The Mantingerveld: effects of fragmentation and defragmentation followed by carabid beetles

Rikjan Vermeulen & Arnold Spee
Foundation Willem Beyerinck Biological Station
Kanaaldijk 36
9409 TV Loon
The Netherlands
E-mail: stichtingwbbs@freeler.nl

Abstract

In 1958 the reclamation of heathlands and drift sands in the area of Mantingerveld (Netherlands, centre of province Drenthe) came to an end, leaving 300 ha of fragments scattered over this area. In 1992 several areas of arable land between those fragments were restored by removal of the nutrient-rich topsoil layer. The effects of both fragmentation and defragmentation were followed by the Biological Station and compared to a large continuous area (the Dwingelderveld), using ground beetles as indicator species for the soil fauna. Pitfall trapping began in 1959 at the Dwingelderveld and in 1963 at the Mantingerveld and the series have been continued to the present. Although some species were lost from both areas due to overall working factors, more species were lost from the Mantingerveld. After the restoration there was a slight growth in number of individuals in the fragments and some species were caught in the newly restored areas. Also new heathland and drift sand species were caught. As the amount and quality of habitat has increased, it is recommended to reintroduce the non-flying species or to introduce soil transplantates to give the entire poorly dispersing soil fauna a chance to re-establish.

Introduction

By cultivation of the so-called wastelands in the 19th and early 20th centuries, 95% of the Dutch peat bogs, heathlands and poor sandy grasslands were lost (Vermeulen, 1995). Most of the remnant patches were too small for specialised plant or animal populations to survive for long periods. Moreover, the habitat quality in these remnants has decreased because of drying up, acidification and excess fertilisation of the surrounding areas during the second half of the 20th century. The characteristic flora and fauna has decreased and some species have become locally extinct. Because the remnants were scattered in a hostile matrix, populations became isolated from each other, making recolonisation after local extinction nearly impossible. Over the last 10 years attempts have been made in the Netherlands to reverse this process by means of nature restoration, in which the top-soil with its excessive nutrient load was removed. In

this way poor soil conditions were immediately achieved (Klooker *et al.,* 1999, Verhagen *et. al*., 2003), leaving bare substrate for colonisation by characteristic plant species and their corresponding fauna.

One of the largest nature restoration projects in the sandy areas of the Netherlands is the Mantingerveld, Drenthe (Plan Goudplevier, Berris & Gorter, 1991). Up until 1930 there were still several thousand hectares of heathland and drift sand in this area. Cultivation started here relatively recently and stopped at the end of the 1950s. At that time about 300 hectares of the original heathland and drift sand area were left, scattered throughout the area as six fragments of various sizes (Fig. 1), surrounded by arable farmland. From 1990 the nature organisation Natuurmonumenten started to buy the farmland surrounding the heathland fragments. This organisation initiated the first top-soil removal in the area between Hullenzand and Lentsche Veen (number 3 and 4, Fig. 1) in 1992. Today, nutrient poor conditions have been restored in the complex Hullenzand/Lentsche Veen/Martensplek and between Mantinger/Balingerzand and Koolveen. The connection between these two complexes was established in autumn 2003. In the entire area of heathland and drift sand will occupy about 1000 ha. The costs of the project were estimated at about 4 million Euros in 1991.

The hypothesis was made that fragmentation of the Mantingerveld led to a loss of heathland species. Further, it was hypothesised that the decline of heathland species and populations in the fragments could be stopped by restoring the Mantingerveld. The target species were expected to benefit from the habitat improvement of the fragment surroundings and to colonise the restored areas without assistance. For carabid beetles this research aimed to find out whether or not species were lost because of fragmentation; whether or not immigration to the restored areas is taking place, and how quickly.

Methods

In 1963 the Biological Station in Wijster started to sample the carabid fauna in the Hullenzand fragment, which had 23 ha of heathland. Sampling was done with two standard series consisting of two live pitfall traps and one filled with formalin. The traps were emptied weekly up to 1970. In 1986 the sampling was started again with the same trap combination in exactly the same places, and it has continued to the present with only a few years missing.

In 1992, the year of the first topsoil removals, the Mantingerveld was sampled at nine different locations, eight of them repeated in 1993. Of these eight locations several were sampled again in 1996 and 1997 (Fig. 1). The locations in Lentsche Veen and Hullenzand, and those in between, were also sampled in 2002 and 2003.

