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INTERREG-BioGrenzKorr - part 1

Cross-border conservation of the hazel dormouse:

Presence, genetics, management and perspectives

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Cross border conservation of the hazel dormouse:
Presence, genetics, management and perspectives

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1 Introduction and background

By Mogens Krog

The landscape in the region is dominated by efficient often large scale agriculture, urban areas, roads and other infrastructure, even the majority of forests are cultivated with only small fragments of "nature" interspersed. This means that nature is fragmented often into small isolated areas with little or no connection to other nature areas. This becomes a significant barrier for flora and fauna especially for amphibians, insects and small mammals as it limits their ability to spread in the landscape. Small isolated populations are vulnerable to sudden changes such as local habitat destruction, extreme weather events or diseases and may suffer from genetic depression. Improving connectivity between small and large habitats such as forests via corridors in the landscape makes it possible for small populations to disperse over larger areas and the populations are likely to become more robust and resistant towards changes and ultimately survive extinction.

The Interreg Project BioGrenzKorr is a Danish-German nature conservation project which aims to develop trans-boundary habitat corridors for protected European species (common dormouse, birch mouse and bats species) and implement conservation measure to improve their habitat and networks. The common dormouse (Muscardinus avellanarius) is the only species of dormouse in Denmark and Schleswig-Holstein. The existence of the common dormouse in Schleswig-Holstein, the country with the lowest proportion of forest area in Germany (10%), mainly depends on the hedgerow-network as dispersal corridors and suitable habitats (Ehlers, pers comm.). In Denmark, the dormouse is present in Southern Fyn, in Zealand (3 separate populations), Southern Jutland (Gråsten) and a small enigmatic population in Middle Jutland (near Vejle).

The common dormouse is totally protected and red-listed as "vulnerable" on the IUCN Red list of threatened species from 2000. It is also on the EU Habitat Directive annex 4, which requires full protection of the species in its natural areas of distribution. The EU directive has recently been integrated into Danish national legislation and in 2011 a new national action plan for management and protection of common dormouse in Denmark was made (Vilhelmsen, 2011).

The dormouse prefers a forest environment with high plant diversity, glades with regeneration, deciduous trees and a rich understory supplying berries and herbs, so mainly stages of young immature forests. Such habitats are not common in forests under intensive management (monocultures) as well as under natural forests management with permanent tree cover with regeneration in small gaps. Natural forest succession (expansion) on open land (considered a perfect habitat for the dormouse) is also rare due to clear and fixed division between forest and agricultural land in the landscape. Management by coppicing is probably the best method to maintain a wooded area under permanent re-growth creating enough light and vigour for trees, bushes and herbs to maintain a high plant diversity and dense cover. By establishing and regularly managing corridors inside forest

and hedgerows in the open land by coppicing a constant cover and supply of food is available for the dormouse.

Besides international requirements for protection of the dormouse, protection of its habitats will create good conditions for a number of other species and thus biodiversity. In both forests as well as in open agricultural landscapes management of forest edges as well as hedgerows create cover and corridors for a large variety of flora and fauna. Thus, the dormouse is regarded as an indicator of high biodiversity.

The common dormouse must have been widespread in the past throughout Schleswig-Holstein and Denmark. But the current distribution is very much scattered most probably due to repeated landscape change in historical times, nowadays natural re-colonisation in fragmented and intensively used landscapes is very unlikely.
According to EU and national legislation the governments of Schleswig-Holstein and Denmark must safeguard existing populations; a degradation of the species' conservation status must be prevented.

In a binational meeting of experts on dormice and mammal conservation (2nd February 2011 in Kiel) the participants agreed that action needs to be taken in the Danish-German border region in order to safeguard the isolated dormouse population close to Graasten and Kliplev.

The following points were agreed to as elements in a common strategy:

- Further Improvement of existing habitats in Graasten and on Fyn to be conducted.
- Improvement of habitats close to Flensburg, each site must be suitable for at least a small but viable dormouse population.
- Improvement of habitat connectivity, to increase the probability for natural dispersal processes also in the long-term in order to safeguard populations.
- Artificial population growth by means of putting up a dense network of nestboxes, so that „supported populations" can tolerate the removal of several individuals („pre-compensation of removal")
- Breeding of a sufficient number of individuals for „founder populations" and subsequent soft release on sites.
- Only late born juveniles are removed as this is the part of population with lowest probability of surviving first hibernation

Project objectives - dormouse conservation
The overall objective of the project is to take action in order to secure and improve the habitats of the common dormouse in forest and hedgerows in its presently known distribution at Southern Funen, Southern Jutland and Northern Schleswig-Holstein contributing with significant input to a regional cross-border Action Plan for Dormouse Conservation. Specific objectives are:

- To monitor dormice in the project areas in and near its known distribution in Southern Funen, Southern Jutland and Northern Schleswig-Holstein as a basis for management interventions.
- To improve habitat quality and habitat management methods in forests for dormouse conservation.
- To improve management of hedgerows as habitats for dormouse and for improved connectivity between dormice habitats with the long term aim of creating a cross border corridor.
- To boost the regional population by re-introduction of dormouse to the German part of the region based on new knowledge of regional dormouse genetics.
- To develop and recommend management regimes which are both ecologically and economically sustainable.
- To increase the awareness and information on the dormouse and its conservation.

Activities
The activities in the project are divided into four main work packages:
WP 1: Management of corridors and habitats in the forest.
WP 2: Management of corridors in the open land linking fragmented habitats.
WP 3: Networking and exchange of knowledge.
WP 4: Public participation, dissemination and information.

This report focuses on 1) and 2) for dormouse conservation. Regarding activities under paragraph 3) and 4) these are briefly mentioned in relation to dormouse activities only. A full account of project publications, public events, press etc. is provided elsewhere (see www.biogrenzkorr.de or www.biogrenzkorr.dk). Besides the main focus on dormice conservation the project includes activi-

ties concerning bats conservation, bat monitoring and birchmouse monitoring. These issues are dealt with in two separate reports.

The layout of the report

Status of dormouse: The reports start out with a status of dormouse in Denmark and Schleswig-Holstein as a background for the project.

Habitats surveys and data collection: In chapter 2, border region habitats are assessed and more detailed monitoring of the presence of dormouse in the project areas is documented.

Habitat management: Chapter 3 describes a variety of activities to improve habitats in the 4 project areas. The project areas are: In Denmark the Danish Nature Agencies (Naturstyrelsen) areas at Funen near Faaborg and the forests of Gråsten in Southern Jutland. In Schleswig-Holstein the State forests (Landesforsten) Kluesries and Handewitt and the nature area Schäferhaus administrated by Stiftung Naturshutz.

Connecting habitats: The overall objective of the BioGrenzKorr project is to create a corridor between the dormouse habitats in the forests of Gråsten in Denmark and the forests and nature areas just south of the border around Flensburg on the German side of the border. The project areas managed by the project partners are important core habitats in the corridor, however in order to connect them, hedgerows on private land in the matrix between these protected areas need to be developed. Chapter 4 describes some of the experiences and not least the challenges posed in involving farmers to participate in such action.

Population management: Besides the low habitat quality in most existing woods the main problem for dormice to re-establish in uninhabited areas is the poor potential of dispersal. Scientific studies show, that dispersal works mostly only at low distances. Thus, long-distance dispersal between existing populations in Southern Jutland and Middle Schleswig-Holstein is not realistic. There are already several woods with good habitat quality for dormice, but re-establishment of a German population south of the border through a hedgerow-network will last at least 1 – 2 decades. Therefore the project also works with population management, as dormouse will be bred and translocated into the project areas near Flensburg. Chapter 5 describe the different steps in the breeding programme includes the following activities:

- A genetic study based on samples of Danish and German dormice
- Trapping dormice in well-populated habitats in Denmark and Germany
- Breeding and rearing dormice in special “breeding” stations
- Releasing of approximately 25 dormice per site
- Controlling of the success at release sites (monitoring)

1.1 The Hazel Dormouse in Denmark

By Helle Vilhelmsen

In Denmark the common dormouse (Muscardinus avellanarius) is one of the rarest mammals and the only representative of the rodent family Gliridae. Its postglacial immigration probably occurred c. 10.000 B.C. with the extension of the deciduous forest including species as oak, lime, hazel and alder, influenced by a warmer climate. From that time its distribution was more extensive than now, probably due to the fact that it prefers a forest environment of high plant diversity, glades with regeneration, deciduous trees of different age groups and a rich understory supplying berries and herbs. These conditions favour the dormouse and also provide resting places as well as food and breeding sites. Mono-cultures, landscape barriers and intensive forestry management that obstruct dispersal and re-colonization may be responsible for reduced numbers and distribution. Due to these factors the population has been declining.

Investigations and distribution

Until 1980, no attempts of systematic and general mapping by means of studies in the field had been made, and knowledge of the distribution was formerly based on circular letters and museum pieces (Walhovd).

In the years 1980-86, 1989-92, 2001-07, investigations on the habitat types and distribution pattern of the Danish populations were carried out in Zealand, Funen and selected sites of SE/S-Jutland (Vilhelmsen; Berglund). The presence of dormouse was carried out directly by observing dormice visits and nesting activities in nest boxes placec in selected regions and indirectly by searching systematically for summer nests in the vegetati visiting all major woodland areas, smaller patch of woods, hedgerows connecting woodland are All areas were visited twice during the leafless periods of the year in two adjoining years (in or to prevent missing findings).

A total of 98 forest districts, 248 woods were searched by walking along parallel transects, 10 metres apart with at least 2 sample areas exami ned in each forest area, especially after leaf fall. Impassable areas take the greatest amount of ti (Vilhelmsen). All localities showing dormouse ac tivity were described, recording forest types, ne

Figure 1: Dots: Investigated area, 1990-1999. Black areas: Distribution 1990-1999

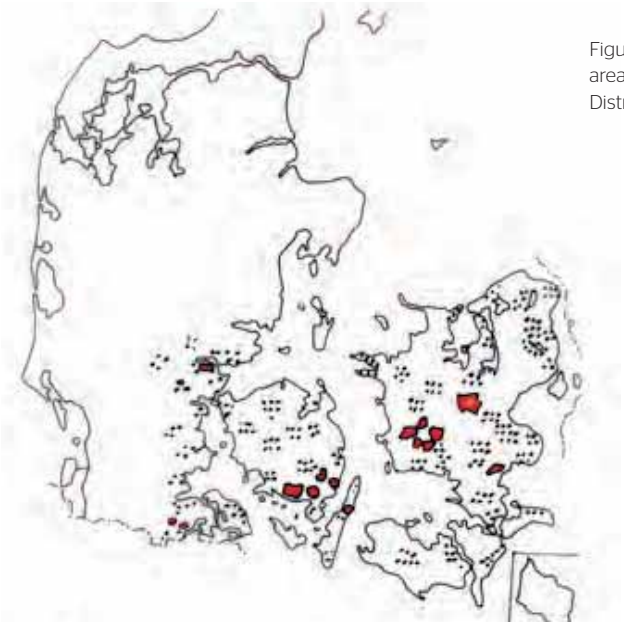


Figure 2: Dots: Investigated area, 2000-2010. Red areas: Distribution, 2000-2010

Figure 3: Blue squares: Distribution 10x 10 km, NOVANA 1

characteristics, forestry and details of dormice. The presence of dormice was confirmed from 31 forest districts (59 localities), - of these 29 localities laced on Funen, 24 localities in Zealand and 6 in Jutland. The localities in Zealand are placed in 3 isolated woodland areas: the forests between Slagelse and Sorø; the forests south of Kirke Hvalsø and near Leestrup forest in SE-Zealand.

On Funen the distribution follows an almost continuous line from Ringe towards Fåborg and Svendborg, including lots of smaller wooden parts and hedgerows.

In Jutland 3 localities have been recorded (Vejle, Kliplev, Gråsten).

In 2012-2014, NOVANA-project an updated record of the distribution pattern has been started (no data have been published so far).

Typical habitats

In Denmark typical habitats can be classified as:

- Young woodland growth (age group of 10-15 years)
- Deciduous woods (oak, ash, beech) with "scrub" characteristics and many horizontal shoots
- Mixed cultures of deciduous and coniferous woods where bushes have not been cleared, under-storey includes raspberries, blackberries, ferns and high-growing weedy vegetation, besides climbing plants (e.g. honeysuckle, ivy)
- Marginal areas in or along coniferous woods with regenerations of ferns, weeds and soft fruits
- Forest regeneration
- Deciduous wood e.g. in glades, clearings, fire breaks, along edges of high forest and forest paths
- Scrub vegetation surrounding forest bogs, edges of ditches and forest brooks
- Marginal forest areas (without forestry/extensive management)
- Woods being left without forest management or cultivated by means of very mild thinning
- Thick, well-planted edges of wood with high diversity of light-sensitive trees, especially native, thorny and fruit-carrying bushes (e.g. blackthorn, hawthorn, raspberries, blackberries)
- Hedges connecting woodland areas with the above-mentioned characteristics
- High forest (4% of the total investigates)
- High deciduous woods where thinning allows development of horizontal shoots and glades where under-storey and stratification of trees may be promoted
- Glades in soft-woods with regeneration of deciduous woods, if situated near areas of deciduous forest
- Alternative habitats (beehives, holes in trees, piles)
- Fruit-gardens and orchards near woods containing dormice

Preferred Danish dormouse habitats seem to be characterized by high plant diversity, varied age groups among trees, high percentage of bushes and herbs, a distinctive physical structure (with lateral branches) and plenty of light allowing vigorous regeneration, flowering, fruiting and seeding.

1.2 The Hazel Dormouse in Schleswig-Holstein

By Sina Ehlers

The knowledge about the distribution of hazel dormice in Schleswig-Holstein is relatively recent and still incomplete: The current distribution data are mainly based on data from several FFH-reports (MLUR 2009), as well as on random findings. However, the distribution of dormice was updated by the results of the "Great Nut Hunt" project based on findings of gnawed hazelnuts, starting in 2006 (Project Management: Naturschutzring Segeberg and Stiftung Naturschutz Schleswig-Holstein; www.nussjagd-sh.de).

Only 10% of the area of Schleswig-Holstein is forest, therefore, hazel dormice are mainly dependent on hedgerow-networks as habitat and dispersal corridors. They use hedgerows throughout the growing season and even establish permanent populations in them, given that sufficient shrub diversity is present.

The current main distribution area of the species is in the eastern part of the country with a larger island-population west of the city of Neumünster. Systematic searches for nests in 2006 and 2007 documented a large coherent population east of the Great Plöner Lake near the city Plön. Also, we have many other confirmed historical records from the southeastern Schleswig-Holstein.
It seems that within the main distribution area, especially in the county "Ostholstein" in the east of SH, dormouse populations may reach high densities: Recently a great number of dormouse nests were verified within a few hundred meters, mainly in hedgerows as habitats. Also nest tubes were occupied in large numbers. Based on knowledge recently achieved, it seems that populations in this part of the country are largely connected with each other.

Only few old records of dormouse have been made North of the Kiel Canal (NOK, see Figure 4) and none of them could be confirmed, yet: searching for nests in the northern part of the county Rendsburg-Eckernförde in 2007 finished without any records. Therefore the current dormouse presence in this Region is still uncertain, while it seems certain that in former times this region was inhabited by dormice, as dormice populations occur just north of the German-Danish border and as there are old records.

A possible reason for the disappearing from current potentially suitable habitats seems to be loss of forest habitats, as well as the loss of habitat connections and shrubs. Especially from the

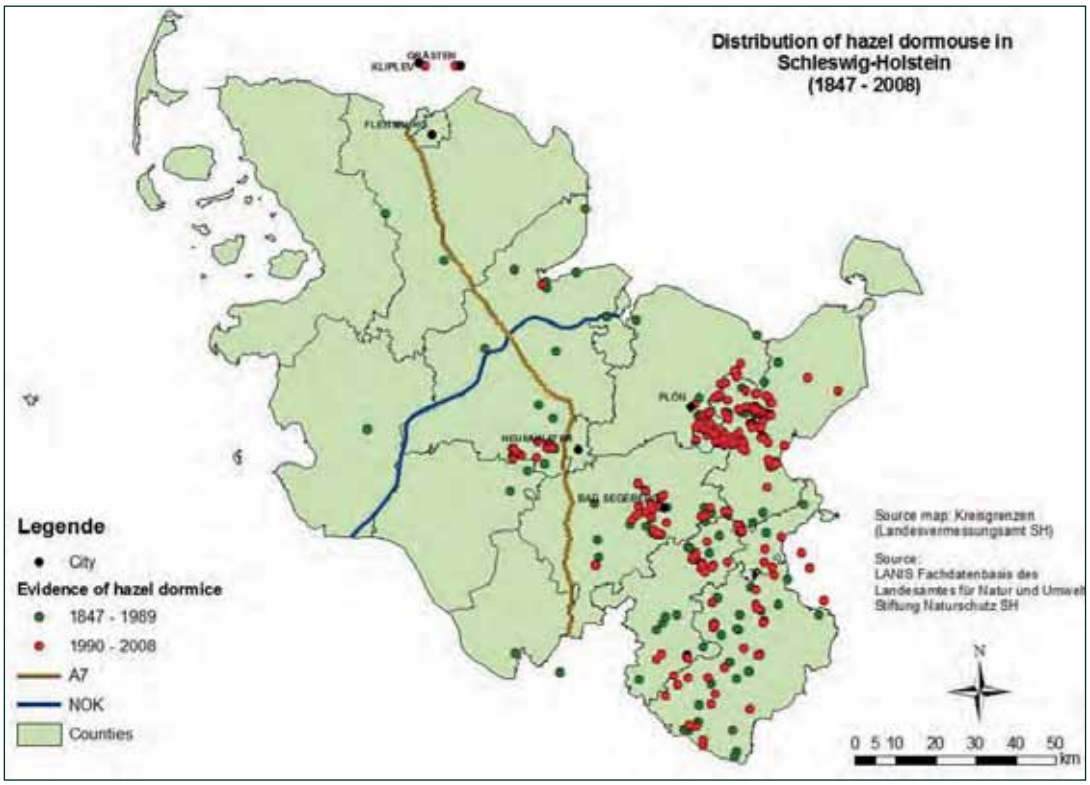


Figure 4: The current distribution of hazel dormouse in Schleswig-Holstein.

Middle Ages to the 18th Century the forest area in Schleswig-Holstein decreased significantly: forest was converted to agricultural land.

Therefore, the disappearance of the species from previous habitats is often a result of past events that are no longer given today. According to this, large areas of present suitable dormouse-habitats are not populated, as the hazel dormouse is unable to re-colonise these areas naturally due to the lack of a continuous forest- and hedgerow-networks. On the other hand it seems that the requirements of hazel dormice related to the location of a habitat in Schleswig-Holstein are relatively low, if a good habitat quality is given. Recently we often observed dormice in sites which seem to be unsuitable at first glance, e.g. numerous evidences directly in roadside habitats and even in small-scaled scrubs completely surrounded by roads.

Furthermore, it can be assumed that populations of hazel dormouse in Schleswig-Holstein play an important role within the entire region of Northern Germany: So far, there are only little current evidence of the species in Mecklenburg-Western Pomerania (close to the border to SH and on the island "Rügen") and Lower Saxony (occurrence focus in the south of the country).

Despite these monitoring gaps, it seems – also with regard to the habitats in less suitable landscapes – that the dormouse populations of Schleswig-Holstein are today not only isolated from the main distribution area of Germany but also from the Scandinavian populations.

Figure 5: Range of the hazel dormouse in Germany

1.3 How safe is the hazel dormouse in the project region?

By Helle Vilhelmsen

In spite of new findings in Denmark throughout the years 1990-2010, some of them in hitherto unknown regions and localities and habitat types, the Danish regional distribution of dormice has apparently been shrinking to certain forest regions. Even within woods with well-established populations, only few areas are considered as high quality habitats for maintaining stable populations. Many habitats seem to be too small, isolated from one another, affected by different areal use (highways, building constructions, cutting, felling, different management), lacking diversity. Their populations may thus be susceptible to further extinction. The most favourable habitat; permanent scrub, bushes, smaller forest cleanings, botanically diverse fringes of high forest edges is vanishing probably due to intensive forestry. Furthermore, fragmentation of woodland areas is a threat to the population.

The future – safeguarding of dormice in SE/S Jutland?

In order to safeguard dormice, their breeding activity and habitat qualities, certain proposals have to be considered if the local dormouse population is not going to die out - if not already extinct?

Proposals:

- New habitats of preferably native bushes, trees and herbaceous regeneration
- Better possibilities for dispersal inside the wood and between woodland areas
- Interconnecting hedges and edges of woods
- Establishment of corridors between habitats improving genetic interaction
- Considerate forest management in all habitats (not in breeding season and during hibernation)
- Always taking into account rotational management, selective felling of bushes and trees in small areas
- Securing stable habitats for colonization, spreading and movements of the animals
- Re-introduction and translocation of animals/ young from breeding projects across the border

Are German project sites in the region suitable for hazel dormice?

On a first glance the landscape is very suitable for dormice: the forest cover is compared to neighbouring districts relatively high, it is a partly very hilly landscape with high-quality broad-leafed forest, that are connected with local dense network of hedgerows.

But: The presence of the hazel dormouse has up to now never been taken into account, nothing has been done deliberately for dormouse survival, only accidentally (small clear-cuts, storm damages, hedgerow management). All in all this «accidental management» seems to be very inefficient, as populations have declined or died out at most of the suitable places. And on both sides of the border suitability of forests and hedgerow network seems to vary very much. There are different management strategies in both countries, legislation differs. But dormouse conservation is a legal duty on both sides of the border, best habitats are close to the border, the conservation of the last remaining population between Skagen and Kiel is a cross-border task!

1.4 Project targets – schematic overview

By Björn Schulz

The targets of the dormouse part of the project are mainly the safeguarding and increase of local dormouse populations by means of habitat management. If it comes out, that for a long-term survival population management is necessary, the project partners should find a way how to manage it.

In cooperation with experts from the UK and Germany in the beginning of the project the partners defined a workflow for the years 2010 – 2012 as shown in Fig. 6 – 8. Eventually the process took longer than planed; therefore 2013 is not included in the schematic overview.

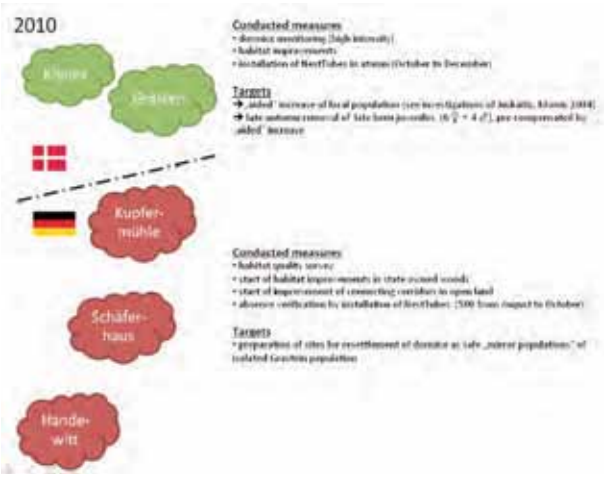


Figure 6: 2010: project targets and action

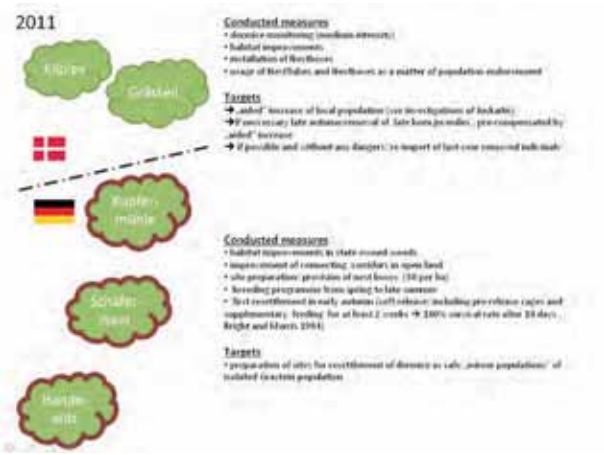


Figure 7: 2011: project targets and actions

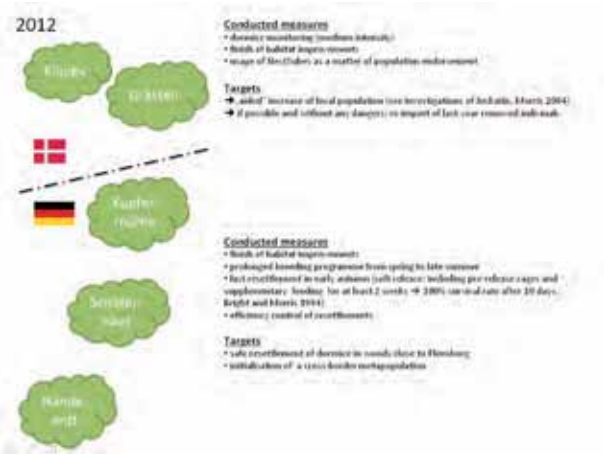


FIgure 8: 2012: project targets and actions

2 Survey and data collection

By Helle Vilhelmsen

2.1 Habitat survey

2.1.1 Habitat survey in Southern Jutland

Monitoring dormouse localities in hedges and small forest areas in Southern Jutland
Dormice have a minor ability to disperse and they prefer high degree of stability. Today many Danish habitats are isolated (e.g. Vejle, Gråsten (Jutland), Rønnede (Zealand), Lundeborg, Langeland (Funen), and also inside larger forests dormice sites are sparse and scattered. Forest management, practical activities, implementation of considerate felling, plantations and appropriate trees and bushes are needed if fragmentation and decline of local dormice populations should be avoided.

Hedges and smaller patches of woodland adjoining bigger forests are very important as they represent the only suitable habitat in a very intensively cultivated open landscape. Often they represent both sites of settlement and breeding. Hedges and smaller woodland areas may be the only possibility of migration and settlement, connecting dormice habitats being isolated from one another. Great effort should be taken into account as for protection, conservation and improving such localities in future dormousee conservation.

Monitoring of hedges during the INTERREG project
From 2010-2013 hedges and smaller woodlands have been examined (Vilhelmsen) by means of looking for dormice summer nests, by putting up nest-tubes and by visits (car, foot, maps) in order to make proposals for habitat improvement and propose green corridors for connectivity and as future habitats.

In the regions of Gråsten,Kliplev, Åbenrå and Sønderhav the distribution of dormice has been checked from 2010-2012 by:

- Searching for summer-nests by means of line-transects during the months of November-March (indirectly search method). Figure 9, 10 and 11 show maps of woods examined.
- Observations of dormice from nest-boxes and nest-tubes placed in selected areas throughout the forests. See chapter 2.2.2

Specific potential corridors between suitable habitats are suggested in maps (figure 12-15).
See also the report:

- Vilhlemsen, H., 2012: Hegnskorridorer og småskove i Sønderjylland – Undersøgelser og bonitering. 10 sider.

Figure 9: Forests-examined near Åbenrå

Figure 10: Forests – examined: the Gråsten and Kliplev/Søgård area

Figure 11: Forests- examined: Sønderhav area between Graasten and Kruså at the border

Figure 12: Possible dormouse habitats (green), suggested corridors (blue) at Sønderhav near the border.

Figure 13: Possible dormouse habitats (green), suggested corridors (blue) near the lake of Søgård

Figure 14: Possible dormouse habitats (green), suggested corridors (blue) north of Kelstrup Plantation

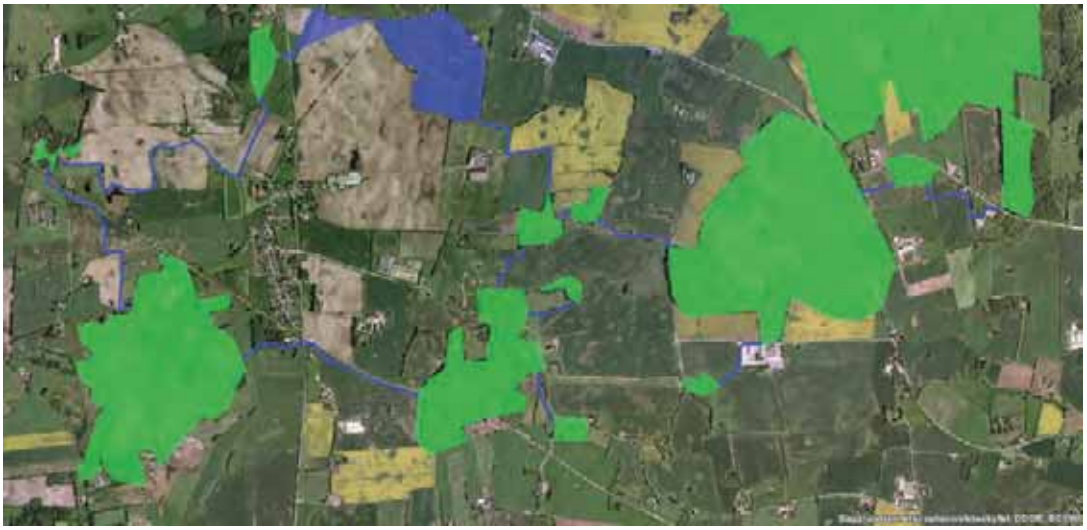


Figure 15: Possible dormouse habitats (green), suggested corridors (blue) at Buskmose, near Graasten.

How can hedges and small woodland areas be improved as habitats for dormice?

Plantation:

- Varied plant diversity *(Corylus avellana, Fagus sylvatica, Quercus robur, Sorbus aucuparia, Fraxinus excelsior, Prunus spinosa, Crataegus monogyna, Viburnum opulus, Frangula alnus, Rubus fructicosus, Rubus idaeus, Lonicera periabymemum, Prunus padus, Malus sylvestris, Rosa rubiginosa, Syringa vulgaris, Rhamnus cathartica, Juniperus comunis, Amelanchier spicata, Ribes alpinum, Sambucus nigra)*
- Mostly, native bushes, trees and herbs with rich seeding, fruits all over the season
- Many age classes
- Different succession stages
- Creation of openings, glades in a rotation of 7-10 years
- A minimum of 7-9 different main species of trees (no monotony), as well as any thorny and climbing herbs and bushes
- Planting of 20% trees and 80% bushes
- Connect habitats with corridors
- A mosaic pattern of different plantations

Management and forestry:

- Manage plantation in order to develop more horizontal and less vertical growth
- Avoid clear cutting and felling during the breeding period
- Use top-cutting (only 25% of the bushes and trees in a rotation of 5 years) (favour blooming)
- Use selective thinning instead of clear cuts.
- Leave piles of branches, leaves, felling as sites for hibernation, movements and hiding places
- Avoid soil management and heavy machinery during hibernation
- Implement considerate dormice forestry in local management and administration

Management for hedges:

- 1/3 of the hedges should be left without vertical cutting 7-10 years
- Only vertical cutting every 3 year, and the height should be at least 3-4 m
- Very important not to cut at both sides in 1 year
- More than 5-7 different species in hedge in order to secure feed sources
- Wood waste may be left to close gaps and openings in the hedge.
- Avoid grazing animals in coppiced hedges by fencing.
- Appropriate machinery should be used for hedge management and tree-cutting. Mechanical felling (coppice) is to take place in winter when dormice are hibernating. It is essential to leave stumps at a minimum height of 30-50 cm height and not to disturb the ground layer.

2.1.2 Suitability of habitats for dormouse in Schleswig-Holstein

By Sina Ehlers

The German project areas including surrounding hedgerow networks were evaluated regarding their suitability as potential dormouse habitats. Fieldwork was done as part of the search for dormouse in the same area in 2010.

Based on our knowledge on the habitat preference for hazel dormice by Bright & MacPherson (2002), Bright et al. (2006) and own studies, the following parameters have been applied in order to describe the qualities of potential habitats.

- Continuity of trees and shrubs (conrridors as "dormouse highways"),
- Number of tree and shrub species,
- Occurrence of preferred food plants such as blackthorn (*Prunus spinosa*), bramble (*Rubus sp.*), hazel *(Corylus avellana)*, hawthorn (*Crataegus monogyna*), honeysuckle (L*onicera periclymenum*) and oaks (*Quercus sp.)*.

It is assumed that a continuous presence of trees and shrubs, a high coverage of the shrub layer, a high number of woody plant species and a sufficient number of food plants makes a habitat of very good quality for the hazel dormice.

Some very good potential dormouse habitats were detected locally on the German side of the border. Especially good, species-rich hedgerow-networks in the surroundings of the small town *Niehuus* offers suitable dormouse habitats. Dominant species are hazel, blackthorn, hawthorn (occasionally standing beside hops), honey-suckle and dogwood aggregations. Oak and poplar predominate in the tree layer.

