Abbeyleix Bog 2020 ecotope survey report






Abbeyleix Bog Project

Ecology and Environmental Consultants Ireland Ltd.

ACKNOWLEDGMENTS

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A report for Abbeyleix Bog project produced by Fernando Fernandez and Willie Crowley

Summary

This report details the findings of the 2020 ecotope survey of Abbeyleix Bog and compares the results to the two previous ecotope surveys undertaken at the site; in 2009 soon after the restoration works were carried out and again in 2014. These surveys have shown a significant increase in the area of Active Raised Bog (ARB) (priority EU habitat) on the site from 1.12ha in 2009, to 3.19ha in 2014 and 13.78ha in 2020. This equates to a 12.66ha increase (1,130%) in ARB in eleven years. The survey has also reported the recording of small areas (0.13ha) of central ecotope for the first time, which is the finest quality vegetation type found in Irish raised bogs, thus indicating also an improvement in habitat quality. The impact this restoration has had on the carbon balance of the site is also estimated with CO_2 emissions connected with the high bog estimated to have fallen from 443.3 tonnes per year in 2009 to 407.5 in 2014 to 209.9 tonnes per year in 2020. This equates to a 52.7% decrease in annual CO_2 emissions or put more simply it equates to 81 fewer standard cars on the road per year or 116 new cars (with lower annual CO_2 emissions).

A number of recommendations are also given such as the need to block drains not previously blocked, install more dams in a number of drains as not all drains were blocked following the national raised bogs restoration guidelines (Mackin *et al*., 2017) which recommended a dam at every 10cm drop in elevation and a minimum of three and maximum of ten dams per 100m length of drain. In order to ensure a sufficient number of dams are installed, a comprehensive survey of the drains and dams on the site needs first to be carried out (this could be done using remote sensing). Monitoring of the high bog should continue with another ecotope survey carried out in 2025.

Contents

1. INTRODUCTION

Abbeyleix Bog is the most south-easterly raised bog in County Laois and the Habitats Directive (92/43/EEC) Annex 1 priority habitat Active Raised Bog (code number 7110) within it is at the south-eastern edge of the habitat's national geographic range. The bog was split into two when the Portlaoise to Kilkenny railway tracks were inserted in a north-south direction across the bog in the 1860s. The railway closed in 1963 and the tracks have since been removed. The path of the old line is now used by the local community for walking, education and recreation and continues to split the bog in two, with a larger western section measuring 63.3ha in extent and a smaller eastern section measuring 40.2ha in extent amounting to a total of 103.5ha of high bog on the site.

Turf cutting has taken place around most if not all the margins of the bog, but was abandoned in the late 1960s. Traditional hand-cutting with a sleán was the modus operandi and no machine cutting ever took place on the site. Parts of the eastern boundary of high bog closely match the extent of bog mapped by the Ordnance Survey in the 1840s and it is possible that these areas were never cut for turf. Bord na Móna purchased the bog and inserted an intensive drainage network in the western section in the 1980s inserting east-west parallel drains (ca 1m deep) every 15m. Similar drainage was inserted into the eastern section, but this was carried out at a later date (post 1995). The intention was to develop the bog for industrial peat production, but these plans were shelved due to local objections, and eventually BnM opted to conserve the site. In 2009 BnM carried out restoration works, blocking high bog drains with peat dams and in 2010 a 50-year lease was signed between BnM and the local community who are now tasked with managing the site, primarily for conservation through the Abbeyleix Bog Project (ABP). In 2014 a boardwalk was constructed across the western section of high bog to facilitate recreation and education.

The importance of peatlands in combating climate change is nowadays widely recognised. Abbeyleix Bog was chosen as one of the first bogs in Ireland where carbon emission factors associated with specific vegetation types, both high bog and cutover were assessed (Swenson *et a*l., 2019). These factors are now used at national level in raised bogs Greenhouse Gas (GHG) emissions assessments.

Abbeyleix Bog is of national conservation value due to the importance of the high bog habitats as well as the presence of rare lagg areas such as petrifying springs, fen and wet woodland detailed by Smith and Crowley (2019). The site is likely to be of importance at European level for the protection of these habitats not only because of their extent and quality but also due to its geographical location at the south-eastern range of raised bog habitats in Ireland.

This report details the findings of a 2020 ecotope survey of the site and compares the results to the two previous ecotope surveys undertaken at the site; one in 2009 (Ecologic Environmental & Ecological Consultants, 2009) soon after the restoration works were carried out by BnM, and one in 2014 (Bord na Móna, 2014).

2. METHODS

The 2020 ecotope survey was carried out across two days by two surveyors on July 8th and 10th using sub-meter accuracy GPS devices and followed the same methods used by the 2009 and 2014 surveys that were developed by Kelly *et al*. (1995) and adapted by Fernandez *et al*. (2014). Vegetation quadrats (4x4m) were also recorded (see Appendix V and 2020 survey notes map in Appendix II).

The limitations of such surveys are outlined by Bord na Móna (BnM) (2014) and include the recognition that a general characteristic of formerly drained Bord na Móna (BnM) high bog sites is that there can be a zonation of vegetation composition and ecotope type associated with the blocked drains. This zonation can occur at very small scales and thus an area mapped as being of a particular ecotope can frequently contain smaller patches of another ecotope reflecting poorer or better quality patches. This ecotope complexity is not reflected by the ecotope map but is reflected by the community complex-point map (BnM, 2014).

In addition to the ecotope survey the extent of the bog in the 1840s and 1910s was estimated from GIS analysis of the Ordnance Survey maps from those periods.

Scientific names of vascular plant species named in text follows Stace (2019) and bryophyte nomenclature follows the British Bryological Society (2009).

3. RESULTS

3.1.CHANGES IN ECOTOPES

The results of the 2020 ecotope survey are given in Tables 1-3 below, which indicate a **significant increase in the area of Active Raised Bog (ARB) on the site from 1.12ha in 2009, to 3.19ha in 2014 to 13.78ha in 2020** equating to a **12.66ha increase in ARB in eleven years** (see table 3 below). This equates to a **1,130 % increase in ARB extent since 2009** (see Maps within Appendix II).

In the 2009 baseline survey, the eastern section had the largest area of ARB with 0.98ha, and this was also the case in 2014 (2.14ha). This may be due to the fact that the eastern section was drained at a later stage than the western section. In 2020, the area of ARB on the eastern section has increased to 6.05ha, but now there is a larger area of ARB in the western section (7.73ha), increased from 1.05ha in 2014 and 0.13ha in 2009.

The 2020 survey was the **first to map small areas of central ecotope (i.e. finest ARB quality) indicating that the quality of the ARB is also continuing to improve** (see figure 1 below).The following ARB good quality indicators were recorded: Cranberry (*Vaccinium oxycoccos*); Great Sundew (*Drosera anglica*); Bog Bead-moss (*Aulacomnium palustre*); Austin's Bog-moss (*Sphagnum austinii*); *Sphagnum beothuk*; Feathery Bog-moss (*Sphagnum cuspidatum*) and Magellanic Bog-moss (*Sphagnum magellanicum*), and while some (if not all) of these species were present in 2014, their relative abundances (particularly that of *S. magellanicum*) has increased in the last six years.

