Monitoring of the raised bog
Holmegaards Mose 2012

Miljøministeriet
Naturstyrelsen

Monitoring of the raised bog Holmegaards Mose 2012

Report by AGLAJA for Nature Agency, Storstrøm, 2012
Field studies: Irina Goldberg and Eigil Plöger
Text and photos: Irina Goldberg and Eigil Plöger

AGLAJA
v. Eigil Plöger
Lundevej 48, Vråby
4652 Hårlev
www.aglaja.dk

Contents

Summary

Holmegaards Mose is the largest raised bog in East Denmark that has been subject to drainage and peat cutting in the past. The LIFE project in Holmegaards Mose is aimed at restoring active raised bog habitat in previously wooded/drained areas as well as at improving conditions for this and the secondarily originated habitat types in the area.

In 2012 a survey of the vegetation and a number of rare, protected species (Fen Orchid *Liparis loeselii*, a water beetle *Graphoderus bilineatus* and butterflies *Boloria aquilonaris, Cynonympha tullia* and *Plebius optilete*) was done after the clearings at the site had been competed. The results of this survey are described in the report.

Survey of the vegetation gives a status of eight parts of the raised bog within the project area where the effect of restoration activities (removal of birch forest and raising of the water table) is expected to be different. The westernmost and easternmost parts of the project area are not monitored. Regular measurements of water level in all study areas are needed.

In the population of Fen Orchid, *Liparis loeselii* a decline in numbers of vegetative and generative plants was observed since 2009. In 2012 there was a minor increase in the number of plants in the permanent plot. The population is overshadowed by taller herbs and shrubs, and affected by periodical flooding of the habitat.

Mapping of potential habitats for *Graphoderus bilineatus* (2011) revealed that five flooded peat pits could be suitable habitats for the species. In winter / early spring 2011 trees and bushes were removed from the edges of two investigated pits, no. 29 and 30. All though the habitats have become more exposed for wind due to the clearings, this action at the same time partly improve spreading potential of the beetles. It is recommended to allow some re-growth of trees and bushes along the pit edges. This will protect the habitats from the influence of wind and thereby make them warmer.

Boloria aquilonaris that was observed both in 2010 and 2011 is apparently not present in Holmegaards Mose any longer. Already in 2011 there was a rather drastic decline in the number of individuals compared to 2010. In 2012 two new common butterfly species were observed – *Gonepteryx rhamni* and *Maniola jurtina*.

1. Introduction

Holmegaards Mose is the largest raised bog in East Denmark that has been subject to drainage and peat cutting in the past. This has resulted in the loss of raised bog habitat (7110) and development of a number of secondary habitat types in the old excavation areas, e.g. wooded bog, quaking bog, rich fen and flooded peat pits.

Holmegaards Mose is a part of a Habitats area H145, and it has been selected for the presence of the Annex I habitats Active raised bog (7110), Degraded raised bog capable of regeneration (7120), Transition mire and quaking bog (7140), Calcareous fens with *Cladium mariscus* (7210), Alkaline fen (7230) and Annex 2 species *Liparis loeselii* (Fen Orchid) and *Graphoderus bilineatus* (a water beetle) /9/.

The LIFE project in Holmegaards Mose is aimed at restoring active raised bog habitat in previously wooded/drained areas as well as at improving conditions for this and the secondarily originated habitat types in the area.

In 2012 a survey of the vegetation and a number of rare, protected species (Fen Orchid *Liparis loeselii*, a water beetle *Graphoderus bilineatus* and butterflies *Boloria aquilonaris, Cynonympha tullia* and *Plebius optilete*) was done after the clearings at the site had been competed. The results of this survey are described below.

2. Survey of vegetation and re-growth of birch and shrubs

2.1. Methods

In 2010 the project area was divided in six study areas with various vegetation types, where the effect of restoration activities (removal of birch forest and raising of the water table) was expected to be different. Within each study area a number of permanent plots were installed. In addition two permanent transects were established in the eastern part of the study area. For a detailed description see the report “Baseline monitoring in the raised bog Holmegaards Mose 2010” /4/.

Every plot consisted of two circles – with a radius of 5 m and 15 m. In 2012 only the 15 m circles were investigated where the coverage of open water surface, shrubs, trees and bushes < 1 m and > 1 m tall was estimated. The data are presented in Appendix 1.2.

From the center of two plots in each study area / transect panorama pictures of the site and vegetation were taken with a digital camera.

The field work was carried out in October and November 2012.

2.2. Results

In the previous reports /4, 5/ the vegetation and restoration activities within each study area / transect were described. After the last survey in 2011 the birch wood was

removed completely in the northern half of transect 2. In addition to the permanent fenced grazing area in the western part of the bog (study area 2) movable fences were established in several places (Appendix 1.1), both in the north-western part of study area 6 and outside the areas and transects where the vegetation survey is carried out. These fenced grazing areas will only exist for two years at a time, allowing a more dynamic grazing regime. The areas with the most birch re-growth and the highest need for treatment will receive the highest grazing pressure.

In the study areas 3 and 4 as well as in both transects where the birch forest was removed in 2010-2011 re-establishment of vegetation is taking place.

Since 2010 the plan of restoration activities has been revised /12/. Changes in the original planning mean that in the westernmost and easternmost parts of the project area where the birch forest was cut and the water table is expected to raise, the vegetation development is not monitored (Appendix 1.1).

As a result of ditch blocking the western part of the project area where the plots are located seems to be more humid than in autumn 2010 when the survey began, and the open water surface within some of the investigated plots has become larger, particularly in the study area 5 which eastern part is constantly flooded (see below). There have been established only 4 water data loggers within the study areas (in plots 3.2, 6.1, 6.3 and 6.7); all of these are located in the parts of the bog where the water level is not expected to raise according to the model COWI 3.1 /12/.

2.2.1. Vegetation changes in the six study areas

Area 1 ("Westphalerskæret"): Old peat pit with secondary alkaline fen vegetation overgrown by *Phragmites communis*. No remarkable changes in the vegetation have been observed since 2010. It seems like the water level is raising slowly, at least the open water surface has increased.

Area 2: Degraded bog dominated by shrubs and *Molinia caerulea*. Despite grazing by sheep the coverage of birch (predominantly < 1 m tall) seems to be increasing.

Area 3: The part of the area where the birch forest was felled in 2010-2012 is dominated by *Molinia caerulea* and *Myrica gale*. The coverage of peat mosses is highest in the wettest, central part of the area. A part of the area north of plot 3.3 and west of plot 3.1 is dominated by *Phragmites australis*, and the water seems to be enriched with nutrients.

Area 4: Removal of *Betula pubescens – Molinia caerulea* woodland started in 2010 and was completed in 2011. The dead wood was removed from the bog in the late autumn of 2011. Re-growth of *Betula pubescens* and *Myrica gale* takes place, and *Molinia caerulea* dominates the vegetation (Photo 1).

Photo 1. Vegetation re-establishment in the south-eastern part of area 4 (plot 4.2). *Molinia caerulea* has become a dominating species.