The woods of the project site *Schäferhaus-Nord,* dominated by young oak or spruce, constitute mostly unsuitable habitats (status 2010). However, especially a few wood edges and several hedgerows of this area are suitable as dormouse habitats. The dominant species are hawthorn, blackthorn and roses *(Rosa rugosa)*. The woods and hedgerows of site *Schäferhaus-Süd*, however, were mostly classified as a good to moderate habitats for the hazel dormouse. They are dominated by hawthorn and bramble and in the west of roses *(Rosa rugosa)* and maple. The tree layer consists mostly of pine, oak and poplar.

Also, some of the studied forest edges are partially good dormouse habitats, with a well-developed shrub layer. The dominant species in the forest of *Handewitt* are bramble, honeysuckle and sometimes elder *(Sambucus nigra)* and black alder *(Frangula alnus)*. The tree layer of many wood edges is mainly characterized by spruce and oak, beech as well as birch is regularly represented. Especially in the south of the forest *Kluesries* an edge with a good suitability as a dormouse habitat exists, which is dominated by bramble, blackthorn, honeysuckle and hazel. Here the tree layer consists mainly of beech, spruce and single maple, the shrub layer is dominated by ilex. However, some of the studied areas in both forests are species-poor with a moderately developed shrub layer; these areas will be considered as an unsuitable dormouse habitat. It should be noted that the potential dormouse habitat suitability in both forests has not been evaluated in coverage, but only at the sites where nest tubes were installed during the monitoring in 2010.

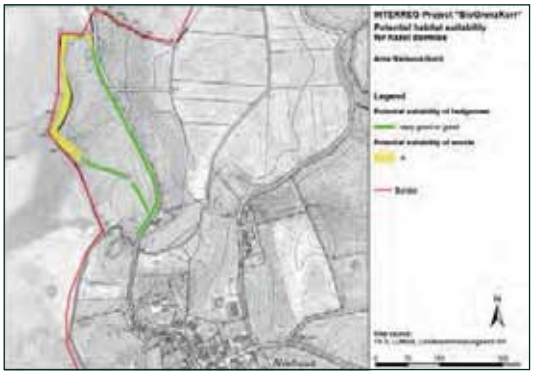


Figure 16: Potential habitat suitability for dormouse in "Niehuus-Nord". December 2010.

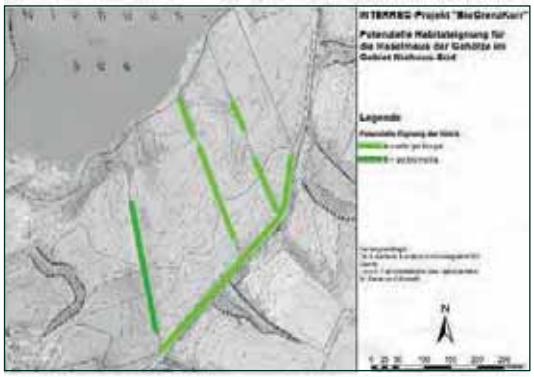


Figure 17: Potential habitat suitability for dormouse in "Niehuus-Süd". December 2010.

Figure 18: Example of a hedgerow in "Niehuus" as a potential habitat for dormouse with a good quality, dominated by hazel and bramble.

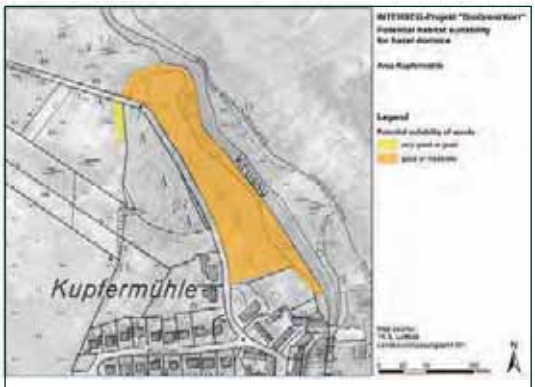


Figure 19: Potential habitat suitability for dormouse in "Kupfermühle". December 2010.

Figure 20: Example of a wood edge in "Kupfermühle" as a potential habitat for dormouse with a good quality, dominated by blackthorn, cranberry bush and bramble.

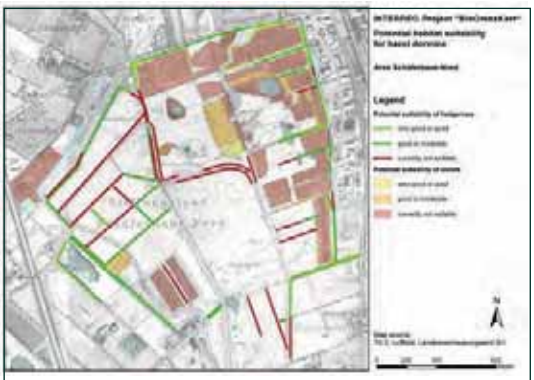


Figure 21: Potential habitat suitability for dormouse in "Schäferhaus-Nord". December 2010

Figure 22: Example of a wood edge in "Schäferhaus-Nord" as a potential habitat for dormouse with a good quality, dominated by blackthorn.

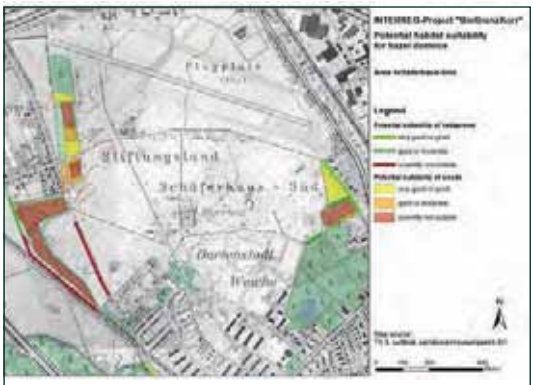


Figure 23: Potential habitat suitability for dormouse in "Schäferhaus-Süd". December 2010

Figure 24: Wood section in "Schäferhaus-Süd" as a potential habitat for dormouse with a good quality; shrublayer dominated by bramble and raspberry.

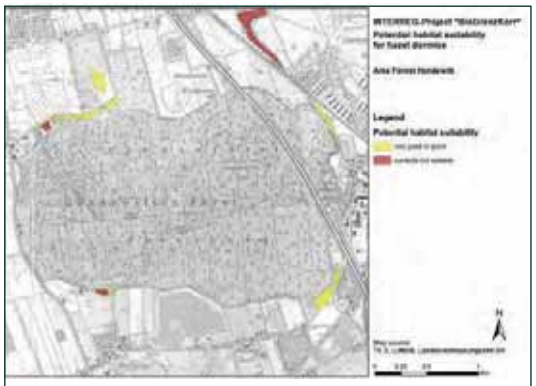


Figure 25: Potential habitat suitability for dormouse in the forest "Handewitt". December 2010.

Figure 26: Woodland section of the study site within the forest "Kluesries" as a potential habitat for hazel dormice with a good quality; shrublayer dominated by hazel, bramble and blackthorn.

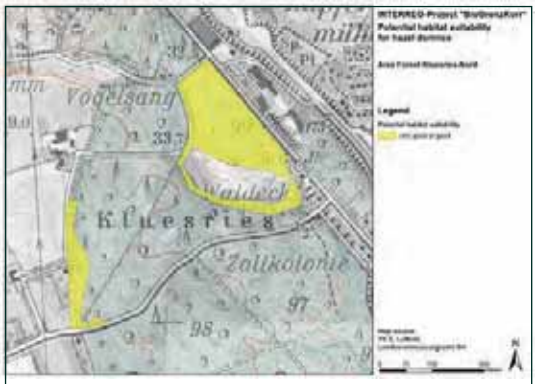


Figure 27: Potential habitat suitability for dormouse in the forest "Kluesries-Nord". December 2010.

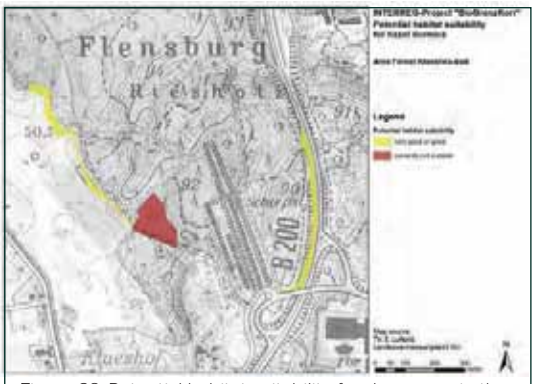


Figure 28: Potential habitat suitability for dormouse in the forest "Kluesries-Süd". December 2010.

2.2 Dormouse Monitoring

by Sina Ehlers

There are different survey methods for monitoring dormice (see Bright et al. 2006).
Three methods are usually applied to detect dormouse.

- Search for gnawed hazelnuts in areas where hazel is present
- Search for natural nests
- To put out nest boxes and/or tubes for monitoring.

Searching for gnawed hazel nuts

Hazel dormice open hazel nuts in a distinctive manner. Voles and wood mice eat hazels too, and all three gnaw a neat hole in the shell. However, mice and voles leave clear vertical tooth marks that make a rough edge to the hole. The dormouse turns the nut sideways after gnawing into the shell and then uses its teeth in a scooping action to enlarge the hole. As a result, the hole becomes very smooth and almost perfectly circular. Any tooth marks present always run along inside the cut edge of the hole (Morris 2004). This method requires participation and training of many volunteers for collection of nuts in large areas, as well as organization of handling the found nuts: receiving, checking and recording found nuts as well as responding to the people who found the nuts. The method - a so called "nut hunt" - has been applied with success in several areas such as: Schleswig-Holstein, England and Saxony and have brought new knowledge about the distribution of dormice locally.

Searching for natural nests

Dormice build tightly woven nests with an laterally entrance hole in tree holes or in abandoned bird nests as well as in the low-growing shrub layer or in whirling branches in heights from 0.5 to over 30 m (Büchner 2002). Dormouse nests are mostly woven from grasses and frequently have whole fresh leaves incorporated into the outer layers (Bright et al. 2006).

But locating and determining the nests require some experience: The search should focus on very dense vegetation structures and preferred dormouse food plants. Since many dormouse nests are similar to those of harvest mice and some bird species, a found nest should be investigated further. It is advisable to look for nests in autumn / winter, after the end of the growing season, when

Figure 29: Natural nest of a hazel dormouse

the leaves are mostly fallen so that they are more visible in the leafless shrubs. For the advanced season (late January / February) a decline in last year's nests is to be expected, so that remains of nests may not be clearly assigned to a species.

Nest boxes and/or tubes

Dormice readily use artificial nest holes (nest boxes and tubes) - especially in the months of May and September / October (Ehlers 2012, Juškaitis & Büchner 2010). Depending on the location and duration of the survey at least 50 nest tubes or 20 nest boxes should be set out at a distance of about 15 to 20 m. Nest boxes are more suitable for monitoring in forest areas, nest tubes on the other hand especially for the survey of dormouse populations in hedgerows and other habitats where natural tree holes are rare.

Timing and duration of monitoring using nest tubes

Nest tubes should be left in place for several months. They are most frequently occupied in May and August/September. Timing their deployment is therefore important. It is best to leave them out for the entire active season, from March to November.

Figure 30: Monitoring: Nest tube (above) and nest box (below) set out in a potential dormouse habitat

2.2.1 Dormouse monitoring in Schleswig Holstein

By Sina Ehlers

An extensive survey on suitable woods and hedgerows in the project sites on the German site of the border took place in 2010. The aim was to make sure that wooded areas within the German part of the border region do not already inhabited the hazel dormouse, In order to monitor potential dormouse occurrences, the survey methods of setting out nest tubes and incidental searching for natural nests and gnawed hazelnuts were chosen. A total of 500 nest tubes were deployed within the study sites Schäferhaus Nord, Schäferhaus Süd, Niehuus Nord, Niehuus Süd, Kupfermühle and the woodlands of Handewitt and Kluesries: Number, date of installation and removal in the respective study sites are shown in the following table and figures.

The nest tubes were inspected monthly.

The monitoring in all surveyed sites resulted in no evidence of dormice in the German part of the project area. Within the nest tubes in all study sites, however, nests and / or food depots of wood and yellow-necked mice *(Apodemus spec.)* were occasionally found, only.

The tooth marks on opened hazelnuts demonstrated the presence of red squirrel (*Sciurus vulgaris)*, wood mice (*Apodemus spec.*) and bank voles (*Myodes glareolus*).

Study sites	**No. of nesttubes**	**Date**		**Duration**
		Installation	**Removal**	
Stiftung Naturschutz SH				
Schäferhaus Nord	100	26.07.2010	22.10.2010	3
Schäferhaus Süd	80	05.08.2010	22.10.2010	2.5
Niehuus Süd	70	11.08.2010	12.10.2010	2
Niehuus Nord	35	13.08.2010	12.10.2010	2
Kupfermühle	15	13.08.2010	12.10.2010	2
Landesforsten SH				
Handewitter Forst	100	17.+19.08.2010	25.11.2010	3
Kluesrieser Forst Süd	55	19.08.2010	2011	3
Kluesrieser Forst Nord	45	23.08.2010	2011	3

Table 1: Monitoring dormice: Number of installed nest tubes within the stdudy sites in SH and duration of the survey

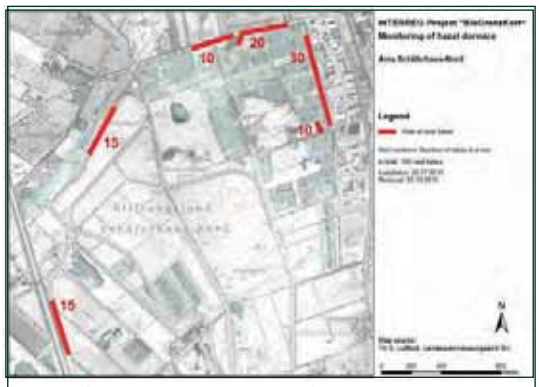


Figure 31: Location and number of nest tubes within the study site "Schäferhaus-Nord"

Figure 32: Location and number of nest tubes within the study site "Schäferhaus-Süd"

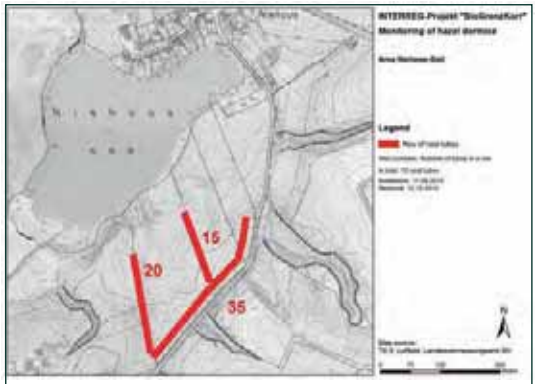


Figure 33: Location and number of nest tubes within the study site "Niehuus-Süd"

Figure 34: Location and number of nest tubes within the study site "Niehuus-Nord"

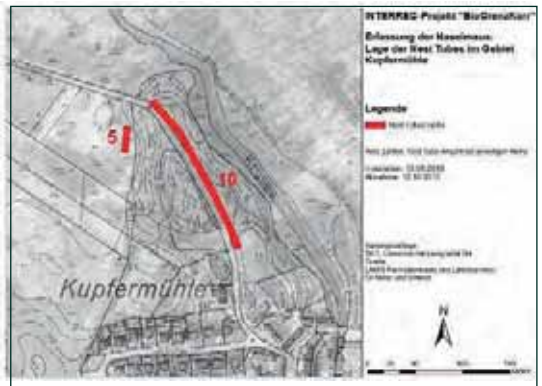


Figure 35: Location and number of nest tubes within the study site "Kupfermühle".

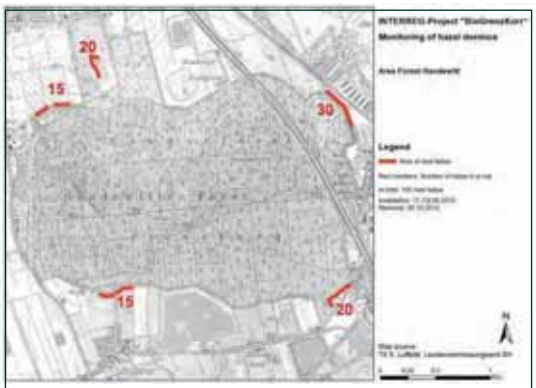


Figure 36: Location and number of nest tubes within the study site "Forest Handewitt"

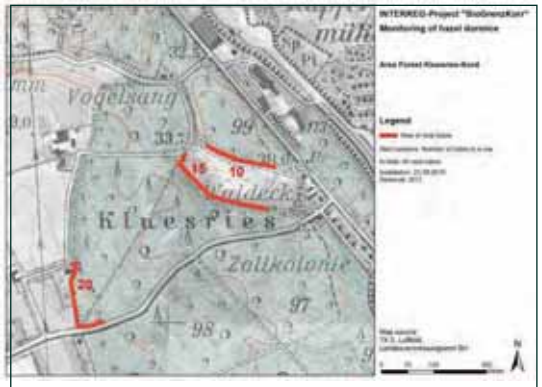


Figure 37: Location and number of nest tubes within the study site "Forest Kluesries-Nord"

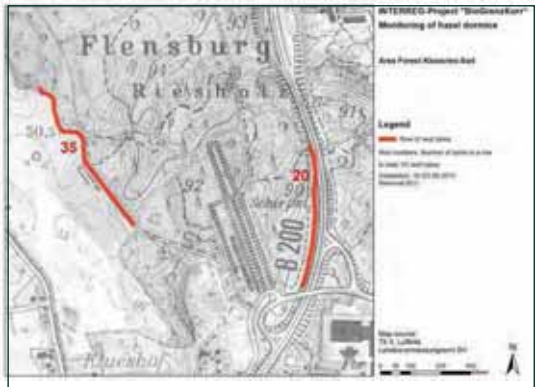


Figure 38: Location and number of nest tubes within the study site "Forest Kluesries-Süd

The probability of detecting dormice is significantly reduced by a short monitoring period, even if this coincides with a period of high detection probability:

According to the evaluation system of Chanin et al. (2003), the attachment of nest tubes from March to October / November achieves the highest probability of occupancy by dormice in a populated habitat. Is it not possible to keep this timeframe, there is the possibility to increase the probability of finding dormice present in nest-tubes through increasing the number of the tubes. Accordingly, the relatively short duration of the monitoring in Schleswig-Holstein is compensated by the high number of installed nest tubes. Hence, further studies in the study sites are not necessary.

Summarized, it may be assumed that the hazel dormouse currently does not exist on the German side of the border region.

Reasons for the absence of the species in the study area could not be clarified in this project.

The above chapters 2.1.2 and 2.2.1 are based on the report:

- Ehlers, S. 2010: Bestandsmonitoring der Haselmaus (*Muscardinus avellenarius*; Anhang IV Art der FFH-Richlinie) in ausgewählten schleswig-holsteinischen Gehölzen im Rahmen des INTERREG 4a-Projectes „BioGrenzKorr". 32 pages.

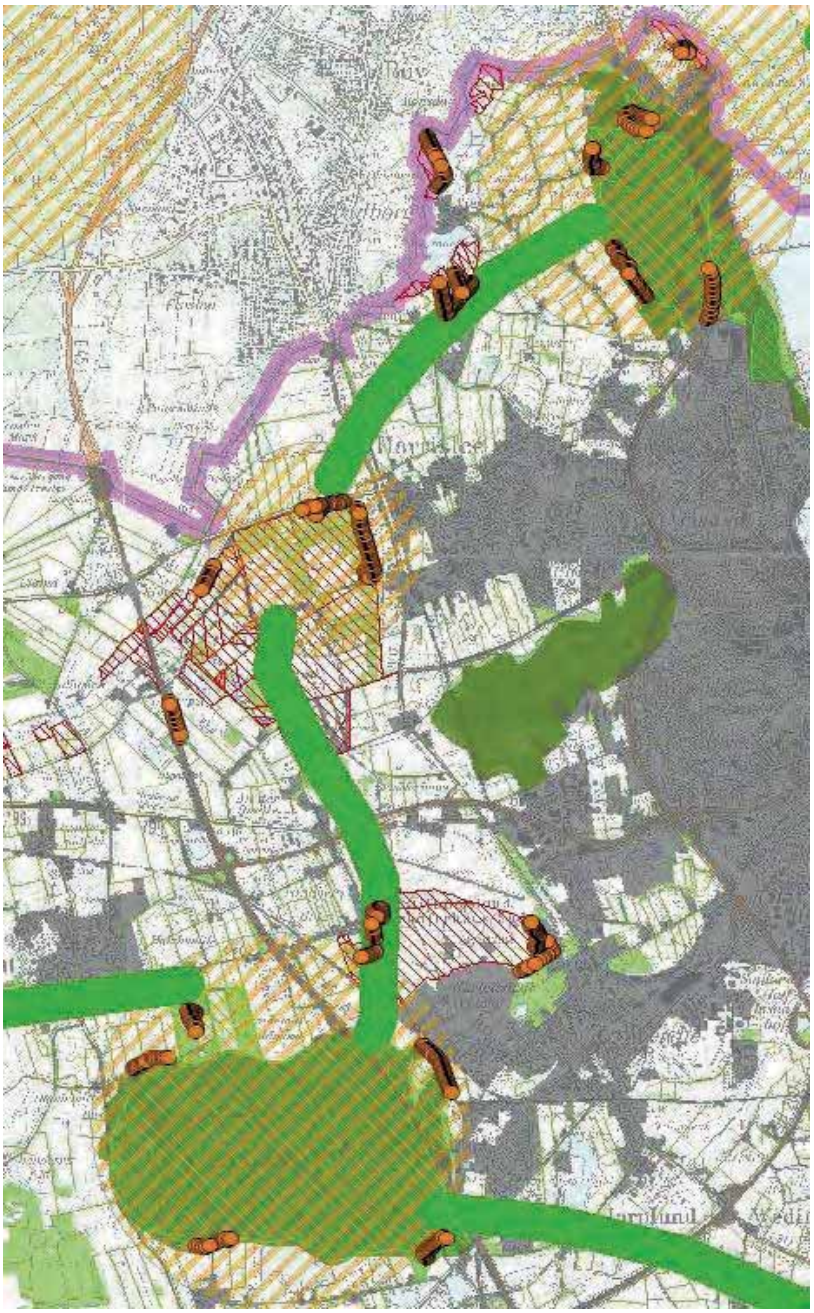


Figure 39: distribution of monitoring sites in SH

2.2.2. Dormouse monitoring in Southern Jutland

In the years before the INTERREG-Project natural dormouse summer-nests were registered at Søgård, Gråsten, Rinkenæs, Rode and Buskmose forests (Baagøe & Jensen, 2007) and animals have been reported by local people now and then. However, 100 dormouse nest boxes (25 boxes at 4 localities), hanging for several years in the Gråsten forest complex have never been occupied by dormice. In order to get a status of the dormouse population in the area an intensive search was initiated. Besides increasing the probability of finding dormouse presence in nest tubes and boxes, a secondary objective was to catch dormice in order to extract DNA-samples. Two methods have been applied in order to detect presence of dormouse:

- Lay out of nest tube transects.
- Search for free hanging nests.

Nesttubes: A total of 407 nest-tubes were placed in Gråsten (Rode, Rinkenæs, Buskmose), Kliplev (Søgard skov) and Kelstrup plantage (Vilhelmsen and Ehlers) from 2010-12, at suitable inner and outer forest edges. However, no evidence of any dormouse occupation has been observed in the tubes till now. During the inspections in 2011 and 2012 no dormouse nests were found in the nest tubes or the old nest boxes. Thus, no individuals could be caught to collect DNA-samples.

The tubes were inspected once every month. Several nest-tubes were cut down, replaced etc. due to forest management, disturbances etc., but despite of that, the results and the status of the local dormice population is depressing and uncertain. The number and location of the installed nest tubes are shown in the figure below.

Figure 40: Number and location of nest tubes on the Danish side of the border.

Figure 41: Location of the natural nests found at a southern wood edge of the Rinkenæs Skov.

Search for free hanging nests: Most forests in the area between Åbenrå-Graasten-Kruså have been searched for free hanging nest. See Chapter 2.1.1., figure 9, 10 and 11.

On a southern edge of the forest of Rinkenæs, near Graasten, four single and two litter dormouse nests were found, all of them not occupied, See figure 41 and table 2. These were the only free hanging nests found in Southern Jutland in the project period 2010-2012.

In an attempt to get hair for DNA samples two nests were collected, but these led to no result.

Type of nest	Measure	Material	Height a.s.	Tree/Bushes
Mixed (M)	12x10 cm	Leaves, grass	70 cm	Brambies
Mixed (M)	10x6 cm	Leaves, grass	80 cm	Hazel
Leaf (B)	7x7 cm	Different leaves	65 cm	Hazel
Breeding (S)	10x8 cm	Leaves with inner core	100 cm	Prunus
Grass (G)	8x8 cm	Grass	75 cm	Brambles
Mixed (M)	11x10 cm	Leaves, grass	100 cm	Beech/brambies

Table 2: Description of the dormouse nests

Figure 42: Dormouse nest (H. Vilhelmsen)

Figure 43: Nesttube (H. Vilhelmsen)

The few scattered evidence of hazel dormouse - despite the intense survey effort - seems to confirm the assumption that the density of the remaining dormouse populations on the mainland of Denmark (Southern Jutland) is very low.

While evaluating the situation of the dormouse in Jutland, however, it is also to be noted that the surveyed woodlands cover a large area and present a largely good habitat quality for dormice as well, i.e. there are numerous structures available where dormice can build their nests, the supply of natural tree holes is relatively high and there is a mosaic of age classes with many connections between the different levels of the tree canopy and undergrowth.

Therefore the offered nest boxes and tubes at comparatively low installation heights become less attractive for dormice - in particular at a low population density.

For the full report of the survey see:

- Vilhelmsen, H., 2012: Undersøgelser over hasselmusens forekomst i Sønderjylland, 2010-2012. Dormouseconsult.dk . 21 pages.

Figure 44: One of the last nests detected during the intensive monitoring (16. Sept. 2011)

2.2.3. Dormouse monitoring on Fyn

By Helle Vilhelmsen

Introduction

The project area on Fyn is found in the Sollerup forest – Svanninge Bakke – Nørremarken nature area. The Nature Agency manages approximately 500 ha in this area. Sollerup forest is known for is stable dormouse population, which has been monitored regularly during the last 25 years. During this period nest boxes for long term dormouse monitoring have been put up in Sollerup. In this project 100 new nest boxes have been installed to be able to follow the population in areas developing into new optimal dormouse habitats (succession). As we already have a relatively good overview of the dormouse population in Sollerup forest, the focus in this project has been to monitor dormouse in the open mosaic landscape in Svanninge Bakke and Nørremarken situated to the south west of Sollerup. Monitoring of dormouse has never been done systematically in this area before. This area is also the core area of the demonstration area for hedgerow management. See overview of the Fyn project area in chapter 3. Two methods have been applied in order to detect presence of dormouse:

- Search for free hanging nests
- Lay out of nest tube transects for documentation of dormice presence.

Free hanging dormouse nests in Svanninge Bakker and Nørremarken

Search for free hanging nests was done after leaf fall in autumn and in early spring before leafing. When the vegetation has no leaves the nests are easier to detect. Helle Vilhelmsen has many years of experience in applying this monitoring method in Denmark.

In Svanninge Bakke and Nørremarken hedgerows were searched two times on both sides as line transects. In forest and shrub, line transects were laid out at a distance of 2 m, as a structured search covering most bushes or trees. The map below shows the distribution of free hanging nests in the area and the tables below provide data on each nest found.

Types of nest:

- Mixed: Nest made of mix of leaves, fibre and grass
- Leaves: Nest made of leaves only
- Core: Breeding nest with an outer layer of leaves and an inner core of grass etc.
- Grass: Nest primarily made of grass, fibre and few leaves

Table 3: Data on free hanging dormouse nest found in 2010 in Svanninge Bakker

No.	Nest type	Size cm x cm	Nest material	Meters above ground	Nest found in/locality
1	Mixed	7,0 x 8,1	beech, fibre, grass	1,50	lonicera/schrub+forest
2	Leaves	7,5 x 6,0	beech, thistle, fern	1,20	beech/schrub+forest
3	Mixed	8,0 x 10,0	sambucus, blackthorn, thistle	0,95	blackthorn/hedgerow
4	Core	10,1 x 7,6	beech, fern, grass	1,75	blackthorn/hedgerow
5	Mixed	6,8 x 7,3	oak, willow herb	0,85	oak/schrub+forest
6	Grass	7,4 x 6,5	grass, fibre, beech	1,30	bramble/hedgerow
7	Mixed	10,4 x 6,6	bramble, grass	0,80	bramble/hedgerow
8	Core	8,8 x 7,0	beech, oak, fibre	1,70	sambucus/blackthorn/hedgerow
9	Leaves	5,7 x 6,8	hawthorn, raspberry	1,35	hawthorn/hedgerow
10	Core	8,5 x 7,1	fern, grass	0,85	hazel/hedgerow
11	Core	12,0 x 6,5	thistle, fibre, beech	1,40	frangula/hedgerow
12	Mixed	7, 8 x 6,6	sorbus, hawthorn, fibre	1,60	malus/hedgerow
13	Mixed	10,0 x 6,8	oak, raspberry, grass	0,60	blackthorn/beech/hedgerow
14	Mixed	9,5 x 7,7	fern, bramble	1,85	hazel/hedgerow
15	Grass	9,0 x 5,5	grass, fern	1,50	bramble/schrub+forest
16	Core	11,2 x 8,0	fibre, raspberry	1,00	lonicera/schrub+forest
17	Mixed	9,5 x 7,0	hazel, beech, grass	1,80	beech/schrub+forest
18	Mixed	8,5 x 7,1	beech, acer, fibre	0,95	acer/hedgerow
19	Mixed	7,0 x 5,8	oak, fibre, fern	1,60	oak/hazel/hedgerow
20	Leaves	6,9 x 8,2	beech, sorbus	1,20	blackthorn/hedgerow
21	Leaves	7,4 x 7,9	oak	0,95	hawthorn/hedgerow
22	Mixed	6,6 x 5,9	fern, grass, oak	1,00	cornus/hedgerow

No.	Nest type	Size cm x cm	Nest material	Meters bove ground	Nest found in/locality
23	Leaves	5,2 x 6,3	beech	1,25	spruce/hedgerow
24	Core	10,1 x 8,8	fern, thistle	1,20	amelanchier/hedgerow
25	Mixed	7,3 x 7,0	oak, acer, fibre	0,60	blackthorn/hedgerow
26	Grass	7,6 x 9,0	grass, fibre, moss	1,00	raspberry/hedgerow
27	Mixed	6,7 x 5,8	hazel, blackthorn	1,35	hazel/hedgerow
28	Mixed	7,0 x 5,9	acer, fern	0,85	sambucus/hedgerow
29	Mixed	7,8 x 8,9	beech, bramble	1,34	bramble/hedgerow
30	Leaves	10,0 x 7,4	lonicera	1,00	lonicera/hedgerow
31	Core	9,0 x 6,4	thistle, willow herb	0,98	sambucus/hedgerow
32	Core	9,8 x 8,8	beech, fibre, grass	1,40	beech/schrub+forest
33	Mixed	8,5 x 7,1	oak, raspberry, grass	1,75	spruce/schrub+forest
34	Grass	10,1 x 7,5	grass, fibre, moss	1,70	lonicera/hedgerow
35	Core	9, 7 x 7,5	P.padus, willow herb	1,62	P.padus/hedgerow
36	Mixed	6,5 x 5,5	beech, thistle, fibre	0,82	hazel/hedgerow
37	Mixed	5,5 x 7,3	bramble, fibre	1,59	blackthorn/hedgerow
38	Mixed	7,8 x 5,6	beech, fibre	0,58	bramble/hedgerow
39	Leaves	6,7 x 5,2	willow herb	1,26	willow herb/schrub+forest
40	Mixed	5,5 x 5,6	acer, beech, fibre	1,74	syringa/hedgerow
41	Core	8,0 x 6,8	fern, thistle	1,00	hawthorn/hedgerow
42	Mixed	5,9 x 4,9	raspberry, grass	0,79	malus/hedgerow
43	Mixed	6,7 x 7,5	beech, sorbus, fibre	1,26	blackthorn/hedgerow
44	Mixed	7,2 x 7,9	oak, fern, fibre	1,50	hazel/hedgerow
45	Mixed	8,6 x 5,7	beech, willow herb	1,60	ilex/hedgerow
46	Mixed	7,5 x 8,1	bramble, fibre	0,50	bramble/hedgerow

Table 4: Data on free hanging dormouse nests found in 2011 in Svanninge Bakker

Nest-tubes transects in Svanninge Bakker and Nørremarken

Five transects were laid out with 10 nest tubes in each. The nest tubes were checked once each month from August to December both included. One dormouse and 7 dormouse nests were found. A number of nest tubes were also occupied by *Apodemus*. See results in map above.