The community complexes recorded on the site are described in the Appendix IV and their location and extent shown in the Maps section of this report (Appendix II). To aid understanding of the community complex descriptions a general explanation these descriptions is given in Appendix III.

Project deliverables are listed in Appendix I.

Table 1 Abbeyleix Bog ecotopes extent

Ecotope	Area (ha) by Year		
	2009	**2014**	**2020**
Central	0.00	0.00	0.13
Sub-central	1.12	3.19	13.66
Sub-marginal	26.15	21.62	50.45
Inactive flush	0.00	1.61	1.99
Marginal/sub-marginal mosaic	10.21	8.62	0.00
Facebank/sub-marginal mosaic	0.00	0.00	11.25
Marginal	26.85	42.20	10.29
Facebank/marginal mosaic	0.00	7.59	0.00
Facebank	44.33	18.70	15.76
Total high bog extent	**108.65**	**103.53**	**103.53**

Table 1 shows showing a comparison of the ecotope areas recorded at Abbeyleix Bog by the three ecotope surveys of 2009, 2014 and 2020. Note that the smaller high bog extent in 2014 and 2020 compared to 2009 is **not** due to real differences but

merely reflects improvements in mapping techniques. This difference would not have impacted on the areas of sub-marginal, sub-central and/or central ecotope recorded by the surveys, and would largely have resulted in the over-estimation of facebank ecotope in 2009. Note also that the inactive flush was already present in 2009 and there is no evidence that it has increased in extent since then or since 2014.

Table 2 Abbeyleix Bog ecotopes extent simplified

Ecotope	Area (ha) by Year		
	2009	**2014**	**2020**
Central	0.00	0.00	0.13
Sub-central	1.12	3.19	13.66
Sub-marginal	29.31	25.93	56.08
Inactive flush	1.99	1.99	1.99
Marginal	31.32	49.92	10.29
Facebank	39.79	22.50	21.38
Total high bog extent	**103.53**	**103.53**	**103.53**

Table 2 shows a simplified comparison of the ecotope areas recorded at Abbeyleix Bog by the three ecotope surveys of 2009, 2014 and 2020. In this table, areas recorded as mosaics are treated as containing equal amounts of the constituents of the mosaic. In addition, the 2009 high bog area is corrected to reflect its improved mapping in subsequent surveys. This was carried out by clipping the 2009 HB boundary with the 2014 HB boundary, totalling the ecotope areas (facebank 4.54ha, marginal 0.24ha and sub-marginal 0.35ha) mapped in these clipped areas in 2009 and subtracting them from the 2009 areas. The area of inactive flush is assumed not to have changed since 2009 and the marginal and sub-marginal ecotope areas have been amended accordingly by subtracting 1.60ha from sub-marginal and 0.39ha from marginal ecotope in 2009 (the area where inactive flush should have been mapped), and by subtracting 0.38ha from marginal ecotope in 2014.

Table 3 Abbeyleix Bog ARB ecotopes

	Area (ha) by Year			Ha increase		% increase	
	2009	**2014**	**2020**	**2009-20**	**2014-20**	**2009-20**	**2014-20**
Central ecotope (finest ARB quality)	0.00	0.00	0.13	0.13	0.13	NA	NA
Sub-central ecotope	1.12	3.19	13.66	12.54	10.47	1,120	328
Total ARB extent	**1.12**	**3.19**	**13.78**	**12.66**	**10.59**	1,130	332

Table 3 highlights the change in the area in hectares of ARB ecotopes in the three survey years as well as the percentage increase of these ecotopes in that time.

No known surveys of the high bog took place prior to the drainage network being inserted, but GIS analysis of the 1840s and 1910s Ordnance Survey maps indicate that the extent of bog at those time was approximately 258ha and 168ha respectively and that ca 600m of the current high bog margin in the east of the eastern section of the site has not changed since the 1840s (see change in bog extent (1840s-2020) map in Appendix II).

