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Invasive scrub and trees in the coastal dunes of Flanders (Belgium): an overview of management goals, actions and results

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Abstract

Even in nature reserves and under the European Habitat Directive protected dunes of the Flemish coast, species and habitats of the open dune landscape (especially Habitat-types 2130, 2170 and 2190) have become seriously endangered. On the other hand, natural dune scrub and pioneer woodland (Habitat-types 2160 and 2180), together with alien species and manmade habitats (plantations,…), strongly increased. Since the Nature Division became responsible for nature management in Flanders (1995) and with the aid of European funding (Life-projects ICCI and FEYDRA), action was undertaken to stop and reverse this trend. The management dilemma (species rich open dune *vs.* natural scrub and woodland) is tackled on the basis of an Ecosystem Perspective for the Flemish Coast and by drawing up scientifically based management plans. This paper gives, from a nature managers point of view, an overview of the history and nature of these changes, the problems and dilemmas for nature conservationists, the extent and management techniques of scrub and alien tree removal and of open dune restoration, and a first evaluation of results.

Keywords: Flemish coast; Scrub encroachment; Biodiversity loss; Removal of scrub; Alien trees.

Introduction

Written and photographic descriptions (Massart, 1908a, 1908b, 1912) and botanical data (De Raeve *et al.*, 1983) picture the historic Flemish dunes as a very open landscape, mostly poor in shrubs and even completely lacking spontaneous trees and woodland. It was predominantly made up of (semi-)mobile dunes and low vegetation and was rich in typical open dune plant species and populations of what we now consider to be Red List or Target species (Biesbrouck *et al.*, 2001; Provoost and Bonte, 2004) of various dune valley habitats. The actual landscape of the protected dune areas looks very different: large areas of wet to humid dune valley systems and even dry dunes are covered with various thickets. Locally, even extensive plantations and scattered (sub)spontaneous pioneer woodlands have become established. Alien species form a growing part of the dune flora, even in protected nature areas. Parallel with landscape and vegetation change, important changes in species composition of the dune area occurred. A great number of highly specialised (plant) species of the open dune habitats has disappeared or

has become very rare, while widely dispersed and less typical taxa are spreading. Alien species make up a growing part of the dune flora, even in protected nature areas. The direct impact of urbanisation and lowering of the water table on dune landscape, flora and fauna has of course been even more drastic than that of vegetation change, but is not the subject of this paper. As an evaluation tool, this overview mostly uses botanical criteria, but results and conclusions probably also hold when other organisms are concerned.

20th century scrub expansion in the Flemish dunes

The nature reserve De Westhoek (De Panne, Belgium; Fig. 1) is one of the best studied dune areas of the Flemish coast and may be used as a good example for the description of landscape and botanical evolution over the past century. Despite protection as Belgium's first public nature reserve (est. in 1957) and the presence of large-scale dynamic geomorphological processes with continuous formation of new wet dune slacks up to this day, a series of Red List species had become locally extinct or very rare by the 1980's (D'Hondt, 1981). Two groups of species and their habitats (Romao, 1999) seemed to be especially affected: 'Humid dune slacks' (Natura 2000-code 2190), often intermingled with 'Dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*)' (code 2170) and 'Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.' (code 3140), and dune grasslands belonging to the 'Fixed dunes with herbaceous vegetation ('grey dunes')' (code 2130). Although the area of 'Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes')' (code 2120) and moss dunes (code 2130) also decreased (De Vlieger, 1989), this did not (yet) lead to the complete loss or endangerment of valuable plant species. Animals, especially invertebrates and birds, of the open dynamic dune landscape may however be much more influenced! On the other hand, dune scrub ('Dunes with *Hippophae rhamnoides*'; code 2160), mostly dominated by *Hippophae* and/or *Ligustrum vulgare*, and to a lesser degree 'Wooded dunes of the Atlantic, Continental and Boreal region' (code 2180) increased. These phenomena were not restricted to De Westhoek, but were observed by scientists and managers in most of the coastal dune areas in Belgium and adjacent France (De Vlieger, 1989; De Raeve *et al.*, 1983; Provoost and Hoffmann, 1996).

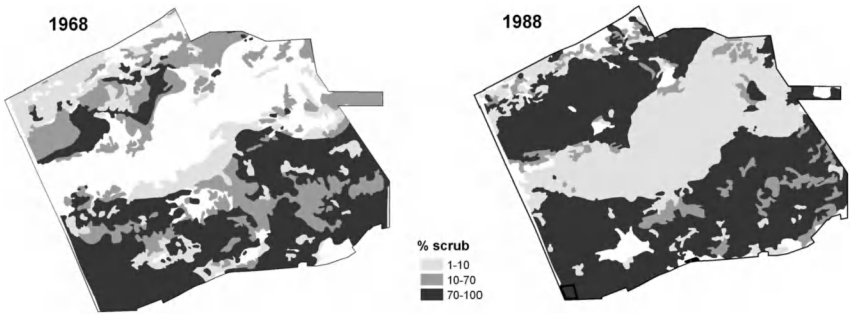

Fig. 1. Scrub extension in De Westhoek nature reserve (De Panne, Belgium) between 1968 and 1988 (Van Nieuwenhuyse, 2002, based on De Vlieger, 1989).

