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Monitoring in the raised bog Holmegaards Mose 2011

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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 2011 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, Plebius optilete*) was done after the restoration work at the site had been almost 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.

In the population of Fen Orchid, *Liparis loeselii* a further decline in numbers of vegetative and generative plants was observed. This may be due to overshadowing by taller herbs and shrubs as well as flooding of the habitat.

Mapping of potential habitats for *Graphoderus bilineatus* reveals that five flooded peat pits can be suitable habitats for the species.

Three rare butterfly species, *Coenonympha tullia, Plebeius optilete* and *Plebeius idas* were more numerous in 2011 than in 2010. A rather strong decline was observed in the population of *Boloria aquillonaris*.

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 habitats area, 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) /11/.

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 2011 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, Plebius optilete*) was done after the restoration work at the site had been almost competed. The results of this survey are described in the report.

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” /6/.

Every plot consisted of two circles – with a radius of 5 m and 15 m. In 2011 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 collected 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. Two examples of vegetation changes after removal of birch forest in 2010 are shown in Appendix 4.

The field work was carried out in October 2011.

2.2. Results

In the previous report ("Baseline monitoring.., 2010") the vegetation and restoration activities within each study area / transect were described. In the areas 3 and 4, and a part of transect 2 where the birch forest was removed in 2010 re-establishment of vegetation is taking place. Some of the areas (most of transect 1 and southern part of transect 2) have been cleared during 2011, but the largest part of the project area had already been open before 2010 (Appendix 1.1).

Due to the rainy summer 2011 the bog seems to be more humid than in autumn 2010, and the open water surface within the investigated plots is slightly larger. It is difficult to say whether the planned raising of water table has taken place in some areas.

2.2.1. Vegetation changes in the six study areas

Area 1 ("Westphalerskæret"): Felling of trees took place in 2005, and re-growth of birch and willow from the remaining stumps has not been taken under control. The alkaline fen vegetation is dominated by *Phragmites australis. Myrica gale* is abundant in the northern part of the area.

Area 2: Degraded, dried bog that had been covered with birch woodland until 2007 when it was cleared of trees and grazing by sheep was established in order to prevent the regeneration of birch. No changes in the vegetation are observed.

Area 3: Removing of the birch forest in the area started in 2010, and at the time of field survey in 2011 the trees were felled in approximately a half of the area. The dead wood has not been removed from the area probably because the bog soil is constantly very moist here. The vegetation is now dominated by *Myrica gale* that is actively regenerating after cuttings (Foto 1, see also panorama picture from plot 3.6 in Appendix 4); its coverage is estimated as ca. 36% (vs. ca. 13% in 2010). The coverage of *Molinia caerulea* and peat mosses is high. 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, with plenty of green algae in it.

Foto 1. Vegetation re-establishment in the north-eastern part of area 3. *Myrica gale* and *Molinia caerulea* are dominating species.

Area 4: Removal of *Betula pubescens – Molinia caerulea* woodland started in 2010 and was completed in 2011. At the time when field work was conducted the dead wood was

being taken out of the bog. Due to this activity it was not possible to investigate some study plots in the area. Vegetation re-establishment has already started: re-growth of Betula pubescens and Myrica gale takes place; their coverage is estimated as ca. 29% (vs. ca. 14% in 2010).

Area 5: Degraded, dried bog dominated by *Molinia caerulea,* towards north moist / wet depressions with peat mosses, *Vaccinium oxycoccos, Eriophorum angustifolium* and *Drosera rotundifolia*. Grazing by sheep in order to prevent the regeneration of birch and reduce the growth of *Molinia caerulea* has terminated in the end of 2010 / beginning of 2011. No changes in the vegetation are observed.

Area 6: Bog vegetation is dominated by peat mosses and shrubs, and the surface microtopography 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. No changes in the vegetation are 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 pit (trench) that is crossing the transect in its southern part. The stakes marking permanent plots along most of the transect were destroyed. The plots 1-15 were re-established, but it was not possible to locate them exactly the same place as in 2010. No changes in the vegetation of the southern part of the transect (plots 16-21) are observed.