Area 5: Degraded bog dominated by *Molinia caerulea,* towards north moist depressions / old peat pit with *Sphagnum* spp., *Vaccinium oxycoccos, Eriophorum angustifolium* and *Drosera rotundifolia*. Grazing by sheep stopped in the end of 2010 / beginning of 2011. Since then the coverage of shrubs and birch has slightly increased. The open water surface within some of the investigated plots has become larger, particularly in plot 5.5 located in the eastern part of the area that is constantly flooded by the water enriched with nutrients. *Phragmites australis* is spreading from the minerotrophic flooded bog east of the blocked ditch (Photo 2).

Photo 2. Eastern part of study area 5 is flooded with water enriched with nutrients. *Phragmites australis* is spreading.

Area 6: Bog vegetation is dominated by peat mosses and shrubs, and the surface micro-topography with hummocks and pools is developed at some places. The central part of the area bears the stamp of peat cutting in the past, and much of the area looks dry, dominated by heaths. Although the area seems to be more humid then in the beginning of the survey, no remarkable changes in the vegetation can be observed.

2.2.2. Vegetation changes in the two transects

Transect 1: Birch wood was removed completely in the area located north of the long and narrow old peat trench that is crossing the transect in its southern part (plots 1-15). The vegetation is re-establishing after the last year clearings (Photo 3), and *Molinia caerulea* is abundant. The open water surface has increased particularly in the northern part of the transect.

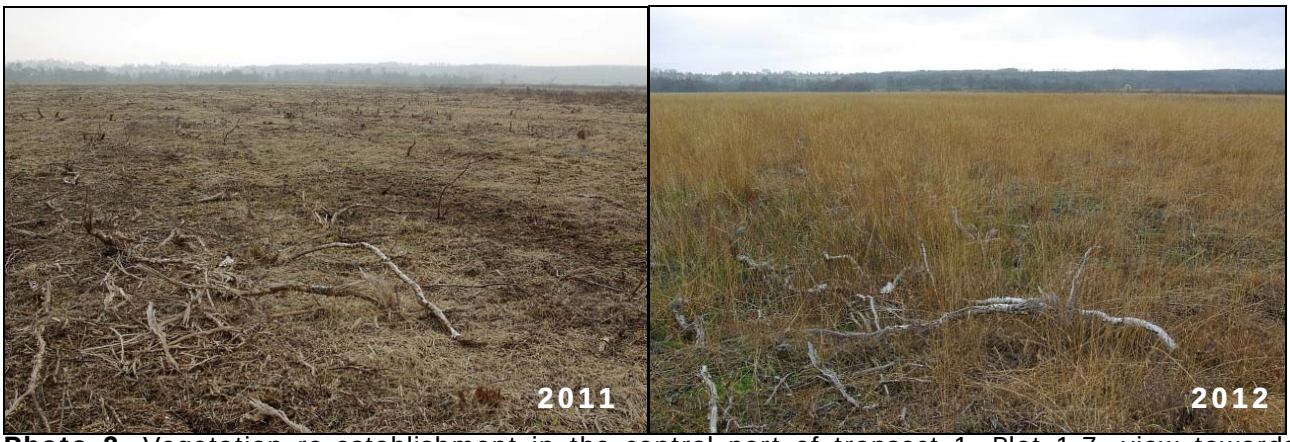


Photo 3. Vegetation re-establishment in the central part of transect 1. Plot 1.7, view towards south.

Since there will be no restoration activities in the southernmost part of the transect situated in a dry birch forest, the plots 18-21 will not be monitored any longer.

Transect 2: The forest had been partly (in plots 1-2 and 9-13) removed in 2010 before the field survey was done. The southernmost part of the transect (plots 14-16) was cleared in 2011, and most of the northern half (plots 3-8) in winter 2012. The vegetation is re-establishing after the last years cuttings (Photo 4): *Eriophorum vaginatum*, peat mosses and shrubs are regenerating at wet places and *Molinia caerulea* at the dry ones.

Photo 4. The birch was cleared in the central part of transect 2. Plot 2.7, view towards south-east.

2.2.3. Conclusion

The time since drainage of a bog has started strongly affects the hydrological and vegetation changes in the ecosystem. In recently drained areas, it is likely that restoration can help the area to revert to its original habitat type. The longer the area has been drained, the more difficult it is to fully recreate the original stage. In such cases, restoration leads to a 'new natural state', different from the original, but nevertheless recognizable as some other peatland habitat type /15/.

In Holmegaards Mose, the vegetation of the former wooded bog seems to be changing back to the state of the year 2010, before the restoration activities began: in the places where the birch forest floor vegetation was dominated by *Molinia caerulea* and/or *Myrica gale* the two species are prevailing, and the parts of wooded bog where the coverage of peat mosses and *Eriophorum vaginatum* was high look more like a "pristine" bog. This is very likely due to the differences in hydrological conditions that have existed in the different parts of the project area: the relative position of the water table within the peat as well as the water and peat chemistry.

Since drainage ditches in Holmegaards Mose were blocked in 2010 in order to raise the water level the project area where the survey of vegetation is taking place seems to become more humid. Since the measurements of water level have not been carried out it is impossible to say for sure which parts of the bog have undergone the greatest changes. The open water surface is a subjective parameter and it can be a result of too high ground water level, peat destruction by machinery as well as flooding by the water from ditches.

The assessment of basic hydrological parameters is an essential part of peatland monitoring. Water levels and water level fluctuations play a major role in peatland ecosystems. Too high water levels may reduce plant productivity which negatively impacts on peat formation. Too low water levels may encourage plant productivity /13/, but also impede a number of processes taking place within the peat that affects both its physical and chemical properties: an increase in the air-filled porosity of the peat, which in turn affects microbial processes and thus decomposition rates /6/. A number of studies have observed that the exchangeable cat-ion content in drained peats is lower than in undisturbed peats, and total concentrations of N and P often increase whereas K always decreases in the topsoil (0–20 cm) of peat after drainage /8, 14/. Besides, the absence of the active peat-forming layer and associated natural vegetation generally contribute to increased run-off from the peat bog /10/.

Measurements of water level changes should be carried out regularly to assess their whole spectrum (e.g. due to weather changes, either with data loggers or at least once every week or fortnight). To detect hydrological interrelationships between the peatland and its surroundings information on various hydrological processes have to be gathered /13/.

Most attempts at peatland restoration to date have concentrated their efforts within the boundary of the peatland area and – in the case of Holmegaards Mose - within the boundary designated for the LIFE-project, which is considerably smaller than the original peat extent. In recent years workers have begun to think about integrated catchment management, and considered approaches using buffer zones outside the area of peat

(Holden et al. 2004). These are also called '*hydrological protection zone*' and are needed between the wet raised peat bog sites and the drained agricultural land that often surrounds them to maintain suitable hydrological conditions within the site itself, and to include the accommodation of the occasional flooding which inevitably takes place in such locations in response to natural groundwater fluctuations and/or surface water run-off. Such zones would have historically existed as part of the overall wetland complex at each site as lagg fen that collects surface run-off and groundwater flow (or seepage) from the bog; these have been lost, over the years to agricultural encroachment, peat cutting and/or scrub invasion /10/.