The decrease of wet dune slack species probably started in the 1950's or even earlier, for a large part due to the exponential expansion of *Hippophae*-scrub. At the beginning of the 1980's dense *Hippophae*-thickets had already colonised the open pioneer stage of all unmanaged Westhoek dune slacks some 15 (max. 20) years after their formation (Fig. 1). By that time several typical Red List-species were extinct (*Liparis loeselii, Orchis morio, Teucrium scordium,…*) or had become very rare (*Schoenus nigricans, Equisetum variegatum, Herminium monorchis, Gentianella uliginosa,…*). Only species adapted to rapid spreading into the most recently formed dune slacks (such as *Centaurium littorale, Parnassia palustris, Sagina nodosa,...*) and/or commonly present in the local persistent seed bank (*Anagallis tenella, Carex trinervis, C. viridula,...*) were able to survive this evolution. Nevertheless, by 1984, the population of *Parnassia palustris*, symbol species of the nature reserve, was almost restricted to a central complex of young dune slacks, including some of the first actively managed (mown) parts (Fig. 6c: with scores of 'occasional' and 'frequent' predominantly in the managed sites). This decline in species and quality was even (much) greater in the more isolated and/or less dynamic dune ecosystems, such as the nature reserve 'Dunes Marchand' at Zuydcoote (France) or the 'Zwinduinen en -polders' at Knokke (Belgium).

Even though populations of humid and dry grassland species may also have been diminishing since World War II, it was only from the 1970's onward that a threatening decline really became obvious. Key species in this encroachment process was mostly *Ligustrum*, together with *Hippophae* and dominant grass species as *Calamagrostis epigeios*. Few species (*e.g. Anthyllis vulneraria*) disappeared completely from the reserve, but a high number became very rare (*Thesium humifusum, Asperula cynanchica, Briza media,…*) or survived only locally. For instance, by the beginning of the 1980's, *Helianthemum nummularium* had probably already suffered great losses, but was locally still widespread in scattered small open patches between the *Ligustrum*-scrub of late-medieval dune valleys and low dunes in the southern part of De Westhoek (Fig. 6a). Twenty years later, almost none of these populations survive (Fig. 6b). This also seems a general feature, even in areas where dune grasslands once dominated the landscape.

If scrub invasion of the open dune ecosystems caused the loss of important and vulnerable species and populations, it also raised the general number of species in the dune area. A considerable part of the present dune flora in fact consists of 'new' species, often species from disturbed sites or garden escapes, but also indigenous species related to scrubs and woods. The losses in biodiversity of the open dune landscape are partly outweighed by the gain of rare species such as *Polygonatum odoratum, Rhamnus catharticus, Rosa stylosa* and others. Just as in some dune areas the nightly concerts of *Natterjack toads* have been replaced by the singing of *Nightingales*. Also epiphytic mosses, lichens and fungi have often profited from this evolution (Provoost and Bonte, 2004). Most of these species, however, are generally increasing in the whole of Flanders. Of some of them (*e.g. Berberis vulgaris, Lonicera xylosteum, Narcissus pseudonarcissus,...*) the indigenous status is even dubious.

External factors, *e.g.* lowering of the water table (due to water abstraction, nearby urbanisation, etc.) or increasing N-deposition (due to air pollution), and the loss of geomorphological dynamics (sometimes called 'fossilisation' of the dunes; Van der Hagen, 2002) are often cited as the main causes for this expansion. Field-experience and

historical data indicate however another important cause. Rapid and massive colonisation of the younger stages of secondary dune valley development by pioneering *Hippophae*-scrub may well be the normal natural process in lime-rich dunes, in Flanders and elsewhere in NW-Europe. In any case, pollen analysis reveals high amounts of *Hippophae*-pollen in dynamic medieval stages of landscape development (De Ceuninck, 1987). Also De Bruyne (1906) describes the presence (and extensive cutting!) of *Hippophae* in young dune valleys of the very dynamic historical dunes of De Panne. On the other hand there are no indications that the species-rich mixed thickets that are actually replacing grey dunes and older dune valley grasslands have ever existed in the medieval dune landscape.

The historical open dune landscape was probably the product of the introduction and breeding for hunting purposes of rabbits since late medieval times, the use as grazing ground for livestock (cattle, donkeys, sheep,...) up to 1940, the cutting of shrubs for firewood or dune stabilisation, etc. All these oppressing factors gradually came to an end by the middle the 20th century, at the time scrub expansion started. So, the almost completely open dune landscape of Massart (1908ab) must at least to some degree be considered as semi-natural. And the invasion of indigenous shrubs probably was the natural process of primary (*Hippophae*) or secondary (*Ligustrum* and mixed scrub) succession once the stressing and disturbing influences of agropastoral use had stopped.

Parallel to the increase of natural dune thickets, a new phenomenon came into view by the 1990's: the invasion of alien species, both woody and herbaceous. This tendency occurred in the already endangered open dune slack habitats, dry dune grasslands and moss dunes, but even more in the natural scrub communities and pioneer woods. It was essentially a somewhat postponed effect of the unrestrained urbanisation and fragmentation of the natural Flemish dune belt during the 20th century. Provoost and Bonte (2004) point out that, with the end of the 19th century as a reference, more than half of all plant species are 'new' to the actual coastal area and that no less then 20% are real aliens. Not all of those species act as aggressive threats ('pest species') to indigenous ecosystems. However, seedlings and shoots of some species derived from local plantations (*Populus xcanescens, P. xjackii, Acer pseudoplatanus*, *Salix* spp.,...) or derelict brushwood used for the stabilisation of drifting sand (*Populus* spp.), garden escapes (*Mahonia aquifolia*, *Rosa rugosa, Claytonia perfoliata,...*) or accidentaly introduced species (*Senecio inaequidens*,...) can thoroughly influence (semi-)natural dune ecosystems and lead to an additional loss in biodiversity. Speaking of 'alien species' in this context may be somewhat ambiguous, as almost all trees in the actual dune vegetation descend from cultivated ancestors and some authors even regard species as *Populus (x)canescens* and *Acer pseudoplatanus* as indigenous in Flanders, albeit not necessarily autochthonous in the coastal dunes. Therefore, the emphasis is mostly on the 'invasive' character and the threat to historical biodiversity, rather than on the 'alien' character of the species.