Transect 2: The forest had been partly (in plots 1-2 and 9-13) removed in 2010 before the field survey was done. In the southernmost part of the transect (plots 14-16) was cleared in 2011, and wooded bog is still present in the central part of the area (plots 3-8). The vegetation is re-establishing after the last year cuttings (Foto 2), see also panorama picture from plot 2.2 in Appendix 4): *Eriophorum vaginatum*, peat mosses and shrubs are regenerating at wet places and *Molinia caerulea* at the dry ones. Re-growth of birch that was cut down last year seems to be a problem (Foto 3).

Foto 2. Vegetation re-establishment in the northern part of transect 2.

Foto 3. Re-growth of birch seems to be a problem both at wet places dominated by *Eriophorum vaginatum* and peat mosses, and dry places dominated by *Molinia caerulea*.

2.2.3. Conclusion

Restoration activities in Holmegaards Mose have so far focused on removal of trees and scrub in the areas where drainage has converted open bog communities into forest. Despite the great effort, re-growth of *Betula pubescens* and *Myrica gale* is already observed in the areas where the forest was removed in 2010, and the vegetation seems to be changing back to its original state.

The fundamental basis for peatland restoration is its rewetting. According to Price and Whitehead (2001), hydrologic conditions where *Sphagnum* has re-colonized block-cut trenches on a cutover peatland suggest three threshold conditions for its re-establishment: high water-table (mean –29 ± 14 cm), soil moisture >50%, and soil water-pressure –100 cm for the whole season, allowing the moss to extract water from the decomposed and compacted cutover peat. Besides re-growth and seedling establishment of birch can be kept under control much easier at the sites with high water table. Another advantage of rewetting is that the bog structure (hummocks with shrubs and pools with peat mosses) does not become destroyed by machinery at the places where it is developed, and the bog fauna will not be affected in the same degree, because raising of water table takes a longer time.

In the restoration of peatlands, successes have generally been those of short-term repair. Periods of restoration have been much too short to ensure progression to, or even well toward, a fully functional peatland reasonably compatible with the pristine state of similar peatlands elsewhere (Gorham & Rochefort 2003). An estimate is that a significant number of characteristic bog species can be established in 3–5 years, a stable high water-table in about a decade, and a functional ecosystem that accumulates peat in perhaps 30 years.

Drainage ditches in Holmegaards Mose were blocked in 2010 to raise the water level. Monitoring of changes in hydrologic conditions of different parts of the project area is needed to be able to choose the appropriate restoration activities in the future.

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 Enviroment.

3.1.1. Methods

Fen Orchid is monitored by the methods described in technical manual for NOVANA-monitoring of *Liparis loeselii* /4/.

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.

3.1.2. Results

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

In 2011 the number of plants in the permanent plot is reduced to 5 (3 vegetative and 2 generative). The satellite population was reduced from 8 plants in 2009 to 3 plants in 2010, and in 2011 no plants were found here.

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.

There have never been so few plants in the permanent during the monitoring period since 2004. The cause of this decline is likely to be overshadowing by taller herbs and shrubs as well as flooding of the habitat.

In other populations of *Liparis loeselii* on Zealand monitored as a part of NOVANA-programme no decline was observed in 2011, and the number of generative individuals and produced fruits in some populations was even higher than in 2010.

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. It was found in a flooded peat pit in the northern part of Holmegaards Mose just outside the habitat area in 2007 (Appendix 2). 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.