Dormouse in Svanninge Bakker and Nørremarken

A total of 54 records of dormouse presence indicate that the area holds a viable and stable population. The distribution of nests also indicates that individuals are expanding from closed forest habitats in the east into habitats such as hedgerows and small woods to the west, including into the demonstration area in Nørremarken. See more about habitats improvements in this area in chapter 3.5.

Applying nest-tubes as a monitoring method

As seen the method of using nest-tubes was successfully applied. The method is new in Denmark and was not tried in Denmark before it was tested in this project. Application of the nest tube survey method is based on successful experiences from England and Germany. The method is particularly useful for surveys in open land mosaic landscapes with a mix of hedgerows and small forest patches. In contrast nest boxes are best for long term monitoring in forest. Stiftung Naturschutz has shown that applying nest tubes is an effective monitoring method in hedgerow systems. Now the use of nest tubes is standard procedure in the Danish National monitoring of dormouse (NOVANA). See more details in report on dormouse monitoring on Fyn.

- Vilhlemsen, H., 2011: Kortlægning af hasselmusens forekomst i hegn/kratskov, Svanninge. 18 pages.

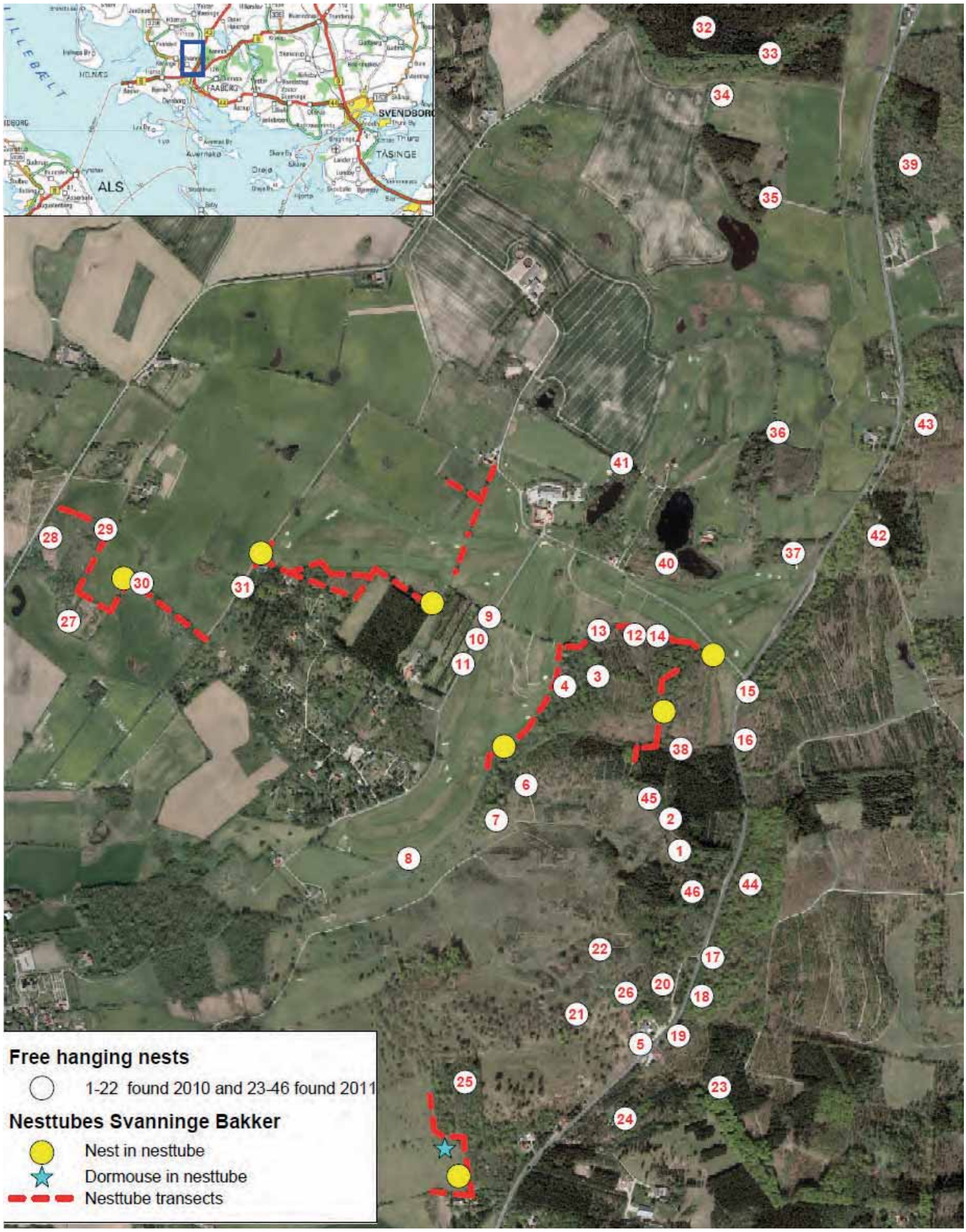


Figure 45: Result of dormouse monitoring in Svanninge Bakker and Nørremarken

2.3 Perspectives for the dormouse in the border region

By Björn Schulz

Stochastic extinction and repopulation events are to be regarded as natural processes. However, looking at the current lack of dormice in the northern Schleswig-Holstein and the few sporadic evidence of the species on the Danish side of the project area (Southern Jutland) - a total of six natural nests at a southern wood edge of the woodland complex close to Gråsten, despite a major monitoring effort – it seems that the natural balance has shifted in this region, so that the remaining, highly isolated populations in Jutland is likely to disappear as the former populations in the northern Schleswig-Holstein did. This was the perspective at the beginning of the project.

However, facing the already good habitats within the surveyed woodlands and hedgerows throughout the German-Danish project area, there is a potential for successful implementation of appropriate conservation measures.

Thus, the specific resettlement of hazel dormice in improved sites within the border region, and hence in their former natural distribution area, as mirror populations of the Danish isolated and threatened populations – accompanied by the development of a sustainable and coordinated cross-border German-Danish landscape corridor – could lead to a long-term stabilization of the few isolated dormouse populations of Southern Denmark and thereby counteract the final extinction of the species in this region.

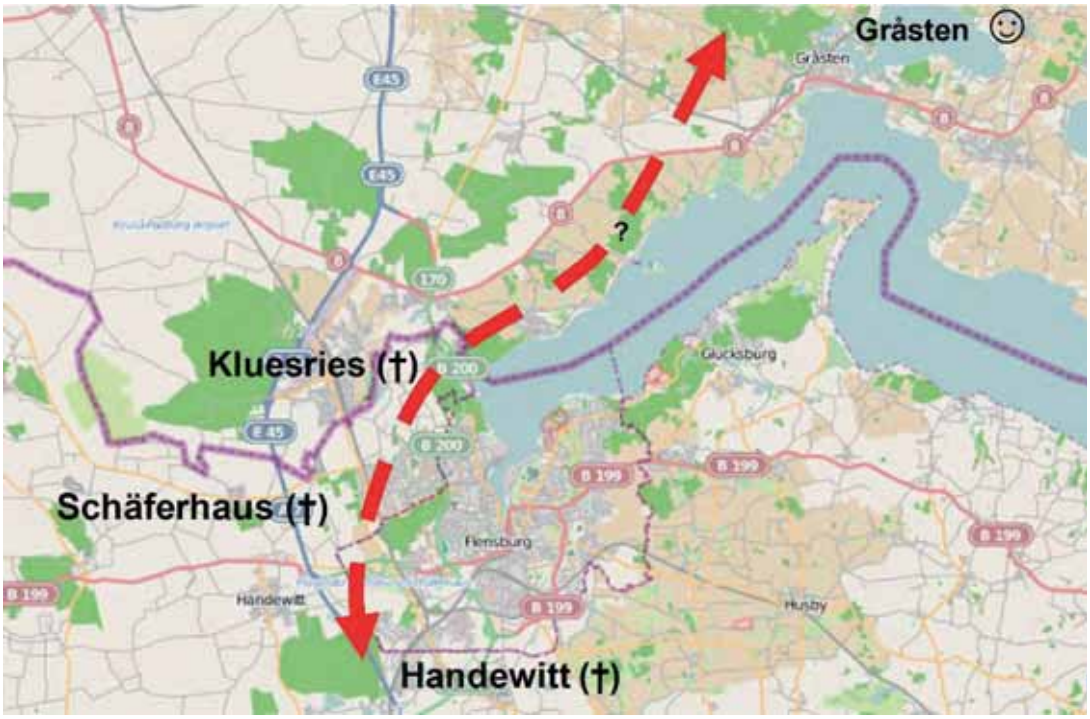


Figure 46: The planned cross border connection between German populations (to be resettled) around Flensburg and danish populations (to be safeguarded) around Graasten

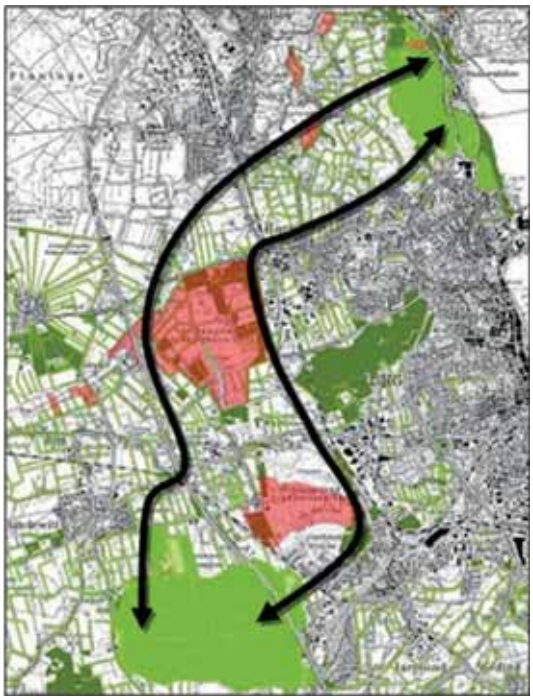


Figure 47: Connectivity between German project sites is potentially high
Comments: Green line: hedgerows, red polygon: Stiftungsland Schäferhaus, green polygon: state forest Kluesrieser Forst (North) and Handweitt (South)

3 Habitat Management

Figure 48: The project partners meet on site to study field actions (10.5.2012)

3.1 Introduction

It is relatively well know, what the key factors for dormice are (Juskaitis & Büchner, 2013). The main factors are high shrub diversity, high vertical habitat continuity between the vegetation on the ground, the shrub layer and the canopy, high horizontal habitat continuity inside the forests and along linear habitats and finally a continuous supply of different flowers, fruits, seeds and nuts during the whole spring, summer and autumn season. However, there is relative low practical experience, especially among the project partners, how these key factors can be implemented in normal forestry or site management.

Such conditions may be found in secondary forest under regeneration. In forests under traditional management, areas under regeneration grow up to become a closed canopy. When the forest grows into a closed forest with no or a poor understory the habitats has to shift to another site under regeneration. In intensively managed forest, areas under regeneration focus on a few main tree species reducing the quality of dormouse habitats. In forest under natural forest management harvest and regeneration focus on single trees, with small gaps for regeneration and a constant tree cover, which also reduce a dense understory.

Improving habitats for dormice in forest may therefor include

1) establishment of core areas planted with a large variety of bushed and managed as coppice and/or
2) establishment/management of corridors in forest edges or along forest roads in order to connect core habitats in the forest.

Thus, the projects key focus is development and practical testing of different types of habitat management and especially integration with normal site management.

In the project areas dormouse oriented management was tested. Besides improving present or future dormouse habitats, these sites serve as demonstrations areas for future activities in dormouse conservation. The sites also contribute to an overall cross border corridor network. The following types of management interventions are demonstrated in the project areas:

- Clearings and succession in forests and forest edges
- Plantings and understory management
- Hedgerow management
- Habitat connections in open land

Figure 49: A typical picture from the forests of Graasten

Comments: Open forest meadows with beech forest in the back and a forest edge zone with bushes in between..

3.2.The Forests of Gråsten

By Martin Reimers

Habitat improvements in the forests of Graasten: Establishment of corridors and core habitats for dormouse.

The dormouse was first found in the forests of Graasten in 2008, however it has been very difficult since then to document its present status and it is at risk of local extinction (see more in chapter 2.2.2 and 2.3). Establishment of corridors and core habitats for dormouse has the primary objective of safeguarding this small population. A secondary objective has been to recommend methods for establishment of core habitats and corridors between the core habitats in the forest.

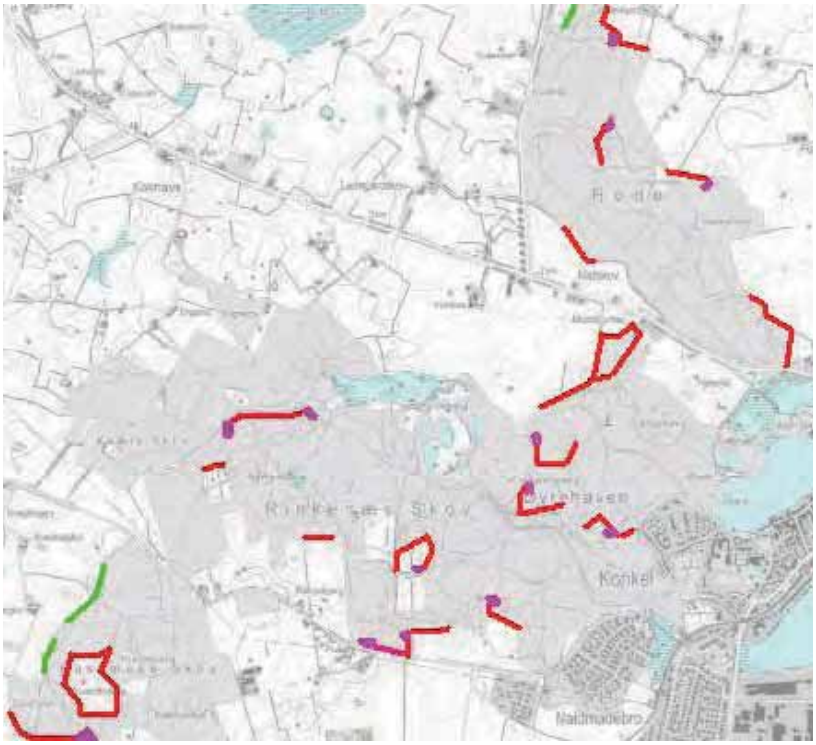
The forests of Graasten

The forests are situated two kilometres from the fjord of Flensburg in the south eastern corner of Southern Jutland. The area has been selected as a demonstration site as it is the largest forest with a known dormouse population in Southern Jutland, with a total area of 700 ha. The forest area is very diverse regarding the opportunities to test different habitat improvements for dormouse. The forests of Graasten are situated east of the edge of the icecap that created the landscape 17.000 years ago, on nutritious clay soils in a hilly landscape. Beech *(Fagus sylvatica)* is the main tree species covering 75% of the forest area. Oak (*Quercus robur)* and other deciduous species covers 15%. Open areas in the forest constitute of 11% of the total area with several forest meadows, lakes and grasslands.

The overall framework

Core dormouse habitats were established on strategic locations in the forests. Corridors were established in order to improve connectivity between core habitats. In places with existing oak stands with well-established understories with bushes such as hazel and hawthorn, as well as other concentrations of bush vegetation in the forests, these worked as the corridors. Finally, forest edges where thinned heavily in order to improve habitats for dormouse. See appendix 4 for an overview of the costs of interventions.

Figure 50: Map of the forests of Graasten
Comments: New established core habitats (purple), corridors (red) and hard forest edge thinning (green). Besides newly established core habitats the forests contains of numerous core habitats; primarily oak stands with well-established understories of bushes, corridors with bushes in inner and outer forest edges as well as overgrown cleared areas with bushes



Establishment of core dormouse habitats
13 core habitats were laid out with an average size of 1500 m2. Before planting mainly spruce was felled if needed and the surface cleared for logging debris, after which each plot was planted with trees and bushes. Finally the plot was fenced in order to keep out roe deer, which are plenty in the forests of Graasten. In a less intensive model (model 2) no surface clearing and fencing was applied (Table 5). No soil cultivation was applied and tree and bushes were planted in groups of the same species. *Prunus avium* was planted at the edge of the plots near forest roads, as they grow fast and may serve as "bridges" across the roads. *Viburnum opulus* was given priority as it grows well on the moist clay soils in the forests of Graasten. The core habitats were mainly placed near forest roads in order to increase the recreational value of the forest. Also core areas were laid out on the northern side of spruce stands in order to avoid storm damage after clearing.

The two models were tested so as later to be able to compare an advanced model with a simpler and cheaper model. Eleven core areas were planted using model 1 and two areas according to model 2.

Model 1	Model 2
Corylus avellana, 15%	*Corylus avellana, 34%*
Crataegus laevigata, 15%	*Crataegus monogyna, 33%*
Viburnum opulus, 15%	*Viburnum opulus, 33%*
Euonymus europaeus, 15%	
Prunus spinosa, 15%	
Sambucus nigra, 10%	
Rosa canina, 10%	
Malus sylvestris, 2%	
Ilex aquifolium, 2%	
Prunus avium, 1%	

Table 5: Planting of core habitats (Distribution of species %)

Management of core areas: It will be necessary to remove the fence after some years. Also it may be necessary to cut down naturally grown trees e.g. every 15-25 years as well as to coppice the vegetation as such. Alternatively to thin or coppice some parts of the core areas if some bush species become too dominant.

Conclusion: Fenced core areas are an effective but expensive method to increase the area with bushes in order to improve dormouse habitat.

Figure 51: Newly planted and fenced core habitat. Model 1: The forest of Roden, Dep. 3007a.

Establishment of corridors

17 corridors with a total length of 8 km and a width of app. 12 m were laid out in the forests. Primarily spruce forest was felled and if needed the forest floor was cleared before planting.No soil cultivation was applied and plants were planted in 2-3 rows, 25 m in a row with one species and then another species etc. The corridors were not fenced for roe deer. Corridors were primarily placed in the northern edge of spruce stands to avoid storm damage after felling.

Model 1	Model 2
Corylus avellana, 50%	*Corylus avellana, 34%*
Crataegus laevigata, 20%	*Crataegus monogyna, 33%*
Viburnum opulus, 20%	*Viburnum opulus, 33%*
Sambucus nigra, 9%	
Prunus avium, 1%	

Table 6: Planting of corridors (species distribution %)

Five corridors were planted according to model 1 and 12 corridors according to model 2.

Management of corridors: It may become necessary to cut down naturally grown trees as well as thin or coppice dominant bushes with 15-25 years interval.

Conclusion: Corridors without fence is a relatively cheap method with limited effect regarding increased connectivity between core areas. It is important to use hardy plants that to some extend will resist roe deer, as well as be tolerant to some level of shade. It is optimal to fence corridors to avoid roe deer. However, fencing the long and narrow corridors will be expensive. Bramble (*Rubus sp.*) will typically take over in areas where plants are damaged by roe deer, which creates good dormouse habitats. Bramble (*Rubus sp.*) is very common in the forests of Graasten.

Management of forest edges

In order to improve forest edges as habitats for dormouse, heavy selective thinning was applied in order to bring more light into the understory and promote natural growth of bushes. 50% of the stems were taken out in a 15 m wide row along westward forest edges in deciduous stands. Dominating dark trees such as beech (*Fagus sylvatica)* were primarily taken out in contrast to trees allowing more light to the understory such as ash (*Fraxinus excelsior*). No planting was applied in the forest edge.

Figure 52: The forest of Roden, Dep. 3028a.Cleared and planted corridor, model 1.

Figure 53: The forest of Buskmose, Dep. 3213b Comments: Forest edge with a narrow natural bush zone to the left after reduction of the number of stems with 50% in the outer 15 m.

Future management of forest edges: It will in most places be necessary to repeat the increased selective thinning in forest edges turning west, south and east until the understory has developed sufficiently.

Conclusion: Heavy thinning in the forest edge is an easy and cheap method to apply when deciduous forest stands are being thinned anyway. Heavy thinning is repeated until the understory receive enough light to develop. One may see young trees dominate instead of bushes, when the level of light increases in the understory. However, the level of bushes in the understory will probably increase if heavy thinning is applied over time. Monitoring for several years is needed in order to assess the effect.

Other methods

The above mentioned three methods were used in the forests of Graasten. However other actions may by applied in order to promote the development of the understory in forest stands.
1) Bushes may be planted in existing forest stands, 2) selective thinning of "dark" trees in contrast to "light" trees and finally 3) laying out small clearings for natural succession.

In addition one has to consider the costs of alternative land use. In core areas one has to consider the lost income from traditional forest management. The same apply to a lesser degree in the corridors and forest edges where tree cover remains and bushes are found in the understory. However, improved values are created when it comes to increased biological diversity, recreation and hunting.

Recommendations

It is recommended to establish core areas and corridors as described above according to economic capability. The better method the more expensive core areas and corridors. If it is not an option to prioritise economic resources for core areas and corridors it is recommended to apply a heavy thinning in forest edges. One has to be patient as it is expected that several thinings will be necessary before a proper understory is established. This may therefore have to be combined with e.g. small clearings in the forest and thinning that favour light trees.

3.3 State forest Handewitt & Kluesries

By Christiane Herty

The two forests Handewitt and Kluesries are owned by the Schleswig-Holsteinisches Landesforsten (SH-LF) and are situated south and north of Flensburg (Figure 54).

The measurements in Handewitt and Kluesries focus on habitat improvement for dormouse and bats within the two forests. The second focus is on habitat connectivity, especially with the neighbouring project site Schäferhaus, which is owned by the project partner Stiftung Naturschutz. Schäferhaus is situated in between Handewitt and Kluesries.

Small open areas are found spread in forests. These islands of light, warmth and sun serve many species well. Besides being attractive for insects and reptiles these areas are frequently used by deer for feeding. The management of these sites differs: some are kept open to ensure the above mentioned functions; others develop with natural succession. The management of open forest structures with shrubs is important within the project as core habitats for dormouse.

Kluesries (Figure 55) (175 ha) is situated to the North on the border to Denmark. The forest is characterised by nutrient-rich soils and partly steep slopes. The highest elevation at 57 m a.s.l., down to the seashore at 0 m. At low elevation the clay soils retain water, which has traditionally been drained with dishes. The forest is well-structured with a high amount of broadleaved trees, namely about 45 ha ash-stands (Fraxinus excelsior), maple (Acer pseudoplatanus) and other broadleaved species and about 55 ha of beech (Fagus sylvatica) stands. Of special value are the oldest forest structures in the forest enclosure. Oak is present, mostly as a mix within the other stands, but also as a dominant species. Only 20 % consists of coniferous trees. About 9 ha of 100-year old beech and mixed broadleaved stands are set aside for natural development. These "Naturwälder" develop without human intervention, and no actions, neither felling nor any other habitat improvement is done here.

Project actions in Kluesries: A spruce stand was cleared for natural succession in order to connect

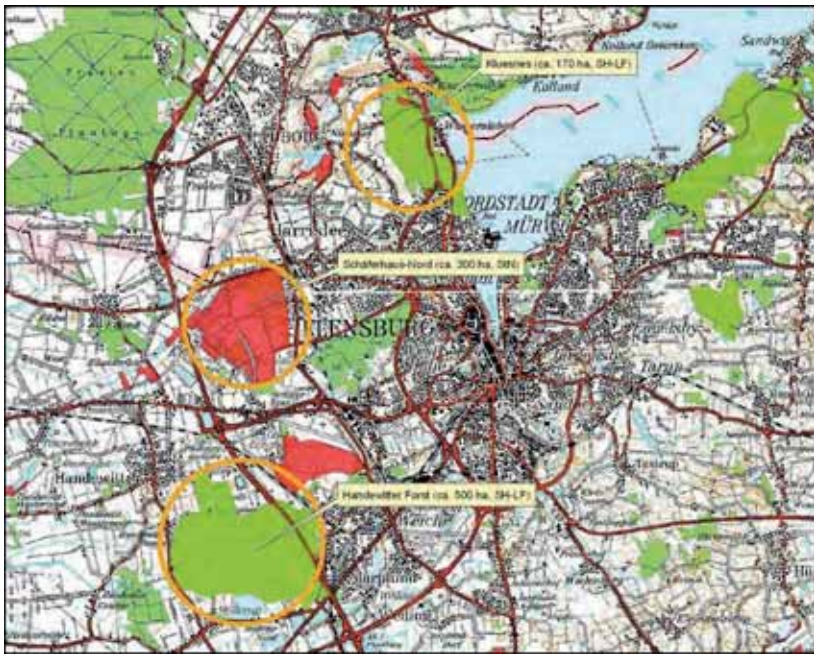


Figure 54: The German project sites: Kluesries at the Danish border, Schäferhaus in the centre and Handewitt to the south.

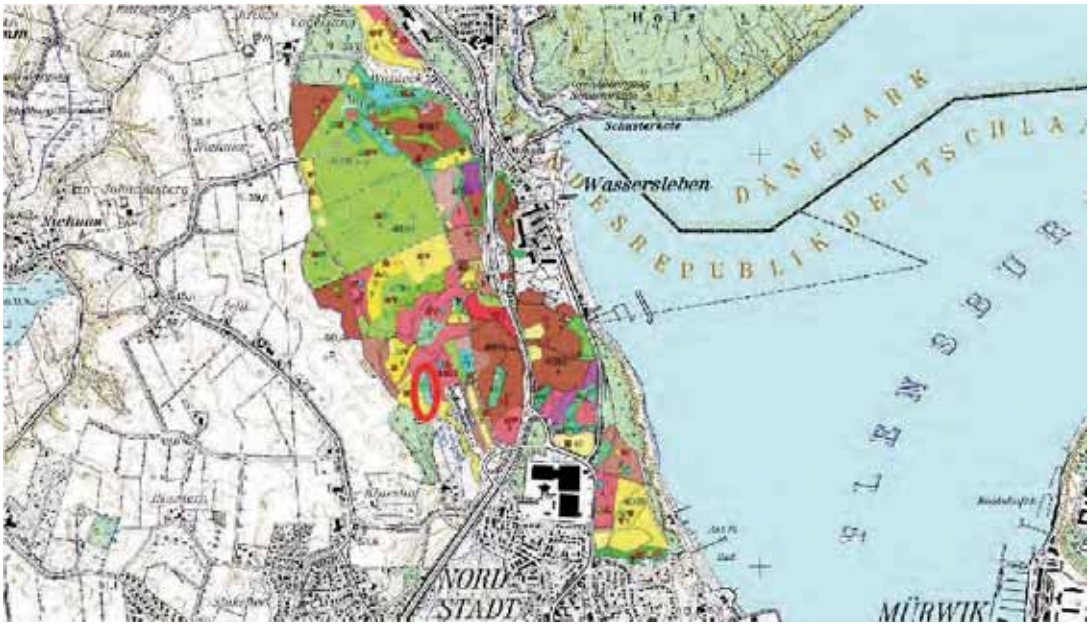


Figure 55:
Actions in Kluesries

Comments: Red circle: removal of spruce and restoration of the initial water level. Partly planting of shrubs and bushes and connection between old oak stands and „Naturwald"

Colour code:
Brown=beech, yellow=oak, green=broadleaved trees, violet=Douglas fir. Scale: 1:20 000

the “Naturwald” and an old oak-beech mixed stand. This brings more light to a species-rich part of the forest and creates a natural corridor for dormouse between the two areas.

The shrubs *Sambucus nigra, Crataegus monogyna, Prunus spinosa* and *Corylus avellana* were planted for improved core habitats for dormouse. As preparation for planting *Picea sitchensis* was removed and upcoming regeneration of *Picea sitchensis* was cut down. In addition ditches were closed. These measures also supported the existing *Acer pseudoplatanus, Corylus avellana, Lonicera xylosteum, Sorbus aucuparia, Rubus ideaus* and blackberry.

The forest o**f Handewitt** (figure 57) (562 ha) south of Flensburg is more homogenous than Kluesries. The soils are sandy, vary less, and are well drained and less nutrient rich compared to Kluesries. Only some areas have a constant water supply. These parts are potential sites for the development or restoration of bogs, as the water level in Handewitt is strongly influenced by a drainage system. Elaboration with a height model visualizes the drainage system in detail and shows the relevant places to close drainage. Nature conservation oriented water management is a major project action in the forest. Handewitt is dominated by larch (*Larix kaempferi*; 32%) and spruce (*Picea abies* and *Picea sitchensis;* 38%). There is a remarkable 250 years old oak stand at the south-western edge of Handewitt forest. Besides some younger oak stands, these oaks are the only broadleaved parts in Handewitt (in total 15% of the forest enclosure).

Project actions in Handewitt:

Coppice of oak stand: A 40-year old oak stand was partly opened in Handewitt. The future management follows the old forest management of rotational forestry in little parts of the site. This kind of “Niederwaldwirtschaft” (coppicing) was a common method to produce firewood in former times. It favours light and warmth in the forest as the different development stages of a forest stand are always present at the site, but spatially separated. The oak-site is neighbouring a natural clearing. This area will be kept open. The site is also close to a 111-year old beech stand with several habitat structures. The whole complex is almost surrounded by a younger oak stand (30 years old). It was opened up during the project and the management criteria where vice versa the conventional forestry managements: trees with rather bad qualities in

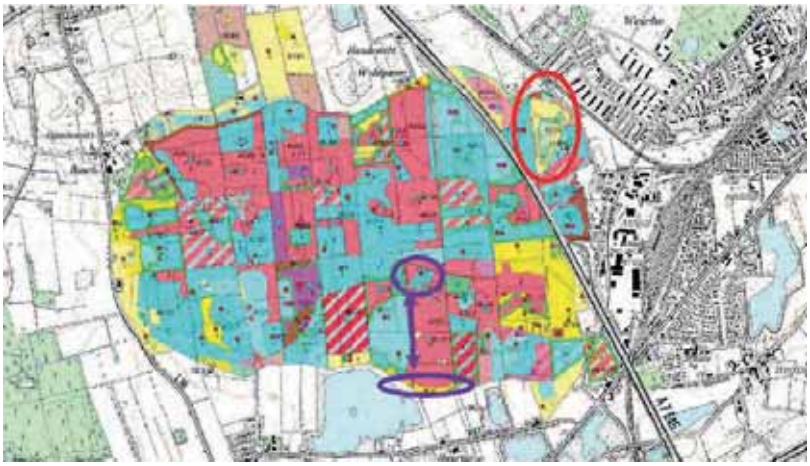
Figure 56: Two pictures of succession site in Kluesries

terms of further use where left over as future “Habitatbäume” (habitat trees). Better qualities were harvested. At this young age it is expected that the oak stumps will sprout again. The branches of the felled trees were left on the stumps to prevent roe deer to eat the upcoming regeneration (figure 58). This management is known as “Mittelwald” in Germany.

Plantings and under-storey management

Handewitt forest is dominated by coniferous species. Of special value are the ancient oak stands, which are rich in structure. Exposed to the south, these parts are especially warm and sunny. Older oak stands are endangered by upcoming natural regeneration especially by *Picea sitchensis*,

Figure 57: Actions in Handewitt forest
Comments: Red circle: Coppice of oak. Violet circles: In southern edge: 250 years old oaks and removal of spruce and planting of shrubs and bushes. In the centre: bog restoration area and corridor via partly removed spruce to southern edge.
Colour codes: blue=spruce, red=larch, yellow=oak; violet=Douglas fir, brown=beech. Scale: 1:20 000



which origins from the surrounding stands. *Picea sitchensis* is a very fast and successful species on any conditions with a high potential for natural regeneration. However, it does not suit the envisaged forest profile neither in Handewitt nor in Kluesries. As outlined above older relict broadleaved stands are of high nature conservation value. The upcoming natural regeneration of spruce was partly removed where it was about to endanger the older stands. The removal improved ground conditions in terms of light and (warmer) temperatures. Some of the places were replanted with shrubs and suitable bushes to create attractive habitats for dormice. The dormouse needs a sufficient amount of flowers to feed on, especially after winter hibernation. Attractive summer habitats consists of several bush species, flowering in different periods and carrying either berries or nuts in the autumn. Blackberry serves well as main structures, as blackberry hedges are dense and a good hiding place for dormouse.