Management planning

The evident decline in quality of the open dune habitats (especially wet dune slack vegetation and dune grasslands) caused by an, at least partially natural, extension of

Hippophae- and *Ligustrum*-scrub creates a management dilemma for nature conservationists. International criteria are not very helpful either, as the EU-Habitat Directive Annex I obliges the protection of *all* (semi-)natural dune habitats, albeit that humid to dry dune grasslands and moss dunes (= 'grey dunes', Habitat-code 2130) enjoy a priority status. Do we thus accept the losses in historical and internationally valuable biodiversity connected to the actual, more or less autonomous (= 'natural') processes in vegetation development? Or do we interfere for the preservation of, in the actual situation, mostly semi-natural habitats with high biodiversity value, resulting in a loss in autonomy of the dune ecosystem as a whole? Or should we search for some compromise?

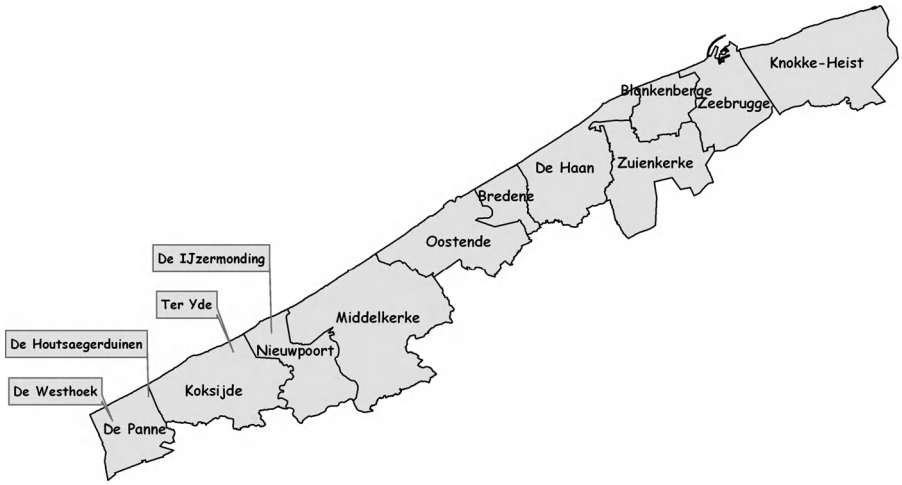

Fig. 2. Location of the concerned nature reserves and managed sites.

Due to the lack of a scientific and integrated approach of coastal conservation and the lack of sufficient means, the management policy remained ambiguous for a long time (Herrier and Killemaes, 1998). When the Nature Division of the Ministry of the Flemish Community became responsible for nature management in 1995, a general Ecosystem Perspective for the Flemish Coast (Provoost and Hoffmann, 1996; Herrier, 1998) and a number of specific management plans were drawn up, creating the necessary solid base for nature management. With Provoost and Hoffmann (1996) as a beacon, each management plan could emphasis its own specific aspects (location of concerned sites in Fig. 2). On the military base of Lombartsijde/IJzermonding (30ha, Nieuwpoort), partly managed by the Nature Division, for example, a radical policy of preserving the completely open, '19th century' dune landscape with dune grasslands, moss dunes and dune slack vegetation was agreed upon (Degezelle and Hoffmann, 2002). *Hippophae*-scrub and *Populus*-plantations are systematically removed here. In De Westhoek (345ha; Hoys *et al.*, 1996a) a compromise-scenario was chosen, based on the (virtual) division of the reserve in a western part with emphasis on biodiversity and a variety of vulnerable habitats ('pattern-oriented management'), and an eastern part with emphasis on undisturbed natural vegetation development ('process-oriented management'). Extensive grazing by large herbivores and geomorphological dynamics act as unifying landscape

processes. A comparable policy was developed for the nature reserve of Ter Yde (62ha, Oostduinkerke; Van Nieuwenhuyse, 2003). In the nearby Hannecartbos (32ha), the remnant of a marshy medieval beach plain now largely covered by not very vital plantations, the restoration of wet dune slack grasslands, historical ditches and dry 'hedgehog-dunes' goes hand in hand with the conversion of the plantation towards a more natural dune woodland. Special attention is given to the connection with adjacent open dune ecosystems and the maintenance of tall-herb fringes (habitat of *e.g.* Annex II-species *Vertigo moulinsiana*) (Hoffmann *et al.*, 1999). On the other hand, the management plan for the Houtsaegerduinen (80ha; De Panne), an isolated reserve enclosed by urban area, aimes especially at the development of natural scrub and woodland and the suppression of aggressive alien species (Hoys *et al.*, 1996b). Grazing should maintain species and landscape diversity during this process. Here only some small patches of relict dune slack and grassland are temporary mown to prevent scrub encroachment.