3. Monitoring of selected species

3.1. Fen Orchid (*Liparis loeselii*)

Fen Orchid (*Liparis loeselii*) is a rare, threatened species in Denmark. Its population is located in a secondary rich fen (habitat type 7230/7210) in the northernmost part of the habitat area. As a part of the restoration project the water table is expected to be raised 25-50 cm at this site.

Fen Orchid is monitored every year as a part of the National Monitoring and Assessment Programme for Aquatic and Terrestrial Environment (NOVANA) carried out by the Ministry of Environment.

3.1.1. Methods

Fen Orchid is monitored by the methods described in technical manual for NOVANA-monitoring of *Liparis loeselii* /1/.

The method implies counting of the number of vegetative and generative plants in a permanent plot which area is approximately 300 square meters. Counting has been done every year since 2004. A satellite population was discovered in 2009 during habitat mapping, and this population is also monitored.

In 2012 monitoring of the permanent plot was done by employees at the Nature Agency department in Roskilde (Ministry of Environment) on the 28th of June.

3.1.2. Results

The results of counting of *Liparis loeselii* in the permanent plot are shown in Figure 1.

In 2012 there was a minor increase in the number of plants in the permanent plot. 13 plants (5 vegetative and 8 generative) are counted vs. 5 (3 vegetative and 2 generative) in 2011. Though the number of individuals is much lower compared with the previous years.

Just outside the permanent plot 8 plants of *Liparis loeselii* was found. A satellite population which was counted for the first time in 2009 (9 plants) seems to be disappeared. This population was situated approximately 300 m north-east of the permanent plot.

Both populations are developing negatively and *Liparis loeselii* is threatened by expanding of *Cladium mariscus, Myrica gale, Phragmites autstralis* and *Alnus glutinosa*. In 2009 as well as in 2011 both habitats were very wet due to heavy rain and flooding.

In 2012 the permanent plot has not been flooded and can be characterized as "semi-humid". In fall 2012 shrubs and trees as well as tall, robust sedges such as *Cladium mariscus* were removed in the permanent plot. This effort was done by volunteers to improve the habitat for *Liparis loeselii*.

Both the main and satellite population are still overshadowed by taller herbs and shrubs, and affected by periodical flooding of the habitat. This is the obvious cause of the decline in this population that will probably lead to its extinction in the future.

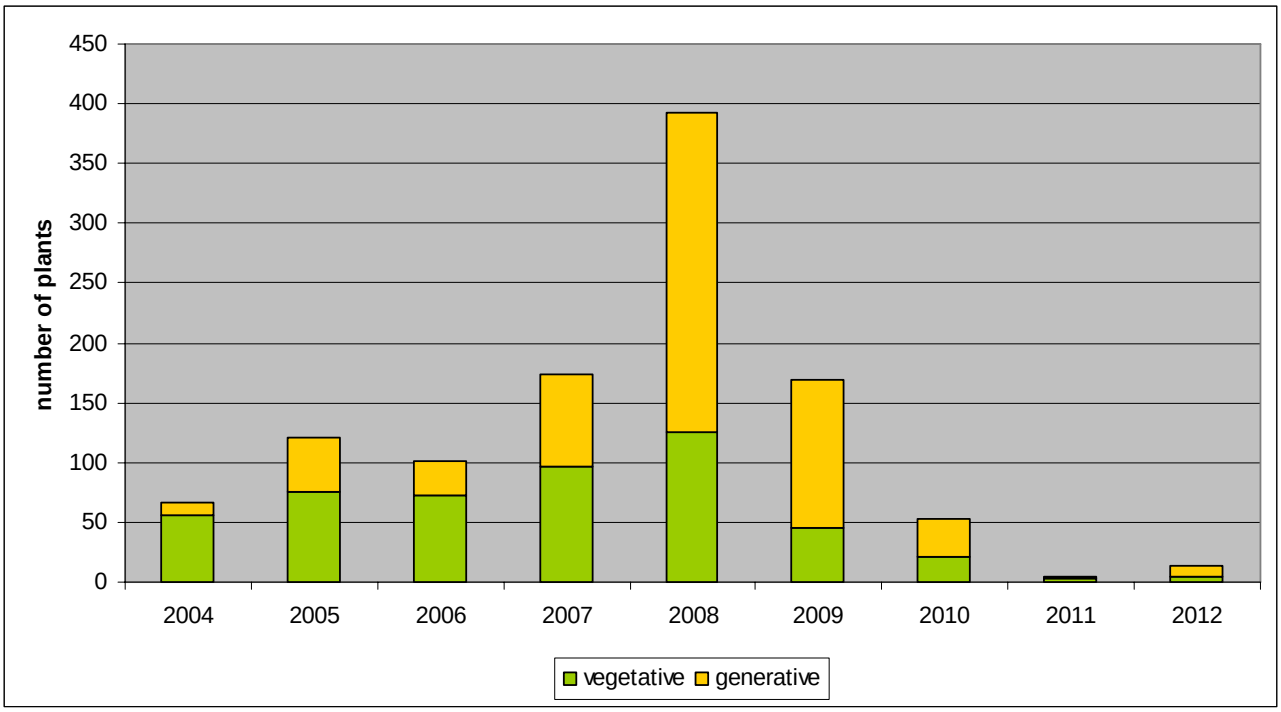


Figure 1. Number of individuals of *Liparis loeselii* in the permanent plot during the period of NOVANA-monitoring.

3.2. A water beetle *Graphoderus bilineatus*

Graphoderus bilineatus is a rare, threatened aquatic species. It occurs in lakes and ponds with clean, oligotrophic water, not shaded by trees and bushes, often with abundant submerse and emergent vegetation /7/. It was found in a flooded peat pit (no. 39) in the northern part of Holmegaards Mose (Appendix 2) just outside the habitat area in 2007 /11/.

In Holmegaards Mose the water beetle was monitored in 2011 as a part of the National Monitoring and Assessment Programme for Aquatic and Terrestrial Environment (NOVANA) carried out by the Ministry of Environment. Under this monitoring *Graphoderus bilineatus* was caught in pit no. 36 (Appendix 2) /11/.

The purpose of this survey is to assess whether it is possible to improve the quality of potential habitat for the species by removing trees and bushes along the shaded edges of the old, flooded peat pits within the project area.

3.2.1. Methods

In 2010 a number of abandoned, flooded peat pits were investigated in search of suitable habitats for the water beetle *Graphoderus bilineatus.* The method implies registration of structural parameters of the habitat and the surroundings as well as registration of vascular plants and mosses occurring in the marginal, floating and submerged vegetation /2, 4/.

In 2011 the water beetle was searched using a catching net. The purpose of this monitoring was to determine which pits could be a suitable habitat. Five out of ten pits were considered to be potential habitats for the water beetle *Graphoderus bilineatus.*

This year the water beetle fauna was monitored in these five pits using traps /3/. The monitoring took place in the end of May and beginning of June. The position of the traps can be seen on Maps 1 and 2.