Spruce was removed at the edge of Handewitt. In contrary to other sites in Handewitt, the area was mainly left for succession. Birch and blackberry dominate the current vegetation. The succession is supported by partly removing the blackberry and upcoming grass vegetation with a special designed excavator, which is able to remove the surface vegetation without harming the soil structure. *Lonicera xylosteum, Rosa canina, Crataegus monogyna, Frangula alnus, Viburnum opulus* and *Corylus avellana* were planted to support the development of hedges.

Figure 58: Branches left on the stump to ease sprouting

The southern forest edge: *Picea sitchensis* close to the oldest oak-stands with high habitat quality on the southern edge of Handewitt was removed. The spruce-stand was about 70 years old. The removal of the trees along a line in the southern edge of the department opened up space for planting of *Lonicera xylosteum, Sambucus nigra, Crataegus monogyna* and *Corylus avellana* in a corridor. The planting was fenced. The oak-stand is about 250 years old and is connected in the field with several hedgerows. The hedgerows consist of species such as *Crataegus monogyna, Cornus mas, Rosa canina* and *Prunus avium;* the structure is far from good but could be improved especially with respect to regeneration of the different bushes and trees (figure 59).

Figure 59: Left: Clearing of larch in a small bog in Handewitt (dept. 4022), chosen for regeneration. Right: Inner forest edge and corridor connecting the bog with the southern forest edge (Violet circles map fig. 57).

Figure 60: Left: Southern forest edge in Handewitt with a high number of old oaks (Abt. 4021) and (right) an Incomplete hedgerow nearby.

3.4 Stiftungsland Schäferhaus

By Björn Schulz

Schäferhaus (app. 415 ha) is located west of Flensburg and is divided into two separate parts. It is a former military airport. The area is owned by the Nature Conservation Foundation (Stiftung Naturschutz, Schleswig-Holstein (SN-SH)). Schäferhaus is a semi-open pasture land and is grazed throughout the year, extensively with cattle. The southern part of Schäferhaus is classified as a conservation area, while the northern is classified as a nature reserve. The soils consist of sandy loams and pure sand west of Flensburg. There are several old gravel pits in the area. The forest in the project area Schäferhaus consist of plantations of conifers and oaks. Open areas of land are kept according to the concept of half-open pasture land by grazing, with grassland and heaths.

The forests in Stiftungsland Schäferhaus are formerly intensively used coniferous forests or oak dominated stands. The general target for most of the forests is a mid-term change into natural broad-leaved forests. For different reasons this change has not yet been fulfilled on the whole site, but is done stepwise and on-going, applying different methods.In general the habitat quality for hazel dormouse is high especially at many forest edges, oak-dominated parts of the forest or shrubby areas.

Figure 61: Suggestions for actions in Schäferhaus

Figure 62: Sites at Schäferhaus-Nord chosen for forest edge management

Soil management as a preparation for natural succession into shrubbery

Background: The neophytic and invasive black cherry (*Prunus serotina*) is very competitive amongst other shrubs. In many similar places in Northern Germany the black cherry is the dominating species on forests edges, preventing a higher shrub diversity. This has many disadvantages especially for the hazel dormouse, but for other native species as well. Also in Schäferhaus there are many places, where black cherry is dominating or at least spreading, so there is the risk of having a monotonous forest edge with black cherry only, if no preventing actions are done.

Action Description: Older black cherry stands are known in two different areas with a total size of 1.3 ha. This was removed and also the uppermost layer of the topsoil with roots of black cherry was removed by a dozer and an excavator. The soil material remained on site, but was cumulated into small earth banks below trees, beside blackthorn and other shrubs. Exact location and extent was determined on site depending on the local specific situation. To manage the whole site of 1.3 ha all in all 32 hours of excavator time was used. After removal of black cherry native shrubs were planted. Management was finished in April 2012.

Natural forest edge and shrub development by protection against browsing

Background: Browsing by wild and domestic animals can do major harm to dormouse habitats depending on the intensity of browsing. So usually new planting are protected by fencing against browsing. But fencing is expensive to put up und and remove and creates artificial elements in the landscapes. Especially in large scale semi-natural landscapes like Schäferhaus additional fences are disturbing. Instead, new plantings for the dormouse are protected against browsing by building up walls of branches of thornbushes, as an experiment.

Action description: Forest workers had to cut or coppice thornbushes (mainly *Crataegus)* on Schäferhaus anyway, so there was plenty of material for the natural fences. The branches were deposited directly around the new plantings. For 12 patches with each of them of ~ 1.600 m² it took 132 standard working hours. Management was finished in April 2012. Workers were instructed by a local forestry expert.

Figure 63: Locally the clearing of the tree layer was very intense

Figure 64: Shrubbery stepping stones protected by fences against browsing by domestic cattle and additionally by hornbeam branches against browsing by wildlife

Figure 65: Planted shrubs inside the forest, protected against browsing by sheep wool

Plantings of shrub layer

Background: The forests of Schäferhaus have a long history of forestry focussing on the coniferous trees. The shrub layer was very poor developed, most typical species are completely lacking or only very scattered distributed. This also led to consequences for the development of shrubs in the open land between the bigger forest complexes of Schäferhaus.

Action description: On both sites in forests and in open land bushes were planted. Inside the forests this took part mainly at the forest edges, which were widened up in advance. Outside the forests bushes were planted among the widely distributed hawthorn bushes. The species are listed in Table 7, mainly native bushes being especially important as nesting sites or as a food plant for the hazel dormouse were chosen.

In the open land bushes were planted in 12 squares of appr. 1.600 m². In the forests several edges of each 1.200 m length were chosen for planting.

All in all 4.000 bushes were planted, some of them were protected against browsing by fences, some (appr. 500) protected by "tree protector tubes", some protected with some sheep-wool on their terminal shoot. Actions were finished in April 2012.

Table 7: Number of planted shrub species

Species name	Botanical species name	Age (ys)	Height (cm)	number
Field maple	Acer campestre	1+2	50-80	60
Birch	Betula pendula	1+1	50-80	60
Hornbeam	Carpinus betulus	2+0	50-80	160
Hazel	Coryllus avellana	1/2;3y	80-120	1.100
European spindle tree	Euonymus europaeus	1/2;3y	80-120	160
Holly	Ilex aquifolium	1+1	10-15	100
Apple tree	Malus sylvestris	1+1	50-80	100
Native black cherry	Prunus avium	1+1	50-80	100
Cherry	Prunus padus	1+1	50-80	100
Blackthorn	Prunus spinosa	2 shoots	40-70	60
Oak	Quercus robur	2+0	50-80	450
Oak	Quercus robur	½	80-120	100
Rose	Rosa canina	2 shoots	40-70	550
Rowan tree	Sorbus aucuparia	1+1	50-80	160
Lime	Tilia cordata	1+1	50-80	160
Elm	Ulmus carpinifolia	1+1	50-80	160
Russian elm	Ulmus laevis	1+1	50-80	160
Snowball bush	Viburnum opulus	1+1	80-120	260
Sum				**4.000**

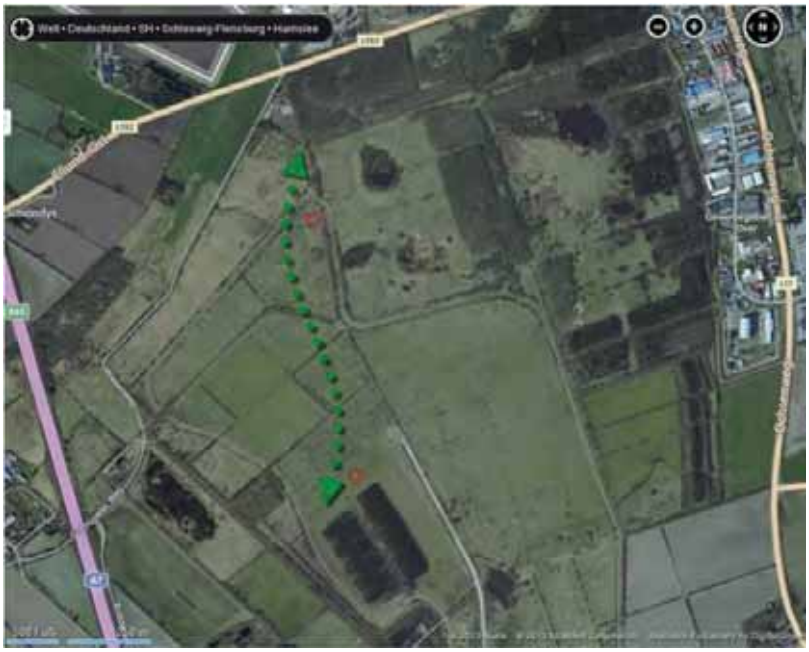


Figure 66: Aerial view on stepping stones between forests of Schäferhaus (bing maps 2013)

3.5 Fyn

By Mogens Krog

All habitat management activities on Fyn have been established in the Sollerup forest – Svanninge Bakker - Nørremarken nature area app. 10 km north of the city Faaborg on southwest Fyn. This is a diverse hilly area with forest areas, large stretches of open grassland and a mosaic of lakes, hedgerows and small forest patches in an agricultural landscape. The landscape was created 16.000 -11.000 years ago in the last ice-age as hilly lateral moraines formed as deposits of sand, gravel and clay. A kettle hole created Fyns largest lake Arreskov Sø, which is bordering the area to the north east. The Danish Nature Agency on Fyn manages app. 500 ha in this area. See overview map (Figure 67).

Sollerup Forest: The area has been selected as a demonstration area due to the mosaic landscape and the fact that Sollerup forest hosts the best know and stable dormouse population in Denmark. The dormouse population has been monitored regularly during the last 25 years. Due to the fact that the forest hosts a nationally important dormouse population, the dormouse has been given special attention in the management of the forest. Since 1998 specific guidelines have been integrated in the forest management plan for Sollerup forest (Skov & Naturstyrelsen, 2000). Sollerup forest is a mix of oak and beach forest and some coniferous forest stands. Older oak stands all have well developed understory with a variety of bush species, considered optimal for dormouse.

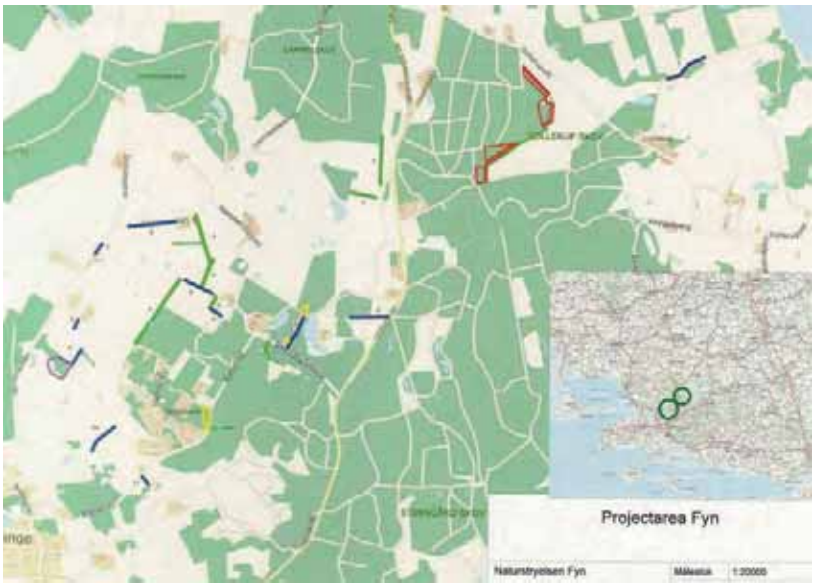


Figure 67: Overview of habitat improvements on Fyn

Forest edge management (Sollerup forest, comp. 259a)

Comp. 259a is a 25-year old oak stand with 10% mix of *Tilia cordata*. It was thinned in 2009-2010. Most of the *Tilia* was cut down as they were very dominant. They will however continue growing as coppice. The forest edge comprise of a single row of a mix of *Crataegus* and *P.spinosa*. Three activities where initiated to develop the forest edge in order to make it wider with a more diverse structure.

Figure 68: Planting at public event

Figure 69: Size and location of the forest edge measures

1) Heavy thinning in 15 m wide edge. More than 50% of the trees where taken out in a 15m wide edge-zone. This creates more light to the forest floor for natural growth of the ground flora and bushes in the understory.

2) Planting of bushes under oak: In the above 15 m edge six different bush species were planted under the oak: *Cratagegus laevigata, Corylus avellana, Lonicera xylosterum, Euonymus europaus, Viburnum opulus* and *Sambucus nigra*. Planting was done as part of a public event.

3) Natural succession: The electric fence around the neighbouring grassing area outside the forest was moved 7 m into the grass area in order to create a 7 m broad area along the forest edge for natural succession. *P.spinosa* quickly invaded this area. The latter intervention requires the same owner of both forest and grassland. Some areas e.g. forest meadows may be protected areas and it is not possible, without a permit, to allow natural succession to develop.

The three types of interventions where made in different variation:

1. Heavily thinned in 15 m edge zone (1).
2. Thinned and planted under oak in 15 m edge zone (1+2)
3. Thinned, planted and forest edge expanded into grassland (1+2+3)
4. Expansion into grassland, no interventions in the forest (3).

Hedgerow management

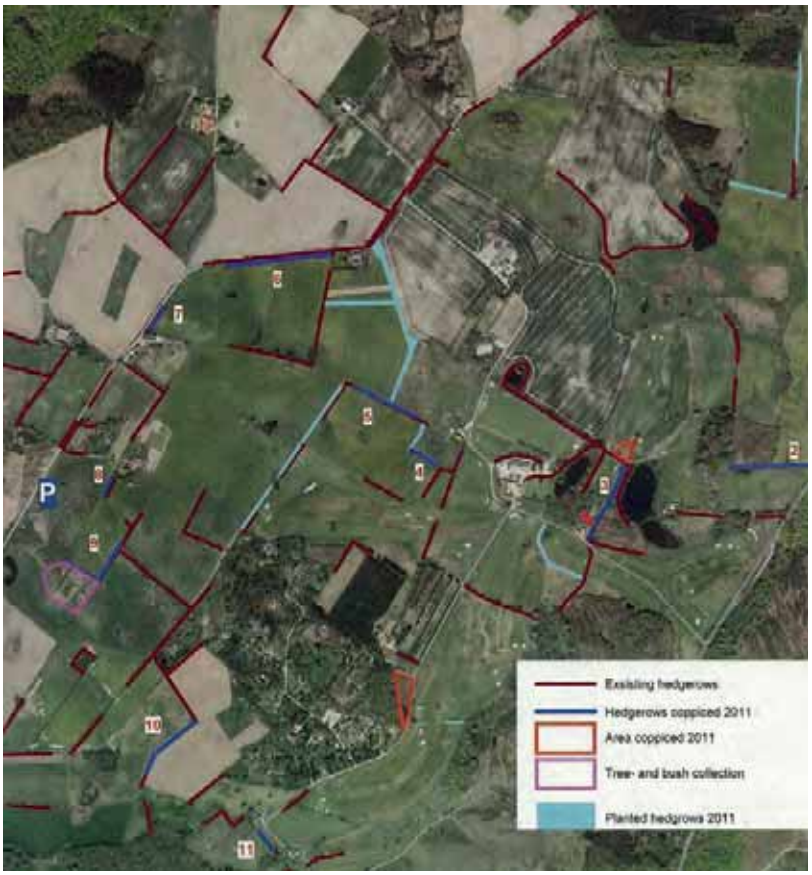
The majority of activities concerning hedgerow management are made in Nørremarken. It is situated in the south western part of the project area. See overview map above. Only one hedgerow is found in the Sollerup forest area. Nørremarken is mainly grassland, hedgerows and small ponds. To the east the area it is bordered with an urban area and a golf course. Dormouse nests have been found in the hedgerows in the area. See chapter 2.2.3.

The area is intended as a demonstration area for farmers, advisors and others interested in or working with plantings and hedgerow management in the open land. The demonstration area includes three main elements:

1) Planting of new hedgerows
2) Coppicing of existing hedgerows
3) A Tree- and Bush collection

Figure 70: In the forest edge bat boxes have been installed. When checking for bats a dormouse nest with a sleeping (torpor) dormouse was found.

Figure 71: Overview of existing, planted and coppiced hedgerows in demonstration area



Planting of new hedgerows: A total of 2 km of new hedgerows were planted in the area. They were divided on 9 hedges. 8 of the hedges are planted with three rows and one with six rows. The plantings include 13 different tree- and bush species with 95% bushes. Oaks are planted as the main tree species intended to grow old in the hedge (5% trees) the rest of the hedgerows will be managed as coppice with 20 year intervals. The bush species are planted in groups of 3-5 together in the row followed by 3-5 of another species. As they grow up it creates larger coherent habitats in the hedgerow. It also makes planting easier. Planting distances are 2m between plants in the row and 2m between rows. This is a wider distance than normal for hedgerow planting and has been recommended for dormouse hedgerows, in order to give more room for the bushes to develop. Today it is possible to get subsidies from the Danish Government when planting according to the recommendations for dormouse hedgerows.

Connectivity: Besides the technical aspects of planting hedgerows, part of the purpose of the demonstration area is to put focus on the planning of the layout of new hedgerows for improved connectivity between habitats in the open landscape. Therefore the layout of the new hedges contribute to improve the local hedgerow network, closing gabs between existing hedges in order to improve connectivity to neighbouring habitats.
2 of 9 plantings cross the golf course. One of these plantings consists only of *Rosa rubiginosa* in order to make a connection between Svanninge Bakker to the east and an urban area to the west and still suite the interests of the golf course.

Two plantings are linking to habitats on private land outside the project area. To the north east a corridor is connected to a private forest. Where this planting reach the forest, it continuous along the forest edge and as such improve and expand the forest edge where the hedgerow and forest connect. To the north-west a corridor is linked to an existing hedgerow network, connecting to forests further north and west.

Coppice of existing hedgerows: 2 km of old hedgerows distributed on 11 hedgerows have been coppiced in 2011 in order to regenerate the hedges. The objective is to demonstrate the effect of coppicing on the hedgerows: how fast do they regenerate and how do they develop? It is possible to compare planted hedgerows with coppiced

Figure 72: Establishment of new hedgerows for improved connectivity

Figure 73: Hedgerow no. 6 before coppicing in winter 2011 and same hedgerow in august 2012.

hedgerows in the area. It is not surprising that coppiced hedgerow grow faster compared to planted hedgerows, as the coppiced hedgerows have well established root systems. Photos of hedgerows before and after coppicing are shown below.
Also, technical methods have been tested: The hedges were felled with a special felling machine with equipment resistant to stones that normally damage the equipment. It is also able to handle multi stemmed bushes. Whole trees and bushes were forwarded to 5 processing sites at roadside and processed to wood-chips for bio-energy. A total of 635 rm woodchips were produced. Production data and costs from the process are presented in (see appendix 5).
Initially after coppicing the hedgerow does not look like at suitable dormouse habitat, however already the same year in spring bushes re-sproute. Due to the sudden light exposure seed sources in the ground mobilises a variety of annual herbs. Bramble is one of the dominate species at this stage, which is good for dormice, as long as it doesn't prevent hedgerow-growth in the long run and as long as it doesn't dominate on a large spatial scale. After two growing seasons the hedgerow is dense and grows with new vigour.

Figure 74: Hedgerow No. 6 development after coppicing

After coppice winter 2011 | Spring 2011 | August 2012

Figure 75: Coppiced *Viburnum opulus*

Figure 76: Sign plate at each tree and bush species

A Tree- and Bush collection: In the west end of Nørremarken a Tree- and Bush collection is part of the demonstration area. The objective of this collection is to show the different tree and bush species found in open land plantings, such as hedgerows and small plantings. The collection displays 42 different species all of which are part of subsidy programmes for planting in open land in Denmark. It serves as an inspiration for farmers or others who want to plant. The collection was originally planted in 2001 as demonstration planting for hunters who want to plant to improve habitats for game. The area is divided into blocks with 50 plants of each species. As part of the BioGrenzKorr project we updated and renovated the planting in order to serve a wider ordinance and integrate the collection in the overall demonstration area. The following was done:

- Exotic species for which no subsidies are given were taken out of the collection.
- Missing indigenous species which are part of subsidy programmes were planted.
- For incomplete plantings. New plants were added.
- Existing dense plantings were thinned.
- Half of most plantings were coppiced, in order to show how the individual species respond to coppice.
- New signsplates for each plant species with Danish and Latin names where put up. Each sign has a QR-code, providing access to a web-side with information on each species.
- A new electrical fence and entrance was installed to safeguard the planting from cattle.
- A new flyer was produced.
- New information signboards were put up.

The visitor has the opportunity to see the individual tree or bush species in two stages: before and after coppice. Depending on the season the plants display flowers, autumn colours or fruits. As all plants were planted at the same time it is possible to compare the growth, size and structure between species. At each tree and bush species is a sign with plant species name and a QR-code which provides access to the web-side www.plantevalg.dk. Here information on botany, use, ecology, optimal growth conditions and management is available for each species. The hedgerow management demonstration area is aiming at farmers for inspiration, as farmers are the main actor if habitats are to be connected in the open land. The following chapter describes some of the challenges posed in involving farmers to participate in such action.

Figure 77: Overview of Tree- and Bush collection (from inside flyer)

Figure 78: information about the demonstration area in Nørremarken. Flyer and information board

4. Connecting habitats – Hedgerow management

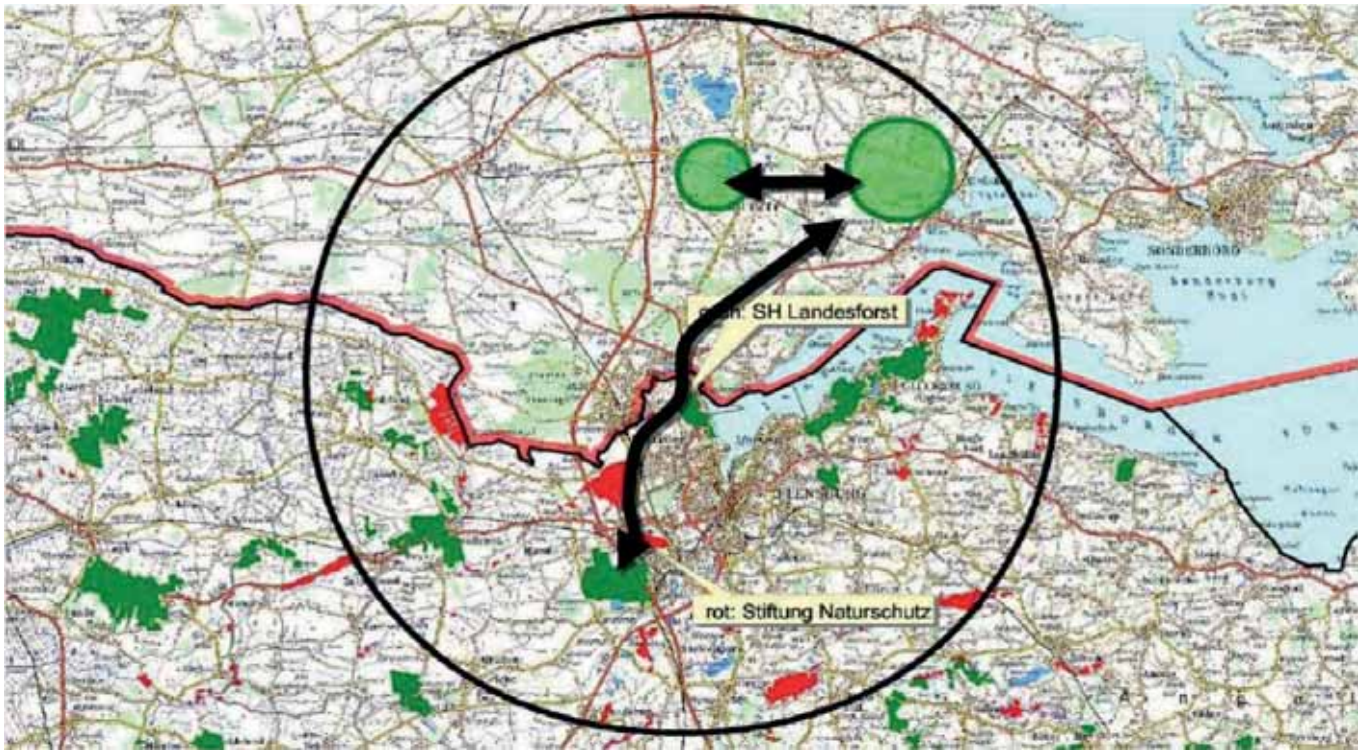


Figure 79: Action Plan: Connecting habitats across the Danish-German border

The overall objective of the BioGrenzKorr project is to create the foundation for a corridor between dormouse habitats in the forests of Graasten in Denmark and the forests and nature areas just south of the border around Flensburg, on the German side of the border. The project areas managed by the project partners are important core habitats in the corridor, however in order to connect them, hedgerows on private land in the matrix between these protected areas need to be developed.

Deciduous hedgerows are an important part of the cultivated landscape on southern Funen, south eastern Jutland and in Schleswig-Holstein east of the marshes. There old hedgerows are still. Our knowledge of dormouse in hedgerows in both Denmark and Germany is limited, but recent publications reveal hedgerows being possible permanent habitats for dormice (Ehlers, 2012). Improving the habitat for dormice in hedgerows will also benefit a number of other threatened mammals, reptiles, birds and insects as well as the diversity of the flora.

In Northern Germany and Southern Denmark the forest coverage is relatively low. Nevertheless a habitat network between the existing forests is possible via hedgerow networks, which here existed since the end of the 17th century. The majority of the hedges are still in a good situation, thus, experts believe that core habitats could be connected via the existing network. However, some hedges have become degraded and their suitability for dormice is locally quite poor due to lack of high shrub diversity and due to major gaps in the hedges continuity. Habitat improvements are technically easy and planting of missing shrubs into gaps is a well-accepted method. But usually land owners dispense with planting of shrubs.

Reasons are that the decline of hedgerow quality is regarded as a natural process, that planting costs money and it is time-consuming (especially when veterinary fences are necessary) and sometimes farmers even appreciate thin hedges, because of more net farmland. As hedges in most cases belong to the farmers, habitat improvement in

hedges must be done in cooperation with farmers. In order to bring nature conservation perspectives into the management of hedgerows the project aims at cooperation with farmers and farmers organisations.

Figure 80: Hedgerow network in an open land matrix

4.1 Hedgerow management in Schleswig-Holstein

In Schleswig-Holstein hedgerows are protected by law and landowners have to manage their hedgerows. This regulation makes the incentive to plant new hedgerows limited. The farmers are not interested in locking land for hedges not being able to bring the land back into agricultural production. However, due to the regulation the network of hedges is probably denser compared to Denmark. However, utilization of hedges has intensified during the last years as wood has become an important resource for bio-energy. As shortened growing cycles of hedges reduce the habitat suitability for dormice, there is a need to focus on nature conservation objectives as part of hedgerow management.

On the German side of the border there were several meetings between the project partners and local and regional farmers association to negotiate a projects programme for hedgerow habitat improvement. Even though single farmers were interested in cooperation, the farmer's association refused any cooperation. Thus, the projects target to set up a hedgerow programme ended at an early stage of the process.

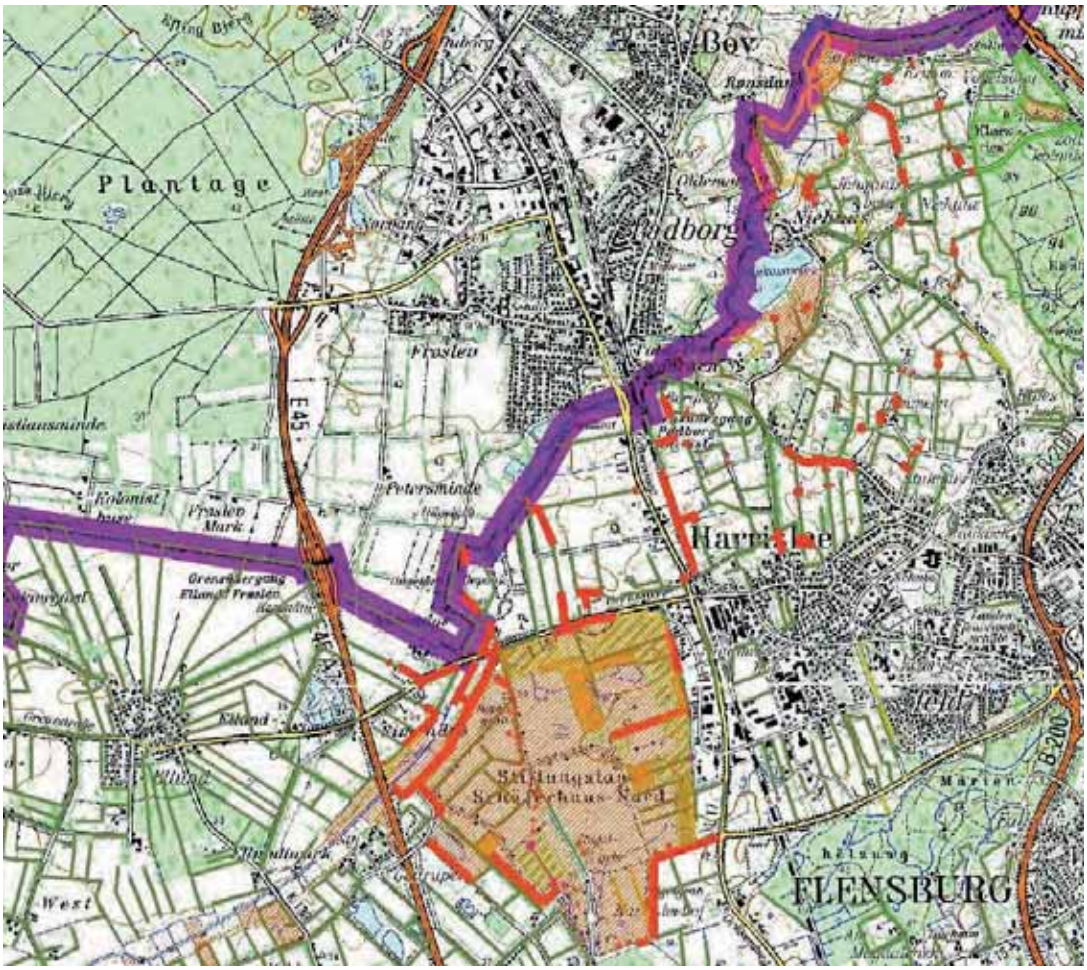


Figure 81: Hedgerows and important gaps in the hedgerows network around Schäferhaus
Comments: green lines. hedges, red polygon: Stiftungsland Schäferhaus, red lines: gaps in hedgerow network

Landwirte reagieren misstrauisch auf das Angebot der Stiftung Naturschutz, Knicklücken zu schließen

Wird das Engagement zur Haselmausefalle?

Die Haselmaus ist aus dem nördlichen Schleswig-Holstein verschwunden. Nun soll sie im deutsch-dänischen Grenzland wieder angesiedelt werden. Die Stiftung Naturschutz und die Landesforsten wollen dies vorrangig auf eigenen Flächen umsetzen, doch um Wanderkorridore für die Haselmaus zu schaffen, sind sie auf die örtlichen Landwirte angewiesen. Denen bietet die Stiftung Naturschutz nun an, Lücken in vorhandenen Knicks zu schließen, Einverständnis vorausgesetzt. Bei einem Gespräch mit dem Bezirksbauernverband Harrislee-Niehuus in der Alten Schule in Niehuus zeigte sich: Die Befürchtungen sind groß, dass der Schuss nach hinten losgeht und die Bauern für freiwilliges Engagement später „bestraft" werden.

Die Haselmaus ist dem Siebenschläfer verwandt und hat im Gegensatz zu echten Mäusen einen stark behaarten Schwanz und hält Winterschlaf. Sie stellt wenig Ansprüche an ihre Umgebung, aber dichtes Gestrüpp braucht sie. Foto: Björn Schulz, Stiftung Naturschutz

Die Haselmaus ist ein seltenes, europaweit streng geschütztes Tier. Eigentlich ist sie nicht sehr anspruchsvoll. Sogar an Autobahnen oder Siedlungsrändern wurden ihre Nester gefunden. Aber sie bewegt sich nur in dichtem Gestrüpp. Da ist es ungünstig, wenn Knicks große Lücken haben.