During the entire period the Dwingelderveld was also sampled; in all but two years since 1959 to the present, traps have been run at two sites at least. The Dwingelderveld is an old

Table 1. The 17 specialist heathland species (A1-species; Turin, 2000, Boeken *et al*., 2002) that were present before 1970 both at the Dwingelderveld and the Hullenzand, compared to their presence from 1990 up till now. * = species recorded 1990 or later. 'M' = monomorphic macropterous, 'D' = dimorphic in wing-length, and 'B' = monomorphic brachypterous, (fl) : seen in flight.

Species	Dwingelderveld since 1990 (1600 ha)	Hullenzand since 1990 (23 ha)	Dispersal power
Agonum ericeti	*		B
Agonum sexpunctatum	*	*	M (fl)
Amara equestris	*	*	M
Amara infima	*	*	B
Bradycellus ruficollis	*	*	M (fl)
Carabus arvensis	*	*	B
Carabus cancellatus			B
Carabus nitens	*		B
Cicindela campestris	*	*	M (fl)
Cymindis vaporariorum	*	*	B
Harpalus latus	*	*	M (fl)
Harpalus solitaris	*	*	M
Miscodera arctica	*	*	M (fl)
Olisthopus rotundatus	*	*	D
Poecilus lepidus	*	*	D
Pterostichus diligens	*	*	D (fl)
Trichocellus cognatus	*	*	M (fl)
Total	16	14	

heathland area of about 1600 ha, which has never been fragmented and thus can be used as a control site.

The heathland carabid beetles of the Dwingelderveld and Hullenzand

During the 1960s, 22 heathland specialist species (A1-species, Turin, 2000) were found at the Dwingelderveld and 17 at the much smaller Hullenzand (Table 1). These numbers are remarkable considering that no more than 29 heathland specialist species have been found in the North-Netherlands. An additional species, *Acupalpus dubius*, was recently captured by hand at Hullenzand. Though *A. dubius* is a good flyer, it has never been found at Hullenzand before. All the heathland species found at Hullenzand were also present at the Dwingelderveld. Of the species found in the 1960s*, Carabus cancellatus* has disappeared from both. This wingless species is rapidly disappearing in the whole of north-western Europe due to unknown factors (Turin, 2000). Two other brachypterous heathland species, *Carabus nitens* and *Agonum ericeti*, have disappeared from the Hullenzand but not from the Dwingelderveld. These species have also declined elsewhere in north-western Europe. Habitat destruction and fragmentation are thought to play a major role in this decline (de Vries & den Boer, 1990; Turin, 2000).

Table 2. The carabid species of poor sandy and open habitats (B1-species) which have ever been found at the Hullenzand. Their presence is compared with that of the Dwingelderveld. Presence (*) is indicated both for the periods before and after 1990. "M" = monomorphic macropterous, "D" = dimorphic, "B" = monomorphic bachypterous, (fl) = seen in flight.

	Dwingelderveld		Hullenzand		Dispersal power
	1959/ 1989	Since 1990	1963/ 1989	Since 1990	
Bembidion nigricorne	*	*	*	*	B
Calathus ambiguus			*	*	M (fl)
Cicindela hybrida	*	*	*	*	M (fl)
Cicindela sylvatica	*		*		M (fl)
Cymindis macularis	*	*	*	*	D
Harpalus neglectus				*	B
Masoreus wetterhallii			*	*	D
Notiophilus germinyi	*	*	*	*	D
Notiophilus substriatus		*		*	M (fl)
Stenolophus teutonus				*	M (fl)
Total	5	5	7	9	

Originally more heathland specialists were found at the Dwingelderveld. However, it is unknown whether these species never occurred at the Mantingerveld or had already disappeared before the area was first sampled. They might have disappeared during the period before, when habitat destruction and fragmentation took place. Since 1990, 18 heathland specialist species have been found at the Dwingelderveld, while only 14 at the Hullenzand. In addition, the heathland species *Carabus arvensis* was caught for the last time at Hullenzand in 1991 as a single individual. From 2000 to 2003, *C. arvensis* showed a strong recovery at the Dwingelderveld but was still not caught at Hullenzand. This seems to be an important example of the necessity of a large habitat area for the recovery of a wingless species. Since 1977 only 23 heathland specialist species have been found in the North-Netherlands.