The traps were placed in warm parts of the pits along their edges, where submerse and emergent vegetation was abundant and the water depth was between one and two meters (Photos 5 and 6).

The traps, using raw liver or ham as bait, were placed in the late afternoon and removed three days later in the morning.

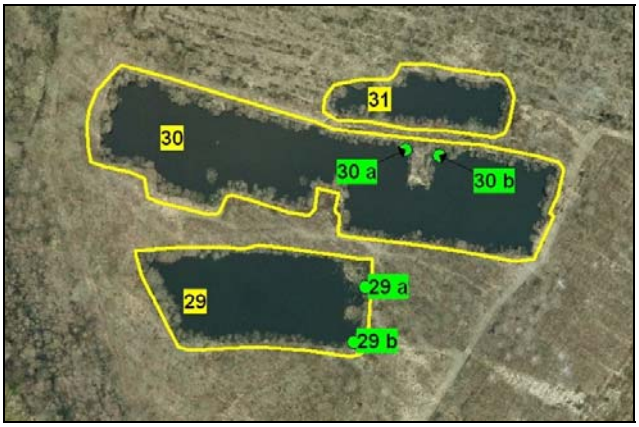
3.2.2. Results and remarks

Graphoderus bilineatus was not caught in this study, but other water bug species were found in the traps (Photos 7 and 8).

The fauna of two monitored pits, no. 29 and no. 30, in the western part of Holmegaards Mose was the most rich in species of water beetles. In the pits in the eastern part of the bog some of the traps were empty, and the only water beetle caught was a large species, *Cybister lateralimarginalis*.

As mentioned above *Graphoderus bilineatus* was previously caught in pit no. 36 located close to the former find of the water beetle, in pit no. 39 /11/. This pit is located less than 1 km from some of the investigated pits in the north-western part of the project area and it is likely that *Graphoderus bilineatus* would be able to colonize new habitats if those were suitable. The water beetle is not an eager flier, but flying is the only way to spread from one habitat to another.

In winter / early spring 2011 trees and bushes were removed from the edges of two investigated pits, no. 29 and 30. All though the habitats have become more exposed for wind due to the clearings, this action at the same time partly improve spreading potential of the beetles.



Map 1. Position of traps (green) in the north-western part of Holmegaards Mose.

Map 2. Position of traps (green) in the eastern part of Holmegaards Mose.

Photo 5. Part of pit 30 where trap no. 30a was placed.

Photo 6. Part of pit 25 where trap no. 25a was placed.

Photo 7. *Cybister lateralimarginalis** and *Dytiscus* sp.*

Photo 8. *Graphoderus* cf. *cinereus**.

*: identification is kindly done by Mr. Mogens Holmen, Nature Agency department in Roskilde

It is recommended to allow some re-growth of trees and bushes along the pit edges. This will protect the habitats from the influence of wind and thereby make them warmer.

The submerse and emergent vegetation is still sparse, but the increased amount of light after the clearings will facilitate the growth of water plants in the future.

All in all it is likely that the conditions in some old peat pits (particularly no. 29 and no. 30) will improve enough to become suitable habitats for *Graphoderus bilineatus.*

3.3. Butterflies

The whole ecosystem of the bog is a mix of microhabitats where different species of butterflies live. The restoration activities cause changes both in macro- and microhabitats and affect e.g. the species that occur in the peat or lower part of the vegetation – at least at some stages of their life cycle.

In 2010 a simple monitoring /4/ was established to observe the impact of the restoration project, especially of the water level raise on populations of three species that are rare in Denmark and endangered on the isle of Zealand.

Cranberry Fritillary (*Boloria aquilonaris*) and Large Heath (*Coenonympha tullia*) are listed on the Danish Red List of Threatened Species as endangered, EN, and Cranberry Blue (*Plebeius optilete*) has a status of near threatened, NT.

The caterpillars of *Boloria aqulionaris* and *Plebeius optilete* feed on Cranberry (*Vaccinium oxycoccos*), while *Coenonympha tullia* feeds on sedges such as *Rhynchospora alba, Eriophorum vaginatum* etc.

3.3.1. Methods

A fixed route (transect) was established at the site, and butterflies were recorded while walking along the route under reasonable weather conditions (Appendix 3.1). The butterflies were monitored in the middle of June and the beginning of July 2012. It took approximately the same time as in 2010 and 2011.

3.3.2. Results and remarks

Boloria aquilonaris (Photo 9) that was observed both in 2010 and 2011 is apparently not present in Holmegaards Mose any longer. In 2011 there was a rather drastic decline in the number of individuals compared to the year before, e.g. 7 individuals in 2011 vs. 22 individuals in 2010.

In the Danish public databases, www.fugleognatur.dk and www.lepidoptera.dk the last registration of *Boloria aquilonaris* goes back to approximately 2005.

It is unlikely that the restoration project itself caused the apparent extinction of Cranberry Fritillary. Small scale catastrophes get big scale consequences when the population size is very small. Also genetic collapse in small population is likely to occur. The possibility or likeliness for genetic exchange is close to zero because the nearest population lives in Kirkemosen situated 50 km north of Holmegaards Mose.

The other rare species have the same distribution pattern as the last year; these are mainly found in the central and western part of the study area (Appendix 3.2 and 3.3). This seems to be the most intact part of the raised bog.

The number of registrations of *Coenonympha tullia, Plebeius optilete* and *Plebeius idas* (Idas Blue) fluctuates during the monitoring period. Population fluctuations of the three species can be explained by differences in weather conditions during hatching, namely air temperature and amount of precipitation. It is also obvious that the weather on the day of monitoring or few days before is an important factor for the butterflies' activity.

The more common species (Whites, Browns and Skippers) were predominantly found close to the eastern or western borders of the study area (points 0-2, 6-9, 14-15) where they were feeding on flowering plants.

In 2012 two new species were observed – Brimstone (*Gonepteryx rhamni*) and Meadow Brown (*Maniola jurtina*). *Gonepteryx rhamni* is common in nutrient poor bogs or scrubs living primarily on *Rhamnus* spp. and *Frangula alnus*. *Maniola jurtina* is still very common in Danish grasslands. It is difficult to explain why they have not been seen at the site before.

The Browns and Heath (*Aphantophus hyperanthus, Maniola jurtina* and *Coenonympha pamphillus*) probably feed on *Molinia caerulea* and sedges in the *Molinia*-dominated part of the bog.

Photo 9. Cranberry Fritillary (*Boloria aquilonaris*) is apparently extinct in Holmegaards Mose. This photo is from a small quaking bog, Kirkemosen east of Roskilde, Zealand.

The monitoring transect is located south and west of the area where removal of birch forest has taken place in order to restore the raised bog habitat. It is strongly recommended to include these parts of the project area in the survey of butterflies to reveal weather the rare species are colonising the restored areas.

Proposal for the new study areas can be seen in Appendix 3.4. It includes the following different types of habitats:

- originally semi-dry areas where clearings of birch have taken place
- humid areas where clearings of birch have taken place
- humid areas where growth of sedges and peat mosses is evident after clearing.