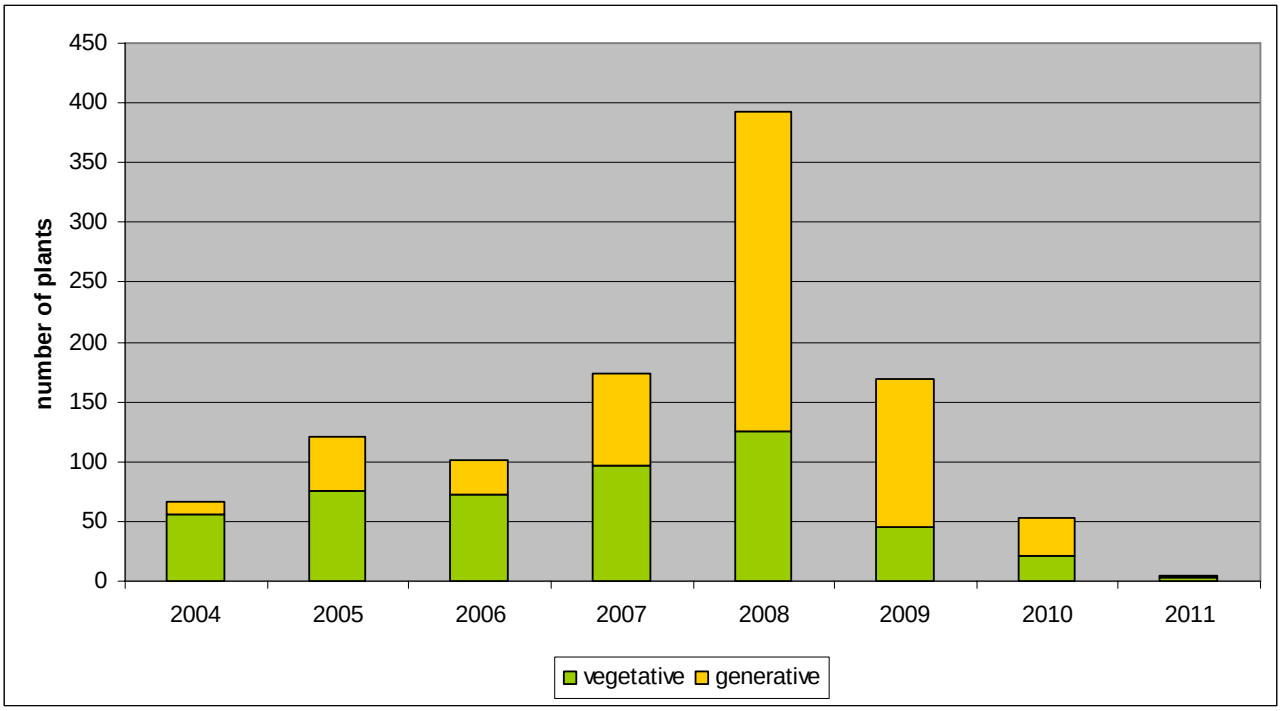

Figure 1. Number of individuals of *Liparis loeselii* in the permanent plot during the period of NOVANA-monitoring.

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 /3,6/.

In Holmegårds 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 Enviroment.

In this project a catching net was used to the search for *Graphoderus bilineatus*. The purpose of this monitoring was also to determine which pits could be a suitable habitat for the water beetle. In these pits the water beetle will be monitored in 2012 using traps /5/.

3.2.2. Results

Results of the monitoring in 2011 are shown in Table 1 and Appendix 2.

During the NOVANA-monitoring carried out by the Ministry of Environment *Graphoderus bilineatus* was caught in pit 36 located close to the former find of the water beetle, in pit 39 /9/.

Graphoderus bilineatus was not caught in this study, but other water bug species were found. The number of different species and individuals is strongly dependent on presence of emergent and submerse vegetation: it was highest in those parts of the pits where water plants were abundant.

Five out of ten pits are considered to be potential habitats for the water beetle *Graphoderus bilineatus.* In winter 2010 or early spring 2011 trees and bushes were removed from the edges of a number of these pits.

Table 1. Results of the monitoring and habitat mapping in 10 peat pits

Peat pit no.	Trees and bushes removed	Potential habitat	Part of the pit which is considered as a potential habitat
20	partly	no	
21	no	no	
22	no	no	
23	no	yes	northern
25	no	yes	northern
26	no	yes	northern
29	yes	yes	eastern
30	yes	yes	nothern
31	yes	unlikely	
32	no	no	

Although *Graphoderus bilineatus* is not a vivid or eager flier it is most likely that it spreads from one habitat to another by flying. Removal of trees and bushes improves the quality of habitat for the water beetles and also facilitates their spread between sites.

3.3. Butterflies

Several butterfly species occur in Holmegaards Mose. 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.

The restoration project may cause some changes in the microhabitats for the species occurring in the peat or lower part of the vegetation – at least at some stages of their life cycle. A simple monitoring was established in 2010 /6/ to observe the impact of water level raise on populations of the three species named above.

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. The butterflies were monitored in the middle of June and the beginning of July 2011.

3.3.2. Results

The rare species have the same distribution as the last year, e.g. *Boloria aquilonaris* is restricted to the central and western part of the study area, Table 2. This seems to bee the most intact part of the raised bog, and *Coenonympha tullia* is mainly found here, but also close to the margin of the investigated area.