Carabid beetles of poor sandy and open soils at Dwingelderveld and Hullenzand

For carabid beetles of poor sandy and open areas (classified as B1-species in Turin (2000)), the Hullenzand is a unique place, even compared to the Dwingelderveld (Table 2). The reason for this probably lies in the history of the two areas. Before 1954 the Hullenzand was part of a very large drift sand and dry heathland area, the Mantingerveld-complex. This kind of habitat is also present at the Dwingelderveld, but only in smaller spots, which are sampled only occasionally (den Boer, 1977; van Essen, 1993).

Cicindela sylvatica has disappeared from both areas. This is a species of old heathland mosaics, which can be found in spots with hard bare sandy substrates. Possibly because such places became overgrown by mosses, a large part of its hunting habitat disappeared. This problem plays a role in many such places in Northwestern Europe (T. Aßmann, pers. comm.).

In the north of the Netherlands, *Masoreus wetterhalli* is only found at the Hullenzand. Another species unique to this area is *Harpalus neglectus*. This flightless species has never previously been found in the north, although sufficient habitat has always been available here (Turin, 2000). According to T. Aßmann (pers. comm.), the species is easily transported with plant material. Indeed, in the beginning of the last decade botanists introduced several plant species here to follow the effect within the restoration areas. Other recently established B1-species at Hullenzand are *Notiophilus substriatus* (also at the Dwingelderveld) and *Stenolophus teutonus*. These two species are excellent flyers and were recorded earlier from neighbouring areas of heathland. Their appearance might be seen as a result of increasing habitat quantity and quality.

The carabid fauna in the fragments of the Mantingerveld

In 1992 Natuurmonumenten started executing the ideas from "Plan Goudplevier". The first topsoil removals on arable land took place west of Hullenzand, somewhat later north of Hullenzand and between Hullenzand and Lentsche Veen (Fig.1). The forest edge around Hullenzand was also removed. At the present day (2003) connections have been made between Martenplek and Lentsche Veen and Mantingerzand/Hullenzand.

To determine the original state of the carabid fauna, Theo van Dijk started to sample all heathland fragments and the arable land west from Hullenzand. All sample sites are shown in Fig. 1. The results for 1992/1993 for these areas are given in Fig. 2 concerning the heathland specialist beetles and beetles of poor, sandy and open areas (A1- and B1-species of Turin, 2000).

Although not the largest fragment in the Mantingerveld, Hullenzand is the richest, with 13 A1- and B1-species in 1992 and 14 in 1993. Within a small area, Hullenzand shows high heterogeneity in the poor environmental conditions: from peat-like heathland (wet) up to partly vegetated drift sand hills (dry). This variation means that within the poor environmental conditions, most species will be able to find a spot to survive adverse circumstances. Furthermore, in the agricultural period the Hullenzand was surrounded by a row of trees. This probably protected the area from high agricultural influences, so that these species had a higher chance to survive this period. Also the highest number of non-flying stenotopes, indicative of old populations, are found in this fragment. At the other end of this spectrum we find one of the largest fragments, Martensplek. Here only few of the A1 and B1 species are found, and most of those found are good dispersers. This area probably had a high turn-over of disappearing and recolonising species. In 1992/1993 Martensplek was a tree covered area with scattered heathland spots. Even at the much smaller place Koolveen, where birches