4. References

1) Danmarks Miljøundersøgelser, Fagdatacenter for Biodiversitet og Terrestriske Naturdata, Danmarks Miljøundersøgelser. 2004. Teknisk anvisning til overvågning af Mygblomst: http://www.dmu.dk/fileadmin/Resources/DMU/MYndighedsbetjening/FDC_bio/TeknAnvisn/TA_A33_mygblomst_v.1.0_DMU.pdf

2) Danmarks Miljøundersøgelser, Fagdatacenter for Biodiversitet og Terrestriske Naturdata, Danmarks Miljøundersøgelser. 2010: Teknisk anvisning til kortlægning af levesteder for vandhulsarter (padder, guldsmede og vandkalve): http://www.dmu.dk/fileadmin/Resources/DMU/MYndighedsbetjening/FDC_bio/TeknAnvisn/TA-OP_vandhulsarter_v_1_2_DMU_27_5_01.pdf

3) Danmarks Miljøundersøgelser, Fagdatacenter for Biodiversitet og Terrestriske Naturdata, Danmarks Miljøundersøgelser. 2011. Overvågning af bred vandkalv *Dytiscus latissimus* og lys skivevandkalv *Graphoderus bilineatus.* TA A05: http://www.dmu.dk/fileadmin/Resources/DMU/MYndighedsbetjening/FDC_bio/TeknAnvisn/TAA05_Vandkalve_v1_6_6_2011.pdf

4) Goldberg, I. & Plöger, E. 2010. Baseline monitoring in the raised bog Holmegaards Mose 2010. Report for the Danish Forest and Nature Agency, Storstrøm.

5) Goldberg, I. & Plöger, E. 2011. Baseline monitoring in the raised bog Holmegaards Mose 2011. Report for the Danish Forest and Nature Agency, Storstrøm.

6) Holden, J. et al. 2004. Artificial drainage of peatlands: hydrological and hydrochemical process and wetland restoration. - Progress in Physical Geography 28 (1): 95–123.

7) Holmen, M. 2010. Overvågningsvandkalve: Oplæg til DMU fagmøde i Ebeltoft: http://www.dmu.dk/fileadmin/Attachments/OvervKalve2010.pdf

8) Laiho, R. et al. 1998. The effect of forestry drainage on the vertical distribution of major plant nutrients in peat soils. - Plant and Soil 207: 169-181.

9) Miljøministeriet, By- og Landskabsstyrelsen. 2010. Forslag til Natura 2000-plan 2010-2015. Holmegaards Mose. Del af Natura 2000-område nr. 163. Habitatområde 145: http://www2.blst.dk/download/nyk/plannotater/163_Holmegaard.pdf

10) Morgan-Jones, W. et al. 2005. Characterisation of Hydrological Protection Zones at the Margins of Designated Lowland Raised Peat Bog Sites. *JNCC Report No. 365.*

11) Naturdatabasen, Danmarks Miljøportal: www.naturdata.dk

12) Naturstyrelsen. 2012. LIFE08 NAT/DK/000466. Mid-term report covering the project activities from 01/01/2010 to 31/12/2011. LIFE Holmegaards Mose.

13) Schumann, M. & Joosten, H. 2008. Global Peatland Restoration Manual. - Institute of Botany and Landscape Ecology, Greifswald University, Germany.

14) Sundström, E. et al. 2000. Nutrient conditions in drained peatlands along a north–south climatic gradient in Sweden. - Forest Ecology and Management 126: 149-161.

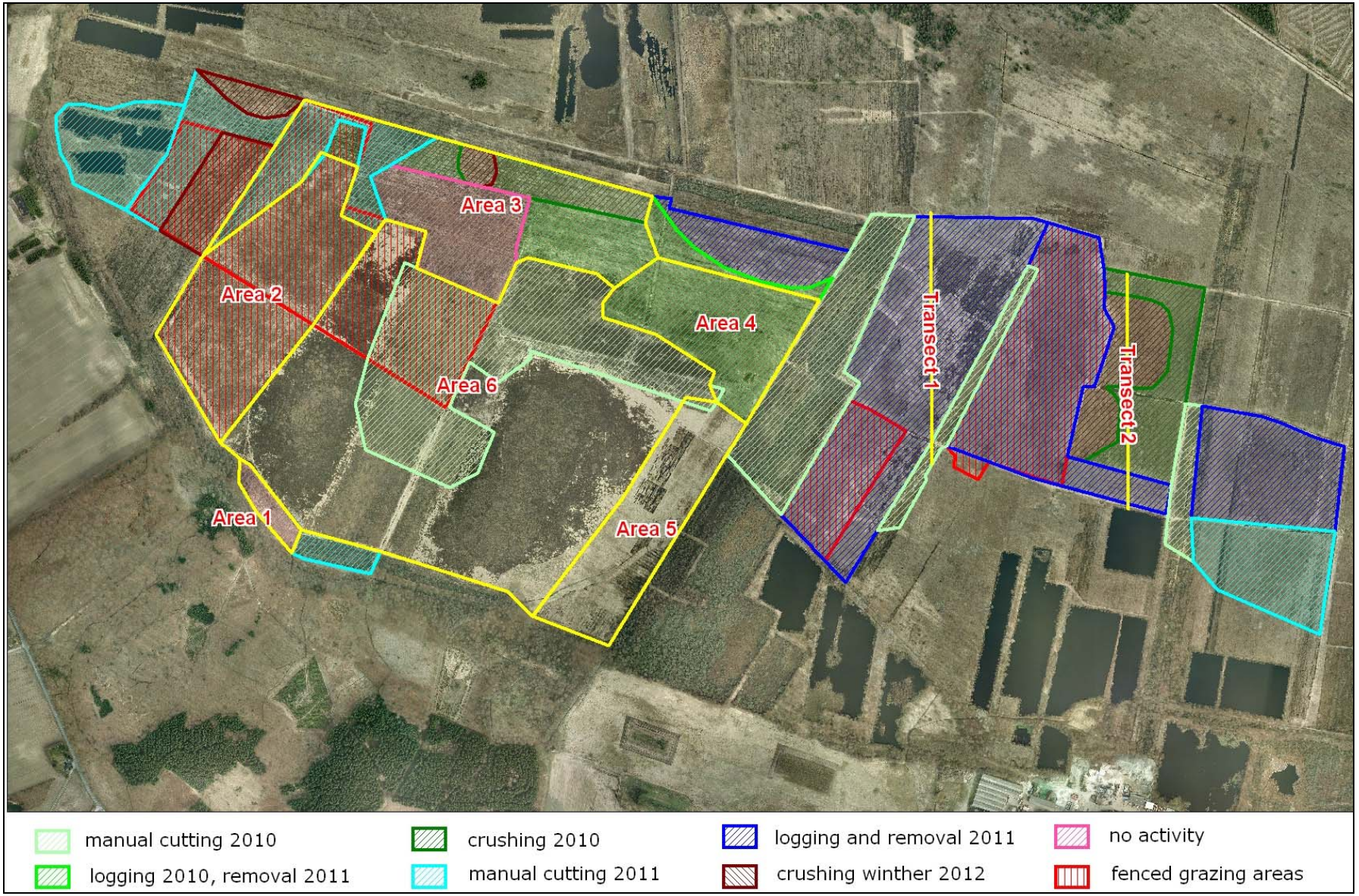
15) Vasander, H. et al. 2003. Status and restoration of peatlands in Northern Europe. – Wetlands Ecology and Management 11: 51-63.