Comparison of the number of observed individuals in the beginning of July 2010 and 2011 indicates a rather strong decline in the population of *Boloria aquillonaris*. Also monitoring conducted in June 2011 showed that the species was sparse in the area.

On the contrary *Coenonympha tullia, Plebeius optilete* and Idas Blue (*Plebeius idas*) were more numerous in 2011. Population fluctuations of the three species can be mainly explained by differences in weather conditions during hatching, namely air temperature and amount of precipitation.

The more common species (Whites, Browns and Skippers) were predominantly found close to the eastern border of the study area (points 0-2, 6-9) where they were feeding on flowering plants. Some of the species, e.g. Ringlet (*Aphantophus hyperanthus*) and Small Heath (*Coenonympha pamphillus*) feed probably on *Molinia caerulea* and sedges in the *Molinia*-dominated part op the bog.

3.3.3. Remarks

The transect where butterflies were recorded in 2010 and 2011 is located south of the area where removal of birch forest has taken place in order to restore the raised bog habitat (Appendix 3). It is 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.

Foto 4. Idas Blue is rather numerous in some parts of Holmegaards Mose.

Table 2. Butterfly species recorded in the transect on the 2nd of July 2011.

		Rare species				Common species									
Point / section number	**Durance (min)**	Boloria aquilonaris	Coenonympha tullia	Plebeius idas	Plebeius optilete	Aglais urticae	Pieris rapae	Pieris brassicae	Pieris napi	Aphantopus hyperantus	Coenonympha pamphilus	Polyommatus icarus	Celastrina argiolus	Ochlodes sylvanus	Diacrisia sannio
0	5									5					
0-1	10									7				2	
1	5						1			2					
1-2	10		3					1		14				1	
2	5		5					1							
2-3	10	1	4	1											
3	5		7												
3-4	10		6												
4	5		1												
4-5	10	1	3												1
5	5		3												
5-6	10		3												1
6	5		1												
6-7	10									2		1			1
7	5					1				3				1	
7-8	10	no observations													
8	5													2	
8-9	10	1	3											2	1
9	5		1											2	
9-10	10	1	2	3											
10	5			1	1										
10-11	10	1	4	2	4	1									
11	5		7		1										
11-12	10	1	2		2										
12	5		2												
12-13	10		2	3	4										
13	5	1	1												
13-14	10			3	5										
14	5		4												
14-15	10		1	10	2	1									
15	5					1			1		1		1		
Total number of counts		7	65	23	19	3	1	2	1	33	1	1	1	10	4
Counts in July 2010		22	25	15	1	1	2	3	0	3	0	3	0	10	0