Where preservation or restoration of open dune ecosystems is the primary goal, management plans generally aim at the creation of as large and little fragmented entities as possible. The creation or preservation of a diversified vegetation structure with extensive transitional zones is also a constant point of attention. Another basic principle, at least when reactivation of mobile dunes is not the main aim of the action, is a respectful approach towards conservation of the soil, seed bank, micro-topography, relict populations, etc., in other words: of the site's ecological history. It is, for instance, known that a too drastic removal of the topsoil is harmful for *Vertigo angustior*, an Annex II-species of lime-rich dune slacks (Janssen and Schaminée, 2004).

Management practice (Table I)

General features

Starting in the 1970's, active vegetation management in the Westhoek nature reserve remained restricted to the yearly mowing of a former farm meadow (<2ha) and of some small patches of wet dune slack vegetation ('maintenance management'). Regrettably, most of these initial management sites were situated in unfavourable parts of the reserve, as they where influenced by a gradual lowering of the water table due to adjacent drinking water exploitation, and some were later abandoned. Following the recommendations of D'Hondt (1981), the first more adequate measures were undertaken. Those early actions concerned the conservation of the often very small relict populations of vulnerable species like *Herminium monorchis* (<10 individuals), *Schoenus nigricans* (2 individuals), *Gentianella uliginosa* (<50 individuals) and others. They mostly consisted of (very) small-scale scrub cutting or tall grass mowing (sometimes less than 0.01ha!). These surface areas were gradually extended in the 1980's and 1990's (c. 6ha by 1994), but remained a more or less anecdotal response (sometimes called 'eco-gardening') on the changes in the whole of the dune ecosystem. The same was true for Ter Yde (small-scale actions from 1994 on) and Hannecartbos (relict management from 1989 on).

Following the new management policy, which started in 1995, the first intervention was the gradual expansion of the area of young dune slacks that were kept in an open state by means of mowing or selective weeding of *Hippophae*-seedlings ('maintenance' management: 10.75ha by 2004). On the most vulnerable or inaccessible sites, relatively small-scale grassland and dune slack restoration through careful manual cutting of scrub (including the use of small machinery as brush cutters and chainsaws) and removal of litter of course continued and was even intensified (by 2004: 12.35ha, generally in small individual patches). It was mostly executed by the staff of the Nature Division, partly with the help of social employment projects. Large-scale mechanical actions, executed by specialised contractors, proved however necessary to realise the management plans. With the help of EU-funding (Life-programs ICCI and FEYDRA; Herrier and Killemaes, 1998; Herrier and Van Nieuwenhuyse, 2005), the often high goals set by the management plans could (or will) be reached in a relatively short time (already 21.47ha by 2004). At last, the (manual) treatment or removal of invasive alien trees (pest control), also took place on a large scale (20.89ha), although this figure of course includes sites where only scattered individuals were treated.

Table I gives a more detailed overview of the actions undertaken by the Nature Division since the start of active vegetation management in the Flemish coastal reserves and nature domains (in total c. 1300ha by the end of 2004). The 6ha of dune habitats that up to 1995 were managed by way of pattern-oriented or pest-controlling actions, have since been multiplied by ten and management plans, approved or in preparation, foresee a substantial extension still. An overview of Target Habitats (Fig. 3) shows that 3/4 of the actions concerned the restoration or preservation of dune slack vegetation (codes 2190/2170) and of dry dune grasslands or moss dunes (code 2130; priority habitat). This is in line with the earlier mentioned, most urgent conservation needs. Most of this management took place in De Westhoek, Ter Yde/Hannecartbos and Lombartsijde. A small but significant area of scrub or plantation removal in these dune slacks was needed to create or restore dune pools (codes 2190/3140). In Ter Yde, also the restoration of a large area of shifting dunes (code 2120) made the removal of scrub and planted trees necessary. Selective cutting of invasive (alien) trees (pest control) to restore natural dune scrub (code 2160) or woodland (code 2180) concerned some 15% of the area, in all reserves. Specific action towards the creation of humid tall herb fringes ('Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels'; code 6430) was only very locally undertaken in the Hannecartbos, but this habitat is, on a small scale, often a 'side product' of local scrub removal or natural scrub succession.

In all restoration actions involving removal of scrub or plantations, several *executive phases* could be distinguished:

1. the cutting of shrubs or trees by means of hand material (small-scale actions) or through chopping with a woodchopper (mostly large-scale actions);
2. the removal and processing of coarse woody debris;
3. the (careful) removal of stumps, fine organic litter and/or topsoil.

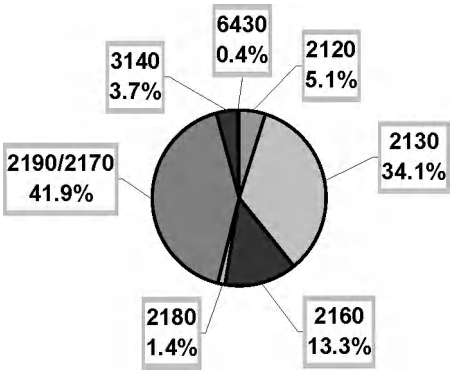

Fig. 3. Target Habitats of the management actions involving removal of scrub and pest control in the nature reserves of the Flemish coast.