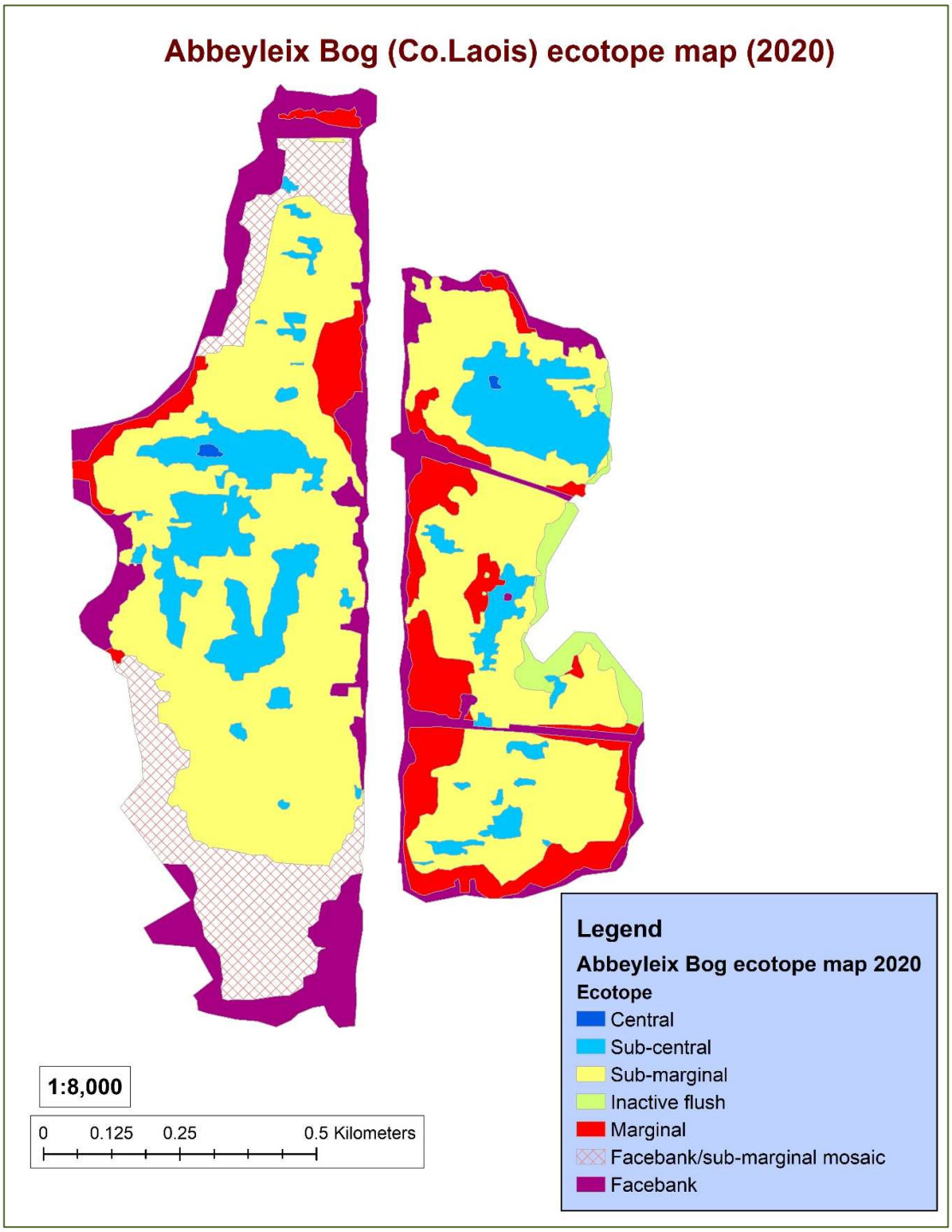

Figure 1. Abbeyleix Bog 2020 ecotope map

3.2.CHANGES IN GREENHOUSE GAS (CO_2) EMISSIONS

An extensive body of work has been undertaken in Ireland on the Greenhouse Gas (GHG) emissions associated with different peatland types (e.g. Wilson *et al.*, 2012). In recent years two research projects specifically looked at assessing CO_2 emissions arising from the main ecotope types on the high bog (Regan *et al*., 2020 and Swenson *et al*., 2019) and some of the most common vegetation types on cutover (Swenson *et al*., 2019) (see Table 4 below). The latter research project specifically investigated the CO_2 emissions associated with the main non-wooded vegetation types at Abbeyleix Bog. Further investigations on emissions factors associated with other commonly found vegetation types both on the high bog and cutover not covered by these two studies are currently being undertaken by NPWS. Nonetheless, those factors calculated by Regan *et al*. (2020) and Swenson *et al*. (2019) largely cover the main ecotopes mapped at Abbeyleix Bog and thus a comparison of the overall annual CO_2 emissions balance on high bog in the 2009 to 2020 period based on changes in ecotopes can be estimated for Abbeyleix Bog (see Tables 5 below).

Table 4 CO_2 emissions factors associated with different ecotopes

Ecotopes type	CO_2 emissions (g C-CO_2 m–2 yr–1)	Source
Central	-50	Sub-central ecotope at Clara Bog (Regan *et al*., 2020)
Sub-central	-50	""
Sub-marginal	18	Sub-marginal ecotope at Clara Bog (Regan *et al*, 2020)
Inactive flush	18	Sub-marginal ecotope at Clara Bog (Regan *et al*., 2020)
Marginal	131	Marginal ecotope at Clara Bog (Regan *et al*., 2020)
Facebank	188	Calluna and bare peat cutover vegetation type at Abbeyleix Bog (Swenson *et al*., 2019)

Table 5 Overall CO_2 emissions per year at Abbeyleix high bog

Ecotopes type	Emissions (tonnes of CO_2) per year		
	2009	**2014**	**2020**
Central	0.0	0.0	-0.2
Sub-central	-2.1	-5.8	-25.0
Sub-marginal	19.3	17.1	37.0
Inactive flush	1.3	1.3	1.3
Marginal	150.4	239.8	49.4
Facebank	274.3	155.1	147.4
Total	**443.3**	**407.5**	**209.9**

Calculations based on ecotopes extent provided in Table 3 and emission actors in Table 4 above.

The results of the above assessment can be summarised as follows:

- Overall, the **CO_2 emissions** reduced from 443.3 tonnes per year in 2009 to 209.9 tonnes in 2020. This is a reduction of **52.7% (234 tonnes per year)**. The reduction in the 2009 to 2014 was much smaller (8.1%). Taking into account than an average car in Ireland emits 2.9 tonnes of CO_2 per year (SEAI, 2020), a reduction in emission in 234 tonnes **equates to 81 fewer standard cars on the road**. **This figure is higher (116) when referred to new cars with lower emissions[1].**

- In terms of **sequestration**, the **active area of the bog** (sub-central ecotope) **was taking in only ca 2 tonnes CO_2 per year in 2009**, compared to over **25 tonnes per year in 2020** (central and sub-central ecotopes) indicating a clear upwards trend.

- **Abbeyleix high bog is still emitting CO_2** (209.9 tonnes CO_2 per year) based on the above calculations, but a much lower rate than before restoration works took place in 2009. This assessment is not taking into account nitrous oxide (N_2O) or methane emissions (CH4). Neither has a reduction in runoff losses of dissolved organic carbon been taken into account.

- The ecotope surveys have shown a clear increase in the extent of the most carbon sink effective ecotopes (central and subcentral) on the site. At the same time there was a 56% decrease in the extent of ecotopes with the highest emissions (facebank and marginal). Given the rewetting trend over the last 11 years and the 91% increase in the area of the wettest non-active ecotope (sub-marginal), it is reasonable to expect that there will be both an ongoing **increase in the extent of the best quality and carbon sink capacity ecotopes** in the future. Higher increases are likely to occur if the drains which remain open are blocked and more dams are installed in those drains identified as having insufficient dams during the 2020 survey. The majority of drains with further works required are surrounded by non-Active Raised Bog vegetation.

- This assessment did not look at current emissions within **Abbeyleix cutover**. The **implementation of restoration works within the site's cutover** is also expected to significantly **reduce overall emissions** associated with the entire site. Finally, it is worth bearing in mind that emission **reductions occur much more rapidly than subsequent vegetation change**. Following drain blocking emissions decrease rapidly as water levels rise significantly, within weeks to months depending on rainfall, while vegetation and ecotope change will take years/decades to reach equilibrium. Therefore, emission reductions based on vegetation change will lag behind the real reductions achieved by drain blocking and thus the emission reductions due to restoration given in this report can be considered as conservative estimates.

[1] According to European Environmental Agency (2018) the 2017 average CO_2 emissions from new passenger car in Ireland is 111.6 gCO_2/Km Taking into consideration that a private cars travelled in Ireland 18,000 km per year in 2016 (CSO, 2016 (https://www.cso.ie/en/releasesandpublications/ep/p-tranom/to2016/rtv/), this equates to 2.01 tonnes of CO_2/year.

4. RECOMENDATIONS

Restoration works

The main nature conservation objective for the high bog at Abbeyleix Bog is to enhance and expand the cover of ARB, which, through restoration actions, has been successfully increased from 1.12ha to 13.78ha in the last eleven years.