APPENDICES

Appendix 1: Vegetation
Appendix 2: A water beetle Graphoderus bilineatus
Appendix 3: Butterflies

Appendix 1. Vegetation

Appendix 1.1. Map of study area



Appendix 1.2. Regrowth of shrubs and trees / bushes

Area 1

15 m	1.1	1.2	1.3	1.4	1.5	avg	year
Open water surface, %	0	0	0	0	0	0	2010
	4	<1	<1	5	<1	2	2011
	6	<1	<1	7	<1	2,8	2012
Shrubs, %	0	<1	0	0	<1	<1	2010
	0	<1	0	0	<1	<1	2011
	0	<1	0	0	<1	<1	2012
Trees / bushes < 1m tall, %	2	25	30	30	20	21,4	2010
	2	25	30	40	30	25,4	2011
	2	25	30	40	30	25,4	2012
Trees - bushes >1m tall, %	100	2	7	20	10	27,8	2010
	100	5	20	30	20	35	2011
	100	7	20	30	20	35,4	2012

Area 2

15 m	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	avg	year
Open water surface, %	0	0	0	0	0	0	0	0	0	0	0	2010
	1	1	1	0	<1	0	1	0	1	<1	<1	2011
	<1	<1	<1	0	<1	<1	<1	0	<1	<1	<1	2012
Shrubs, %	60	80	40	25	50	80	<1	80	70	80	50,6	2010
	60	80	40	25	60	80	<1	80	70	80	51,5	2011
	60	80	40	25	60	80	<1	80	70	80	51,5	2012
Trees / bushes < 1m tall, %	10	20	5	10	10	30	15	20	10	15	13,5	2010
	10	25	5	10	10	30	30	25	10	15	16	2011
	10	25	5	15	15	30	35	25	15	20	19,5	2012
Trees - bushes >1m tall, %	<1	5	0	0	<1	1	1	10	0	0	1,8	2010
	<1	1	0	0	<1	1	1	5	0	0	0,9	2011
	<1	1	0	0	<1	1	1	5	0	0	0,9	2012

Area 3

15 m	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	avg	year
Open water surface, %	<1	0	0	0	0	0	0	0	1	0	<1	2010
	<1	<1	<1	2	1	1	1	5	3	0	1,4	2011
	<1	<1	<1	<1	<1	<1	1	<1	2	<1	<1	2012
Shrubs, %	70	50	30	10	10	0	3	2	0	50	22,5	2010
	70	50	30	10	10	0	3	2	0	50	22,5	2011
	70	60	30	10	10	0	3	2	0	60	22,5	2012
Trees / bushes < 1m tall, %	40	30	10	5	3	10	1	5	5	20	12,9	2010
	40	30	15	70	3	60	1	60	65	20	36,4	2011
		30	15	70	3	60	1	55	65	15	34,9	2012
Trees - bushes >1m tall, %	70	10	70	70	70	20	70	90	40	1	51,1	2010
	70	10	65	10	68	5	70	5	1	1	30,5	2011
		10	65	10	68	5	70	10	1	1	26,7	2012

Area 4

15 m	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	avg	year
Open water surface, %	0	0	0	0	0	0	0	<1	0	0	<1	2010
	1	1	<1	3	not possible	1	2	<1	2	not possible	1,4	2011
	<1	1	2	0	0	1	2	<1	1	<1	<1	2012
Shrubs, %	5	<1	3	<1	5	10	1	40	<1	0	6,5	2010
	5	<1	3	<1	not possible	2	1	40	<1	not possible	6,5	2011
	5	<1	3	<1	3	2	3	40	<1	0	5,7	2012
Trees / bushes < 1m tall, %	20	<1	20	30	<1	30	<1	30	<1	10	14,1	2010
	70	10	35	40	not possible	30	3	32	15	not possible	29,4	2011
	40	10	35	40	5	30	5	30	15	15	22,5	2012
Trees - bushes >1m tall, %	70	10	50	20	2	70	1	20	0	80	32,3	2010
	<1	1	15	5	not possible	2	<1	<1	<1	not possible	2,4	2011
	30	5	15	5	<1	2	5	1	5	<1	6,8	2012

Area 5

15 m	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	5.10	avg	year
Open water surface, %	0	0	0	<1	0	0	0	1	0	0	<1	2010
	0	0	0	1	10	0	0	1	1	2	1,5	2011
	5	0	<1	1	50	2	<1	<1	1	10	6,9	2012
Shrubs, %	0	<1	1	1	0	0	1	10	30	30	7,4	2010
	0	<1	5	1	0	0	5	10	30	30	8,2	2011
	0	<1	5	10	0	0	10	10	30	30	9,5	2012
Trees / bushes < 1m tall, %	<1	<1	<1	<1	<1	0	<1	0	30	40	7,3	2010
	0	0	2	5	0	0	5	<1	30	40	8,2	2011
	0	<1	5	5	0	0	7	<1	50	40	10,7	2012
Trees - bushes >1m tall, %	2	7	<1	0	0	40	0	0	30	30	10,9	2010
	2	7	1	0	0	40	0	0	30	30	11	2011
	2	2	1	<1	0	40	0	0	20	30	9,5	2012

Area 6

15 m	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	6.10	avg	year
Open water surface, %	0	<1	<1	0	0	0	0	<1	0	<1	<1	2010
	<1	<1	<1	0	<1	2	0	<1	1	0	1	2011
	5	<1	<1	0	0	1	0	<1	<1	<1	<1	2012
Shrubs, %	40	90	90	70	90	80	80	20	60	70	69	2010
	40	90	90	70	90	80	80	20	60	70	69	2011
	40	90	90	70	90	80	80	20	60	70	69	2012
Trees / bushes < 1m tall, %	20	0	0	15	<1	10	10	25	10	<1	9,1	2010
	20	<1	<1	15	<1	15	10	25	10	<1	9,2	2011
	20	<1	<1	16	<1	16	10	25	10	1	9,8	2012
Trees - bushes >1m tall, %	0	0	0	0	0	0	0	0	0	0	0	2010
	0	0	0	0	0	0	0	0	0	0	0	2011
	0	0	0	<1	0	<1	<1	<1	0	0	<1	2012

re-established plots (2011)
re-established plots (2012)