As experience grew, the importance of *preparatory action* became more apparent:
1. the administrative and judicial preparation, incl. financing of the actions (is of course crucial and often time and nerve consuming, but will not be treated here in further detail);
2. the acquiring detailed knowledge of the site and conceptual preparation;
3. the planning and creation of (temporary) service infrastructure.

Even more than expected, *direct follow-up* and scrupulous *evaluation* of the results proved to be essential.

Executive phases

Large-scale action for the restoration of the open dune valley landscape of De Westhoek started in 1997, with the reclamation of 6.7ha of (partly already perishing) *Ligustrum* and mixed scrub in the late-medieval and least vulnerable southwestern dune slacks. The technique used generally followed the example of the actions undertaken some years earlier in the French nature reserve Dunes Marchand: a tractor with an improvised woodchopper first 'smashed' the scrub to pieces, only sparing scattered *Quercus* and *Crataegus* trees and some islands of *Prunus spinosa*. In a second stage a caterpillar crane with toothed shovel concentrated the debris and coarse litter in compact heaps. Some of the fine litter was later manually removed with rakes, but most of it was left on the site. The woody debris was burned on the spot and the ashes were transported outside of the reserve. In a last stage, the soil underneath the stakes was excavated and used for the creation of permanent service tracks. The excavations were transformed into (drinking) pools.

In later large-scale actions in the vulnerable young up to middle-aged northern dune slacks of De Westhoek, on the very vulnerable peaty soil of the fossil beach plain of the

Hannecartbos and in Ter Yde, a more 'professional' heavy woodchopper mounted on the 7m-arm of a caterpillar tracked vehicle was employed. Despite the heavy weight of the vehicle, the use of caterpillar tracks combined with the length of the arm and the technique of employing a thick layer of woody debris as an underground for temporary service ways resulted in a remarkably limited disturbance or compaction of the soil. Sole problem proved to be the (high) working speed: sometimes the supervising personnel was not able to correct small errors in time!

The later stages of open dune restoration proved to be more problematic. Even if the basic technique for the removal of woody debris and coarse litter (scraping it together with a toothed shovel) gave good results, removal of the finer litter caused more problems. A variety of techniques was tried out, some of them not very successful (*e.g.* the use of a street sweeper), some successful but very labour-intensive and costly (*e.g.* complete manual removal with rakes), some of them mostly creating a lot of dust… It often obliged the managers to finish off the action by cutting shallow sods (if possible less than 5cm and preserving at least part of the A1-soil horizon). Both manual (with simple shovels) and mechanical (caterpillar crane with flat shovel) techniques were successfully tried out. In De Westhoek, these sods were later used to stabilise service tracks.

As, since 1999, the use of fire (and thus the burning of woody debris) in the Flemish nature reserves was no longer considered justified, the problem augmented. The only efficient solution left was to remove debris and litter together with as little of the topsoil as possible (Fig. 4). Of course, this was only possible in more or less flat dune slacks and risked to be in conflict with the aim of restoring open dune ecosystems while respecting soils, micro-topography and relict populations. The creation of an optimal starting point for the restoration of dune grasslands on undulating dunes and in small slacks thus remains a problem that can probably only be solved through high investments in manual labour.

Fig 4. A caterpillar crane with flat shovel scrapes away woody debris, litter and part of the topsoil in a wet dune slack of De Westhoek (2000).

When accessibility, finances and legal conditions made it possible, the mixture of debris, stubs, litter and topsoil was removed from the reserve (Hannecartbos, Ter Yde), if not it was concentrated and locally stacked as an artificial dune (De Westhoek, Houtsaegerduinen). In all cases, vehicles with low soil-pressure tires or caterpillar tracks were used for transportation. Stems and branches resulting from the smaller-scale manual scrub-cuttings could mostly be chopped with an independent chopping utility and were used to stabilise footpaths in the reserves.

Preparatory action

Because of the difficult accessibility, the demarcation of the first reclaimed Westhoek-site (1997) was rather improvised and often dictated by the topographical features that were, sometimes rather unexpectedly, met with on the spot. Learning from this experience, later actions were prepared in more detail. For instance, in the last, most elaborately planned reclamation site of De Westhoek (2000), the scrub removal phase was preceded by the creation of a raster of passage ways (50mx50m) that was meticulously set out on the spot and executed with a simple woodchopper on a tractor. Meanwhile, based on vegetation mapping, topography, age of the various dune slack parts, old botanical records, etc. a complex reclamation pattern was drawn on detailed aerial photographs in order to create a site with an 'optimal' mixture of open dune vegetation and scrub of all age categories, humidity, etc. This pattern was marked on the now better accessible site, whereupon the caterpillar driven woodchopper neatly 'cut out' this pattern. It resulted, from an aerial view, in a rather artificial looking landscape pattern (Fig. 4: most northeasterly reclamation site), but should guarantee a maximum of diversity in the restored low vegetation as well as in the remaining scrub.

Another type of preparatory action was needed in the Hannecartbos, where a dying 60-year old plantation of *Alnus incana, A. glutinosa* and *Populus xcanadensis* was felled. Here, relict populations of *Valeriana dioica* and especially sedge populations with the Annex II-species *Vertigo moulinsiana* had to be searched beforehand and carefully marked in order to preserve these vulnerable species. All these kinds of preparatory activities may take some time and expertise, and can influence a rational execution of mechanical actions. They nevertheless prove to be essential.