The best practice raised bogs restoration guidelines (Mackin et al., 2017) recommend that there should be a dam at every 10cm drop in drain elevation and a minimum of three and maximum of ten dams per 100m length of drain. During the 2020 ecotope survey of Abbeyleix Bog it was noted that there were lengths of drain where this protocol was not followed. The Survey Notes map in Appendix II illustrates areas where more dams are needed. However, this is not a complete map and ultimately a comprehensive survey of the drains and dams on the site needs to be carried out in order to identify areas of drains that need further dams installed (this could be done using remote sensing). While peat dams are recommended as the main technique, a combination of peat & multi-lock sandwich plastic dams may be needed for wide and deep drains and plastic dams may be the only option in wet areas or those already supporting ARB, as well as those areas where access is difficult for heavy machinery.

Invasive species:

Rhododendron (*Rhododendron ponticum*) was non-systematically recorded at several location on the cutover near the edge of the high bog (see Survey notes map in Appendix II). The continuing control of this species is recommended.

Additional impacts:

Deer poaching was recorded across many sections of the high bog (see Survey Notes map in Appendix II). This negative impact largely occurs on drier areas (marginal ecotope) and very little on ARB areas. Nevertheless, an assessment of the current population size, impacts on the site's habitats and the setting of a sustainable species population size is recommended.

Surveys:

Monitoring of the high bog should continue with another ecotope survey carried out in 2025.

A further LiDAR survey may also be worthwhile in order to assess whether the slopes on the site have changed and investigate why the Degraded Raised Bog model developed by NPWS in 2014 is underestimating the potential of the bog to recover.

5. REFERENCES

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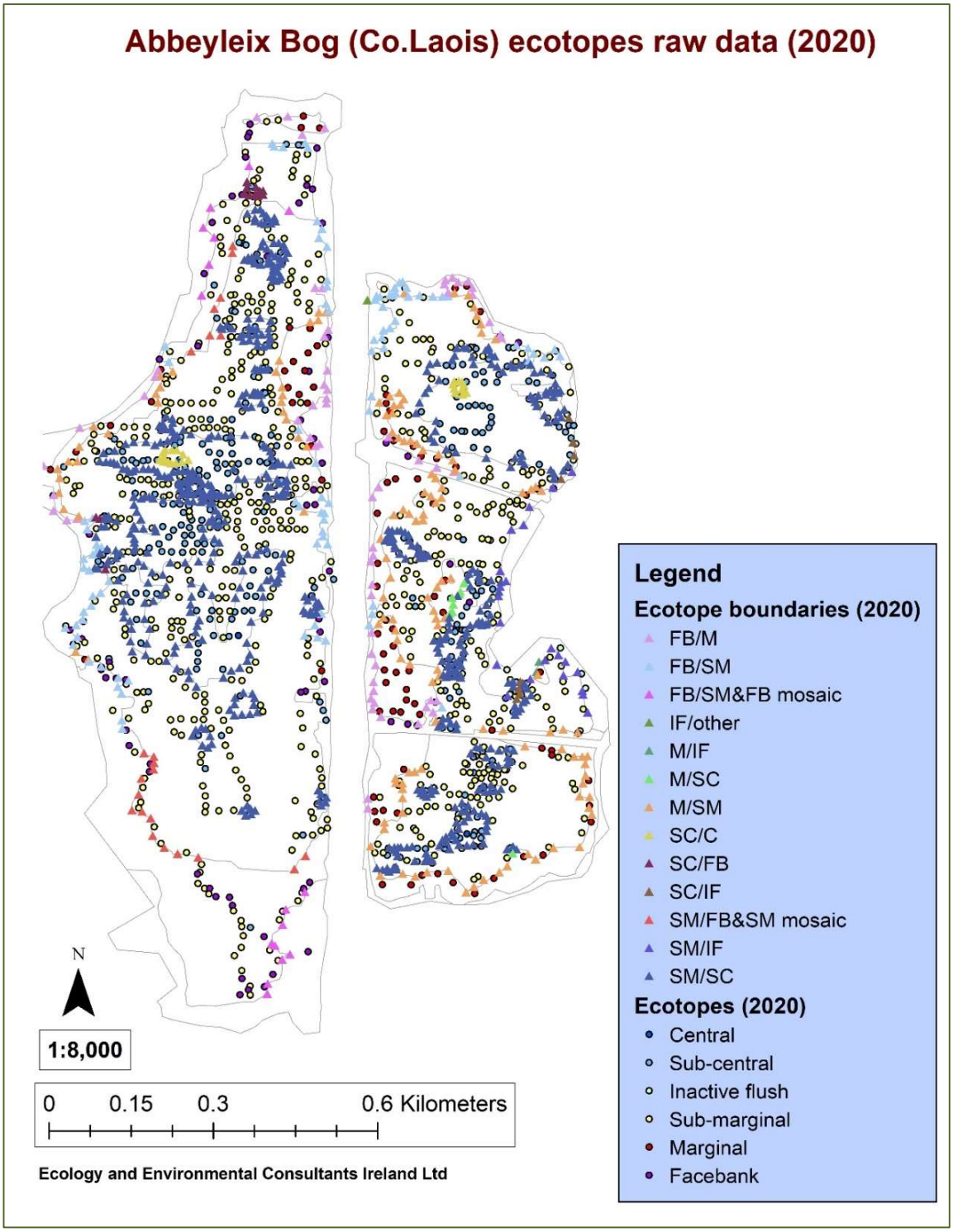
6. APPENDICES