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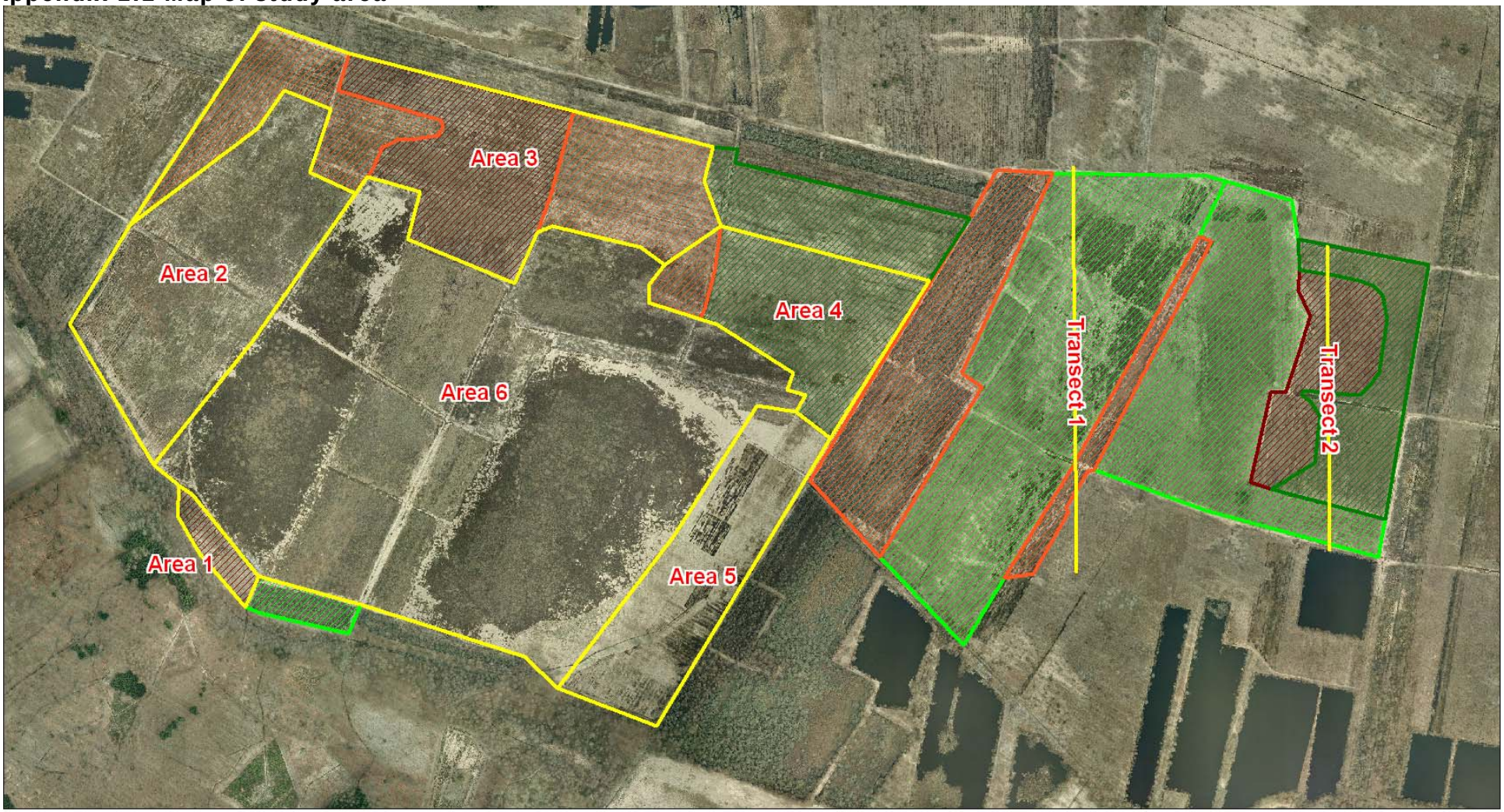
APPENDICES

Appendix 1: Vegetation
Appendix 2: Graphoderus bilineatus
Appendix 3: Butterflies
Appendix 4: Panorama photos

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
Shrubs, %	0	<1	0	0	<1	<1	2010
	0	<1	0	0	<1	<1	2011
Trees / bushes < 1m tall, %	2	25	30	30	20	21,4	2010
	2	25	30	40	30	25,4	2011
Trees / bushes >1m tall, %	100	2	7	20	10	27,8	2010
	100	5	20	30	20	35	2011

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
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
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
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

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
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
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
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

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
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
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
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

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
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
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
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

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
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
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
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

Yellow marking: plots area re-established

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
Open water surface, %	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	1	25	<1	<1	0	0	1	0	0	<1	2	<1	<1	0	0
Shrubs, %	0	<1	1	40	10	1	2	2	1	5	2	1	4	60	7	35
	0	0	5	10	10	5	<1	0	5	4	1	1	1	10	5	35
Trees / bushes < 1m tall, %	<1	2	<1	20	50	25	30	<1	<1	<1	1	<1	<1	1	10	5
	<1	<1	5	1	2	15	5	1	10	5	1	5	1	5	5	10
Trees - bushes >1m tall, %	80	90	90	60	70	60	55	70	75	70	80	90	75	70	50	25
	55	1	1	0	1	0	0	<1	5	5	1	1	0	0	<1	<1