Transect 1

15 m	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	avg	year
Open water surface, %	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2010
	0	1	25	<1	<1	0	0	1	0	0	<1	2	<1	<1	0	0	<1	1,7	2011
	1	2	30	1	<1	<1	<1	1	1	1	1	1	1	1	0	0	<1	2,4	2012
Shrubs, %	0	<1	1	40	10	1	2	2	1	5	2	1	4	60	7	35	30	11,8	2010
	0	0	5	10	10	5	<1	0	5	4	1	1	1	10	5	35	30	7,2	2011
	0	0	1	7	12	5	2	1	4	4	4	1	4	7	5	35	30	7,2	2012
Trees / bushes < 1m tall, %	<1	2	<1	20	50	25	30	<1	<1	<1	1	<1	<1	1	10	5	8	9	2010
	<1	<1	5	1	2	15	5	1	10	5	1	5	1	5	5	10	10	4,8	2011
	<1	1	3	5	5	15	12	2	10	5	6	5	5	10	7	10	10	6,5	2012
Trees - bushes >1m tall, %	80	90	90	60	70	60	55	70	75	70	80	90	75	70	50	25	40	67,6	2010
	55	1	1	0	1	0	0	<1	5	5	1	1	0	0	<1	<1	40	6,5	2011
	55	1	1	0	1	0	0	<1	5	5	1	1	0	0	<1	<1	40	6,5	2012

Birch forest in plots 1-15 was removed after the last field survey; the plots are re-established (2011)

Transect 1

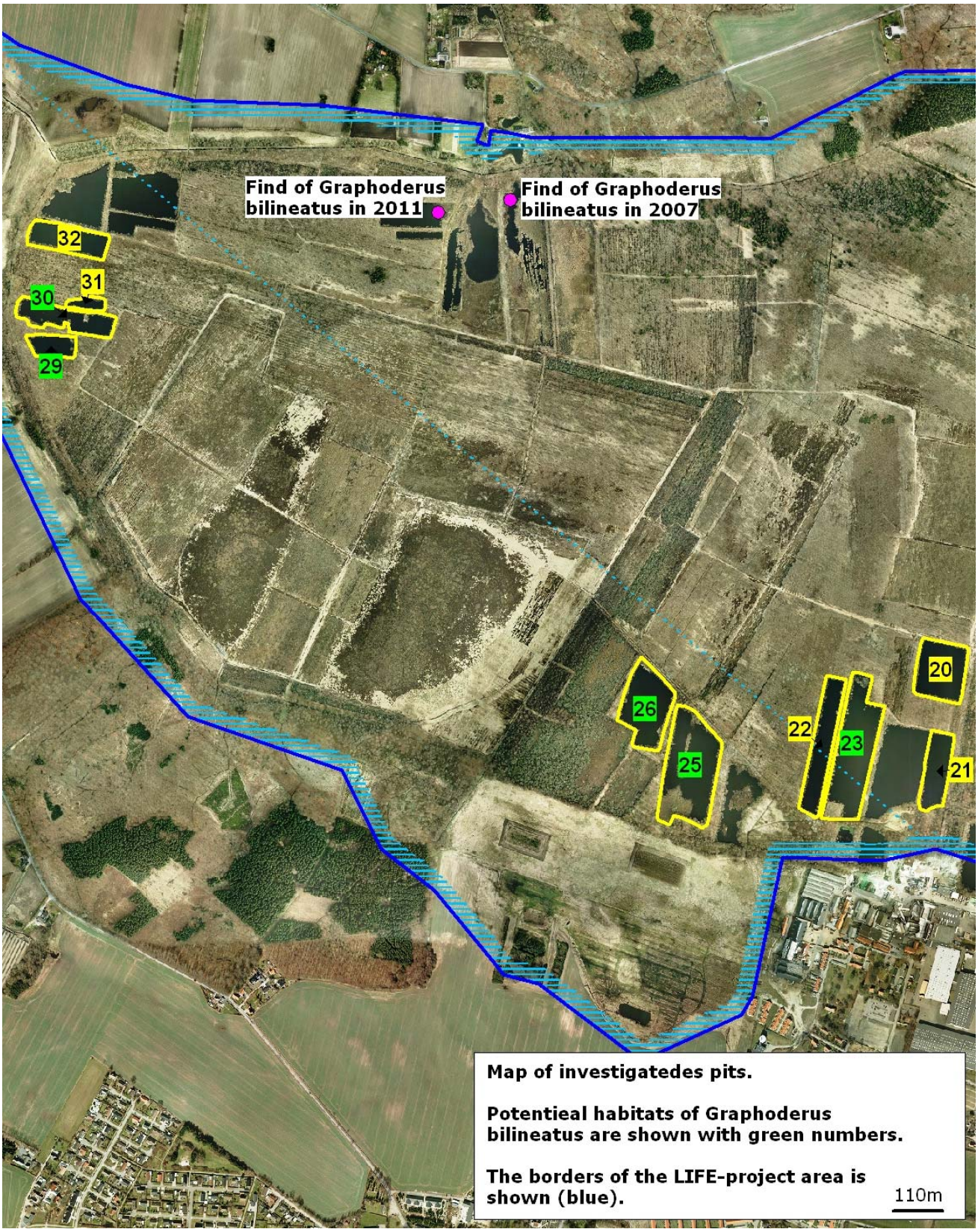
15 m	1.18	1.19	1.20	1.21	avg	year
Open water surface, %	0	0	0	0	0	2010
	0	0	0	0	1,4	2011
						2012
Shrubs, %	1	<1	<1	0	9,7	2010
	1	<1	<1	0	5,9	2011
						2012
Trees / bushes < 1m tall, %	<1	<1	<1	1	7,5	2010
	<1	<1	<1	1	3,5	2011
						2012
Trees - bushes >1m tall, %	90	98	80	80	71,3	2010
	90	98	80	80	21,9	2011
						2012

Transect 2

15 m	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	2.13	2.14	2.15	2.16	avg	år
Open water surface, %	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	**50 - lake**	<1	2010
	0	1	0	0	0	0	0	<1	5	5	7	1	<1	5	2	**50 - lake**	1,7	2011
	<1	<1	<1	<1	1	<1	1	<1	4	5	2	<1	<1	5	3	**50 - lake**	1,4	2012
Shrubs, %	10	1	40	60	85	90	80	75	40	40	30	3	<1	15	<1	10	36,3	2010
	10	3	40	60	85	90	80	75	40	40	15	20	2	7	<1	0	35,4	2011
	10	5	30	55	50	70	70	30	20	10	15	20	3	4	<1	1	24,6	2012
Trees / bushes < 1m tall, %	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	0	<1	<1	10	1	2010
	5	20	<1	<1	<1	1	<1	5	10	10	10	5	5	1	<1	5	5	2011
	5	20	5	<1	<1	<1	<1	1	7	10	7	5	2	2	<1	5	4,4	2012
Trees - bushes >1m tall, %	20	0	70	70	80	85	70	40	20	40	1	0	0	80	90	30	43,5	2010
	20	0	70	70	80	85	70	40	20	40	1	0	0	0	0	3	31,2	2011
	20	<1	0	0	0	<1	0	0	0	0	0	0	0	<1	<1	5	1,6	2012