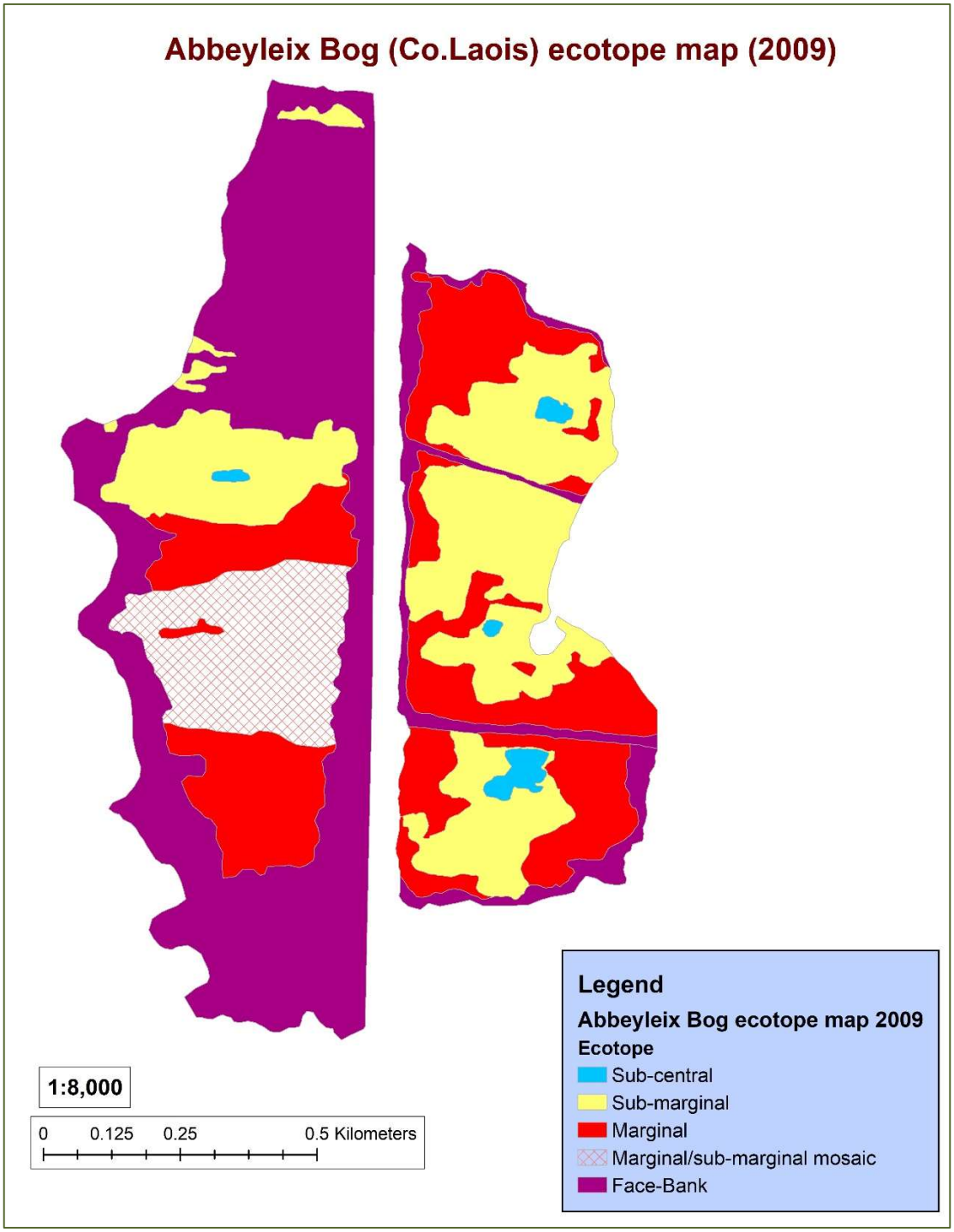
APPENDIX I Project deliverables

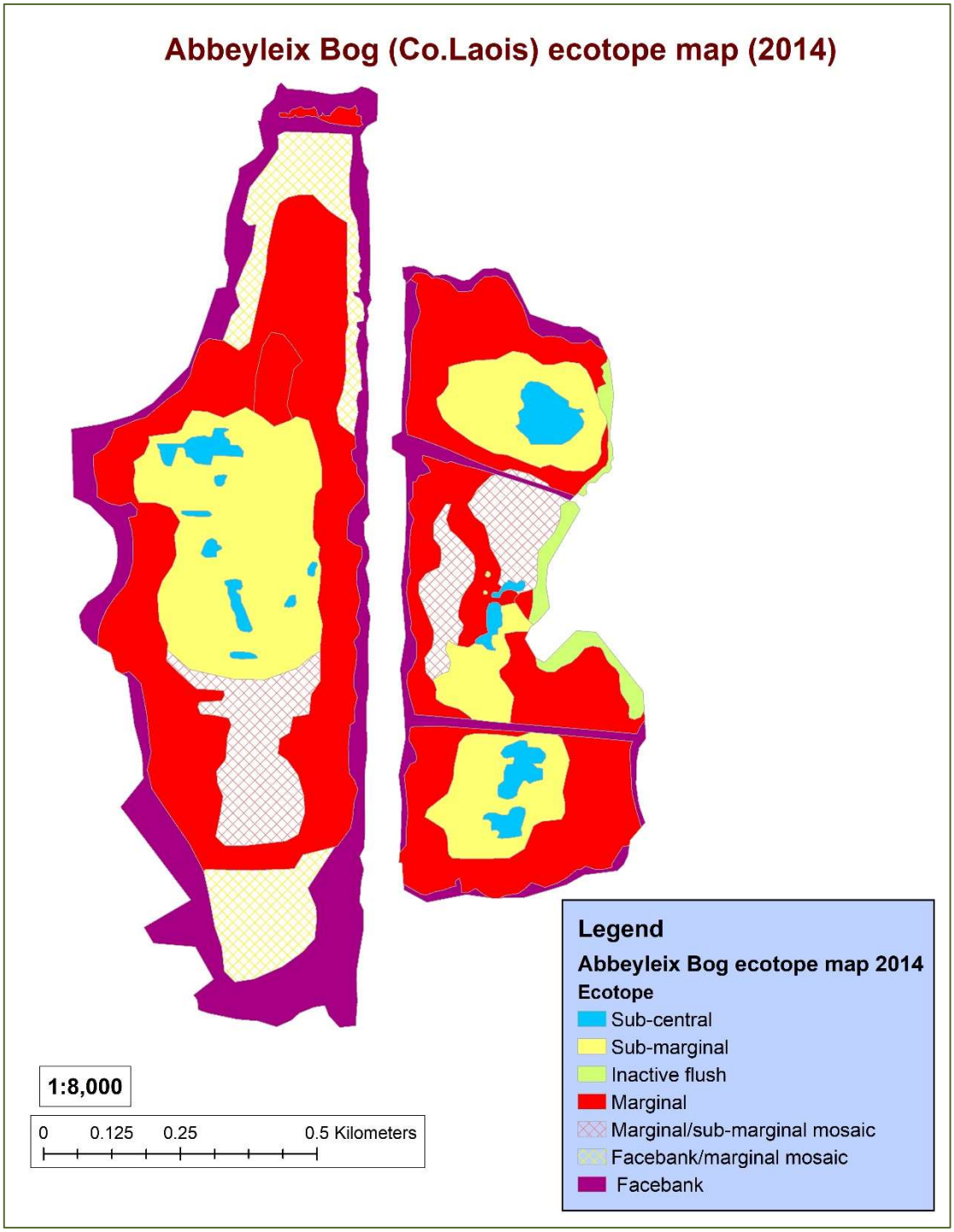
The Abbeyleix Bog (Co. Laois) 2020 ecotope survey has produced the following deliverables:

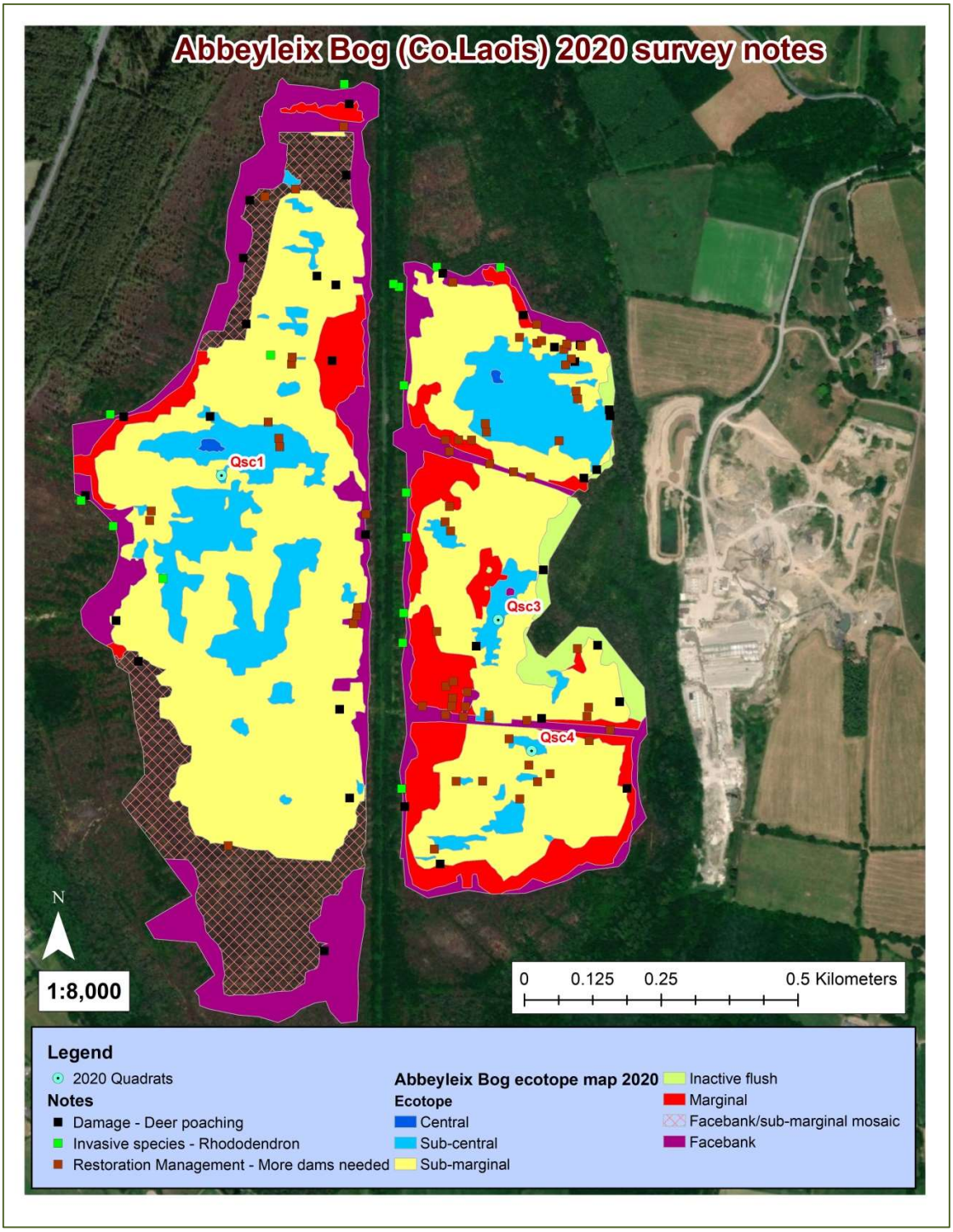
A. This report summarising the results of the assessment
B. GIS datasets:
   - Abbeyleix2020Ecotopes21072 - a vector polygon GIS shapefile of the ecotopes recorded in 2020.
   - Abbeyleix2020Quadrats210720 - a vector point GIS shapefile of the quadrats recorded in 2020.
   - Abbeyleix2020Notes210720 - a vector point GIS shapefile providing information such as invasive species, impacting activities (e.g. deer poaching), species of significant conservation value, further restoration works recommendations recorded in 2020.
   - Abbeyleix2020Ecotope_points210720 -a vector point GIS shapefile of ecotope points recorded in 2020.
   - Abbeyleix2020Boundary_points210720-a vector point GIS shapefile of ecotope boundary points recorded in 2020.
   - Abbeyleix1840sBog – a vector polygon GIS shapefile depicting the bogs 1840s extent.
C. Excel datasets:
   - Abbeyleix2020Quadrats - 2020 ARB 4x4 m vegetation quadrats.
D. PDF maps:
   - Abbeyleix_2014_vegetationmap17.08.20
   - Abbeyleix_2009_vegetationmap17.08.20
   - Abbeyleix_2020_vegetationmap17.08.20