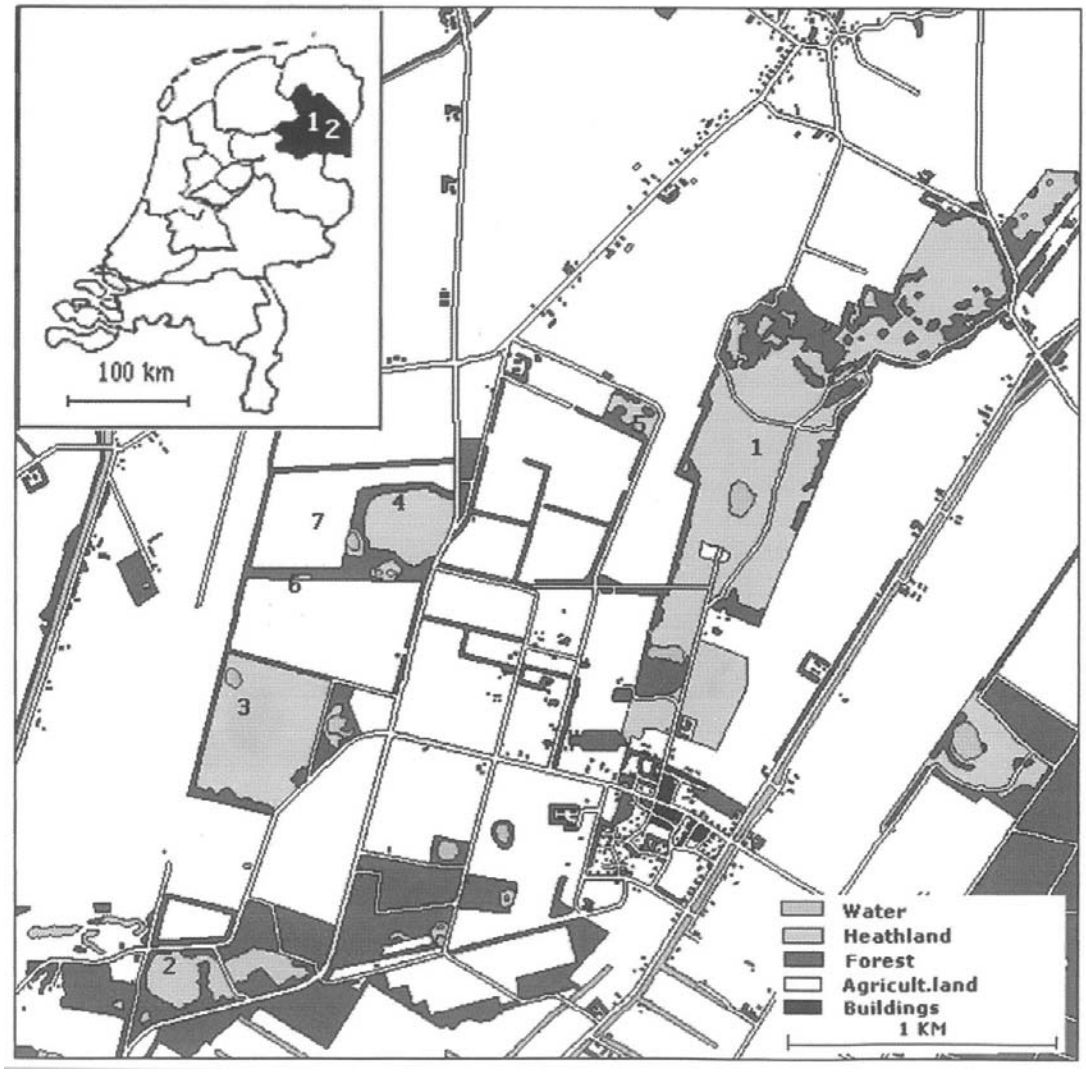

Figure 1. The research areas in Drenthe (Netherlands). 1. Dwingelderveld, 2. Mantingerveld, and enlarged, the Mantingerveld in detail. The situation shown is from between 1959 and 1992. The heath fragments: 1. Mantingerzand (208 ha), 2. Martensplek (56 ha), 3 Lentsche Veen (45 ha), 4. Hullenzand (23 ha), 5. Koolveen (a few ha). Further: 6. Larch-bush, and 7. Arable land from which the topsoil layers were removed in 1992. All locations were sampled in 1992.

invaded the heath, the situation was less adverse. The catches at the large area Mantingerzand were disappointing, but this might be affected by the sampling conditions. Here only one sampling site was used during one year, placed in a field of mainly *Molinia*. In 2004 this area will be sampled more intensively.

The results so far show that Hullenzand and to a lesser extent Lentsche Veen are the backbone of the "Plan Goudplevier", as far as the soil fauna is concerned. This is also shown by the fast colonisation of the adjacent restoration area and the number of species found in a small heath in the nearby larch forest.