Nennenswerte Vorkommen der Haselmaus wurden durch Untersuchung von charakteristischen Fraßspuren an Nüssen in Ostholstein, Stormarn, Lauenburg und Teilen des Kreises Segeberg nachgewiesen. Im nördlichen Schleswig-Holstein kommt das geschützte Tier hingegen seit den 1950er Jahren gar nicht mehr vor und in Dänemark kaum noch. Warum, das weiß man nicht, denn die Lebensbedingungen wären hier an sich gut.

Durch eine Wiederansiedlung im Raum Harrislee hofft man, auch Verbindungsachsen zu der schwachen dänischen Population zu schaffen und damit das Vorkommen insgesamt zu stabilisieren. „30 ausgesetzte Tiere können eine Population gründen, zeigt die Erfahrung", erklärt Björn Schulz von der Stiftung Naturschutz. Man könne sie leicht züchten, früher seien sie statt Meerschweinchen als Haustiere gehalten worden. Als Projektgebiete sind die Stiftungsflächen Kluesries und Handewitter Forst und dazwischen der Landesforst Schäferhaus vorgesehen. Dort sollen die Waldränder optimiert und dann die Tiere ausgesetzt werden. Das Artenschutzprojekt BioGrenzKorr läuft drei Jahre bis Ende 2012.

Zwischen diesen drei Gebieten befinden sich landwirtschaftliche Flächen mit Knicks. Und hier wünscht sich die Stiftung die Zusammenarbeit mit den Eigentümern und Pächtern. Auf Luftbildern sind die Knickverläufe zu sehen – mit einzelnen Lücken, hier weniger, dort mehr. „Wir wollen keine neuen Knicks anlegen", betont Schulz, „nur bestehende, eingetragene wiederherstellen." Die Bepflanzung würde nach einvernehmlicher Absprache durch ein von der Stiftung beauftragtes Landschaftsbauunternehmen erfolgen. Kosten fallen für den Landwirt nicht an. Schulz setzt auf Freiwilligkeit, macht aber deutlich, dass das Projekt auf den Stiftungs- und Landesflächen auf jeden Fall laufen werde. Das heißt: Die Haselmaus kommt, sofern sie in der Flur überlebt.

Um das Ganze auch von der wirtschaftlichen Seite schmackhaft zu machen, war Matthias Kalvelage vom Abfallwirtschaftszentrum Flensburg eingeladen, der auf die zunehmende Bedeutung von Knickholz als Energieträger hinwies – zum Heizen, aber auch zur Stromerzeugung, zum Beispiel im Kraftwerk Flensburg. Auf 60.000 t/Jahr schätzt er das Potenzial in Knicks und bei Straßenbegleitgrün in den Kreisen Schleswig-Flensburg und Nordfriesland. Kalvelage: „Die Preise werden steigen."

Also ein Angebot, das nur Vorteile bringt? Die Landwirte und Bauernverbandsvertreter in dem mit 25 Personen gut gefüllten Schulsaal waren skeptisch, haben sie doch mit dem Naturschutz schlechte Erfahrungen gemacht. „Wir sind gebrannte Kinder. Weil es hier so gut lief, wurde ein Flora-Fauna-Habitat eingerichtet, das für einige Landwirte existenzbedrohend war", betonte der Bezirksvorsitzende Hans-Heinrich Hansen. Und Kreisgeschäftsführer Jens Rosenplänter gab zu bedenken: „Nehmen wir an, wir bekommen eine kleine, labile Population, müssen wir dann nicht Beschränkungen bei Knickverschiebung oder Pflegezeiten befürchten?"

Bezüglich der Pflege konnte Schulz beruhigen: „Knicknutzung widerspricht nicht dem Haselmausschutz." Das Auf-den-Stock-Setzen alle zehn bis 15 Jahre sei auch für ihren Lebensraum wichtig. In der Zeit, in der dies erlaubt ist, schlafe das Tier in seinem Winternest in der niederen Laubstreu, werde von den Maschinen nicht gefährdet. Das zeige die Praxis zum Beispiel in Ostholstein. Allenfalls bräuchte man eine Absprache, um großräumige gleichzeitige Abholzungen zu vermeiden, und vielleicht gebe es Bedenken bei allzu großen Maschinen. Es sei auch sicher, dass für die Haselmaus kein FFH-Gebiet eingerichtet wird.

Dennoch waren die Bauern nicht beruhigt. Vor allem fürchten sie eine Kartierung wie bei den Feldlerchen und Wiesenvögeln, woran Dr. Susanne Werner vom Landesbauernverband erinnerte. Wer seinen Knick aufpflanzen lässt, könnte Einschränkungen erfahren, wenn die Haselmaus da ist. Arne Drews vom Landesamt für Landwirtschaft, Umwelt und ländliche Räume (Llur) konnte diese Bedenken nicht ganz ausräumen, betonte aber, in Gebieten mit Haselmausvorkommen gebe es keine derartigen Probleme. „Wir sind aber in Zugzwang, wenn die Bestände insgesamt zurückgehen. Dann können auch Bewirtschaftungsauflagen kommen – aber für alle. Dem können wir gerade durch solche Projekte vorbeugen." Auf Fehmarn etwa konnte er trotz des Vorkommens von Kammmolchen genehmigen, dass einzelne Tümpel zugeschüttet wurden, weil die Lebensbedingungen für das geschützte Tier insgesamt gut geworden waren. „Das klingt gut, aber Sie sind jederzeit austauschbar", warf der Kreisvorsitzende Hans Erich Mangelsen ein. „Was machen später andere aus der Haselmaus?"

Dem Projekt ganz verschließen wollte sich aber auch niemand unter den Anwesenden. Man einigte sich am Schluss darauf, dass Eigentümer von Flächen in besagtem Korridor, die sich eine Beteiligung vorstellen können, sich bei Geschäftsführer Rosenplänter melden. Ein weiteres Treffen ist im Januar geplant, etwaige Bepflanzungen dann im Laufe des Jahres. Zwar werde die Haselmaus vermutlich erst in acht bis zehn Jahren hineinwandern, aber die neuen Knickteile brauchen ja auch Zeit zum Wachsen. Tonio Keller

Hans-Heinrich Hansen (Mitte), Bezirksvorsitzender des Bauernverbandes, moderierte als Gastgeber das Gespräch in der Alten Schule in Niehuus. Links von ihm Dr. Susanne Werner vom Landesbauernverband, Kreisvorsitzender Hans Erich Mangelsen, rechts Kreisgeschäftsführer Jens Rosenplänter und Matthias Kalvelage vom Abfallwirtschaftszentrum Flensburg. Vorne Arne Drews (Llur, li.) und der Hauptreferent des Abends, Björn Schulz von der Stiftung Naturschutz. Foto: Tonio Keller

Figure 82: Report from meeting between project partners and farmers association. Comments: „Farmers are sceptical to the Sitftung's offer to close gaps in hedgerows - Will the farmers engagement become a mousetrap?" (source: Bauernblatt, November 2010)

4.2 Hedgerow management in Denmark

Hedgerows do not enjoy any legal protection in Denmark, except from stone and soil hedges. Thus, there are no requirements for management of hedgerows, most of which are privately owned. The often applied method of mechanical vertical cutting is done along roads and for access for the farmer's machines in the field. The cut off material is not utilised, thus the operation is a cost for the farmer or road authority. Tree- and bush species growing in the hedgerows are adapted to cutting as they re-sproute vigorously. However vertical cutting do not create an attractive habitat for most flora and fauna, which require dense branches at the base for cover. Introducing coppicing as improved management reduce the costs of cutting, regenerate hedgerows and providing more diverse hedges with vigour and dense branches at the base for animal cover. In addition coppiced wood is made into woodchips for CO2-neutral bio-energy for which there is an expanding marked. However, increasing demand for bio-energy may jeopardise nature and biodiversity concerns. An aim was to put focus on a few nature conservation concerns in relation to this management method.

4.2.1 Collective planting in Denmark

Planning and planting of new hedgerows is another important objective aiming at creating connectivity between habitats. Denmark has a more than 100 year long tradition of government subsidies for collective planting. With limited regulation on hedgerows this creates an effective incentive for farmers to plant. 15 million DKR have been allocated on the government budget every year since 2001; 80% for collective planting and 20% for individual planting. The government subsidence up to 60% of the farmers costs of planting and the first 3 years of mechanical maintenance of the plantings . The effect is estimated at 300 km of new hedgerows per year in Denmark. In some years in the 1980s and 1990s the figure was as high as 36 million DKR per year. The interest for planting has always been larger than the funds set aside for the purpose. It is estimated that at least 80.000 km of hedgerows are found in Denmark. Collective planting are organised at national level by an umbrella planting association coordinating 6 regional and 90 district level planting cooperatives all managed by farmers. The national umbrella organisation prioritises the funds. The aim is a rotational principle where collective planting is possible at district level at 5-6 years intervals. At district level farmers join in order to coordinate purchase of material (plants etc.) and use of subcontractors, thus optimising planting and maintenance cost, normally with the assistance of a professional hedgerow planting advisor. Hedgerows are planted on private land taking the individual farmers interest into account only. Be it hunting, shelter, nature or simply for the beauty of it. There is no planning on a higher level in order to optimise connectivity between neighbouring hedgerows, forest or other types of nature, thus an overall nature conservation perspective is lacking. There is though differentiation on the level on subsidies, as the highest percentage of 60% subsidies is given for planting projects, that benefit eg. annex IV species, bees or other biodiversity aspects. Still, no coordination on a landscape level is part of the system.

Figure 83: Hedgerow on Fyn.

4.2.2 The local planting cooperative

In 2011 the local planting district of Faaborg-Midtfyn was prioritised on Fyn. The district is located in the same area as the BioGrenzKorr project areas on Fyn. Thus, the idea of working together with the local planting district became obvious in order to engage in collaboration on nature conservation in relation to hedgerow planting. This was an opportunity to engage directly with local farmers interested in planting in the open landscape.
The collaboration included the national umbrella organisation of planting and landscape in Denmark (Landsforeningen Plantning og Landskab i Danmark) as well as authorities at the municipality of Faaborg-Midtfyn.

The project presented nature conservation issues

at meetings with farmers. Issues included:

- Basic issues on corridor ecology based on theories such as island biogeography, meta-population theory and landscape ecology eg. Hilty et.al (2006):
  - Small habitats are likely to have: Larger edge effect and small vulnerable populations with increased risk of local extinction.
  - Isolated habitats are likely to have: Large distance between habitats, long dispersal distance, dispersal barriers, less genetic exchange and ultimately populations with increased risk of local extinction.
- The concept of corridors e.g. different types of linear connected habitats or stepping stones such as natural corridors: the coastal zone, river valleys, forests and other protected areas. Outside protected areas in the agricultural landscape hedgerows has a potential to connect habitat, at least for some species. In this regard it is relevant to emphasize that different species need different habitats, at different scale and have different levels of mobility.

The local planting cooperative was made up of a total of 20 farmers who planted in total 12 km of hedgerows. Some of the hedges are located close to known dormouse habitat and contributed to local connectivity between habitats. However, the exact location of new hedges is still very dependent on the individual farmer's interests, as he is the land owner. The first challenge to overcome is to make farmers plant in the first place. This theme was raised at a debate meeting with the minister of environment and the farmer's organisation on Fyn.

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12 km hegn til lille syvsover

■ Sammen med staten betaler midtfynske lodsejere 700.000 kroner til levende hegn

Krarup: Den lille syvsover Hasselmusen lever i Håstrup i syd og i skoven Snarup Have tæt på Krarup mod nord. Snart får den lille fyr endnu større mulighed for at vandre og dermed overleve.

I et storslået projekt, der støttes med landdistriktmidler, er en snes lodsejere, flest fra Midtfyn, villig til at investere i 12 kilometer læhegn.

De samarbejder med Naturstyrelsen Fyn og plantningsforeningen om plantning af læhegn med levende hegn.

Krarup-lodsejere er i front

Ifølge skovfoged Stefan Petersen, Skovdyrkerforeningen, der er hyret af Faaborg-Midtfyn Plantningsforening til at stå for projektet, kan de nye læhegn bruges af hasselmusen til enten at bo i eller at vandre i til et nyt levested.

- Interessen har været stor i Krarup blandt lodsejerne for at være med. Næste forår går vi i gang med at plante 12 kilometer levende hegn, næsten halvdelen i og omkring Krarup, oplyser han.

Tilskudsrammen med 430.000 kroner er fuldt udnyttet, og Stefan Petersen anslår, at projektet med lodsejernes bidrag løber op i 700.000 kroner.

Stefan Petersen skal stå for nyplantningen samt renholdelse af jorden i tre år, indtil beplantningen i de levende hegn kan klare sig selv.

Lodsejere er gået med i projektet af forskellige årsager. Nogle vil gerne have et hegn til vildt, andre et læhegn og andre igen et hegn, der er med til at forskønne landskabet.

Uanset grund er det med til at forbedre livsvilkårene for blandt andre hasselmusen.

- En gang troede man, at hasselmusen kun kunne vandre via trætoppene, men den vandrer også via de levende hegn, og vi ved fra dens udbredelse, at den har vandret på jorden, siger Stefan Petersen.

Vandring i levende hegn

Det sidste burde dog ikke være den lille syvsovers første valg, da den bevæger sig meget langsomt.

I den 100 hektar store skov Snarup Have har Mogens Krog, Naturstyrelsen Fyn, været så tæt på syvsoveren - i et af dens få vågne øjeblik - at han har kunnet fotografere den ved siden af dens lille kuglerunde rede.

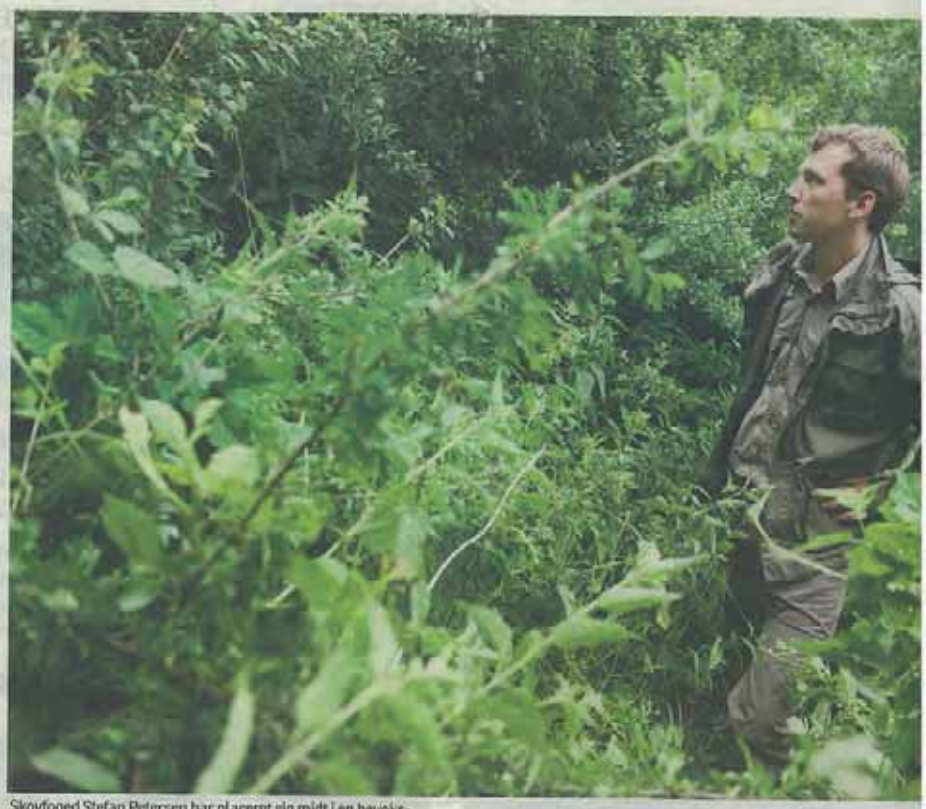
- Hasselmusen er ikke interesseret i mørk bevoksning. Den lever i åbent krat og i løvskov. Den kan godt lidt et sted med blomstrende buske som hindbær, brombær, hyld, slåen og hassel.

Stefan Petersen fortæller også, at hasselmusen aldrig byggeri rede på jorden. Den bor i en højde fra en til fem meter.

I mindre målestok blev der i den sidste plantningssæson plantet to-tre kilometer læhegn og småremser med tilskud til individuelle projekter.

Netop Krarup-området er specielt kendt af Skovdyrkerforeningen, som er i gang med at udarbejde en stor natur- og miljøplan for hele sognet, oplyser Stefan Petersen.

Af Ebba Madsen
Foto: Katrine Becher Damkjær
ebma@fao.dk, hada@fyens.dk



Skovfoged Stefan Petersen har placeret sig midt i en bevoksning, som hasselmusen kunne finde på at slå sig ned i. Hasselmusen spiser blandt andet friske skud fra hassel og tjørn samt bær som hindbær, brombær, hyld og slåen.

Stefan Petersen ved et levende hegn over for Snarup Have. Den blandede vækst har haft fem-seks år til at vokse i.

Den danske syvsover

Hasselmusen er ikke en ægte mus, men den eneste art af syvsovere i Danmark og Schleswig-Holstein. Den er sjælden og opført på IUCN's rødliste over truede arter og nyder særlig beskyttelse i hele Europa. Danmark er derfor forpligtet til at sikre arten og dens levesteder.

Hasselmusen har i Danmark sine kerneområder på Sydfyn og ved Gråsten, samt mindre bestande i skovene ved Sorø og Hvalsø. Især bestandene ved Gråsten og på Sjælland er små og isolerede, mens den fynske bestand er mere stabil.

Hasselmusen er stærkt knyttet til bevoksede arealer med en blandet vækst af planter som underskov og arealer under tilgroning. Det er i landskaber med varierede løvskove bundet sammen af artsrige levende hegn. Her lever den af bær, nødder, frugter, knopper, blomster og insekter. Løvskove er hasselmusens foretrukne levested.

Et BioGrenzKorr. projekt søger at udvikle forvaltningsmetoder der kan sikre hasselmusens levesteder.

Kilde: Miljøministeriet - Naturstyrelsen

Mogens Krog, Naturstyrelsen Fyn, har fotograferet hasselmusen Snarup Have. Den kuglerunde rede bygger det lille dyr med en ne

Naturstyrelsen støtte

Fyn: Naturstyrelsen Fyn støtter initiativet med at skabe bedre forhold for hasselmusen samt i det hele taget kampagnen i Faaborg-Midtfyn Kommune for at etablere flere læhegn.

- Vi har valgt at støtte, fordi kampagnen er med til at sørge for flere korridorer af læhegn. Det har en vigtig betydning for de arter, der færdes langs med dem, oplyser statsskovrider Søren Strandgaard, Søllerup.

Støtten gælder ikke mindst hasselmusen.

- Krarup-området er en del af den væsentligste lokalitet for hasselmusen i Danmark. Den er relativt almindelig i området, fortæller statsskovrideren.

Området er et bælte fra Svanninge Bakker i vest til Hvidkilde Skov i Øst med

Figure 84: 12 km hedgerows for the small dormouse. Article in the regional newspaper Fyns Amts Avis 12.07.2011

4.2.3 Debate: The role of farmers and linking landscapes for biodiversity

On the 23th of August 2011 the BioGrenzKorr project arranged a debate meeting with Karen Ellemann, the then Danish Minister of Environment, as co-host together with Centrovice, the farmer's organisation on Fyn.

The overall theme was: How can farmers contribute to increase connectivity between habitats for biodiversity? The basic assumption is that farmers are part of the solution. This was largely accepted by the farmers organisation present, however they argued for better and clear compensation.
A total of 65 farmers, representatives from NGOs, politicians and the press was present.

Figure 85: The Minister of Environment, Karen Ellemann and the debate panel

Subject	Speaker
Welcome	Niels Rasmussen: Chairman of Centrovice,
Biodiversity and the role of farmers in creating better connectivity between our nature areas.	Karen Ellemann: Minister of the Environment
How will biodiversity benefit from green corridors?	Bettina Nygaard: Researcher, Biologist DCE, Århus University
How may agriculture contribute to increase biodiversity: Opportunities and conflicts?	Heidi Buur Holbech: Agro-environmental adviser, Knowledge center for agriculture
Hedgerows and collective planting: One element in agriculture for the benefit of biodiversity.	Arne Frandsen: Farmer and chairman of the organization: Planting and landscape
Locally managed landscape units as a tool to create connectivity for nature.	Bent O. Rasmussen: Hunting advisor, Danish Hunters Association
Municipalities: Biodiversity, green corridors and planning in the open land.	Christian Tønnesen: Manager of Planning, Faaborg-Midtfyn Municipality

Table 8: Presentations at debate meeting

4.3 Development of habitat model

By Jessica Hillen and Markus Dietz

Modeling of distribution, dispersal corridors and habitat management for the common dormouse (Muscardinus avellanarius) - a basis for a long-term cross border action plan

Aims and scope

The INTERREG 4a project focuses on the conservation and enhancement of a network of species-rich linear landscape elements and woodland patches which are known to be very important feeding and roosting habitats and dispersal corridors for birds, mammals and other species in fragmented landscapes. The hazel dormouse *Muscardinus avellanarius* is an arboreal 'edge-dwelling species' in well-structured, species-rich woodland edge habitats and in hedgerows which provide both food and shelter for resident and dispersing individuals. Due to its comparatively low dispersal abilities and its restriction to edge habitats, the hazel dormouse is used as an indicator species for the habitat diversity and connectivity within the framework of the INTERREG 4a project.

The project module 'Species distribution and dispersal corridor modelling for the target species *Muscardinus avellanarius* (hazel dormouse) as an indicator for habitat diversity and connectivity' focuses on the identification of landscape characteristics that influence the current distribution of the target species in the study area to create an habitat suitability model. This model will be used to identify areas of high habitat suitability which may provide a) the habitats of the recent 'core populations' and b) the 'source' for the re-introduction and/or re-colonisation' of *M. avellanarius* in parts of its former range and to interconnect isolated populations. The habitat suitability model has then been used to estimate the optimal habitat corridors to interconnect 'source' and 'target' populations within the framework of special species action plans.

Methods

The species distribution model for *M. avellanarius* has been created using Ecological Niche Factor Analysis (ENFA). This analysis type only requires presence data for the study species. All input data were transformed into raster data sets in a GIS environment (ArcGIS 9.3, ESRI) and into a special raster format for the Biomapper 4 software (Hirzel et al. 2002) to create a habitat suitability map.

The ENFA procedure requires two types of input data: 1.) presence data for the study species, 2.) a set of environmental variables to describe the habitat configuration (per raster cell). The set of habitat characteristics will be transformed into independent factors. The ENFA estimates the 'habitat suitability' per raster cell by comparing the target species' distribution in the 'space' formed by the ecogeographical factors, which is in fact the multidimensional ecological niche of the species, with that of the whole study area (raster cells).

Map preparation and extraction of the input data

Available input data were extracted from different digital maps and survey data (Stiftung Naturschutz Schleswig-Holstein, Molfsee, Germany and the Danish Ministry of the Environment, Faaborg, Denmark). We used the following digital maps and layers: Denmark:

- GIS-Layers of protected linear landscape elements (hedgerows, earth dikes)
- Digital topographic map 1:10,000 ('Kort 10')
- GIS-Layers of forest types (state forest)

Schleswig-Holstein:

- Digital land use map 'survey of biotope and land use types'
- GIS-Layers of protected linear landscape elements (hedgerows, earth dikes)

Additionally, we included freely available climate and elevation model data (BioClim, www.wordclim.org, raster resolution 1x1 km):

- Altitude
- Mean temperature in the coldest quarter
- Mean temperature in the warmest quarter

The digital maps and layers were first reclassified into coarser classes of land use types to create a continuous land use map because the data for the Danish and the German parts of the study area differed in some details (number of feature types, number of mapped forest types, classification of streets etc.). Linear features were transformed into polygons to create a continuous, overlap-free map for the study area. The new, reclassified map layer was transformed into an ESRI grid. For the habitat use analysis we defined 17 land use classes, 8 of which were included in the subsequent analyses:

- Tree lines and tree groups,
- Hedgerows and protected earth dikes,
- Deciduous forest,
- Mixed forest,
- Coniferous forest,
- Urban/Suburban areas, industry,
- Lakes and ponds,
- Rivers and streams.

We also created two new variables to incorporate the habitat fragmentation in our study area:

- Index of habitat variability (see below),
- Index of connectivity between forest patches, hedgerows and tree lines (called 'network', see below).

The rasters representing different land use types were analysed via a Distance analysis tool in ArcGIS 9.3 Spatial Analyst to calculate Euclidean distances from each raster cell to the focal land use class since boolean data, i.e. presence/absence cells by habitat type cannot be used in the ENFA analysis tool in Biomapper. This tool requires quantitative data. Thus, we calculated the Euclidean distances to the focal habitat type per cell within a radius of 1,500 m to incorporate the mean dispersal distances of *M. avellanarius* and the habitat distribution within a wider landscape patch that might influence the species' distribution. The index of habitat variability was calculated as the number of different habitat types around each raster cell within a radius of 250 m (i.e. half of the mean home range size of *M. avellanarius*). The index of connectivity within the network of forest patches, hedgerows and tree lines was calculated as the number of adjacent raster cells of the 'network' (forest, hedgerow or tree line raster cell) per raster cell.

The procedures described above resulted in the following set of ecogeographical variables EGV:

1. Distance to tree lines and tree groups, radius 1,500 m per cell,
2. Distance to hedgerows and protected earth dikes, radius 1,500 m per cell,
3. Distance to deciduous forest, radius 1,500 m per cell,
4. Distance to mixed forest, radius 1,500 m per cell,
5. Distance to coniferous forest, radius 1,500 m per cell,
6. Distance to urban/suburban areas, radius 1,500 m per cell,
7. Distance to lakes and ponds, radius 1,500 m per cell,
8. Distance to rivers and streams, radius 1,500 m per cell,
9. Altitude, continuous (study area),
10. Mean temperature in the coldest quarter, continuous (study area),
11. Mean temperature in the warmest quarter, continuous (study area),
12. Index of habitat variability, radius 250 m per cell,
13. Index of connectivity between forest patches, hedgerows and tree lines, continuous (study area).

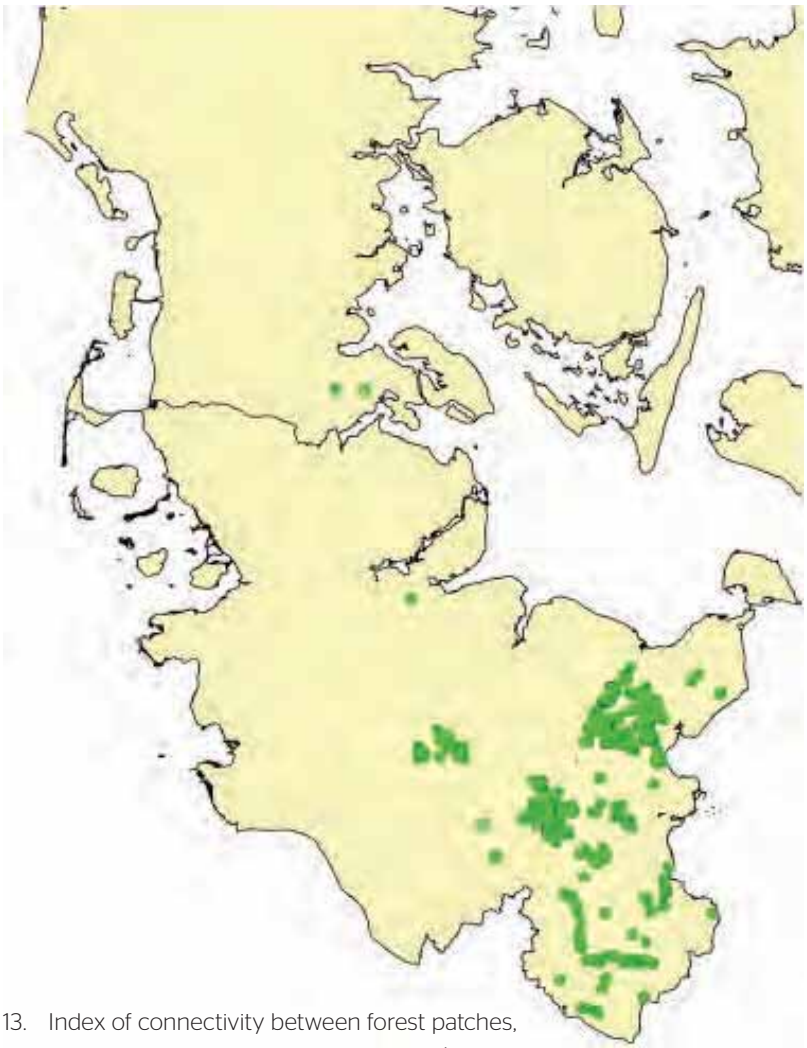


Figure 86: Study area. Dormouse presence data (N = 1,012, excluding Fyn, Denmark).

We used dormouse presence data (field/nest site surveys, animal sightings etc.) from 2000-2013, with altogether N = 1,012 locations from Schleswig-Holstein and the south of Denmark. Presence data of *M. avellanarius* from Fyn, Denmark, could not be incorporated in the modelling process. The presence data set was buffered using 250 m radii, after that we calculated the central presence data point per cluster of 250 m buffers. We excluded the remaining presence data in order to avoid autocorrelation caused by clumped data (i.e. several nests mapped in one small hedgerow). The presence data set used in the ENFA comprised N = 259 locations. These 259 locations were transformed into a raster format (ESRI grid).

Ecological Niche Factor Analysis: Processing

The EGV rasters as well as the presence data raster were resampled to a resolution of 10x10 m pixels (raster cells). We performed the ENFA using the following specifications:

- EGV were used as 'raw' data without using the Box-Cox-Transformation to normalize them because some variables, e.g. index of connectivity, were nearly-boolean, i.e. the range of values throughout the study area was very small. The ENFA algorithm in Biomapper is robust to non-normalized data, i.e. the normality is not a crucial factor (Hirzel et al. 2002).
- The habitat suitability was calculated using the 'Distance Geometric Mean' algorithm because no assumption is made on the species distribution (e.g., the species distribution on the input ecogeographical factors must be unimodal and symmetrical for the Median algorithm).

We first ran a model using all EGV as described above. The EGV showed some degree of inter-correlation which must be removed before calculating the uncorrelated factors which describe the multidimensional ecological niche of *M. avellanarius* and the final habitat suitability model. This procedure comprises a step-by-step reduction of the EGV data set, by removing one EGV of the most redundant pair (with the highest degree of correlation) and running the ENFA algorithm again. We finally got a suitable model comprising the following, reduced set of significant EGV:

1. Distance to tree lines and tree groups, radius 1,500 m per cell,
2. Distance to hedgerows and protected earth dikes, radius 1,500 m per cell,
3. Distance to deciduous forest, radius 1,500 m per cell,
4. Distance to mixed forest, radius 1,500 m per cell,
5. Distance to coniferous forest, radius 1,500 m per cell,
6. Distance to urban/suburban areas, radius 1,500 m per cell,
7. Altitude, continuous (study area),
8. Index of habitat variability, radius 250 m per cell,
9. Index of connectivity between forest patches,

hedgerows and tree lines, continuous (study area). The cross-validation process for this data set, using a 4-fold cross-validation (Boyce et al. 2002, Hirzel et al. 2006) revealed that this habitat suitability model using the geometric mean algorithm, although suitable for this kind of data, the model showed some weaknesses regarding the definition of low-suitability habitat patches and dispersal barriers, e.g. water bodies. We developed another habitat suitability model using a new algorithm available in Biomapper, the 'extreme optimum adjusted Median' algorithm. This algorithm incorporates the spatial patterns observed in specialized species and/or their habitat use in rare, small-sized or disappearing habitat types (Braunisch et al. 2008). Again, we used the 'raw' data without using the Box-Cox-Transformation. We used the same set of EGV for this model as for the preliminary model (see above), but later on we reduced the set by excluding the distance to urban/suburban areas (due to autocorrelation issues). The resulting habitat suitability map ranging from 0 to 100% suitability was reclassified using for bins (25% suitability per bin). The final model validation was conducted using 7 bootstrap samples with 37 dormouse locations per sample. The Absolute Validation Index (AVI), the Contrast Validation Index (CVI) and the Boyce continuous index (Bcont, range 0-1) were calculated to estimate the predictive accuracy of the model (for details please see Boyce et al. 2002, Hirzel et al. 2006).

Another approach incorporating the distances between all hazel dormouse locations as an additional EGV, which might rank the suitable habitats according to their distance to occupied locations, was also tested, but the results were discarded due to statistical problems arising from the clumped data set.

