. The 2nd listed actions are hydrological measures *('optimizing conditions in the sites with intensive management (for restoration) will make them less vulnerable'*) to improve water conditions. Site-specific measures will be incorporated in Natura 2000 management plans, and funding for these measures has been agreed with the Provinces (as set in the Nature Pact).

Achievements

Impacts on the target habitat

About 4,700 ha of dunes benefited from the Dutch Coastal Dunes project, which was the largest area affected by the LIFE projects. Wet and moist pioneer communities (Littorellion uniflora and Nanocyperion flavescentis) were observed on areas exhibiting the first restoration phases of species-rich dune slacks (LIFE database). During the monitoring study of wet dune slacks on Terschelling, 15 IUCN Red List species were observed, of which some were numerous: Shoreweed (*Littorella uniflora*), Round-leaved Sundew (*Drosera rotundifolia*), Bog Myrtle *(Myrica Gale*), Allseed (*Chenopodium polyspermum*), Lesser Water-plantain (*Baldellia ranunculoides*) and Yellow Centaury (*Centaurea solstitialis*). In the Amsterdam Dunes project area, 170 ha of woodland scrub was removed, 24 ha of humid dune slacks were extended and 250 ha of grey dunes were improved. Early impacts from the measures were positive for dune slacks and pools, although the supply of sufficient base-rich groundwater with seepage and sufficient dispersion of the targeted species from the surrounding area might limit full restoration (Van der Hagen *et al*, 2008).

Other impacts (e.g. other habitats and species, ecosystem services, economic and social)

In many of the projects, measures were taken to improve other target dune habitats, such as white and grey dunes. Moreover, many dune habitats and species will gain from the revitalisation of dynamic dune processes and restored hydrology. Effects on other economic and social ecosystem services have not been examined, although effects might be present since Dutch dune areas are highly appreciated and important for recreation (De Vries *et al*, 2013).

Conclusions and lessons learnt

The key targeted conservation measures that led to the improvements

- Various restoration measures in dune slacks have been taken that were aimed at re-establishing favorable (abiotic) conditions that are essential to typical plants, animals and their communities. These measures often focused on restoring hydrological conditions (for example by changing water abstraction) and/or resorting vegetation structure and soil conditions (e.g. by increased mowing/grazing, sod cutting).

Conservation measures that have not been sufficiently effective

- Hydrological restoration alone did not always result in the restoration of the open habitats and pioneer communities as expected, and therefore it seems to be necessary to carry this out in combination with sod-cutting to counteract progressive succession and restore the target communities.

Factors that supported the conservation measures

- Experience shows that it is important that target species are able to repopulate the restored sites. This requires, in the first place, careful handling of the remaining residual populations and the diaspores present in the soil (i.e. seed back) as a resource for the recolonisation of rehabilitated parts of an area (Grootjans *et al*, 2002). But additional efforts to increase the accessibility of the restored sites from the neighbouring landscape can also be important.
- Restoration plans need to concern the total habitat community as a whole, which means that the nature of the restoration measures and the way they are implemented must be such that all target species groups benefit. Measures which focus only on one group (vascular plants, for example) might easily harm the other typical habitat species due to wrong choices in measurement form, scale and timing. The preparation and execution of restoration measures thus always need to be area specific and carefully customised.

Factors that constrained conservation measures

- Various restoration measures (i.e. sod cutting, additional mowing, and grazing) have been taken to reduce the negative effects of increased air pollution. Conservation measures alone however, will often not be enough for long time restoration, and thus need to be combined with emission reduction measures. Without emission measures high deposition levels will decrease the chance and duration of the biological restoration effects. When air pollution levels remain high the restoration measures might need to be repeated throughout time (Grootjans *et al*, 2002). Frequent sod-cutting, does however have negative consequences on the remaining seedbank.
- Given the risks of repetition of some restoration measures, it is not only important to restore favourable abiotic conditions but also to reactivate the natural processes which create favourable conditions. This includes restoring hydrologic processes (i.e. seepage) and dynamic dune processes (i.e. active sand drift) which creates opportunities for the re-establishment of pioneer vegetation (Grootjans *et al*, 2002). However, natural processes can only be restored in areas which are large enough.
- Despite restoration of the essential habitat conditions and meticulous implementation of the measures, it is sometimes found that a large number of species do not return. The fact is that many plant species only have a short-lived seed bank, which might have long disappeared before the restoration (Grootjans *et al*, 2002). Besides, there are only a few species that are capable of spreading over a large area. This is especially true of many of the most endangered species. To increase the chance of recolonisation actions need to be planned near to remaining populations, and sometimes additional attention needs to be given to counteract spatial fragmentation or species introduction could be considered.
- Large scale restoration measures that alter vegetation structure might be effective for the revitalisation of dune swards, but they have received varying degrees of support from the visiting public (van der Hagen *et al*, 2008). Not everyone is enthusiastic about seeing (restoration) actions taking place in nature areas or the sight of the initial effects of vegetation and sod removal.