Colonisation of the restoration area

Immediately after topsoil removal from the arable land west from Hullenzand the first heathland specialist carabids and carabids of poor sandy and open areas were caught at this site (Figs. 2 & 3). In the first five years only a few individuals were caught, suggesting that colonisation took place, but not settlement. However, from 1997 the numbers also increased and catches of species like *Amara equestris* and *Poecilus lepidus* fluctuated between 10 and 100 individuals per year. This suggests that some heathland species could already find suitable habitat although the area still did not look like a heathland (Verhagen *et al*., 2003).

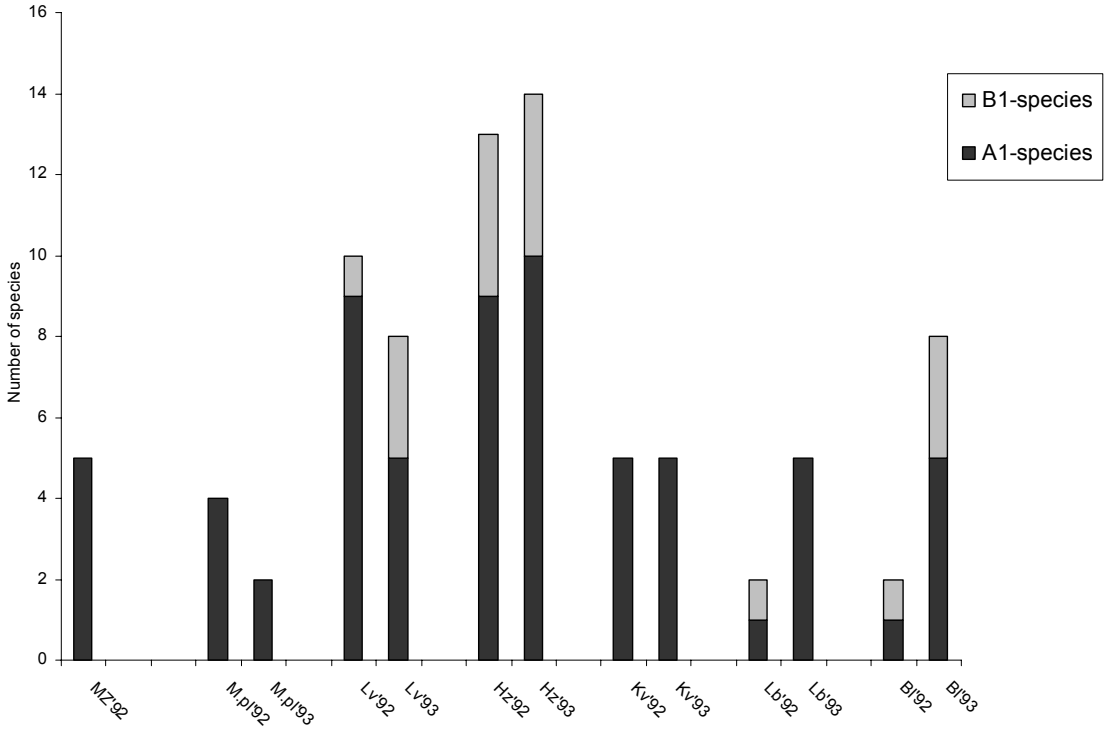

Figure 2. The carabid species of poor soils present on the locations mentioned in Fig 1. A1 = heathland specialists species. B1 = species of drift sand and dry heathland. Since 1977, 23 A1-species and 10 B1-species are known from the northern part of the Netherlands.

Directly after soil removal, the number of eurytopic species and species characteristic of arable land declined dramatically. The yearly catches of species like *Amara plebeja*, *Pseudophonus rufipes* and *Bembidion tetracolum* declined from several hundreds in 1992, to about 10 in 1993, and to hardly any later on. These carabid beetles show rapid responses to changes in soil minerals and are therefore excellent indicators of soil quality. This contrasts with plants, which respond much more slowly (Verhagen *et al*., 2003). Fig. 3 shows the increase in the numbers of heathland specialist species in the restoration area, compared to the number of species found at the old Hullenzand and Dwingelderveld. In 2002 the number of heathland specialist species found at the restoration area already came close to the number found at Hullenzand. The Hullenzand seems to act as a source for the neighbouring restoration areas, and it looks like these areas will have the same carabid fauna as the