Least-cost path modelling

The habitat suitability model provides the basis for a modelling approach to estimate the optimal habitat corridors to interconnect 'source' and 'target' populations of the target species. We used a least-cost path analysis to estimate optimal corridors. The re-classified habitat suitability map (25% suitability per bin) was again re-classified to invert the habitat suitability classes and to obtain a 'cost matrix' for *M. avellanarius*. Due to the smoothing behaviour of the ENFA algorithm across the landscape some unsuitable habitats, e.g. water bodies, were still present in this map. They were deleted from the re-classified habitat suitability to estimate realistic corridors across the landscape and around water bodies. The class (set of cells) comprising 75-100% habitat suitability was assigned a 'migration cost' of 1 (= the lowest migration cost), the class (set of cells) comprising 0-25% habitat suitability was assigned a 'migration cost' of 4 (= the highest migration cost). Thus, the resulting cost matrix comprised the same number of classes (bins) as the habitat suitability map. The least-cost

path analysis estimates the optimal path with the least accumulative cost while passing through the cell matrix. This analysis was conducted using the Spatial Analyst extension for ArcGIS 9.3 (ESRI). The source and the target zones for the estimation of the least-cost path which interconnects them were obtained by buffering the dormouse locations again using 1,500 m radii (see above). The resulting buffers clustered to several 'regions' with *M. avellanarius* occurrence (N = 36; N = 2 for Denmark and N = 34 for Schleswig-Holstein). Here we calculated specific least-cost paths for one Danish and one German 'hazel dormouse region' and their interconnections between the other 35 regions.

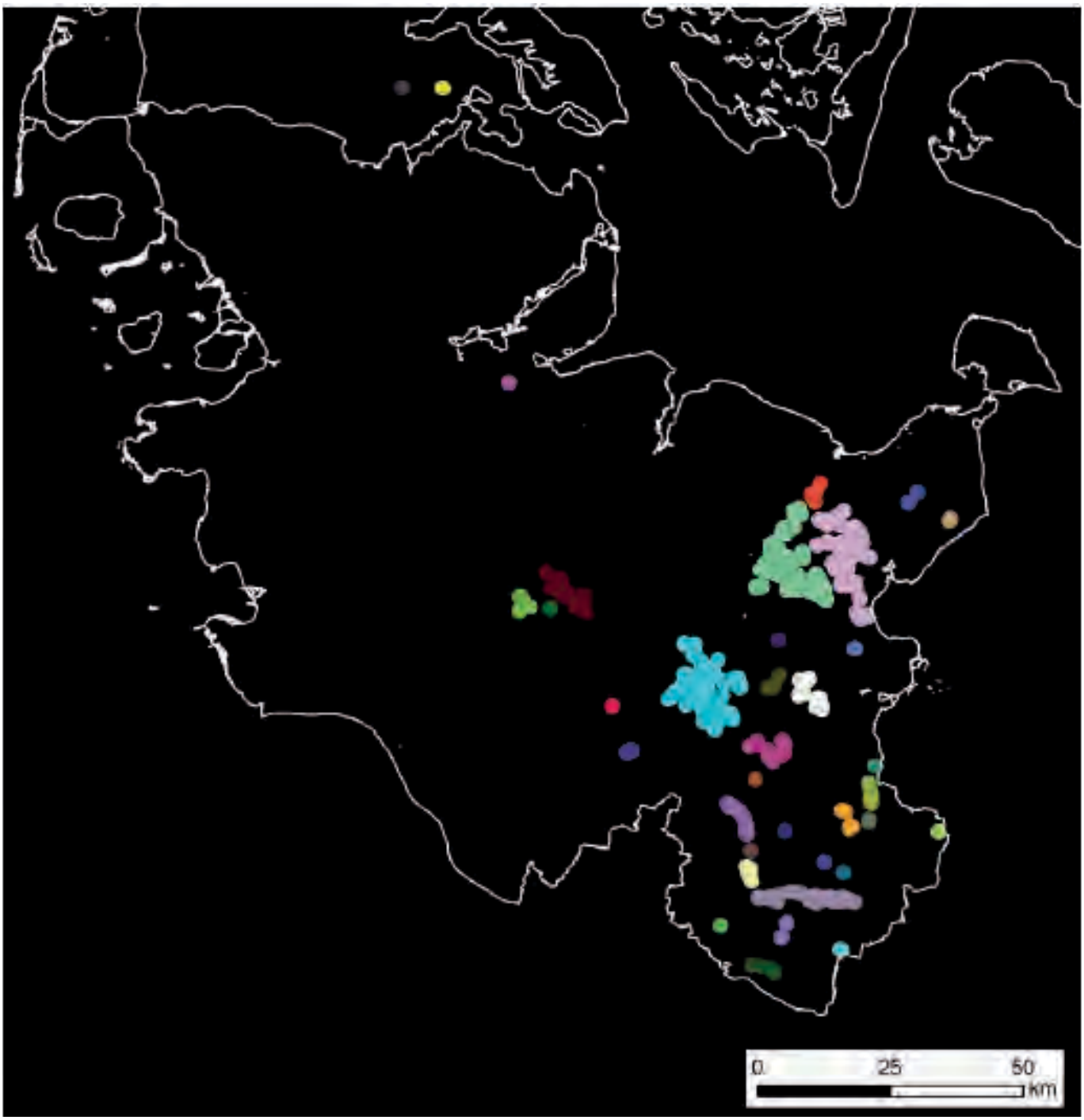


Figure 87: Buffered hazel dormouse locations clustering to N = 36 'regions' of hazel dormouse occurrence which are to be interconnected by least-cost paths.

4.3.1 The ecological niche factor analysis model

The final habitat suitability model also indicates a relative high degree of specialization of the target species. This map showed several areas that might be suitable for the hazel dormouse, but a large area of very low index of habitat suitability is located in the south-western part of Schleswig-Holstein. This area was already identified by the preliminary model, but natural barriers like water bodies were delineated much more precisely. The global marginality (i.e. the difference between the mean species distribution and the global distribution over all EGV in the whole study area) indicates a significant difference between the raster cells occupied by the target species and the study area (M = 1.883). The global specialization also indicates a narrow ecological niche for *M. avellanarius* (S = 5.376), which is also indicated by the small tolerance factor (1/S) = 0.186. Any tolerance factor below 1 indicates a certain degree of specialization. The first factor (i.e. the marginality factor) explains 80% of the specialization (Tab. 9). The correlations of the EGV and the marginality factor (= factor 1) are given in Tab. 9. The resulting habitat suitability map was calculated using the first two factors (containing the most information) only.

Dormouse locations were found in higher altitude levels within a framework of forest patches and hedgerows and tree lines. The model strongly indicates a preference for parts of the 'habitat network' of forest patches and linear landscape elements that are characterized by a higher degree of connectivity, i.e. a preference for a network of landscape elements rather than single small habitat patches like single, short hedgerows. The network quality seems to be a much better descriptor of the habitat preferences than the pure distances to the different habitats. The connectivity decreases from forest edges to the outermost parts of hedgerows and tree lines; this might indicate the relevance of forest patches for the distribution of *M. avellanarius*.

This is in line with the fact that an increasing distance to forests was also avoided by the dormouse in the study area (Tab. 9). Areas of higher suitability were estimated around the forest patches (i.e. the forest edges), but rarely in the forest interior. Additionally, higher habitat variability within a 250 m buffer around the presence cells was also preferred. Habitat connectivity and habitat variability were obviously the most important ecological factors that influence the distribution of *M. avellanarius* in the study area. The obvious proximity of dormouse presences to urban or suburban areas could derive from the fact that tree lines, orchards and hedgerows are often found in close proximity to urban areas. Thus, the habitat suitability map shows areas of higher suitability values around several urban and suburban areas. Furthermore, suitable habitats were estimated around lakes and ponds. This can be explained by the occurrence of tree lines and riparian vegetation around the water

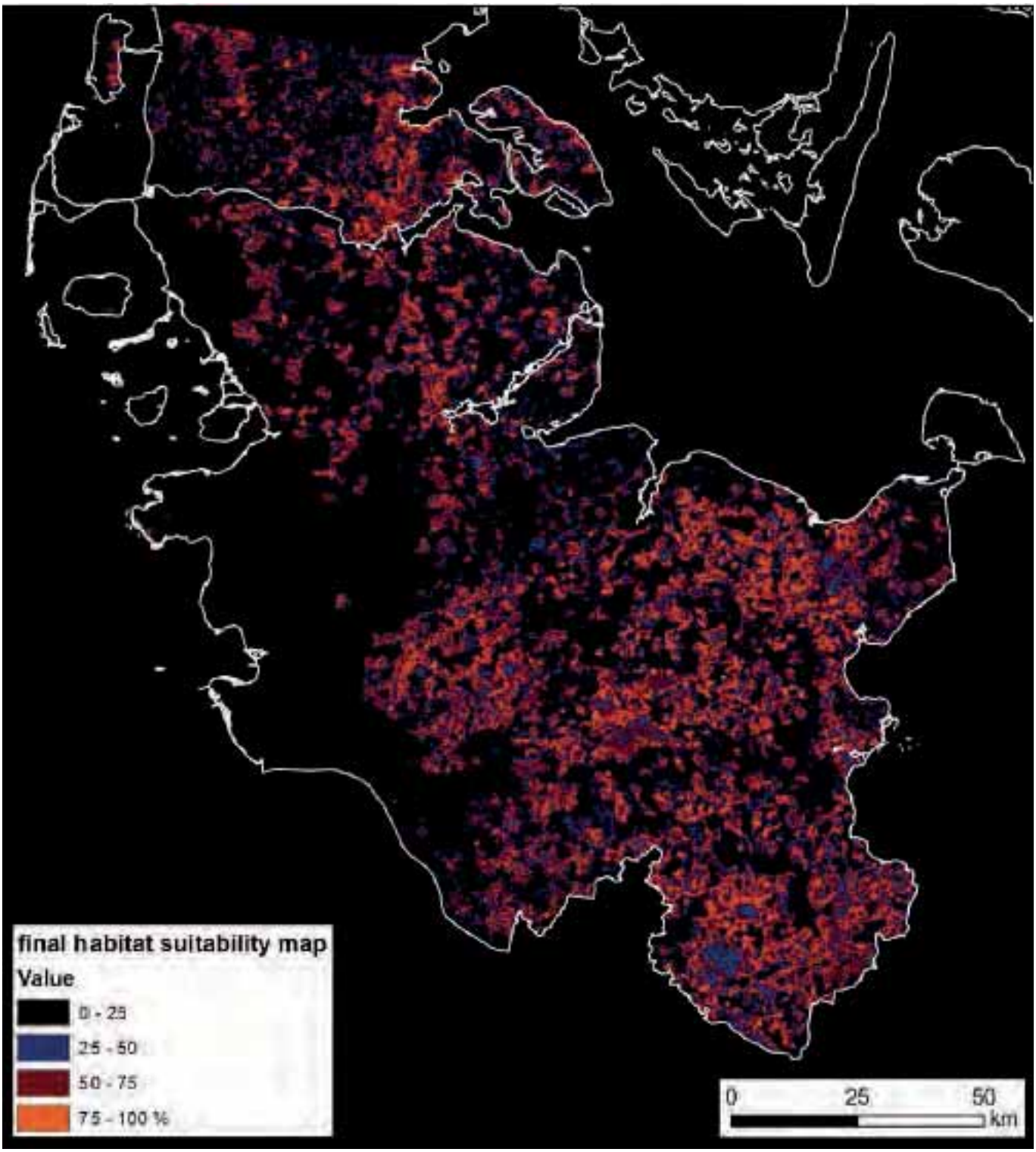
EGV	Factor 1* (80%)	Factor 2** (19%)	Factor 3** (0%)	Factor 4** (0%)	Factor 5** (1%)	Factor 6** (1%)	Factor 7** (0%)	Factor 8** (0%)
Distance to tree lines and tree groups	---	***	*********	*****	**	O	*****	*
Distance to hedgerows and protected earth dikes	----	***	****	*******	****	*****	*	***
Distance to deciduous forest	----	O	*	****	****	*	**	******
Distance to mixed forest	----	O	O	*	********	*	***	*
Distance to coniferous forest	----	O	*	**	*	***	*	*******
Index of habitat variability	++++	*	*	**	**	********	****	**
Altitude	++	*********	O	O	O	O	O	O
Index of connectivity	++++	O	O	O	O	*	******	*

*Positive values: Higher values of the given EGV were preferred.
Negative values: Lower values of the given EGV were preferred; i.e. an avoidance of an increasing distance to a given EGV indicates the preference of the proximity to this EGV.
Greater numbers of symbols indicate high correlations between EGV and species distribution.
**O: weak correlation
Greater numbers of symbols indicate narrower ranges of values in the given EGV.

Table 9: EGV contributions to the ENFA factors. Factor 1 represents the marginality, factors 2-8 the specialization factors.

bodies. The results of the modelling approach are heavily influenced by the quality and accuracy of the input data (map quality, accuracy of the locations). Although we used the most accurate presence data for the hazel dormouse, there still might be a correlation issue that influenced our results. The final model validation revealed a mean AVI of 0.58 (+- 0.08 SD), a mean CVI of 0.47 (+-0.08 SD) and a mean Boyce continuous index of 0.67 (+-0.13 SD). This model showed some weaknesses in the estimation of medium (40-65%) suitability. Thus, we used coarse classes separated by 25%-suitability steps. Nevertheless, the model is not always able to delineate very small, stretched but isolated habitat patches, e.g. small tree lines along a motorway, as suitable habitat, and might overestimate the suitability for the surroundings of the suburban areas in some parts of the study area.

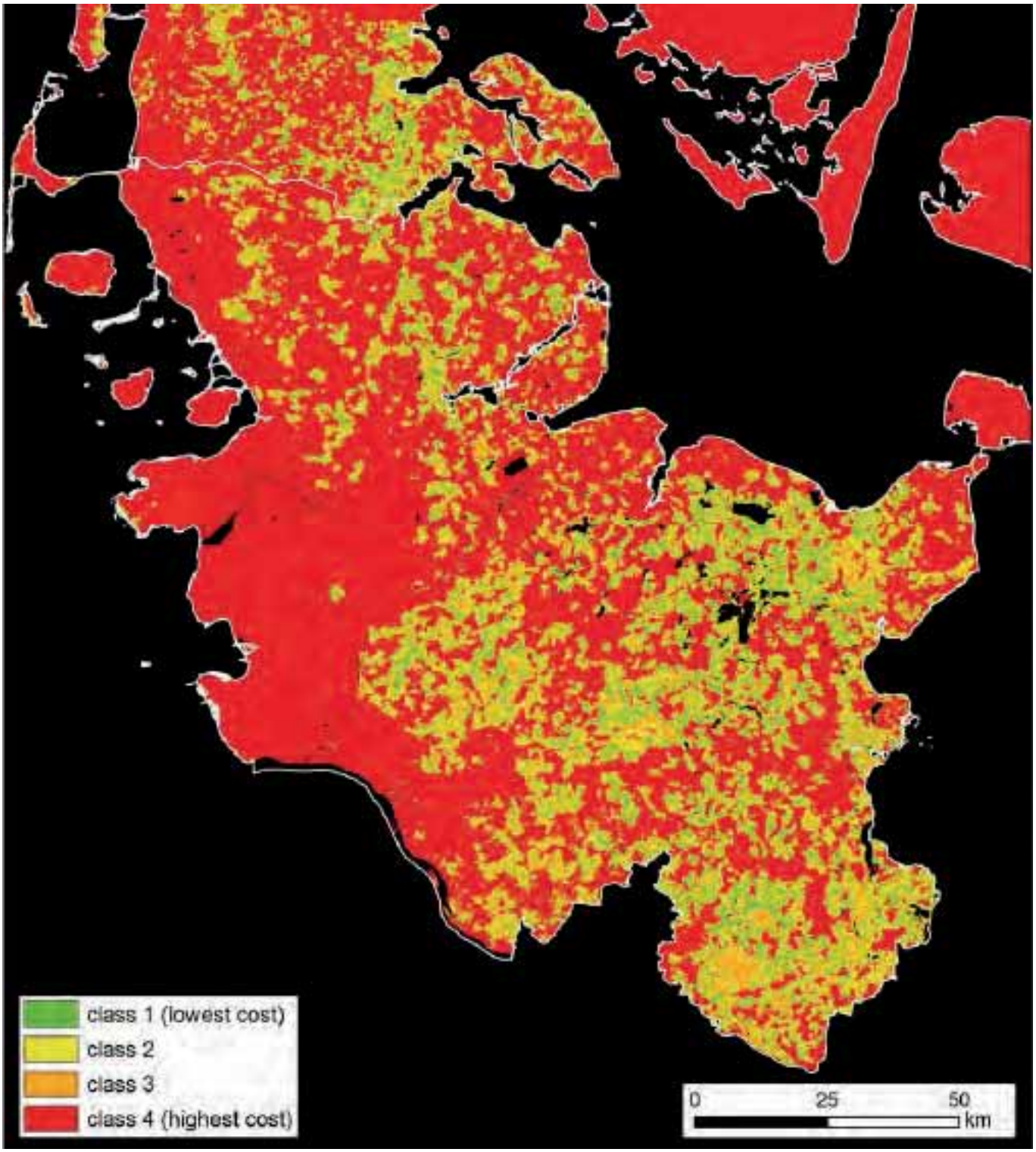
Figure 88: Habitat suitability map for the hazel dormouse in the study area. Red and orange colours represent areas of high suitability.

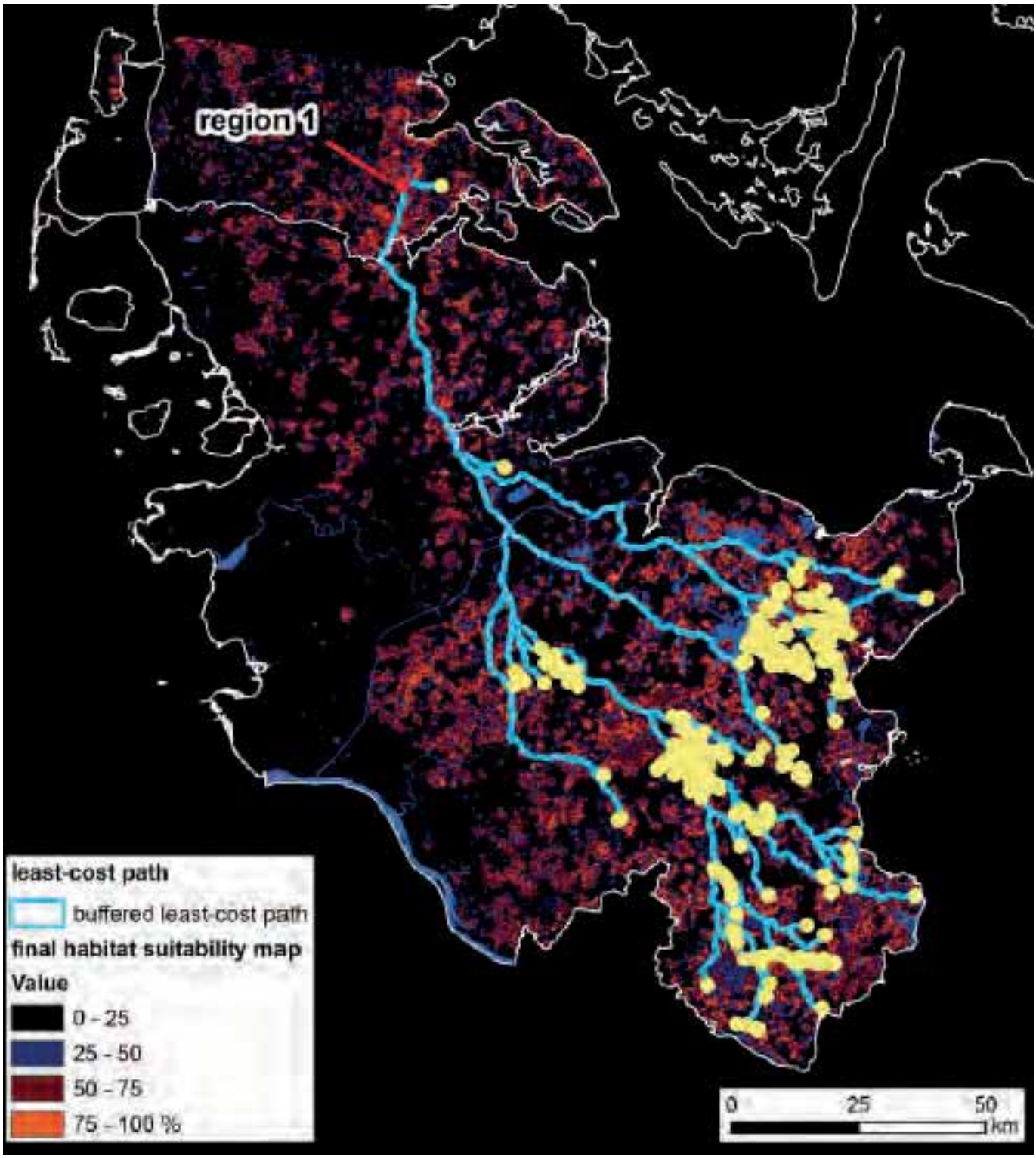


4.3.2 The least-cost path model

In the following we illustrate the cost matrix for the least-cost path modelling approach and the least-cost corridors for two example regions of *M. avellanarius* occurrence.

Figure 89: Cost matrix (inverted habitat suitability map)





The least-cost path modelling can identify regions with a decreasing connectivity (e.g. missing hedgerows or tree lines between forest patches). These regions can then be used for specific management action plans to increase again the connectivity.

Figure 90: Least-cost path (light blue) from the region 1 (red) to 35 other regions (yellow) of hazel dormouse occurrence. Water bodies are shown in blue. The least-cost path (one line) has been buffered by 250 m radii to make it easier to find particular section

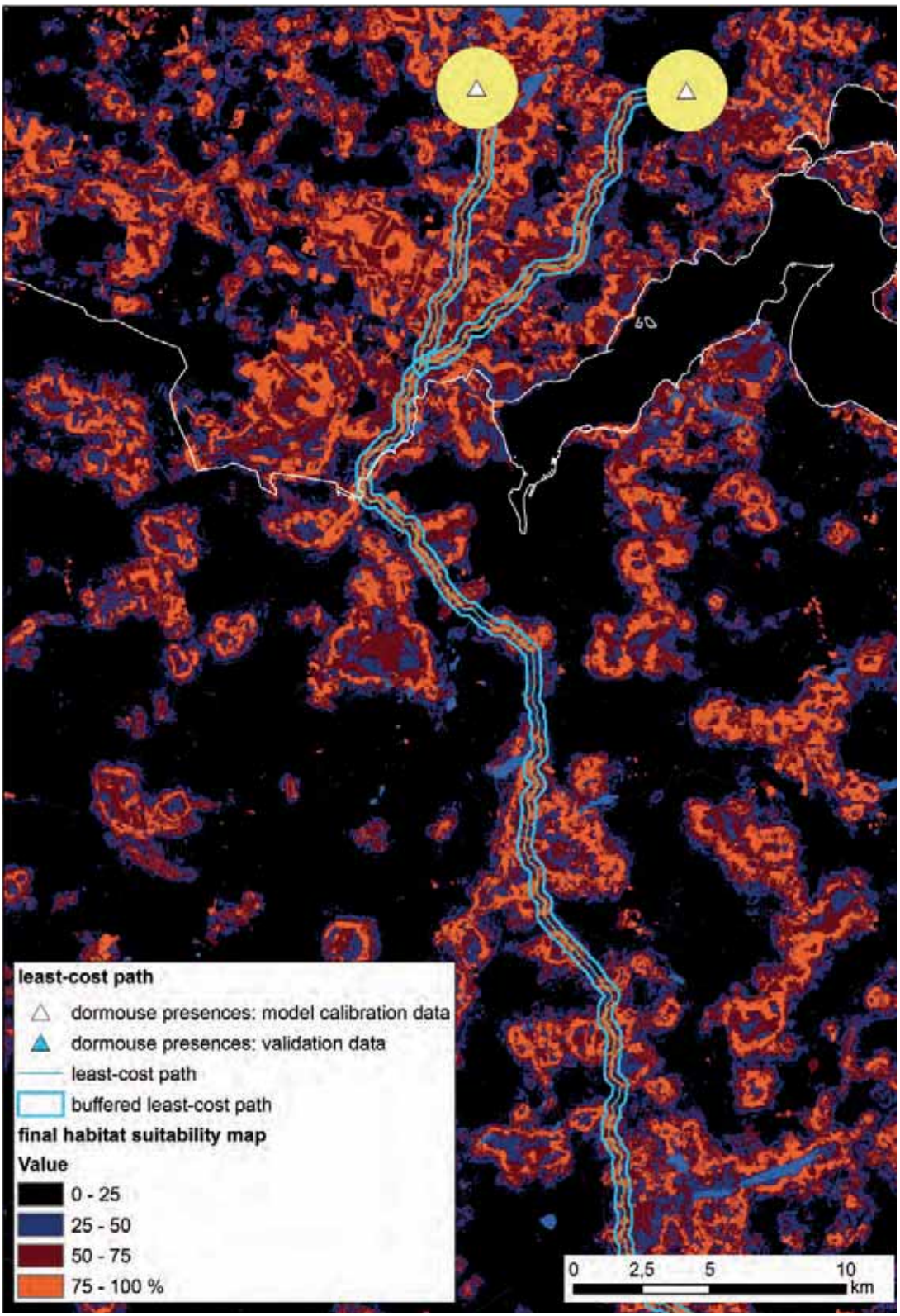


Figure 91: Detail view example of the least-cost path for region 6 (Danish-German border region).

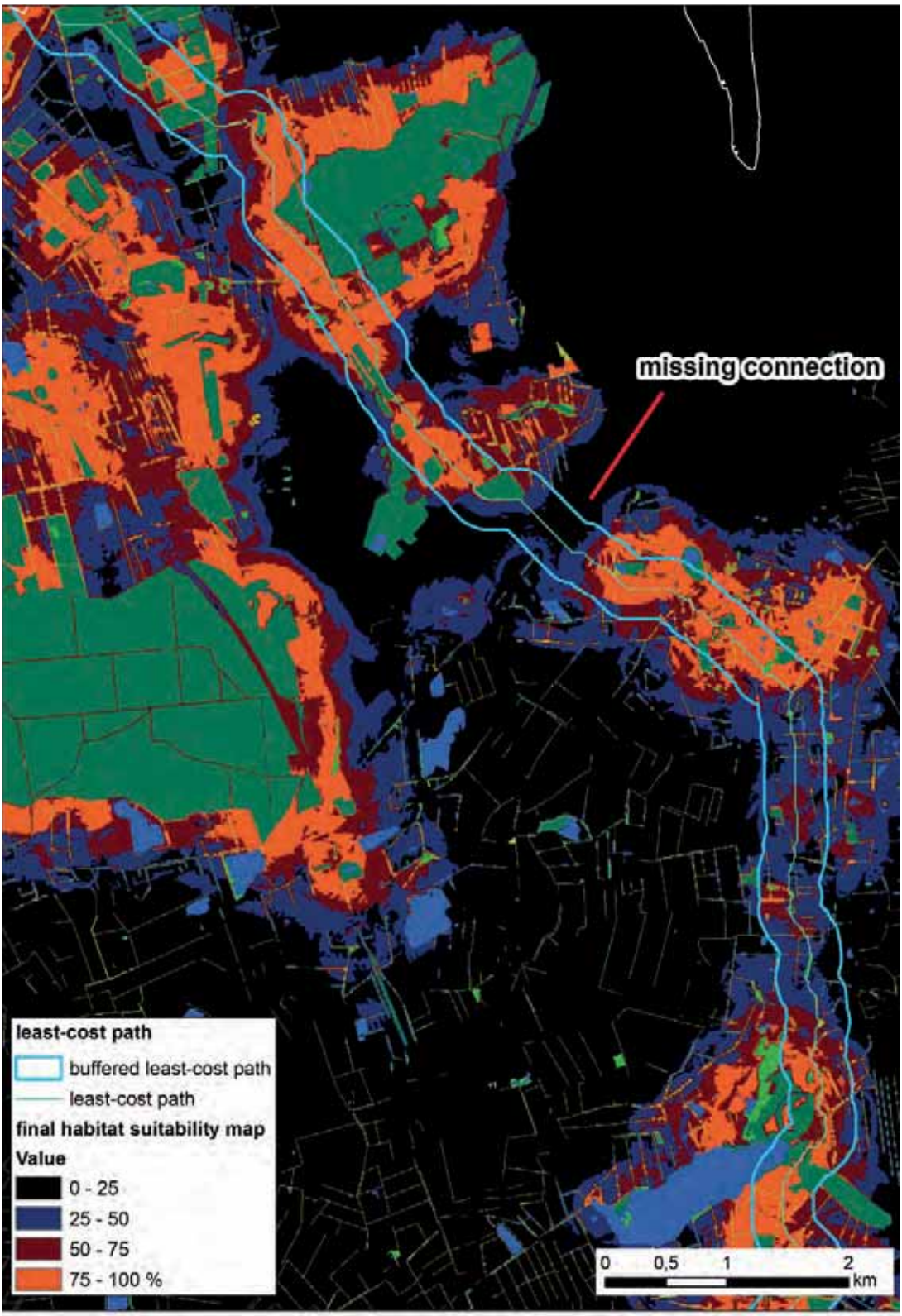


Figure 92: Detail view example of the least-cost path for region 6 (Near Flensburg), showing a 'missing' connection between forest patches.

4.3.3 Conclusion

The habitat suitability model showed that *M. avellanarius* occupies a narrow niche. Suitable habitats were estimated along different types of edge habitats like hedgerows and tree lines in close proximity to forests, riparian vegetation, and forest edges. This is in line with the known habitat use patterns observed for the species. The model identified patches of high habitat suitability that were in fact occupied by the target species, but there are also some limits. The model cannot identify very small stripes of suitable habitat, e.g. small tree lines along

motorways, although nests were found in these habitats. Second, the model always identifies more or less broad zones of low or high habitat suitability, thus it cannot identify accurately very small patches of unsuitable habitat which are common in the study area (matrix), e.g. small water bodies. Nevertheless, the final model in combination with a least-cost corridor analysis identifies regions with decreasing connectivity where management strategies should focus on. Such regions could be optimized via planting of hedgerows and trees, or the creation of more diversified and edge-rich forest habitats connected with hedgerows.

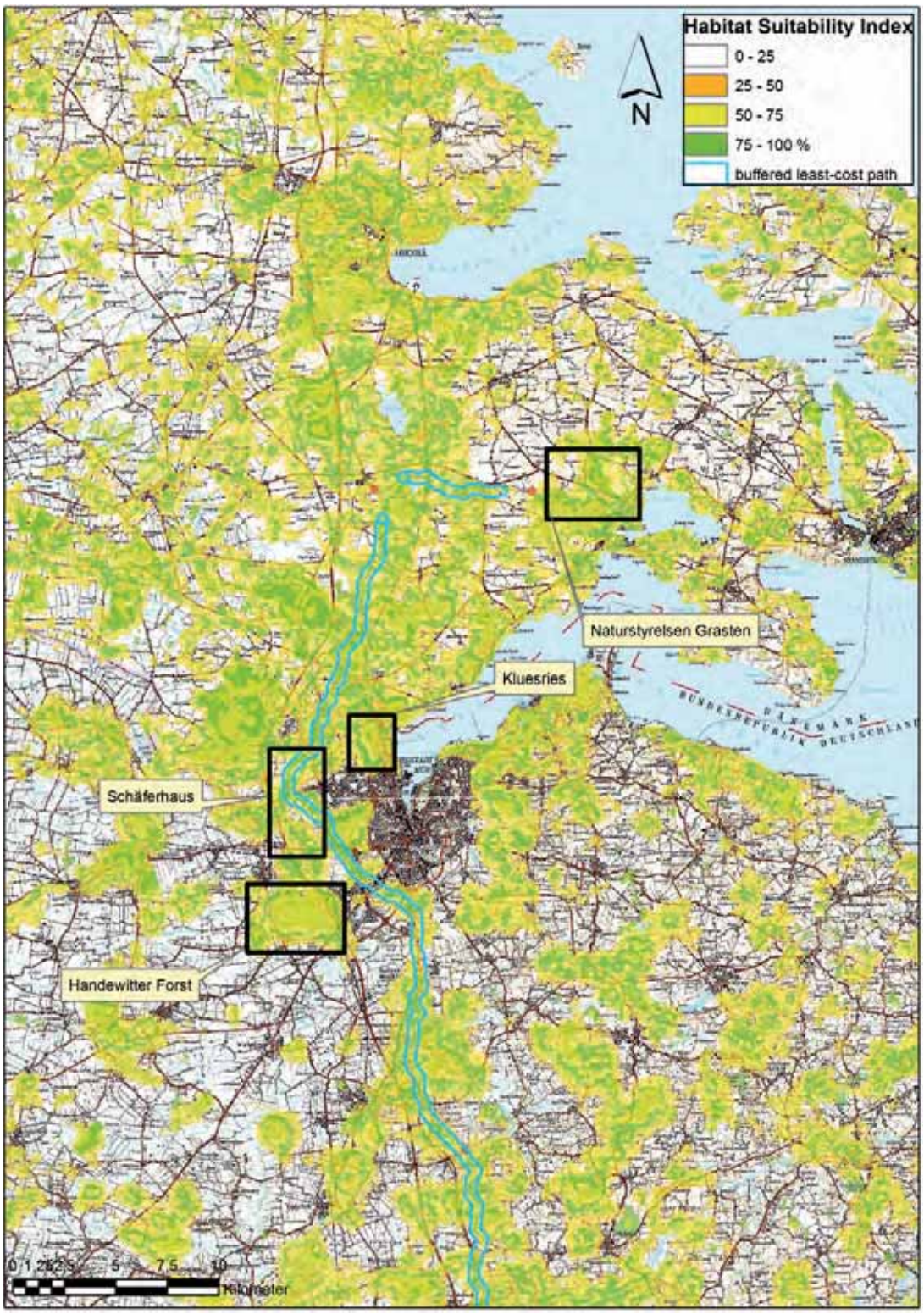


Figure 93: Detail view of habitat suitability in the border region and the project sites

5 Population Management

5.1 Introduction

By Mogens Krog

Population management require another level of expert knowledge compared to habitat management. As we have seen habitat management is about planting, thinning and putting up nest boxes, involving farmers etc. When it is decided what to do it is a matter of planning and resources in order to implement. Working with rare animals as the dormouse poses some fundamental challenges, because the work depends on finding animals to work with.