Examples of good practice, which could be applied to other habitats

- It is important to provide early information to the wider public on plans and intended actions, especially in the direct neighbourhood, to gain trust and support. Broadening aspects of monitoring and reporting might also be worthwhile, given increased policy and public attention to targets other than biodiversity alone.
- Building a community of practice with help from the academic world (in programs such as OBN) can help in developing and disseminating knowledge to enhance nature quality management and conservation.
- Planning restoration in a broader landscape perspective and also focussing on other pressures such as fragmentation and (air) pollution is important for long lasting positive impacts.

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Annex 1 Status at EU and Member States Levels

Humid Dune Slacks

Favourable	FV	Unknown	XX	Unfavourable - inadequate	U1	Unfavourable - bad	U2

Qualifier (+) improving (-) deteriorating (=) stable (x) unknown (n/a) not reported

	2001-06	2007-12				
	Overall	Range	Area	Structure	Future	Overall (with qualifier)
BE	U2	FV	U2	U2	U2	U2 (+)
DE	U1	FV	U1	U1	U1	U1 (-)
DK	U1	FV	FV	U1	U1	U1 (=)
FR	U2	U1	U1	U1	U1	U1 (X)
IE	U2	U1	U1	U1	U1	U1 (-)
NL	U1	FV	U1	U1	U1	U1 (+)
PT	U2	XX	U1	U2	U1	U2 (=)
UK	U2-	FV	U1	U2	U2	U2 (-)
BG	N/A	FV	FV	U1	U1	U1 (=)
RO	N/A	FV	FV	FV	XX	FV (0)
EE	FV	FV	FV	FV	FV	FV (0)
FI	U1	FV	U1	U1	U1	U1 (-)
LT	U1	FV	FV	XX	U1	U1 (=)
LV	U1	FV	U1	U1	XX	U1 (X)
SE	U2	FV	U2	U2	U2	U2 (-)
DE	U1	FV	FV	U2	U2	U2 (-)
DK	U2	FV	FV	U2	U2	U2 (=)
PL	U1	XX	XX	XX	XX	XX (0)
SE	U2-	FV	U2	U2	U2	U2 (-)
GR	U1	U1	U1	FV	U1	U1 (N/A)
ES	XX	U1	XX	U1	U1	U1 (-)
FR	XX	FV	U2	U1	U2	U2 (-)
PT	U2	FV	U1	U2	U1	U2 (=)

Source: Member State Article 17 reports as presented on EIONET https://bd.eionet.europa.eu/article17/reports2012/

Annex 2. LIFE Nature Projects that aimed to help conserve humid dune slacks in the Netherlands

Project Title	Project N°	MS	Type Of Beneficiary
Dutch Coastal Dunes - Restoration of dune habitats along the Dutch coast	LIFE05 NAT/NL/000124	NL	National Authority
SAMARES project - Salt Marsh restoration Eastern Scheldt	LIFE06 NAT/NL/000077	NL	National Authority
Sand dynamics in inland dunes - Revival of dynamics by activation of sand drift in inland dunes	LIFE07 NAT/NL/000571	NL	NGO-Foundation
Revitalising the Noordduinen - from concrete surfaces to grey dune habitats	LIFE09 NAT/NL/000417	NL	NGO-foundation
Dutch Dune Revival - Realisation of Natura 2000 targets for calcareous white, grey dunes and dune slacks in three Dutch dune sites	LIFE09 NAT/NL/000418	NL	NGO-foundation & province
Amsterdam Dunes - source for nature, dune habitat restoration project	LIFE11 NAT/NL/000776	NL	NGO-Foundation

Source: Life Programme database