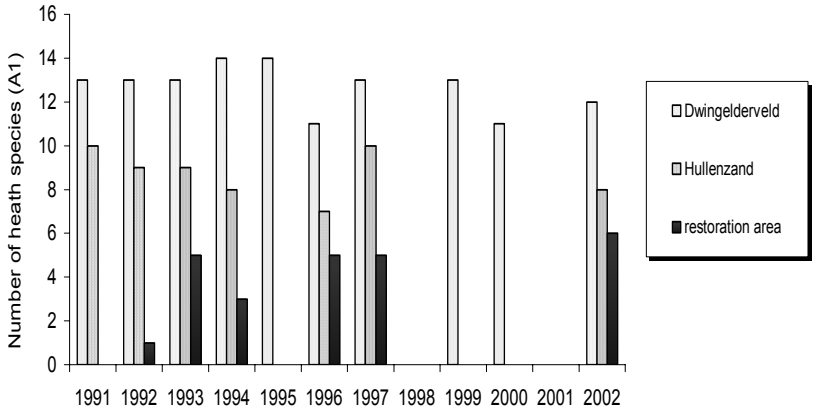

Figure 3. The number of specialist heathland species of carabid beetles caught in successive years on the Dwingelderveld, Hullenzand and the restoration areas adjacent to the Hullenzand (No 7. in Fig 1).

Hullenzand after only a few years. For the vegetation it will probably take some decades more.

New species at the Mantingerveld

Ten new carabid species have been found at Hullenzand and the surrounding areas since the restorations started (Table 3). All these new species are more or less restricted to nutrient-poor sandy areas (Turin, 2000). The species *Laemostenus terricola* must have been there before. This species has still not been caught in the traps of the Biological Station, but was incidentally caught in other research concerning spiders, in traps placed at a site which was previously forest. The non-flying species *H. neglectus* might have been introduced by botanical experiments. *Amara kulti* has never been caught in flight, but it is long-winged and has good flight muscles. There are no flight observations probably because this species is very rare in the Netherlands. This species has also recently been caught near the Dwingelderveld. Thus, eight species have colonised the area spontaneously by flying and can probably find good habitat. This might be due to the exceptional circumstances created by topsoil removal. One might ask whether or not these species will disappear after the area has stabilised as heathland. In that case we have to deal with nomads, species specialised on recent changes in environment. It is worth noting that the eight flying species have their centre of distribution south of the Netherlands; this suggests that recent changes in climate could play a role as well.

Table 3. The 10 new carabid species, found at the Hullenzand and the adjacent restoration areas since 1991/1992. For explanation of dispersal power, see Table 1. A1 = heath/peat moor, B1 = poor sandy and open soils, B2 = extensive arable land on sandy soils. CZ = open sandy soils, but too low number of records (Z = rare) for specific classification, RO = only a few records, habitat definition impossible (in the Netherlands). Codes and distribution according to Turin (2000).

Species	Dispersal power	Habitat	Central point of the distribution
Dromius angustus	M (fl)	CZ	Mid-France/Southern Germany
Harpalus distinguendis	M (fl)	B2	Mid/Southern Europe
Harpalus smaragdinus	M (fl)	B2	Netherlands central
Amara kulti	M	RO	Mid-France/Northern-Italy
Acupalpus dubius	M (fl)	A1	Northern-France
Harpalus melancholicus	M (fl)	CZ	Southern-France/ Northern-Italy (Coast)
Harpalus neglectus	B	B1	Spain/Germany
Notiophilus substriatus	M (fl)	B1	Mid-France/Italy/Balkan
Stenolophus teutonus	M (fl)	BZ	Mid-Europe
Laemostenus terricola	B	B2	Netherlands central

Is nature restoration a success?

In the Netherlands a red list for carabid beetles does not exist. However, some provinces have put carabid beetles on priority lists: lists of species for which the province plays a major role in their distribution. Five carabid species have been placed on the priority list for Drenthe (van Zanten & Dekker, 1995): *C. sylvatica*, *C.nitens*, *A. ericeti*, *Cymindis vaporariorum* and *Harpalus solitaris*. One of these species, *C. sylvatica*, has already disappeared from Drenthe and from the northern Netherlands and has only rarely been found elsewhere in the Netherlands recently. The other four species are still present in Drenthe and, although not widespread, Drenthe is still the province where most catches of these beetles are made.