A "mirror" population

Originally the plan was to re-introduce a so called "mirror population" in the German project sites, based on animals from the Gråsten population. The idea was to take out late born juveniles (born in late summer and autumn). These animals have minimal change of gaining enough weight to survive winter hibernation (JUŠKAITIS, 2008). Thus, by taking out these animals two objectives could be met: First, the animals were safe during winter in captivity. Second, the animals would be used for breeding, founding the mirror population. Also, the mirror population approach have the advantage of not involving genetic analysis, as no new genetic material is introduced close to the original population, with the risk of altering a genetically unique southern Jutland population.

Re-introduction of rare animals is recognised by IUCN (The International Union for Conservation of Nature) and CBD (The UN conference of the Parties on Conservation of Biological diversity) as one of several tools to safeguard and conserve rare animal populations. The IUCN guidelines have been applied in this project. However, translocating a mirror population became impossible as no animals were caught in the forests of Gråsten, despite an intensive search. See paragraph 2.2.2.

A new strategy

A new strategy had to be developed. Translocation based on animals from other Danish or German populations would require genetic analysis. Together with the dormouse experts Pat Morris and Sven Büchner the project group met with experts at PTES (Peoples Trust for Endangered Species) in London, who are also working on translocation and hedgerow projects for dormouse conservation. Additionally, after the 8th International Dormouse Conference in Görlitz, cooperation with the genetic expert Alice Mouton (University of Liege) was set up, to clarify the genetic status of the Danish and German populations. At several meetings a German-Danish expert group was consulted to assess genetic results and plans.

5.2 Collection of genetic material

By Sina Ehlers and Björn Schulz

One of the main targets of the BioGrenzKorr project is to safeguard the endangered dormouse populations in Southern Jutland (DK), among others actions by the resettlement of a so-called mirror populations in Schleswig-Holstein. Furthermore, in the long term genetic exchange must be enabled between the Danish and German populations. To preserve genetic variation at the macro level, it is important only to release animals that are genetically closely related to existing populations. For genetic analysis samples were collected in the whole range known in Schleswig-Holstein and Denmark. Skin samples were taken from ears by using biopsy equipment (2 mm diameter).

Samples from Schleswig-Holstein

In Schleswig-Holstein 60 DNA-samples were collected (Table 10, Figure 97).

Samples from Denmark

In Southern Jutland no dormice were found in the nest boxes, mounted in the project area (see Chapter 2.2.2). But in two of the free hanging nests, hair was detected and could be used for DNA analysis. Additionally older samples taken by H. Vilhelmsen on Zealand and Funen were used for genetic analysis (11 in total; Table 11).

Figure 94: Björn Schulz and Sina Ehlers when taking skin samples for genetic analysis

Sample	Sex	Location	Sampling	Note
1	male	Eutiner See	27.05.2011	
2	female	Stadtheide Plön	27.05.2011	
3	male	Menhorst	27.05.2011	
4	female	Radlandsichten	27.05.2011	
5	female	Stutkoppel	27.05.2011	
6	male	Stutkoppel	27.05.2011	
7	male	Süsel	27.05.2011	
8	female	Schwissel	27.05.2011	
9	female	Söhren OH	27.05.2011	
10	male	Todenredder	27.05.2011	
11	male	Neumünster Mitte	25.05.2011	
12	?	Neumünster Mitte	25.05.2011	
13	male	BAB-Dreieck Wahlstedt	08.06.2011	
14	female + 5 Juv.	BAB-Dreieck Wahlstedt	08.06.2011	Juveniles: eyes closed
15	male	BAB-Dreieck Wahlstedt	08.06.2011	
16	male	BAB-Dreieck Wahlstedt	21.06.2011	16 bis 19 are a common litter
17	female	BAB-Dreieck Wahlstedt	21.06.2011	age appr. 21 days
18	male	BAB-Dreieck Wahlstedt	21.06.2011	
19	female	BAB-Dreieck Wahlstedt	21.06.2011	
20	female + 5 Juv.	BAB-Dreieck Wahlstedt	23.06.2011	Juveniles: age appr. 21 days, not sampled
21	male	BAB-Dreieck Wahlstedt	23.06.2011	
22	male	BAB-Dreieck Wahlstedt	23.06.2011	in tube with female and litter samples 16-19!
23	male	Trittau	15.07.2011	subadult in nest box
24	male	Hammoor	03.08.2011	
25	male	Kreis Plön	14.09.2011	
26	?	Wasbek	14.09.2011	
27	female	Eutin	14.09.2011	Mother of litter sample 28
28	litter	Eutin	14.09.2011	3 naked
29	?	Pölitz	14.09.2011	
30	male	Kneeden	06.10.2011	
31	female	Kneeden	06.10.2011	
32	male	BAB-Dreieck Wahlstedt	06.10.2011	breeding with sample 40
33	female	Griebel	12.11.2011	
34	female	Barkau	12.11.2011	Zucht mit 35
35	male	Süsel	12.11.2011	Zucht mit 36
36	male	Kasseedorf	12.11.2011	†
37	?	Plön Ost	12.11.2011	†
38	female	BAB-Dreieck Wahlstedt	12.11.2011	† mother of litter sample 39
39	litter	BAB-Dreieck Wahlstedt	12.11.2011	† 5 (appr. 2 weeks) mother sample 38
40	female	Aukrug	14.11.2011	
41	male	Linau / Wentorf	28.11.2011	
42	male	Linau / Wentorf	28.11.2011	
43	male	Linau / Wentorf	28.11.2011	
44	female	Aukrug	28.11.2011	

Table 10: DNA-Sampling in Schleswig-Holstein

Sample	Date	Location
1	28.08.2001	Sollerup
2	16.08.2001	Sollerup
3	15.08.2001	Sollerup
4	15.01.2001	Hvidkilde
5	03.06.2001	Sollerup
6	11.02.2004	Trentelund
7	28.10.2003	Hvidkilde, Markvadhuset
8	21.07.1981	Dongs-Højrup
9	21.07.1981	Dongs-Højrup
10	21.07.1981	Dongs-Højrup
11	21.07.1981	Dongs-Højrup

Table 11: DNA-Sampling in Denmark

5.3 Genetic analysis

By Alice Mouton & Johan Michaeux (Université de Liège)

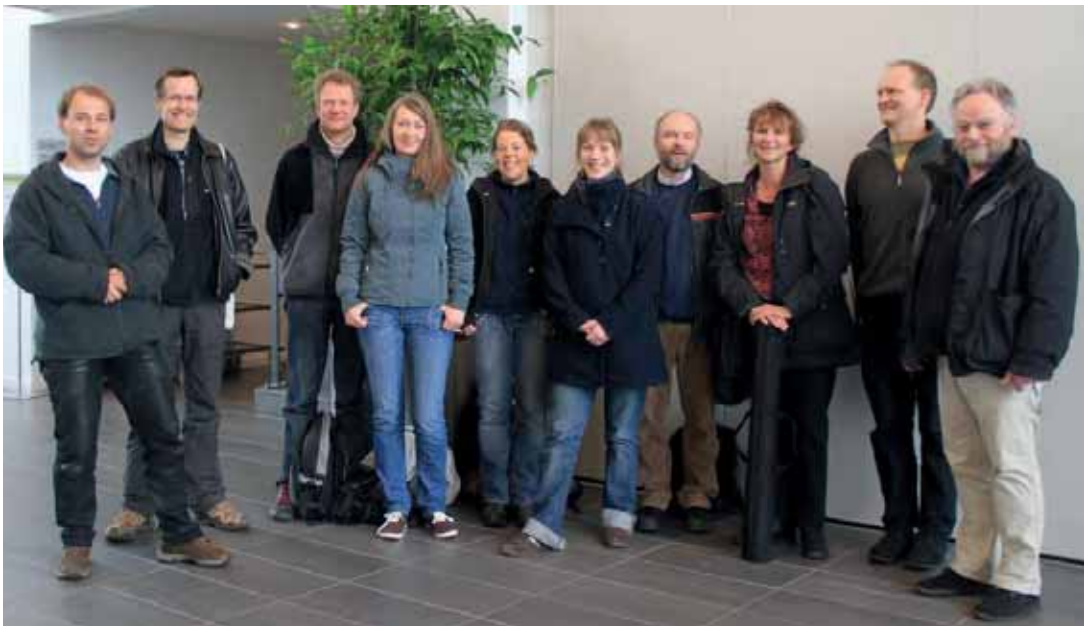


Figure 95: Participants of the workshop about dormouse genetics at 5th March 2012

Introduction

The range of *Muscardinus avellanarius* in Europe is fragmented and populations are small due to high habitat specificity. The level of genetic variation within such population is often low, and genetic differentiation between patchily dispersed populations is high. With reduced movement or gene flow between habitat patches, the effects of genetic drift and mutation may lead to an overall patchy distribution of genetic variability (Frankham 1998, Berthier et al., 2005). Moreover, populations of a fragmented species may experience greater frequencies of bottlenecks and lower population sizes, resulting in increased rates of genetic erosion, sometimes leading to inbreeding effects such as reduced reproductive success (Gaines et al., 1996; Saccheri et al., 1998).

The BioGrenzKorr project seeks to develop management strategies that can ensure the habitats of the common dormouse and to safeguard isolated population by establishment of a cross-border metapopulation in order to obtain more robust species populations.

Information on the metapopulation dynamics of rare or endangered species is a fundamental prerequisite for effective conservation management, but is rarely available. However, population histories can be assessed, and population trends can be predicted based on levels of genetic diversity (Dallas et al. 1999). The present study focus on the genetic diversity and population structure of the common dormouse in Denmark and Schleswig-Holstein using microsatellite markers, which display optimal sensitivity for detailed analyses of genetic structure in space. Can we observe a genetic differentiation between both regions? If so, how many genetic clusters are present and how is the genetic diversity within clusters?

The Danish and German samples in a European context

Previous analyses based on 130 common dormice across the species' range, using sequence data from the mitochondrial cytochrome b gene revealed the presence of two highly divergent lineages in Europe. The Lineage 1 is spread in Western Europe and Italy and the Lineage 2 in the Central Europe, in Balkan Peninsula and in Turkey.
New analyses performed with 5 Danish samples and 18 German samples from the Interreg project revealed surprising results. These individuals belong to the Central European lineages, however 17 German samples share the same haplotypes as individuals from Poland and Slovakia while the Danish samples and one German (from Neumunster) sample share the same haplotype suggesting a divergent origin (Figure 96). This result tends to suggest that a more fine scale analysis with the microsatellite will show the same trend.

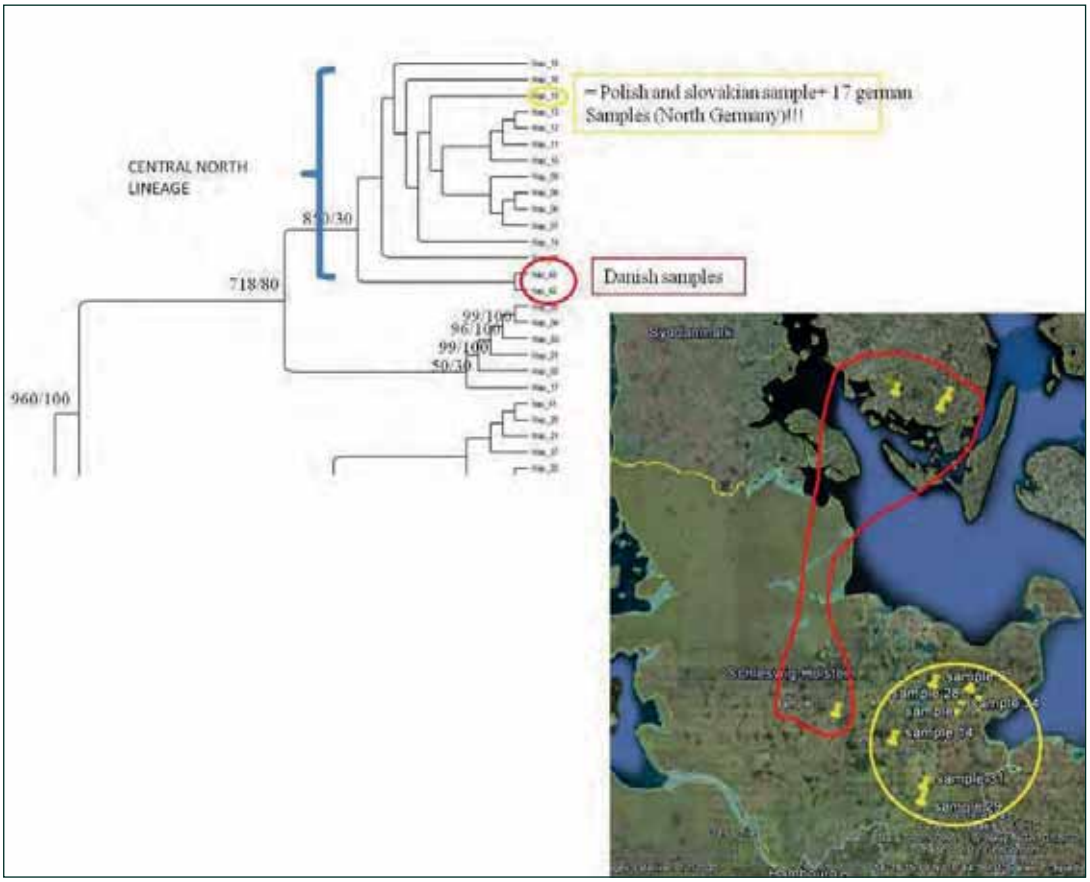


Figure 96: Maximum-likelihood tree with the presence of the central north lineage and geographic distribution of the genetic sampling.

Materials and methods and data analysis

A total of 49 samples were collected in several localities in Schleswig-Holstein and in Denmark (see figure 97 and chapter 5,2). Extractions were carried out using a QIAmp DNA Micro kit (Qiagen). All samples were handled using sterile disposable scalpels.

The amplification successes of the microsatellite markers were quite varied. Some loci contained too much missing data to perform specific analyses and additional samples and markers will be included in the future. Therefore, this study will show the preliminary results.
For detailed information on methods and data analysis see appendix 6.

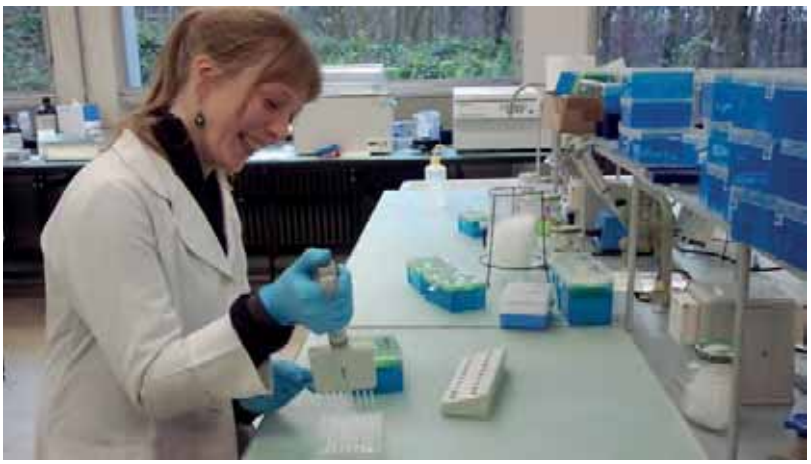


Figure 98: The genetic Alice Mouton in the DNA lab at the University of Liege

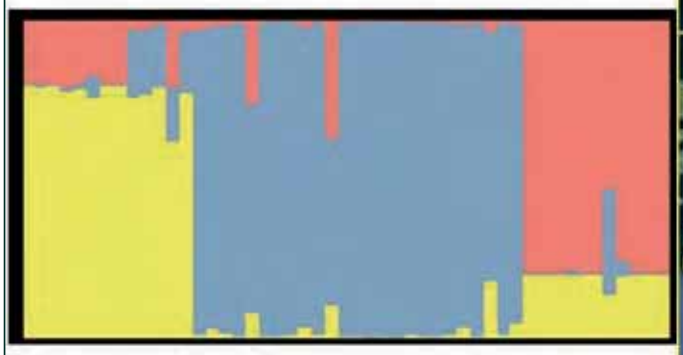
Figure 97: Sampling locations in Schleswig-Holstein and in Denmark

Results

Clustering simulations with STRUCTURE converged towards the highest posterior probability solution of 3 distinct genetic clusters corresponding roughly to the distribution samples (Figure 99). One cluster (yellow) encompasses individuals on

the Danish islands and on the German mainland close to Neumünster, one cluster (red) comprises individuals from BAB-Dreieck Wahlstedt, and one cluster (blue) individuals on the German mainland. The FCA plot based on individual genotypes separated German populations (blue points) from the German population located in the BAB-Dreieck Wahlstedt (red points) and the Danish-German group (yellow point) along the first and the second factorial axis.

Figure 99: Estimated population structure



Comments: from Structure analyses for K=3. Each individual is represented by a thin vertical line divided into K coloured segments that represent the individual's estimated membership fractions in K clusters.

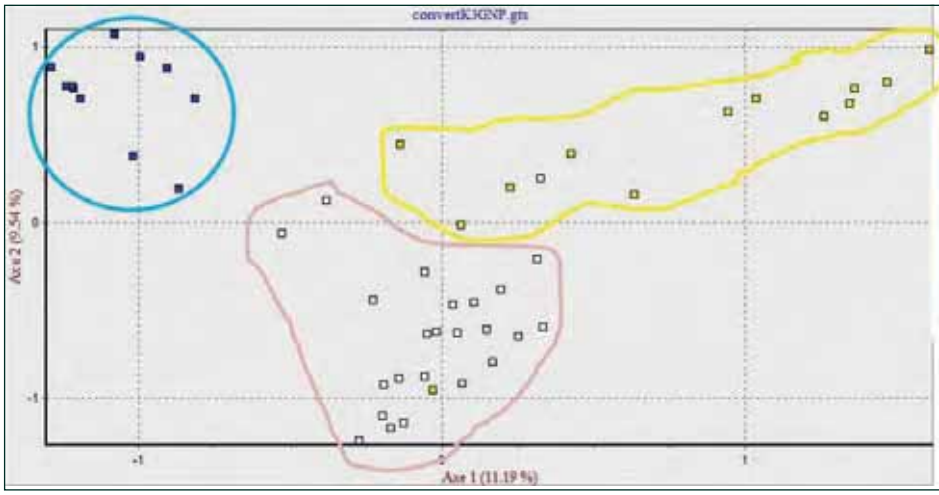
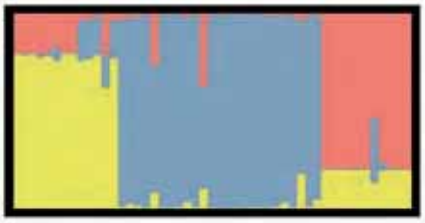


Figure 100: A two-dimensional plot of the FCA performed using GENETIX



Comments: The blue, the yellow and the red points correspond to the same colored clusters in Structure. The first axis explained 11.19% of the variance, and the second explained 9.54% of the varia

The value of Fis, the observed (Ho) and expected (He) heterozygosities with the corresponding p-value, the allelic richness (Rs), are summarized in table 12.

Table 12: Summary of multilocus genetic variation for the three groups:

	n	Fis	Hexp.	Hobs.	P-value	Rs
Neumünster-Denmark (yellow)	14	0.43*	0.6508	0.3585	1	5.5
BAB-Dreieck Wahlstedt (Red)	11	-0.10375	0.3946	0.4048	0.875	2.75
German (blue)	24	0.26635*	0.7278	0.5287	1	7

Comments: (n), number of individuals; Fis, inbreeding coefficient (* : p <0.05); Ho, observed heterozygosity; He, expected heterozygosity; Rs, mean number of alleles/ locus.

Conclusion

These preliminary results evidenced the presence of three genetic clusters in Denmark and Schleswig-Holstein. The use of a higher number of markers in the future will probably help to better understand if a substructure exist or not within these clusters.

The gene flow between them is low and there is a signal of inbreeding for two of them. The presence of a Danish-German cluster is coherent with the landscape's history and the mitochondrial analysis. In the past, these two regions were connected by hedgerows and forests. More genetic analyses will be performed to confirm the isolation and differentiation signals among these populations and to determine when the isolation occurred.

These results tend to suggest that the Danish individuals are closely related genetically to the individuals from Neumünster. In the context of reintroduction, we would strongly suggest to remove individuals from this region rather than the other localities in Schleswig-Holstein for the breeding program.

For further details on the genetic survey see the full report:

- Mouton, A., 2012: INTERREG-BioGrenz-Korr: Genetic report. 9 pages

5.4 Breeding programme

By Sina Ehlers and Björn Schulz

Set-up in 2011 / 2012

At the end of 2011 a total of 12 breeding cages were set up at 4 locations and were provided with a lot of nesting and hiding places, branches for climbing and continuous availability of fresh food. Dimensions: 1m x 1m x 2m, three each in Bordesholm, Plön, Molfsee / Stiftung Naturschutz SH and in the nursing sector of the wildlife park Eekholt, see Figure 101.

Since no Danish dormice were captured in 2011, 6 males and 6 females with a weight of <12 -15 g were at first taken from the main distribution areas of Schleswig-Holstein – Ostholstein (Eutin / Plön), Wahlstedt (special site motorway junction BAB A21 / B205), Aukrug (island population west of BAB A7 / Neumünster) and Lauenburg (Linau) – and were allocated to the cages.

In contrary to the other breeding stations, where no loss during hibernation took part, three hibernating dormice died within the cages in the wildlife park Eekholt in winter 2011/2012. The keepers of the wildlife park Eekholt were informed regarding the demands of dormice and their keeping.

However, the site conditions may not have been wet enough on the quite sandy soil as water loss due to breathing and perspiration was possibly too high during hibernation. After that, the cages were moved to a more humid place. In early 2012 the Schleswig-Holstein pairings did not have success breeding.

Figure 101: Breeding program: Three of the used breeding cages

New breeding population 2012

Considering the results of the genetic analyses, demonstrating that the hazel dormice from the island population "Aukrug" and from the roadsides of the motorway BAB A7 near the city Neumünster are genetically most similar to the Danish dormouse

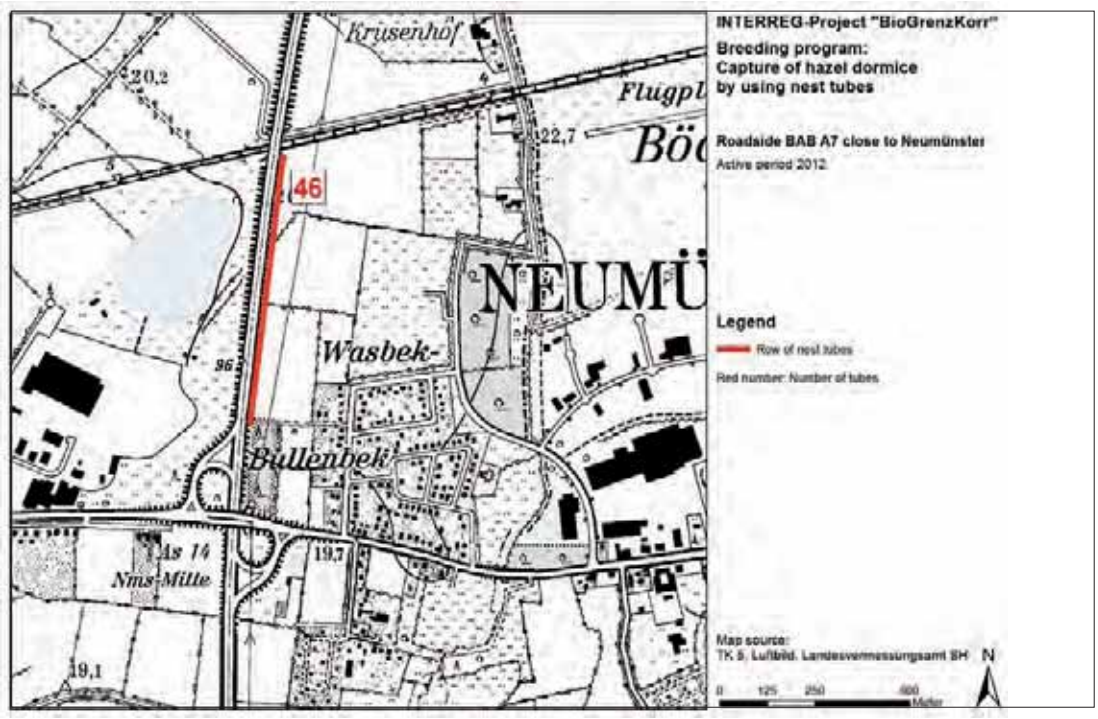


Figure 102: Location of the site "Neumünster (NMS) Mitte)" with nest tubes to capture dormice for breeding

populations (see above), the dormice, which were taken for breeding from the other regions of the federal state, were brought back to the habitats from which they were taken.

Furthermore, 100 nest tubes were set out in March 2012 to catch more dormice with appropriate genetic material for the breeding program in the two relevant areas of Schleswig-Holstein (Figure 105).

The Biologist Iris Pretzlaff (Hamburg University) installed and controlled 60 nest boxes in the area "Waldhütten" of the woodland complex Aukrug as part of her dissertation. Four dormice (2♂ and 2♀) used for this Hamburg University project was handed over to the project for breeding. After the first inspection on 08.05.2012, another male could be captured in this area.

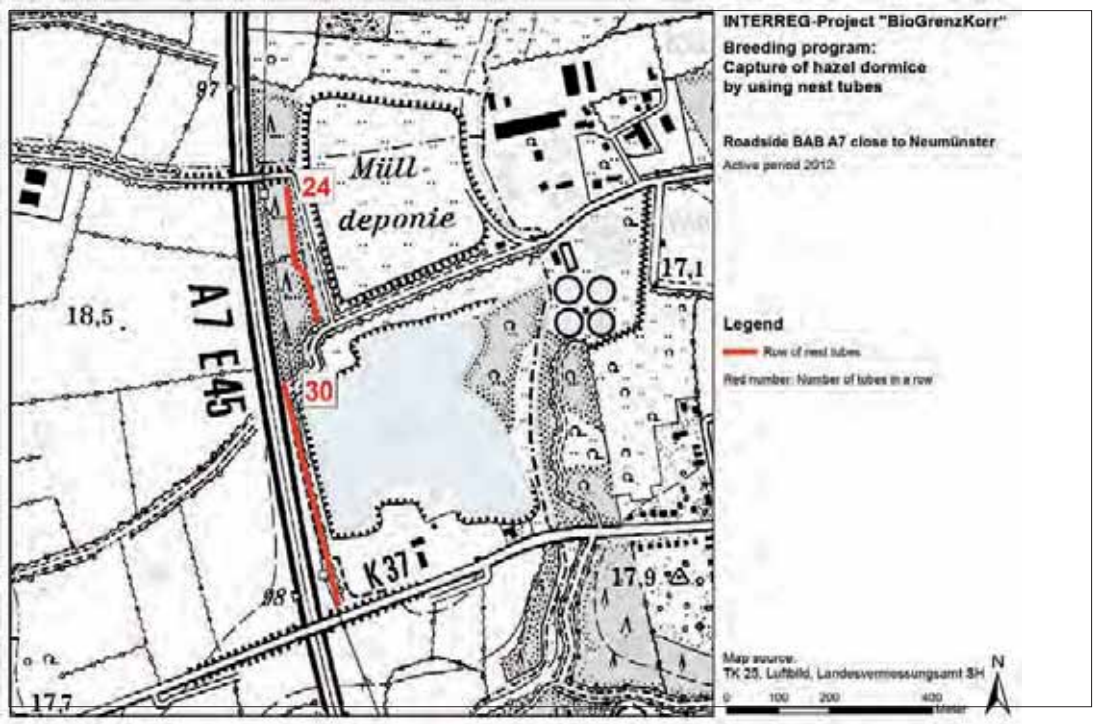


Figure 103: Location of the site " NMS KW" with nest tubes to capture dormice for breeding

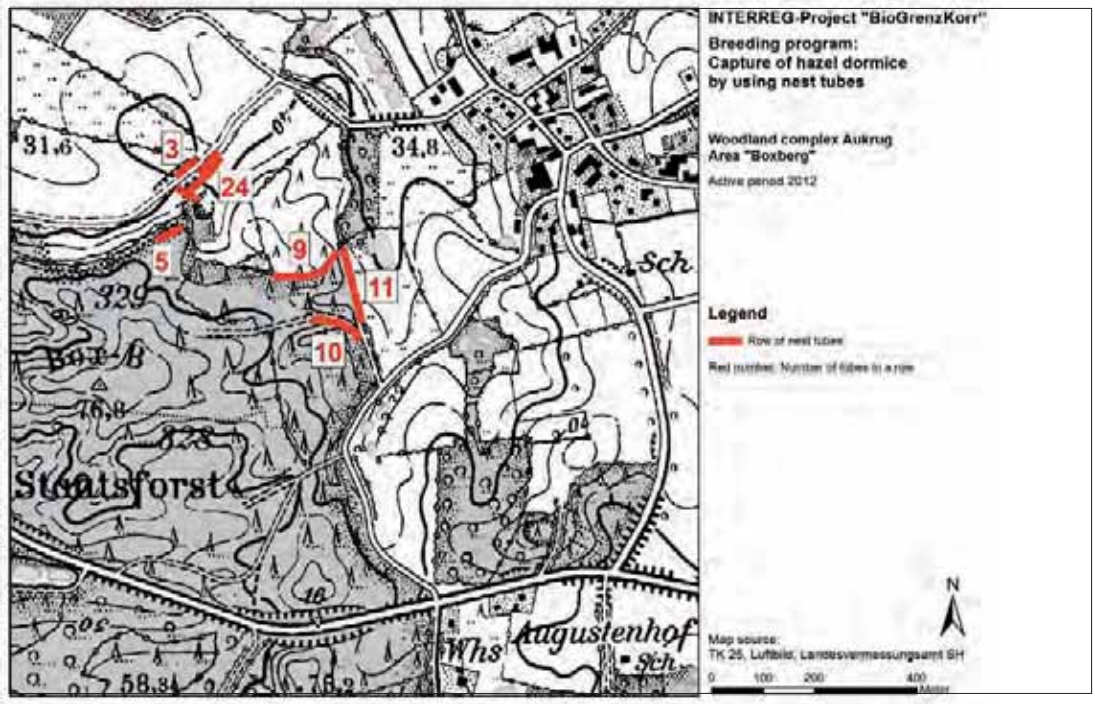


Figure 104: Location of the site "Boxberg" with nest tubes to capture dormice for breeding

Due to the lack of dormouse evidence in the nest boxes and tubes in the forests of Gråsten (see above), animals were captured at Fyn. The biologist H. Vilhelmsen had already installed nest tubes. 4 females and 4 males were captured within the woodland areas Sollerup, Kiestrup and Svanninge on the island of Fyn in mid-September 2012; DNA samples were taken from all (also individual markings) and the dormice were directly transported to Germany and allocated to breeding cages and mixed into German-Danish pairs.