Transect 1

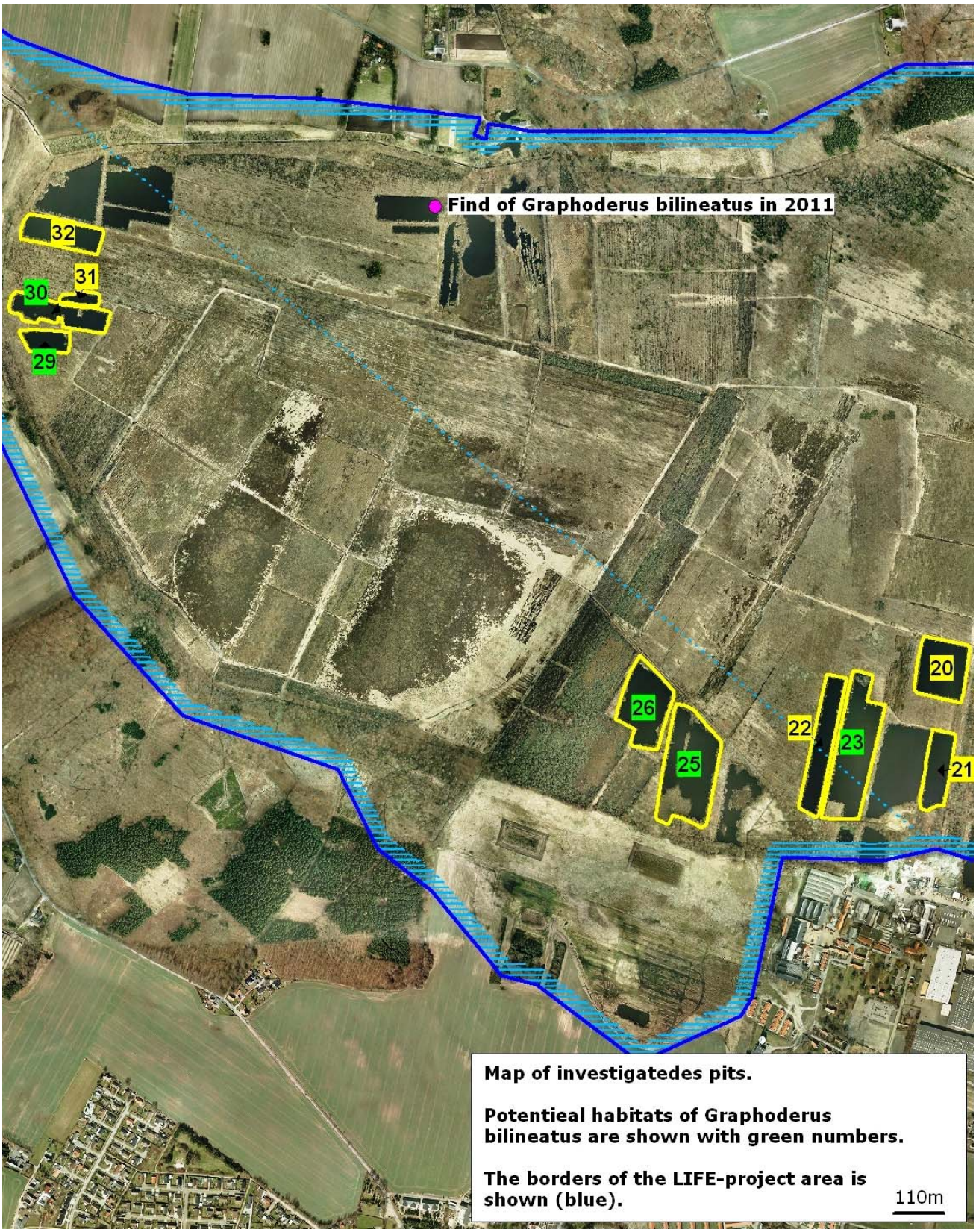
15 m	1.17	1.18	1.19	1.20	1.21	avg	year
Open water surface, %	0	0	0	0	0	0	2010
	<1	0	0	0	0	1,4	2011
Shrubs, %	30	1	<1	<1	0	9,7	2010
	30	1	<1	<1	0	5,9	2011
Trees / bushes < 1m tall, %	8	<1	<1	<1	1	7,5	2010
	10	<1	<1	<1	1	3,5	2011
Trees - bushes >1m tall, %	40	90	98	80	80	71,3	2010
	40	90	98	80	80	21,9	2011