All five priority species have been recorded at the Hullenzand in the past. At this moment only two of these species are present there and four at the Dwingelderveld (Table 1). In 2003 an introduction experiment with *C. nitens* started. Should this experiment be successful, Mantingerveld and Dwingelderveld will harbour the most of these priority species and must be of importance for the province.

As a result of topsoil removal, *H. solitaris* increased, especially in the restoration sites. Also the increasing numbers of A1- and particularly B1-species suggest that these species benefit from this kind of management, both in the restoration and in the old areas. By topsoil removal agricultural influences are removed so that even in the old areas the situation improves and

characteristic beetles can increase. Unfortunately “Plan Goudplevier” probably came too late for *C. arvensis*.

In 5 to 10 years the restoration areas appeared to be colonised by most A1- and B1-species. Especially in 2002 also larger numbers of poor dispersers were found here. The B1- species seem to benefit most from these new areas. At this moment the Hullenzand and surroundings harbour nine of the ten B-1 species that occur in northern Netherlands. Eight of these species have entered the restoration areas as well. Apparently, these larger somewhat bare sandy areas have had a positive effect on these species. However, this means that such areas must be kept partly intact. Extensive grazing with Scottish Highland cattle, as occurs now, might support this.

The fact that “Plan Goudplevier” as far as carabid beetles are concerned can be regarded a success, is mainly determined by the species richness of Hullenzand as a source area. Comparable projects at Eexterveld, Tichelberg and Ennemaborg show more disappointing results so far. In these cases an adjacent source area is missing or the species were already lost in the source area before restoration.

Carabid beetles are often regarded as indicators of the state of the entire soil fauna. Consequently, we should also conclude that “Plan Goudplevier” must be a success for the whole soil fauna that was still present in 1992. Certain species of carabid beetles that have been lost could be reintroduced, giving them a chance to settle again. However, which elements of the soil fauna have been lost during the adverse times is unknown. To give the entire soil fauna a chance for re-settlement, introduction of large and deeply-cut sods might be a solution.

Acknowledgements

We thank Piet den Boer for starting sampling the areas mentioned in 1959 and 1963. Up to the present day, he and his wife Wil are emptying these traps weekly, making these continuous samplings the longest ecological series in the world. We would also like to thank Theo van Dijk, who started the sampling when “Plan Goudplevier” was initiated. Over the last few years, this research has been financed by the Prins Bernhard Cultuur Fonds.

References

Berris L & Gorter J. 1991. Goudplevier, Natuurontwikkeling op zandgronden bij Mantinge. Natuurmonumenten, s’Gravenland.

Boeken M, Desender K, Drost B, van Gijzen T, Koese B, Muilwijk J, Turin H & Vermeulen RJ. 2002. De Loopkevers van Nederland & Vlaanderen (Coleoptera: Carabidae). Stichting Jeugdbondsuitgeverij, Utrecht: 212 pp.

Boer PJ den. 1977. Dispersal power and survival. Carabids in a cultivated countryside. Micell. Papers Landbouwhogeschool Wageningen 14, 190 pp. Veenman & Zn.

Essen S van. 1993. Loopkeverinventarisatie Dwingelderveld 1991. SBB, Biologisch Station & Natuurmonumenten. GSC-Wageningen 97 pp.

Turin H. 2000. De Nederlandse Loopkevers, verspreiding en oecologie (Coleoptera: Carabidae).- Nederlandse fauna 3. NNM Naturalis, KNNV Uitgeverij & EIS-Nederland, Leiden 666 pp.

Verhagen R, van Diggelen R & Bakker JP. 2003. Natuurontwikkeling op minerale gronden. Veranderingen in de vegetatie en abiotische omstandigheden gedurende de eerste tien jaar na ontgronden. R.U. Groningen, 168 pp.

Vries de HH & den Boer PJ.1990. Survival of populations of *Agonum ericeti* in relation to fragmentation of habitats. Netherlands Journal of Zoology 40, 484-498.

Zanten van I & Dekker H. 1995. Sparen voor later, onderzoek naar voorkomen, bedreiging en beheer van zeldzame plante- en insektesoorten in Drenthe. Minist. LNV, directie Noord, van Genne, Hoogeveen, 289 pp.