A thorough study of historical sources and the situation on the site can also be very useful in the planning of necessary service infrastructure. In De Westhoek, for example, half-hardened derelict tracks dating from World War II that visibly had become almost untraceable on the site, could be 'recycled' as permanent service tracks with the help of old maps.

Control and follow-up management

As ecosystems are often rather unpredictable and natural conditions can rarely be described up to the smallest detail, small changes of the specifications on the planning documents (the contractor's base for the execution of the works) were often necessary and sometimes had to be decided instantly on the spot. A direct and intensive control of

the actions on the site proved to be essential to obtain the best possible results or even to avoid 'collateral damage'.

On the other hand and independent of action-scale, scrub-cutting and efficient litter-removal are rarely solely sufficient for successful restoration of vulnerable habitats. Regrowth of wildshoots, seedling establishment on the bared soil, etc. negatively influenced desired vegetation development in almost all reclaimed sites and during some years a follow-up management (mowing, weeding seedlings,...; mostly executed through a social employment project) always proved necessary. In some cases, periodical cutting of regrowth of *e.g. Hippophae* or *Prunus spinosa*, is already foreseen in the future management scheme. Anyway, preventive action, *e.g.* the preliminary search for and elimination of undesired seed-bearing trees (*Salix alba, Alnus glutinosa,...*) in the direct neighbourhood of the management site, might prevent later problems. Also remaining stubs, rubble, pits, etc. sometimes hampered follow-up management.

Pest control of invasive (alien) trees

Suppression of invasive alien species, mostly trees, was necessary in almost all managed dune areas. The first actions against invasive alien trees were undertaken in 1996, with the removal of 2.5ha of trees and wildshoots of *Populus (x)canescens* and *P. alba* from valuable moss dunes of the inner dune ridge of De Westhoek. Trees were simply cut and removed. In the following years, even more extensive action against especially *P. xjackii*, but also *P. (x)canescens*, *Robinia pseudacacia*, *Prunus serotina* and others, was undertaken in De Houtsaegerduinen, partially through the very careful use of a herbicide (glyphosate). In Ter Yde the problem concerned mainly wildshoots from derelict brushwood used to stabilise the dynamic dunes (mostly *Populus xcanadensis*). Because of vulnerable orchid populations in the nearby dune slacks, no herbicide was employed here. So extensive mowing and manual uprooting was used as a management technique. Where possible, stems were almost completely removed from the site and branches were burned on the spot or, later, chopped and transported. Sometimes (*e.g.* dispersed individuals in hardly accessible scrub) treated or felled alien trees where left on the spot. In general, litter removal was not necessary, but the removal and processing of stems and branches had often to be done with great care, *e.g.* when moss dunes (Habitat-code 2130) were concerned. In all cases an intensive follow-up management (repeated mowing, uprooting of wild shoots and even renewed use of glyphosate) was needed to prevent regrowth.

Evaluation and discussion

Parallel to the execution of the nature management plans, a scientific monitoring project was set up in 1997-1999, continued in 1999-2002, by the University of Ghent and the Institute of Nature Conservation, under the supervision of the Nature Division. It focused on the nature reserves of the western coastal area, especially De Westhoek and De Houtsaegerduinen and was supported by the EU-Life-project ICCI (Herrier and Van Nieuwenhuyse, 2005; Hoffmann *et al.*, 2005). However, it is still too soon after management actions to draw definite and general scientific conclusions, especially when taking into account the very abnormal hydrological conditions of 2001 and 2002. And,

as the emphasis of the study lay on the effect of extensive grazing, conclusions have less to do with the specific effects of scrub and tree removal. In any case, one of the main management questions, namely whether grazing in itself can transform scrub into valuable dunes slack vegetation or grassland, can probably only be solved after some decades of study. At the moment, however, there are no indications to suggest such a development. At Oostduinkerke and Nieuwpoort a new monitoring project was set up in 2004 (up to 2008, supported by Life-project FEYDRA) and contracted out by the Nature Division to the University of Ghent and a couple of other scientific consultants. It is of course still in the starting phase. This last monitoring project aims specifically at an evaluation of the effects of scrub and plantation removal. A provisional evaluation by the management team itself, based on empirical, non-systematic observations, of the scrub removal actions is however possible. So, some impressions rather than hard conclusions can already be presented and discussed.

The small-scale actions undertaken since the 1980's to protect relict populations of very rare species were mostly successful. Almost all target species could be saved, although accidents did happen (*e.g.* the loss of *Schoenus nigricans* due to inadequate mowing of the site), populations remained very localised and small, and were sensitive to fluctuating climatic conditions (drought, inundation,...). Nevertheless, as only very few of the species lost before the 1980's were able to recolonise the site, these results stress the importance of a management stage of careful 'eco-gardening' of vulnerable relict populations. This may be even more the case, where some vulnerable invertebrates are concerned.

Species rich vegetation is developing in almost all 'young' (25-50 years) and even 'middle-aged' (50-100 years) wet dune slacks (northern part of De Westhoek, Ter Yde), 4-6 years after large-scale scrub removal and restoration of nutrient-poor soil conditions. It includes not only the species commonly present in the early stages of natural vegetation development of newly blown-out slacks, but also some of the later-stage species. Part of the colonising plants no doubt derived from a local persistent seed bank (*Carex*, *Juncus* and *Centaurium* species, *Blackstonia perfoliata*, *Anagallis tenella*, *Sagina nodosa*,...), while most of the undesired seedlings from this seed bank (*Urtica dioica*,...) seem to be lacking. But also the relict populations in the early (<1996) managed sites (*Epipactis palustris, Dactylorhiza incarnata, Parnassia palustris, Gentianella uliginosa, Linum catharticum*,...) had a clear and positive impact on the colonisation of the newly managed sites. A good impression of the combined results of local maintenance management in young dune slacks, large-scale scrub and litter removal and follow-up by mowing or extensive grazing, is shown by the distribution of *Parnassia palustris* in 2004 (Fig. 6d).