Transect 2

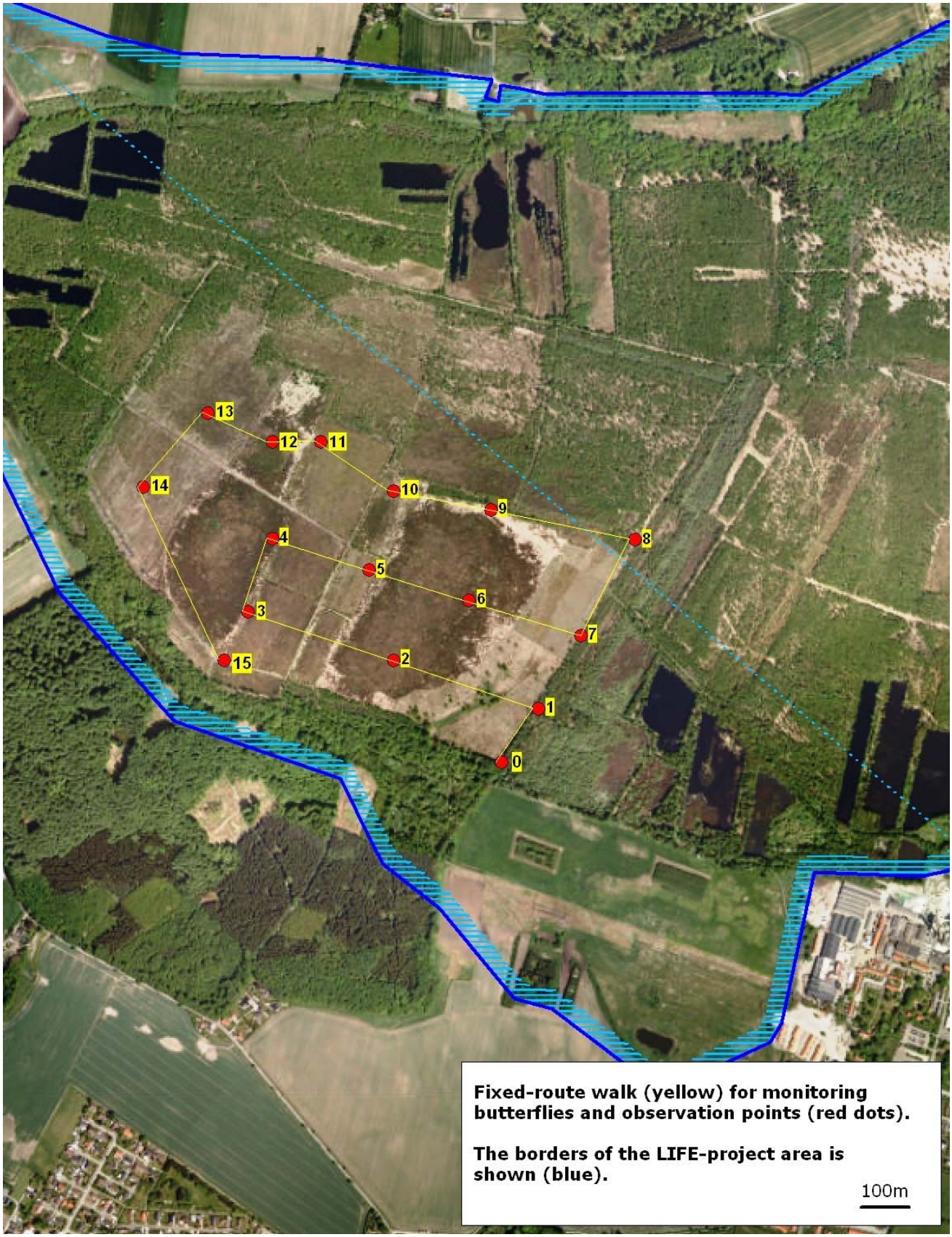
15 m	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	2.13	2.14	2.15	2.16	avg	year
Open water surface, %	0	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	50 - lake	<1	2010
	0	1	0	0	0	0	0	<1	5	5	7	1	<1	5	2	50 - lake	1,7	2011
Shrubs, %	10	1	40	60	85	90	80	75	40	40	30	3	<1	15	<1	10	36,3	2010
	10	3	40	60	85	90	80	75	40	40	15	20	2	7	<1	0	35,4	2011
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
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

Birch forest in plots 14-16 was removed after the last field survey; the plots are re-established

Appendix 2. A water beetle Graphoderus bilineatus



Appendix 3. Map of fixed-route walk for monitoring butterflies



Appendix 4. Panorama photos

Panorama photo of plot no 3-6, study area 3.

The photos should be seen from left to right and from top to bottom. The panorama is taken clockwise with the first picture towards north. .

Panorama photo of plot no 2-2, transect 2.

The photos should be seen from left to right and from top to bottom. The panorama is taken clockwise with the first picture towards north. .