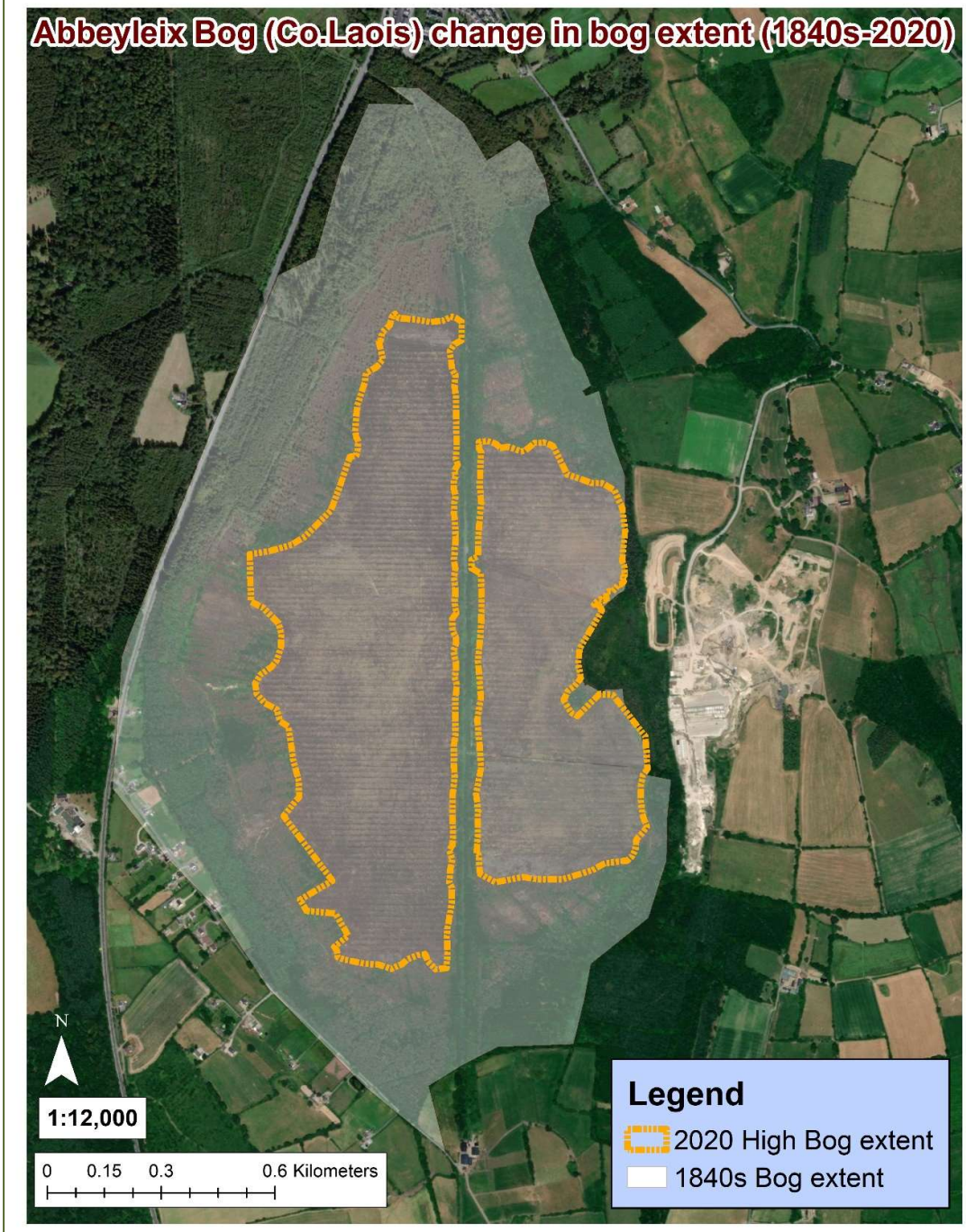
APPENDIX II Maps




Abbeyleix Bog (Co.Laois) ecotope map (2009)
1:8,000
0
0.125
0.25
0.5 Kilometers
Legend
Abbeyleix Bog ecotope map 2009
Ecotope
Sub-central
Sub-marginal
Marginal
Marginal/sub-marginal mosaic
Face-Bank


Abbeyleix Bog (Co.Laois) ecotope map (2014)
1:8,000
0
0.125
0.25
0.5 Kilometers
Legend
Abbeyleix Bog ecotope map 2014
Ecotope
Sub-central
Sub-marginal
Inactive flush
Marginal
Marginal/sub-marginal mosaic
Facebank/marginal mosaic
Facebank


Abbeyleix Bog (Co.Laois) 2020 survey notes
Qsc1
Qsc3
Qsc4
N
1:8,000
0 0.125 0.25 0.5 Kilometers
Legend
2020 Quadrats
Notes
Damage - Deer poaching
Invasive species - Rhododendron
Restoration Management - More dams needed
Abbeyleix Bog ecotope map 2020
Ecotope
Central
Sub-central
Sub-marginal
Inactive flush
Marginal
Facebank/sub-marginal mosaic
Facebank


Abbeyleix Bog (Co.Laois) change in bog extent (1840s-2020)
N
1:12,000
0 0.15 0.3 0.6 Kilometers
Legend
2020 High Bog extent
1840s Bog extent

APPENDIX III Explanation of the Vegetation community complex descriptions

- **Complex**: Each complex is named based on the dominance of one or more of the vegetation types listed here (from Kelly and Schouten, 20020
    1. *Calluna vulgaris* (facebank)
    2. *Trichophorum germanicum* dominated
    3. *Carex panicea* dominated
    4. *Rhynchospora alba* dominated
    5. NA
    6. *Narthecium ossifragum* dominated
    7. *Calluna vulgaris* dominated (not facebank type)
    8. NA
    9. *Eriophorum vaginatum* dominated
    10. *Sphagnum* dominated
    15. Hummock/hollow scattered pool complex
- **Location**: What part of the site the complex was recorded?
- **Ground**: Is ground firm, soft, very soft or quaking underfoot?
- **Physical indicators**: Is there evidence of burning, bare peat, erosion channels or algae etc?
- ***Calluna* height**: How tall is the Calluna?
- ***Cladonia* cover**: An estimate of the percentage cover of *Cladonia portentosa*, *C. uncialis* and *C. ciliata* combined?
- **Macro-topography**: Is the area flat or is there a slight, moderate or steep slope?
- **Pools**: Are there pools present and what type (e.g. interconnected, regular or tear pools)? This refers to natural pools as opposed to those created from borrow pits during restoration unless stated.
- ***Sphagnum* cover**: An estimate of the percentage cover of all *Sphagnum* species combined.
- ***Narthecium* cover**: An estimate of the percentage cover of *Narthecium ossifragum*.
- **Micro- topography**: What micro-topographical features are present (e.g. hummocks, hollows, lawns, flats and pools)?
- **Tussocks**: Is *Eriophorum vaginatum* or *Trichophorum germanicum* growing in tussock form?
- **Degradation or regeneration evidence**: Is there active growth of *Sphagnum austinii* or is there evidence of degradation such as dried out or dying *Sphagnum*?
- **Species cover**: An estimate of the percentage cover of the species recorded.
- **Additional comments**: Any additional comments relevant to the identification of the community.

APPENDIX IV Vegetation community complex descriptions

Central Ecotope Complexes

Complex 10/15

- **Location**: two small areas; one in the eastern section in the middle of the northern lobe and one in the western section to the south-west of the boardwalk.
- **Ground**: very soft
- **Physical indicators**: absent
- ***Calluna* height**: 21-30cm
- ***Cladonia* cover**: 1-3%
- **Macro-topography**: flat
- **Pools**: absent
- ***Sphagnum* cover**: 91-100%
- ***Narthecium* cover**: 11-25% (lower in western section)
- **Micro- topography**: lawns, low hummocks and, particularly in the east section of the HB, *Sphagnum*-filled depressions
- **Tussocks**: absent
- **Degradation or regeneration evidence**: active growth of *Sphagnum austinii* and *S. magellanicum*
- **Species cover**: *Calluna vulgaris* (11-25%), *Erica tetralix* (4-10%), *Rhynchospora alba* (11-25%; lower in western section), *Eriophorum vaginatum* (11-25%; higher in western section), *E. angustifolium* (1-3%; higher in western section), *Narthecium ossifragum* (11-25%; lower in western section), *Vaccinium oxycoccos* (4-10%; lower in western section), *Drosera rotundifolia* (<1%), *D. anglica* (<1%; western section only); *Andromeda polifolia* (<1%); *Aulacomnium palustre* (eastern section only); *Polytrichum alpestre* (<1%; eastern section only); *Sphagnum austinii* (4-10%); *S. magellanicum* (34-50%); *S. papillosum* (11-25%); *S. cuspidatum* (11-25%); *S. capillifolium* (4-10%); *S. tenellum* (1-3%).
- **Additional comments**: These areas of central ecotope are arguably still better mapped as sub-central ecotope as there are no distinct pools present. However, the cover of *Sphagnum* was 100% and while it was dominated by *S. magellanicum* (large amounts of which typically indicate sub-central), there a good cover of *S. cuspidatum* as well as active regenerating low hummocks of *S. austinii*. The area in the east could be further defined as Complex 10/6/15 due to the moderate cover of *Narthecium ossifragum* in depressions with *Rhynchospora alba* while that in the west could be defined as 10/9/15 due to the high cover of *Eriophorum* spp.

Figure 1 Complex 10/15 in the eastern section of Abbeyleix Bog.

Figure 2 Complex 10/15 in the western section of Abbeyleix Bog.