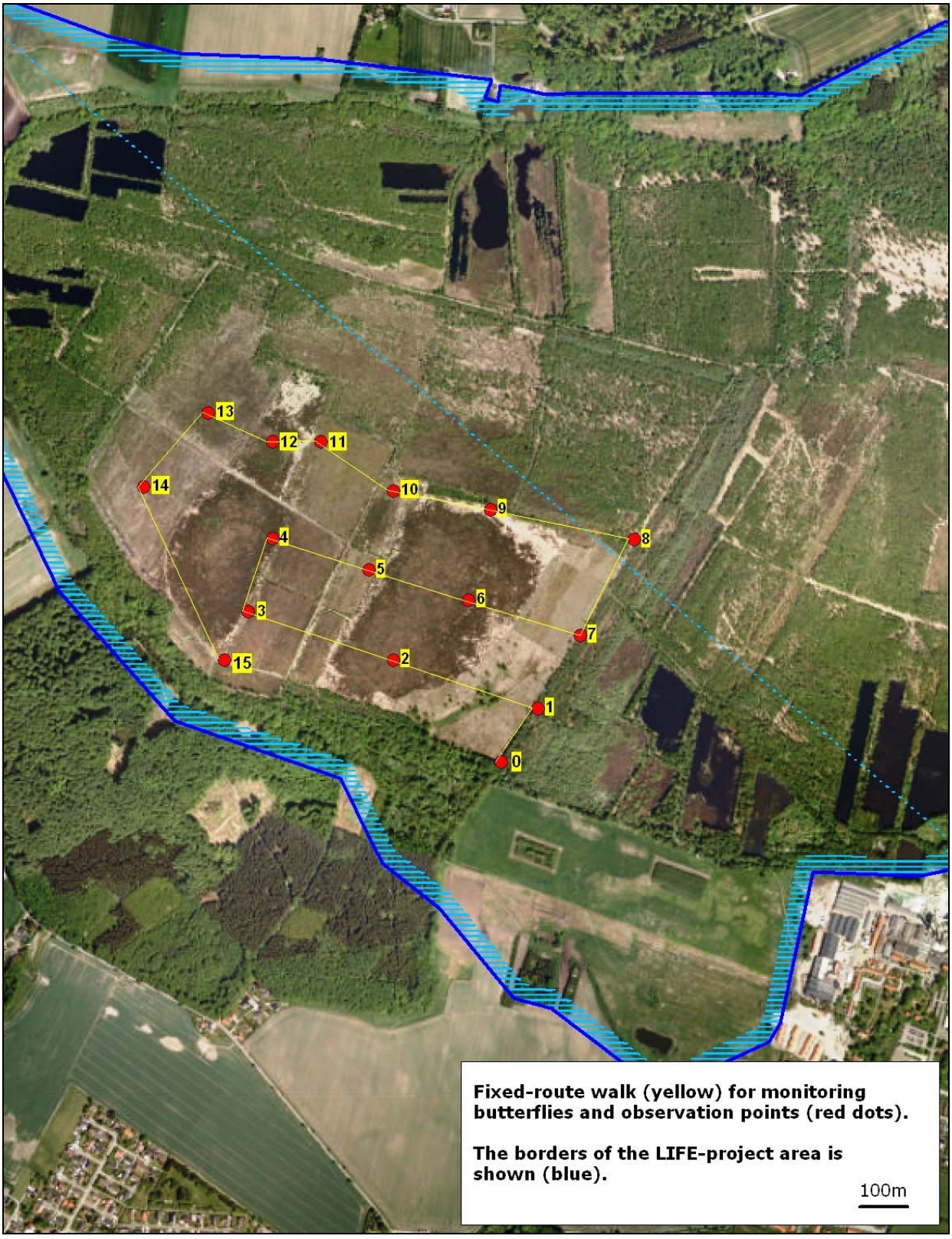
Birch forest in plots 14-16 was removed after the field survey in 2010; the plots are re-established (2011)
Birch forest in plots 3-10 was removed after the field survey in 2011; the plots are re-established (2012)

Appendix 2. A water beetle Graphoderus bilineatus



Appendix 3. Butterflies

Appendix 3.1. Map of fixed-route walk for monitoring of butterflies



Appendix 3.2. Butterfly species recorded in the transect on the 21st of June 2012

Point / section number	Durance (min)	Boloria aqilonaris	Coenonympha tullia	Plebeius idas	Plebeius optilete	Aglais urticae	Goneptery x rhamni	Pieris rapae	Pieris brassicae	Pieris napi	Aphantopus hyperantus	Maniola jurtina	Coenonympha pamphilus	Polyommatus icarus	Celastrina argiolus	Ochlodes sylvanus	Diacrisia sannio	4Ematurga atomaria
0	5																	
0-1	10																	
1	5																	
1-2	10		2														1	
2	5																	
2-3	10		7		1												4	
3	5																	
3-4	10		1														2	1
4	5		2															
4-5	10																2	
5	5																	
5-6	10																1	2
6	5																	
6-7	10																	
7	5										1	2						
7-8	10										1	1	1					
8	5										2							
8-9	10		1															
9	5		1															
9-10	10		1														1	
10	5		1															
10-11	10		2														1	
11	5																	
11-12	10																	
12	5																	
12-13	10																	
13	5																	
13-14	10		2															
14	5		1														1	
14-15	10		2														2	
15	5														1			
Total number of counts		0	23	0	1	0	0	0	0	0	4	3	1	0	1	0	15	3
Counts in July 2011		7	65	23	19	3	0	1	2	1	33	0	1	1	1	10	4	0
Counts in July 2010		22	25	15	1	1	0	2	3	0	3	0	0	3	0	10	0	0

Appendix 3.3. Butterfly species recorded in the transect on the 2nd of July 2012

Point / section number	Durance (min)	Boloria aquilonaris	Coenonympha tullia	Plebeius idas	Plebeius optilete	Aglais urticae	Gonepteryx rhamni	Pieris rapae	Pieris brassicae	Pieris napi	Aphantopus hyperantus	Maniola jurtina	Coenonympha pamphilus	Polyommatus icarus	Celastrina argiolus	Ochlodes sylvanus	Diacrisia sannio
0	5									2							
0-1	10									1	1	2	1				
1	5									1		1					
1-2	10		1														1
2	5		2														
2-3	10		2		1												
3	5		1		3												
3-4	10		4	1													
4	5		2	2	1												
4-5	10		6	1	1												
5	5		2	2	1												1
5-6	10		3														
6	5		1	2													
6-7	10		1										1				1
7	5									1	1	3		1	1		1
7-8	10									2		4					
8	5					1				1		1					
8-9	10		1		1												
9	5		2														
9-10	10		4														1
10	5		1														2
10-11	10		6		1												
11	5		1														
11-12	10		2														
12	5		4	1	1												
12-13	10		2														
13	5		1														
13-14	10		2														
14	5		1				1										
14-15	10									2						2	
15	5					2				2		2	1				
Total number of counts		0	52	9	10	3	1	0	0	12	2	13	3	1	1	2	7
Counts in July 2011		7	65	23	19	3	0	1	2	1	33	0	1	1	1	10	4
Counts in July 2010		22	25	15	1	1	0	2	3	0	3	0	0	3	0	10	0

Appendix 3.4. New areas proposed for butterfly monitoring