Some remarks are however necessary. An absolute condition to obtain desired results is the thorough removal of litter and A_0-soilhorizont or shallow sod cutting. Where removal of organic debris or the A_0-layer was inadequate, the site became quickly dominated by competitive species such as *Agrostis stolonifera*, *Ranunculus repens*, *Trifolium repens*, *Lycopus europaeus*,... and colonisation by Red List-species was feeble. Some difference remained between areas where only the fine litter was thoroughly removed and those where sods were cut. Later stage species like *Gentianella uliginosa* and *Linum catharticum* seemed to prefer the sites, with a somewhat more closed

vegetation, where only litter was (carefully) removed, while species like *Parnassia palustris* and *Carex viridula* had a clear optimum in the open vegetation of areas where shallow sods were cut. On the other hand, after some years, there was hardly any difference left between areas where sods were removed manually or mechanically.

Secondly, at this very early stage, follow-up management by mowing or extensive grazing may not yet be essential (no control plots have been established, however), but it is probably crucial in the long run. Anyway, both the maximum slack-age able to support species rich dune slack vegetation and the obvious recovery of many species from the local persistent seed bank seem to contradict the rather pessimistic conclusions of Bossuyt *et al.* (2003) and Bossuyt and Hermy (2004). We should nevertheless not be too optimistic: in centuries-old, superficially decalcified wet dune slacks with a deep humic soil (southern part of De Westhoek), vegetation development after scrub removal mostly resulted in species and vegetation of more eutrophic soils (*Juncus subnodulosus, Lychnis flos-cuculi,...*).

As was feared that the chances for recovery of the vulnerable old humid and dry valley grasslands were rather low, special care was undertaken to preserve at least the old grassland soils underneath the cut *Ligustrum* scrub. But even in areas with large-scale mechanical scrub-cutting and debris removal, and probably thanks to the care that was taken as to not unnecessarily disturb soils, recovery of some of the basic species of this habitat, such as *Luzula campestris, Veronica chamaedrys, Rosa pimpinellifolia,...* was almost immediate. Others, such as *Viola hirta, V. canina, V. curtisii, Arabis hirsuta, Erigeron acer* and *Polygala vulgaris*, some of them possibly originating from a local persistent seed bank, also quickly established, but may indicate just a temporary 'clearing-effect'. In general, however, recovery from a persistent seed bank may play a minor role in the preservation of Red List-species of this habitat. *Anthyllis vulneraria* and *Primula veris*, both with new populations after scrub removal in De Westhoek, may be some of the exceptions. Most promising, however, was the establishment, within 4 years after large-scale scrub removal, of some small but completely new populations of target species such as *Helianthemum nummularium* (Fig. 6b), *Asperula cynanchica* and *Thymus pulegioides* in relatively 'young' parts of the dune system. As for some more common grassland species, (endo-)zoochorous dispersal by grazing animals may be responsible for these new establishments (Cosyns, 2004).

First results thus seem to indicate that the combination of cautious removal of scrub and litter and the introduction of extensive year-round grazing may be a successful instrument in the conservation of this priority Habitat (code 2130).

As the more radical actions of deforestation and upper soil removal (Hannecartbos) and scrub cutting with complete removal of the humic soil layer (Ter Yde) are too recent (2004) and still incomplete, they cannot yet be evaluated properly. The general impression of the experimental deforestation of 1.3ha in the Hannecartbos is however positive, as it already became clear that even large-scale action with heavy machinery on a marshy and vulnerable soil can be executed without too much damage to the soil. Intensive follow-up by manual actions (local supplementary removal of litter, removal of stubs and remaining roots, mowing regrowth and undesired tree seedlings,...) must however be foreseen.

The results of the suppression of invasive (alien) trees are less uniform and clear. Especially *Populus (x)canescens* and *P. alba*, but to a lesser degree also *P. xjackii* and *P. xcanadensis*, proved hard to handle, as wildshoots regenerating from remaining root fragments were strongly stimulated after cutting of the parental trees. Even the (controlled) use on stubs or stems of a herbicide (glyphosate) did not give completely satisfying results. The foreseen prohibition of the (even very careful) use of herbicides in public domains can however seriously affect future pest control initiatives. Action against these species will therefore include long-term and labour-intensive measures of follow-up management. Some small-scale actions against *Rosa rugosa*, *Symphoricarpos albus*, etc. led to the same conclusion.

Sometimes scrub or tree removal was essential for the restoration of dried up or overshadowed dune pools. Some pools even were the product of the reclamation action itself (conversion of stakes, see above). Nevertheless, also in these cases the removal of scrub or woodland often proved to be a sound decision. In the Houtsaegerduinen a long lost population of the Annex II-species *Apium repens* grew up from the seed bank after felling overshadowing trees and shrubs and deepening of the old dune pool 'D'Achte'. In that same pool, but also in restored pools in De Westhoek, another Annex II-species, *Triturus cristatus*, appeared, while *Bufo calamita* (Annex IV) colonised most of the newly created pools in all nature reserves. Several of the newly created or restored dune pools even guarantee the survival of the protected *Characeae*-habitat (Natura 2000-code 3140) in the Flemish dunes (Denys and Packet, 2004).