The breeding pairs are shown in the following table.

Figure 105: Location of the four areas in Schleswig-Holstein (D) where hazel dormice were captured for breeding

Nov. 2012	left	center	right
Eekholt	♂ Sollerup/Kiestrup, DK	♂ Sollerup, DK	♂ NMS KW (Subadult), SH
	♀ NMS KW (mother), SH	♀ Boxberg, SH	♀ Svanninge, DK
Stiftung	♂ Waldhütten, SH	♂ NMS KW (Subadult), SH	♂ Sollerup/Kiestrup (Subadult), DK
	♀ Boxberg, SH	♀ NMS KW, SH	♀ NMS KW (Subadult), SH
	♂ Sollerup/Kiestrup (subad.), DK		
Bordesholm	♂ Boxberg, SH	♂ Waldhütten, SH	♂ Sollerup, DK
	♂ Sollerup/Kiestrup (mother), DK	♀ Svanninge, DK	♀ NMS KW, SH
Plön	♂ NMS KW, SH	♂ Waldhütten, SH	♂ NMS Mitte, SH
	♀ NMS KW, SH	♀ Waldhütten, SH	♀ Waldhütten, SH

Table 13: Breeding programme: Pairs November 2012.

Legend: colored background = related

Due to the capture of the Danish dormice two dormouse males with sufficient weight could be released at the place of their removal in Aukrug / Waldhütten and close to the city Neumünster.

At the beginning of hibernation 2012/2013 all of the dormice in the breeding cages were checked for weight and parasites. The few fleas which were found on some animals as well as in nests were removed. All dormice showed a sufficient weight. The cage floorings were provided with plenty of damp moss and leaves, the nesting sites were placed on the ground. The keeper Anna Behrens from the Wildlife Park Eekholt was informed about the upcoming winter care: The conditions in the cages seem to be too dry at the wildlife park, so the soil was kept moist using a commercial sprayer (2-3 times weekly spraying with water) to prevent the hibernating dormice from dehydration.

While checking the dormice for parasites and fitness in January 2013, one female in a cage at "Molfsee/Stiftung Naturschutz" seemed to be very thin and another female had a wound at her abdomen, so both were brought in extra, smaller cages for better observation. The rest of the dormice were fine (besides a few fleas and sometimes bare patches in the fur - the reason for this is uncertain, but the animals concerned were agile and in good condition). The majority of the animals were not in hibernation at this time.

The control of all breeding pairs in May 2013 (after a long winter) showed that four of the (25) dormice died while hibernation (two German females in Eekholt and one German female as well as one Danish male in Molfsee). A few of them may have been eaten/violated by shrews, because two dormice could not be found despite intensive search and many traces of mice / shrew were visible. Also one German male in the left cage in Molfsee had an injured jaw. But the bare patches within the fur of some animals regrew. And the wound at the abdomen of one female was healed. As a harvest mouse was observed climbing into the cage (its body sized just fitted into the mesh-size of the cage), species smaller than dormouse can get into and out of the cage.

Considering the deceased dormice it should be noted that also in nature a large proportion of dormice populations died during hibernation: Based on marked dormice, losses between 60 and 80% have been observed in some populations (Juškaites 1999 cited in Juškaites & Büchner 2010). After this inspection, the breeding pairs were mostly regrouped (). Looking at the wounded jaw of one German male and the still relatively poor condition of one small German female, both of these were held at this time alone.

Figure 106: Location of the three areas on the island Fyn (DK) where 8 hazel dormice were captured for the breeding programme

Table 14: Breeding programme: Pairs May 2013.

Legend: colored background = related

May 2013	left	center	right
Eekholt	♂ Sollerup/Kiestrup, DK	♂ Sollerup, DK	♂ NMS KW (Subadult), SH
		♀ NMS KW, SH	♀ Svanninge, DK
Stiftung	♂ Waldhütten, SH (wounded jaw)	♂ NMS KW (Subadult), SH	
		♀ Sollerup/Kiestrup (Subadult), DK	♀ Boxberg, SH (bad condition)
Bordesholm	♂ Boxberg, SH	♂ Waldhütten, SH	♂ Sollerup, DK
	♀ Sollerup/Kiestrup (mother), DK	♀ Svanninge, DK	♀ NMS KW, SH
Plön	♂ NMS Mitte, SH	♂ NMS KW, SH	♂ Waldhütten, SH
	♀ NMS KW, SH	♀ Waldhütten, SH	♀ Waldhütten, SH

Furthermore, it is noticeable that all of the captured dormice from all surveyed woodlands bite, whereas the German individuals do not demonstrate this behavior. Only from a small population in Hesse it is currently known that the dormouse bite there.

Shortly before the end of project period in August 2013 the first offspring (5 juveniles) of a mixed Danish-german couple was born (see article below from Fyns Amts Avis).

Figure 107: Sina Ehlers checking the breeding cages and hazel dormice

Fynske syvsovere skal redde truet jysk bestand

Om projektet

Hasselmusen

Musen og broen

midFyn.dk

Doktor Björn og hasselmusene

5.5 Resettlement

By Sina Ehlers

The primary aim of any reintroduction programs should be to establish a viable, free living population of a species, subspecies or race, which is globally or locally extinct or eradicated in the wild. It should be reintroduced within the original, natural habitat and distribution area of the species and should only require minimal management in the long term.

The resettlement of dormice in their former natural range is based on the following principles:

- The causes of extinction have to be resolved.
- The habitat must satisfy the requirements of dormouse.
- It must be possible in the long term, to establish a stable population.
- The political conditions for the success must be given.
- There must be no serious detriment of other native species.
- The preconditions shall be verified by a professional analysis, the program should be carried out by experts.

The main guidelines for the release of wild animals are taken into account, which were written by the SSC Re-introduction Specialist Group as "IUCN / SSC Guidelines for Re-Introductions" (IUCN 2012). The main points of the guidelines are summarized as a "checklist" below:

1. Protection of populations before resettlement
2. Before resettlement: Analysis of the causes of decline
3. Release only within the historical distribution area at least
4. Optimization of the settlement locations
5. Presentation of the expected success rate
6. PR work
7. Waiver of contrary nature conservation measures (e.g. spacious eradication of indigenous species)
8. Applicable law
9. Taxonomic / ecological closest population
10. No threats of source populations
11. Broad genetic variance (possibly mixed populations)
12. Acclimatization of the animals
13. Support by experts
14. Documentation of results
15. Time limit (and explanation at the beginning of the resettlement program)
16. Documentary evidence of genetics
17. As possible in two stages:
    - trial phase
    - establishment phase

In addition, a control of the success consisting of an appropriate monitoring is to be ensured and to be carried out during and after the resettlement period.

Within the project area of the BioGrenzKorr-Project, the hazel dormouse on the German side of the border seems to be entirely extinct as well as in large parts of Jutland / Denmark.

But today it seems that the area on the German side close to the border is potentially a good dormouse habitat with its large forests and largely coherent hedgerow-network. A possible reason for the disappearance of dormice from current potentially suitable habitats seems to be the forest management of past years, in addition to the loss of habitat connections and shrubs. Especially from the Middle Ages to the 18th Century the forest area in Schleswig-Holstein, as in Denmark, decreased significantly: there were large-scale clearings of woodlands in many places in the course of the agricultural reform. Therefore, the disappearance of a species from places where it may formerly have been present is likely to be a result of past events that are no longer given today. According to this, large areas of present suitable dormice habitats were not populated, as the hazel dormouse is unable to recolonize these areas naturally due to the lack of a continuous wood-network.

As part of the project respectively two large areas of the "Stiftung Naturschutz SH" (Schäferhaus Nord and Süd) and the "Schleswig-Holsteinisches Landesforsten" (Woodland of Handewitt and Kluesries) were improved by appropriate habitat management targeted at demands of hazel dormice. Furthermore, the mentioned proprietors are committed to ensure the necessary management of the sites in the future, so that very suitable dormouse habitats will be preserved also in the long term. Thus, the project area shows a sufficient carrying capacity for the development and long-term maintenance of a viable population.

According to Bright et al. 2006, all four surveyed and improved sites are currently suitable as resettlement sites for dormice.

Sites suitable for releasing dormice have the following features:	
1.	A diverse, unshaded and productive understorey, preferably dominated by hazel.
2.	A variety of other supportive tree and shrub species.
3.	At least 20 ha of suitable habitat, less only if the site is well connected to other woods.
4.	At least 100 nest boxes in place, with appropriate monitoring arrangements.
5.	A commitment to suitable site management in the future.

Table 15: Features of suitable sites for releasing (Bright et al. 2006). dormice

Which and how the sites will be determined for the first resettlement of dormice depends on the number of juveniles produced within the breeding program at the relevant time.
Before the release of the animals at the resettlement sites, a combination of nest boxes and nest tubes should be installed in a density of 20 to 25 per hectare, to provide a sufficient number of nesting sites and for the future monitoring.
The aim of releasing the animals is to establish a viable population, not "just to let them go". Therefore, it is important to introduce the animals to the new habitat. Thus, for resettlement itself the so-called "soft release" is applied (e.g. Bright & Morris 1994, Bright et al. 2006, JUŠKAITIS & Büchner 2010): For soft customization of resettled dormice in their new habitat they should first be established in "pre-release cages" made from welded mesh (50 x 50 x 100 cm). Each cage should contain one or two nest tubes and one nest box and plenty of fresh hazel branches to provide shelter and allow the animals to climb about.

The timing of release is critical (see. BRIGHT et al. 2006):

"If animals are let go late in the summer there will be plenty of food for them, but any offspring they produce will have too little time to fatten up for the oncoming winter. This is important because the production of a large number of young in the first year of reintroduction is critical to its success. Releases should therefore take place no later than early July. Animals should be introduced into the pre-release cages in mid-to late-June and kept there for at least 10 days to become accustomed to their new surroundings. They must be fed fresh fruit like apple daily, with a constant supply of biscuit, peanuts and sunflower seeds. If food is not eaten, the cage should be opened and the health of the animals checked. Releases should be made during fine weather, avoiding cold periods, by making a small opening (about 3 cm) in the cage roof. This will allow the dormice to come and go as they please. The aperture should be small enough (about 5 cm x 5 cm maximum; B in Fig) to exclude squirrels and birds that will otherwise raid the cages for food. Food must be continuously available in the cages, with the fruit renewed daily, for at least 2 weeks. After that, the fruit may be slowly withdrawn. This supplementary food is important during the establishment period. It also helps maintain body condition in the females so that they can successfully produce and rear their young. Moreover, feeding helps to maintain a cohesive population; without it dispersal is likely, reducing the probability of breeding. It is very important that the new population should breed and build up its numbers as soon as possible. Once the natural fruit and nut crop is ripe (usually late August), all artificial feeding should cease in order to encourage the development of natural feeding habits. By late August, the animals should be independent and their cages can be removed, leaving the nest box in place. All the nest boxes should be checked in September and October to count and weigh the dormice and to note numbers of young. After this they should be left alone until May the following year. There should be monthly monitoring of the nest boxes to observe progress

Release of small numbers of animals carries a disproportionate risk of failure. Translocations should therefore be based on releasing groups of 30 or more animals. Released animals should weigh at least 16 g, preferably more than 20 g, or they may have insufficient reserves to survive the first few days.

Ideally, each cage should contain a male and female pair of dormice that have been familiar with each other for several weeks, as they are more likely to stay together. It is also possible to use single dormice, a mother and litter of young, or one male with two females. Release cages containing adult males must be 100 m apart or fatal aggression may result when the animals are released. Cages with only females should be sited inbetween male-only cages. Overall, the aim should be to release similar numbers of males and females."

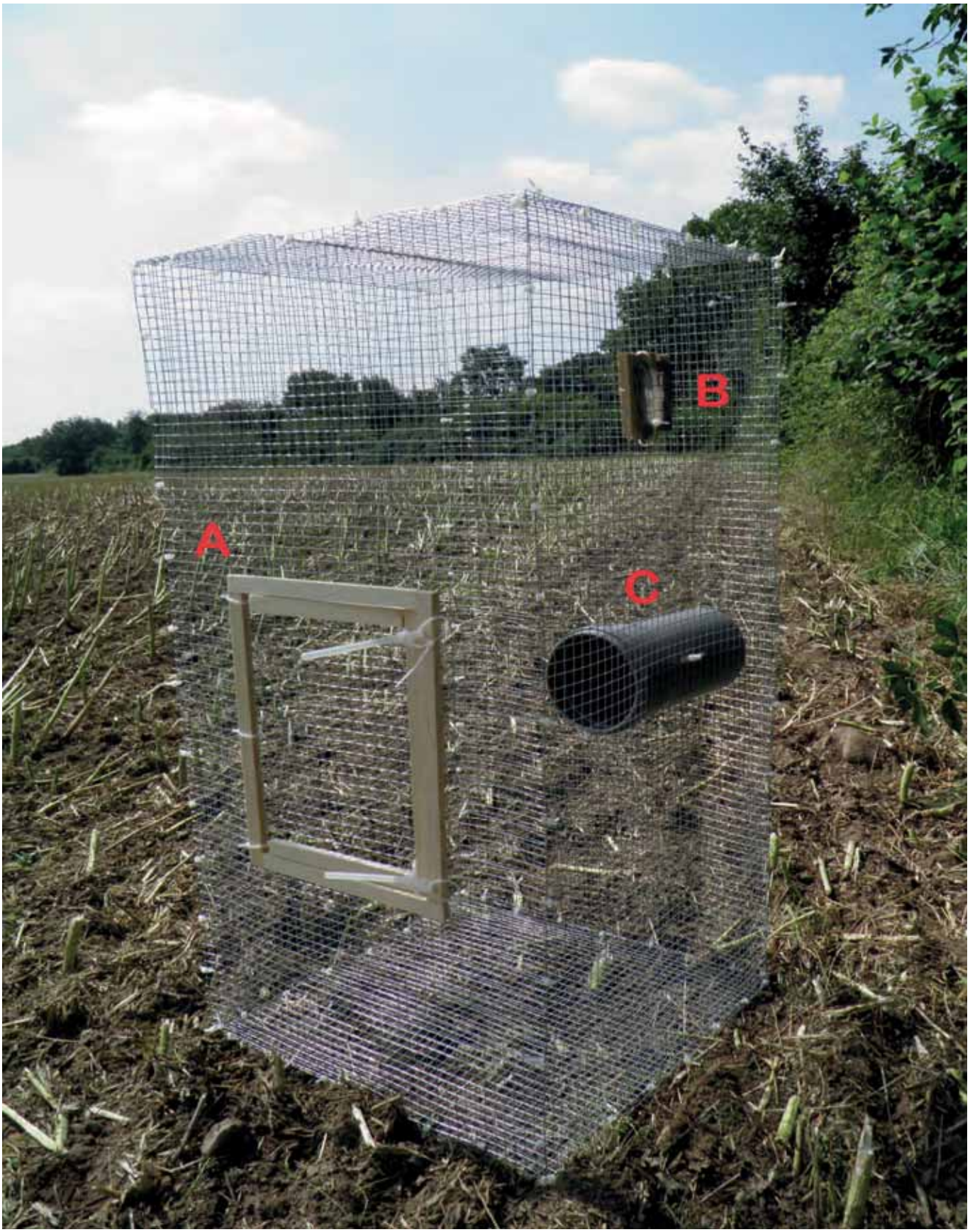


Figure 108: Pre-release cage (50 x 50 x 100 cm) from welded mesh

Comments: A = aperture on the front for access, B = small aperture at the side for the dormice to come and go as they please after opening, C = plastic pipe as "feeder tube".

Figure 109: Installed pre-release cage (closed) with nest tubes and a nest box, fresh branches to provide shelter and allow the animals to climb about and with fresh food available.

Figure 110: Detail of an installed pre-release cage (open) with nest tubes and a nest box, fresh branches to provide shelter and allow the animals to climb about and with fresh food available.

Capture, breeding and re-introduction of dormouse in the border area Gråsten-Flensburg, as part of the Interreg project BioGrenzKorr – an official statement

The reason for this statement is a specific inquiry from the Stiftung Naturschutz Schleswig-Holstein (SN-SH) applying for permission to capture Danish dormouse with the purpose of breeding and reintroduction on sites south of the border, where dormice died out during the last decades. Forest and Nature Agency (SNS), Fyn is leadpartner in the INTERREG project BioGrenzKorr. The project is an EU-financed cross-border project. A collaboration between the Danish partners SNS-Fyn and SNS-Sønderjylland and the German partners Stiftung Naturschutz Schleswig-Holstein and Schleswig-Holsteinische Landesforsten. A central aim of the project is to improve habitats and corridors between habitats of Annex IV species with a focus on dormouse, birchmouse and bat species.

Population viability and genetics: The overall aim of the project group is to safeguard and develop dormice population, a stable metapopulation on best sites should be establishes as soon as possible. Therefore habitat improvements in existing and potential dormice sites are conducted, habitat corridors are developed. And to secure the specific population (due to long-term isolation) the partners want to re-introduce dormouse into state-owned sites around Flensburg. There is historic evidence that the species has previously been in the area. The area has been investigated for dormice this autumn monitoring 500 nesttubes and no dormice were found, so extinction is verified (though investigations are still in progress). In contrast to this, preliminary expert comparisons of the projects sites with known dormice sites in eastern Holstein lead to the conclusion, that present habitat quality are suitable for viable dormice populations. So the reasons for the extinction of dormice around Flensborg remain unknown. This leads to the conclusion, that Danish small and isolated populations are extremely vulnerable! And because still nothing is known about the viability of the South-Jutland populations (no details are known about populatios) it must be taken into consideration that populations could die out at any time. Still very little is known about the genetic variation between dormice populations found in Europe. In order to avoid any issue of genetic differences between populations the idea is to capture animals from the nearest population, which is found in the woods around Gråsten 20 km to the northeast. The nearest German population is found approx. 100 km south of Flensburg in Holstein.

We know very little about the population in Gråsten. It is probably small in size, thus not very stable and therefore vulnerable with the threat of becoming extinguished at any time. The overall target must be to secure this very local population, increase its population size and to combine it with other sites, in a long term a safe metapopulation structure must be developed. So a strict protection of present populations is neededleaving the population undisturbed not doing any interventions. On the other hand, this project is an opportunity to strengthen the population, because it is very vulnerable and in need of interventions. The question is whether it is possible? If it is possible to create a "mirror population" south of the border, it becomes possible to strengthen the Gråsten population, as a proportion of the offspring will be returned to Gråsten, without changing the genetic pool.

Capturing: Research has shown that dormice born early in the season are able to breed late in the same year. Mature females may also get second or third litter late in the season. Juveniles from these litters (late born juveniles) have very low probability to survive the winter because they are not able to consume enough food before they go into hibernation. Research shows that approx. 80% of these juveniles do not survive the winter. The intention is to base the capture and breeding on these "excess" juveniles which is not expected to survive.

For capturing a tight grid of 16 nesttubes per hectare are laid out. The tubes are installed in autumn. Research has shown that the dormouse is very willing to build nests in these tubes (Juskaitis, 2008). Monitoring of the tubes gives a good overview of the population in the area and is the basis for "collection" of late-born-juveniles, just before they leave the nests. In other words, no traps are used for capturing. This method means that the breeding population is not affected and only excess animals are taken. It is the intention to remove 6 females and 4 males when they are 4 weeks old – that is the time when they usually leave the nest.

Breeding: Breeding and re-introduction takes place on the German side of the border. The animals are fed in order to be able to overwinter naturally. In spring and summer the animals breed in captivity. The Germans have experience in handling dormouse from research and conservation projects. Positive indications regarding the necessary permissions have already been given from the German authorities.

Release: Offspring are set out in early autumn, when food supply in nature is abundant. The release is a so-called - soft release. This means that the animals are released in a release cage, where they are fed for at least two weeks. Research has shown a 100% survival rate after 10 days using this method (Bright and Morris, 1994). This method gives the animal time to explore the local area and discover food sources without being under pressure to find food.

Habitat Improvements: The main activities in the INTERREG project concerns habitat improvements for the species in focus. These are made both in Gråsten forests and in forests and corridors on the German side. Plans include improvements of existing hedgerows and woods by increasing the proportion of fruit carrying bushes and scrubs. Second, through thinning of existing hedgerows and forest edges, creating light for the groundfloor, in order to increase the diversity of herbs and shrubs. In addition planting of bushes and shrubs-species in order to improve hedgerows and forest edges are made. Finally, new fence are planted in order to link existing habitats and creating a larger coherent corridor network. More detailed plans for habitat improvements are available.

Monitoring: In order to follow the released animals, dormouse nestboxes are installed (30 pr.ha) - boxes which the animals willingly use for both breeding nests and summer nests. The boxes make it possible to monitor the population systematically over several years.
Why don't we conduct these actions - that are intended for introduction - in Denmark?

Denmark has no tradition and therefore no experience with this type of nature conservation - capture, breeding and reintroduction of wild animals - especially when it comes to the dormouse. In Germany they have some experience with breeding programmes. Through this project and as an end in itself this knowledge may benefit SNS. Capacity building in use of this method may be transferred to conserve other Danish dormouse populations. This is particularly relevant for the vulnerable populations on Sjælland. However, the main objective is to secure an extended population of the dormouse from Gråsten. The cooperation will, although this mirror population is found south of the border, help to secure the Gråsten population and stresses the importance of nature conservation cooperation across national borders. One of the main objectives of INTERREG projects is to strengthen relationships, including the sharing of knowledge between actors across the border also on biodiversity. Collaboration on breeding of dormouse is a very specific and fine example of this cooperation.

5. 6 Suggestions for future actions

By Björn Schulz

Long-term population monitoring

- Long term nest-box sites are present at re-introduction sites for specific monitoring of resettlement success. The nest-boxes also support the population as such.
- Monitoring outside resettlement sites is needed after a few years using nest tubes.

More habitat management in the projects region:

Suggested corridors for improved connectivity between habitats in the border region is so fare only drawn on maps. Collaboration between local authorities and the local hedgerow planting cooperative and farmers is obvious for implementation of habitat network, if possible.

‘

6 Literature

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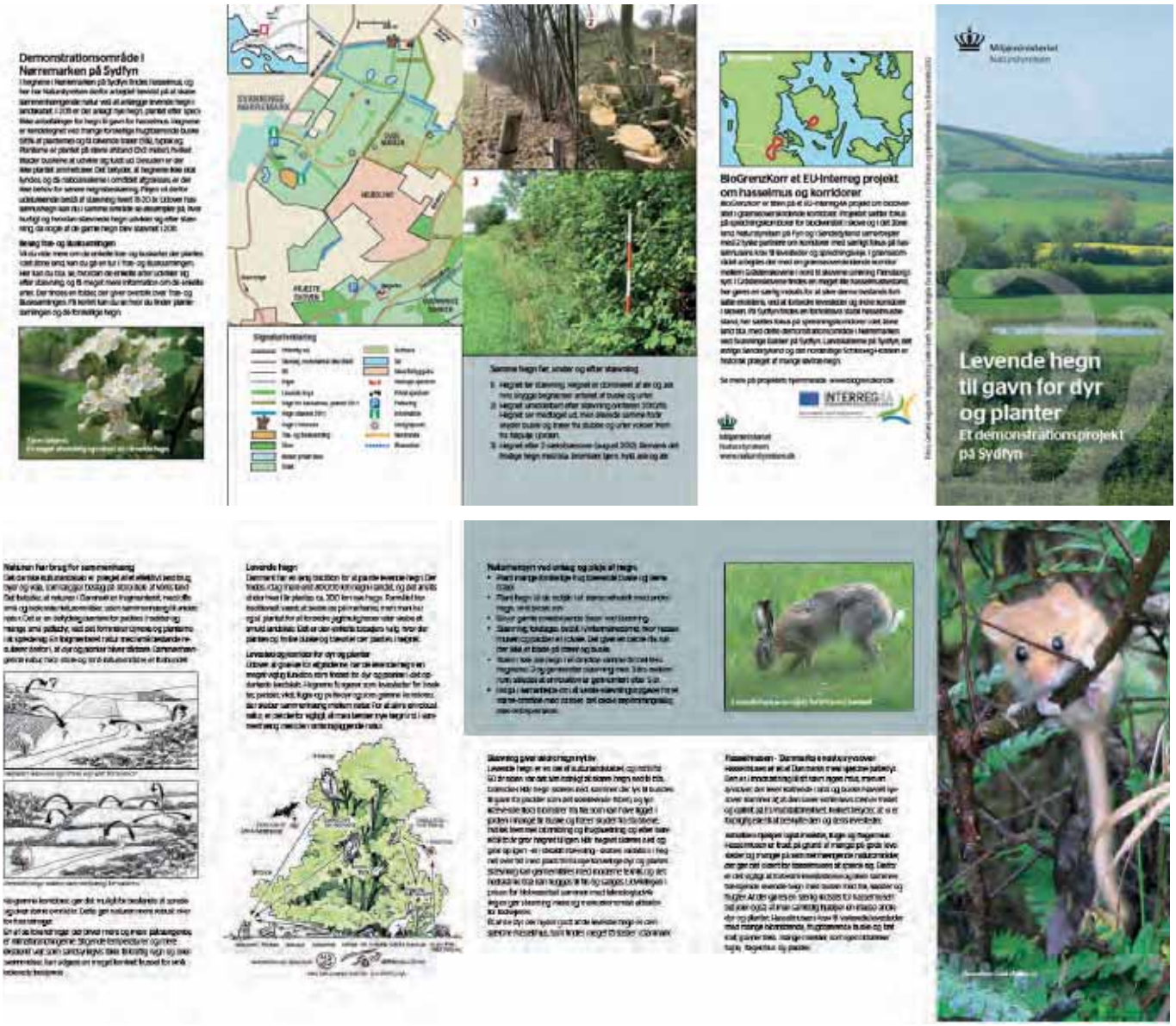
7 Appendixes

Appendix 1:

Karen Ellemann the then Danish Minister of Environment and the project partners meet on 20th August 2010

Appendix 2

Hedgerows for animals and plants – A demonstration project on Southern Fyn, is a flyer on hedgerows for nature conservation and improved connectivity in general and a guide to the hedgerow demonstration area in Nørremarken on Fyn.



Appendix 3

Roll-up poster presenting the project at the international dormouse conference in Görlitz September 2011

Appendix 4: Costs of habitat improvements in Gråsten Forest

The following key figures have been calculated based on the actual costs*:

Costs of different actions in Grasten forest

Core areas		
Model 1		
	Surface clearing	940 € / ha
	Plants and planting (10.000 plants / ha)	13.420 € / ha
	Fence and fencing	5.230 € / ha
	total	19.590 € / ha
Model 2		
	Surface clearing	810 € / ha
	Plants and planting (4.500 plants / ha)	4.830 € / ha
	total	5.640 € / ha
Corridors		
Model 1 & 2		
	Surface clearing	810 € / ha
	Plants and planting (4.500 plants/ha(1,0 ha equal to 833 meter of corridor)	4.830 € / ha
	total	5.640 € / ha
Thinning in forest edges		
	Total (Cost and income from felling as part of preparation of the areas are not included. Cost for administrative staff is not included)	0 € / ha
Management costs (Expected cost for management of the areas)		
	Core areas : Removal of fence (50 m/hour - 1.100 m/ha):	810 € / ha
	Corridors : Other forest management costs	0-100 € / ha
	Forest management costs	0-100 € / ha
	Forest edges	0 € / ha

* = Cost and income from felling as part of preparation of the areas are not included. Cost for administrative staff is not included.

Appendix 5: Coppicing of hedgerows in demo-area Fyn: production and costs

	Hedgerow	Felling	Transit	Forwarder	Woodchips	Woodchipping			Species
	length meter	Hours	Hours	Total hours	Expected rm	Hours	Expected rm	Actual rm	
1 Hedge Sollerup	250	4,5		5,5	90	1	90	80	Corylus, P.spinosa, Acer etc.
2 Hedge Odense vej	220	4	1,5	4,75	90				Syringa, P.spinosa, P.cerasifera
3 Hedge Golfbane	210	5		5	110				Acer, Crataegus, Sambucus
Coppice Golfbanen	1350 + 250m2	3	1	1,5	80	3	355	210	Corylus, A.Campestra, Q.robur
4 Hedge Nørremarken	70	1		0,75	15				Prunus spinosa
5 Hedge Nørremarken	180	3		1,5	60				Prunus spinosa
6 Hedge Nørremarken	275	4		1,5	90				Acer, Fraxinus, Crataegus etc.
7 Hedge Nørremarken	70	1	0,5	1	20				Prunus spinosa
8 Hedge Nørremarken	50	1		1	15	3	255	195	Syringa vulgaris
9 Hedge Nørremarken	200	3		2	60				Crataegus
10 Hedge Nørremarken	200	3,5	1	4,5	70				Syringa vulgaris, P.spinosa
11 Hedge Bjergvej	50				20				Syringa vulgaris
Exstra hedge	175	1	0,5	1	20	0,5	40	45	Syringa vulgaris
Coppice Bjergvej	5000 m2	6		2,5	180	1,5	180	105	Betula pendula
I alt hegn	1950	40	4,5	32,5	920	9	920	635	

Cost calculation (Euro)	1 Euro=	7,45 DKR							
meter hedge/hour		63	433	68				0,23	rm/meter hedge
Costs pr. hour		148	148	107		322			
Start up cost		201		134		201			
Total cost machines		6107	664	3624		3101			
Cost pr.rm		10	1	6		5			
Total machine costs	13497							21	Total cost/rm
Total Income woodchips	8523							13	Income/rm
Total net cost	4973							8	Net cost/rm

Appendix 6: Genetic methods

Microsatellite genotyping

8 successfully amplified polymorphic loci (modified after Naim et al. 2009) were combined into multiplex sets according to their size and fluorescent label and subsequently amplified via multiplex polymerase chain reactions (PCR) in a Mastercycler ep Gradient (Eppendorf). The multiplex PCRs contained 5 ll of Multiplex PCR Master. The multiplex PCRs contained 5 ll of Multiplex PCR MasterMix (Qiagen), 0.2 lM of each primer and deionized waterto the final volume of 10 ll. Cycling conditions included aninitial step at 95C for 15 min, followed by 35 cycles of denaturation at 94°C for 30 s, annealing at 60°C for 90 s, and extension at 72°C for 30 min. 2 µl of PCR product were mixed with 0.3 µl of Liz GS500 (Applied Biosystems) and 12 µl of Hi-Di formamide and loaded onto an ABI 3130 Genetic Analyzer in the University of Bruxelles. The DNA fragments were analysed using GeneMapper v.3.7software (Applied Biosystems).

Data analysis

To identify the likely number of genetically distinct groups within Muscardinus avellanarius, we used Bayesian assignment as implemented in Structure version 2.3.3. (Pritchard et al. 2000). The program simultaneously assigns individuals probabilistically to the population of origin or to more than one population if they are admixed. STRUCTURE analyses were conducted by running a series of independent simulations with different proposal for the number of simulated clusters (K), testing all values from 1 to 10. Each run used an admixture model with correlated frequencies, no prior population information, 1000000 MCMC after a burn-in of 100000 iterations. 10 replicates of each run were conducted to test for convergence of the MCMCs The K value that best fits the structure of the data set is revealed by the increasing likelihood of the data and is to be chosen as the smallest value of K capturing the major structure in the data. The number of k was compared visually with the geographical position of the sampling sites.

The genetic relationships among all genotyped individuals were displayed by factorial correspondence analysis (FCA) using GENETIX version 4.05.2 (Belkhir et al. 1996–2004). The distribution of populations in 2D space was compared visually with the geographical position of the sampling sites. The FCA is a type of factor analysis that detects the best linear combination of variables (in this case, allele frequency at different loci) describing the variation between individual observations. Pairwise FST value between populations was calculated using the Arlequin 3.0 software. Fst (Fixation index (FST) is a measure of population differentiation, genetic distance, based on genetic polymorphism data. The values range from 0 to 1. A zero value implies complete panmixie meaning that the populations are interbreeding freely. A value of one would imply that populations are completely separate. The mean number of alleles (A), and observed (Ho) and expected (He; Nei 1978) heterozygosities were calculated using GENETIX software.

INTERREG-BioGrenzKorr - part 1

Cross-border conservation of the hazel dormouse:

(Muscardinus avellanarius)

Presence, genetics, management and perspectives

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