One somewhat negative and generally neglected aspect of large-scale mechanical management actions may be the possible introduction of new species and genotypes through the used machinery. Although recent newcomers in De Westhoek like *e.g. Juncus acutiflorus, J. subuliflorus* and *Glyceria declinata* probably originated from the Ardennes where the vehicles were employed earlier, they could still be considered as harmless for the local flora. The introduction of species and genotypes from agricultural and urban habitats or far-away ecodistricts can nevertheless profoundly alter local vegetation and the genetic identity of local populations. Examples are the gradual disappearance in De Westhoek of genetic and morphological features of the autochthonous variant of *Cerastium fontanum* (= ssp. *glabrescens*) through introduction of the common *C. fontanum* (= ssp. *vulgare*) and of the local *Erodium lebelii* through introduction of the common *E. cicutarium* s.l.

Monitoring and evaluation, whether on a thoroughly scientific or on an elementary empirical base, prove to be essential for nature management, in order to be able to plan and eventually make adjustments through new actions and to be able to quickly react on negative developments. Thus monitoring should also produce direct and practical advice for nature managers. As the effects of large-scale measures can mostly not be reversed, small-scale preparatory experiments – although often difficult to execute as deadlines and contractual, legal and administrative restrictions are a severe limiting factor – are of high importance.

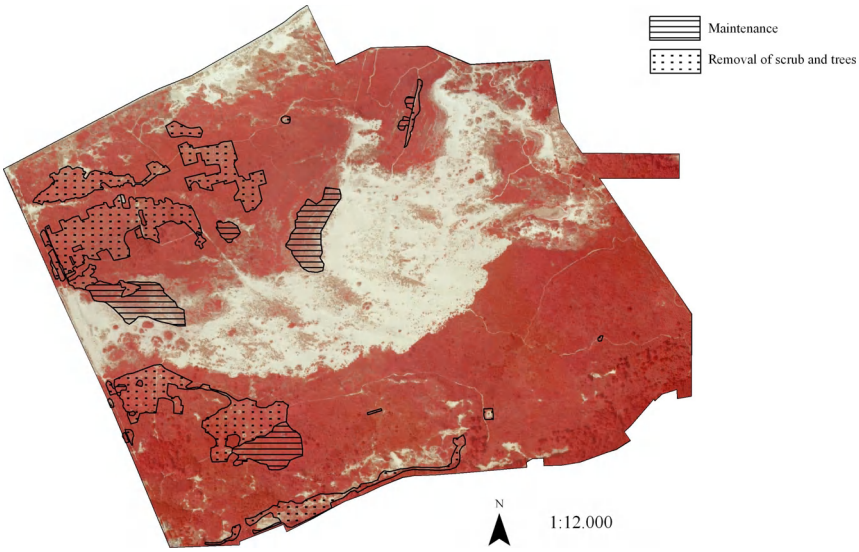

Fig. 5. Management sites in the Westhoek nature reserve (false colour aerial photography, AERODATA 2004) (cf. Table I).

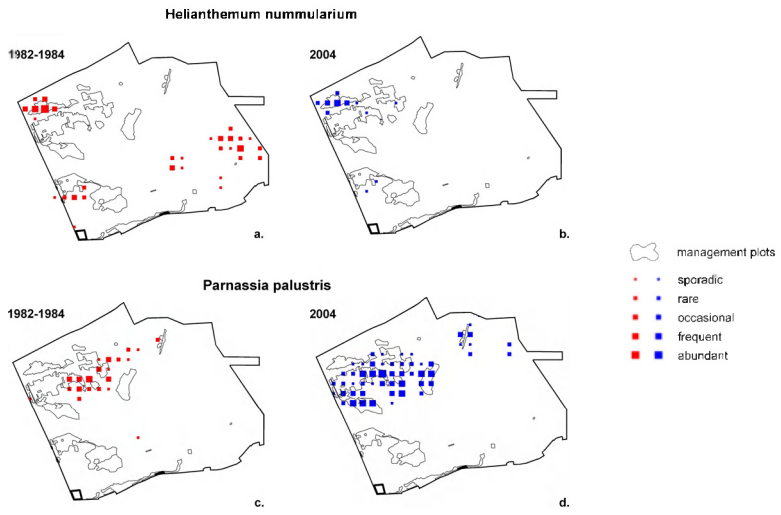

Fig. 6. Distribution of dune grassland-species Helianthemum nummularium *and dune slack-species* Parnassia palustris *in the Westhoek nature reserve (personal data M. Leten).*

Nature conservation theory and management plans often set high and not always reconcilable goals. In reality it proved not always self-evident and sometimes almost impossible to realise all of them within the strict limits set by urban planning, site status, judicial conditions, financial and personal means, technical complications and nature's own unpredictable behaviour. We consider the first results of planned management action in the nature reserves along the Flemish coast generally as very promising and have good hopes that most of our aims will be reached. The future effects of world wide changes, however, cannot yet be foreseen and only the future can judge whether the choices and realisations of this generation of nature managers will have satisfyingly resolved the dilemma's and technical problems of nature conservation in the Flemish dunes.

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