Sub-central Ecotope Complexes

Complex 9/10

- **Location**: covered large areas of the sub-central ecotope across the site
- **Ground**: very soft
- **Physical indicators**: absent
- ***Calluna* height**: 21-30cm
- ***Cladonia* cover**: 1-3% (higher in places)
- **Macro-topography**: flat
- **Pools**: restricted to borrow pits
- ***Sphagnum* cover**: 70-80%
- ***Narthecium* cover**: 1-3% (higher in places)
- **Micro- topography**: lawns, low hummocks and *Sphagnum*-filled pools (in former borrow pits)
- **Tussocks**: absent
- **Degradation or regeneration evidence**: active growth of *Sphagnum austinii* and *S. magellanicum*
- **Species cover**: *Calluna vulgaris* (26-33%), *Erica tetralix* (4-10%), *Eriophorum vaginatum* (34-50%), *E. angustifolium* (1-3%), *Rhynchospora alba* (1-3%), *Narthecium ossifragum* (1-3%; higher in places), *Vaccinium oxycoccos* (<1%), *Drosera rotundifolia* (<1%), *D. anglica* (<1%; western section only); *Andromeda polifolia* (<1%); *Sphagnum capillifolium* (11-25%), *S. papillosum* (4-10%), *S. magellanicum* (26-33%), *S. cuspidatum* (4-10%), *S. subnitens* (1-3%), *S. austinii* (1-3%), *S. beothuk* (<1%), *S. tenellum* (<1%), *Aulacomnium palustre* (<1%); *Polytrichum alpestre* (<1%).
- **Additional comments**: this complex is differentiated from the poorer quality sub-central complex 9/7/10 by its higher cover of *Eriophorum vaginatum* and *Sphagna* particularly *S. cuspidatum* and by its lower cover of *Calluna vulgaris* and *Narthecium ossifragum*.

Complex 6/10

- **Location**: in small areas of sub-central both on the western and eastern sections. In the west if is found towards the middle of the bog while in the east it is found along the eastern edge of sub-central in the northern lobe and across much of the sub-central in the southern lobe.
- **Ground**: very soft
- **Physical indicators**: absent
- ***Calluna* height**: 21-30cm
- ***Cladonia* cover**: 11-25%
- **Macro-topography**: flat
- **Pools**: absent
- ***Sphagnum* cover**: 65-75%

- ***Narthecium* cover**: 11-25%
- **Micro- topography**: lawns, low hummocks and hollows
- **Tussocks**: *E. vaginatum*
- **Degradation or regeneration evidence**: active growth of *Sphagna* including S. *austinii* and *S. magellanicum*
- **Species cover**: *Calluna vulgaris* (11-25%), *Erica tetralix* (1-3%), *Eriophorum vaginatum* (11-25%), *E. angustifolium* (<1%), *Rhynchospora alba* (4-10%), *Narthecium ossifragum* (11-25%), *Vaccinium oxycoccos* (<1%), *Drosera rotundifolia* (<1%), *Andromeda polifolia* (<1%); *Sphagnum capillifolium* (11-25%), *S. papillosum* (1-3%), *S. magellanicum* (51-75%), *S. cuspidatum* (1-3%), *Sphagnum austinii* (<1%), *S. tenellum* (1-3%).
- **Additional comments**: where *Rhynchospora alba* is more abundant than *Narthecium ossifragum* but all other species covers remain similar, this complex is termed Complex 4/10. It is differentiated from the sub-central complex 9/10 (above) by its lower cover of *Eriophorum vaginatum* and by its higher cover of *Sphagnum magellanicum* and *Narthecium ossifragum*.

Figure 3 Complex 6/10

Complex 9/7/10

- **Location**: in small areas of sub-central both on the western and eastern sections, but is more widespread in the eastern section
- **Ground**: soft
- **Physical indicators**: absent
- ***Calluna* height**: 21-30cm
- ***Cladonia* cover**: 26-33% (lower in places)
- **Macro-topography**: flat or gently sloping
- **Pools**: restricted to borrow pits
- ***Sphagnum* cover**: 75-85%
- ***Narthecium* cover**: 5%
- **Micro- topography**: low hummocks and hollows
- **Tussocks**: *E. vaginatum*
- **Degradation or regeneration evidence**: active growth of *Sphagna* including *S. magellanicum*
- **Species cover**: *Calluna vulgaris* (34-50%), *Erica tetralix* (4-10%), *Eriophorum vaginatum* (26-33%), *E. angustifolium* (1-3%), *Rhynchospora alba* (1-3%), *Narthecium ossifragum* (4-10%), *Trichophorum germanicum* (<1%), *Drosera rotundifolia* (<1%), *Andromeda polifolia* (<1%); *Sphagnum capillifolium* (26-33%), *S. papillosum* (11-25%), *S. magellanicum* (26-33%), *S. cuspidatum* (1-3%), *Sphagnum austinii* (1-3%), *S. subnitens* (4-10%), *S. tenellum* (4-10%).
- **Additional comments**: this is the poorest quality sub-central ecotope. *Sphagna* typical of wet areas (e.g. *S. cuspidatum*) are less common in this complex than all other ARB complexes. As well as having a lower cover of *S. cuspidatum*, it is differentiated from other ARB complexes by having a higher cover of *Calluna vulgaris*. It is differentiated from sub-marginal complexes by its higher cover of *Sphagnum* and *Eriophorum vaginatum*.

Sub-marginal Ecotope Complexes

Complex 9/7

- **Location**: covered large areas of the sub-marginal ecotope across the site, particularly adjacent to sub-central ecotope, but is absent from the northern lobe of the eastern section
- **Ground**: soft
- **Physical indicators**: absent
- ***Calluna* height**: 31-40cm
- ***Cladonia* cover**: 4-10%
- **Macro-topography**: flat
- **Pools**: absent

- ***Sphagnum* cover**: 40%
- ***Narthecium* cover**: 1-3%
- **Micro- topography**: low hummocks/hollows
- **Tussocks**: absent
- **Degradation or regeneration evidence**: active growth of *Sphagnum* in places
- **Species cover**: *Calluna vulgaris* (51-75%), *Erica tetralix* (1-3%), *Eriophorum vaginatum* (11-25%), *E. angustifolium* (1-3%), *Rhynchospora alba* (1-3%), *Narthecium ossifragum* (1-3%), *Vaccinium oxycoccos* (<1%), *Drosera rotundifolia* (<1%), *Andromeda polifolia* (<1%); *Sphagnum capillifolium* (11-25%), *S. papillosum* (1-3%), *S. magellanicum* (11-25%), *S. cuspidatum* (<1%), *S. subnitens* (4-10%), *Sphagnum austinii* (<1%), *S. tenellum* (4-10%).
- **Additional comments**: There are occasional patches of ARB within this complex and *Rhynchospora alba* and *Sphagnum cuspidatum*/*S. magellanicum* dominate in some former borrow pits mimicking typical bog pools in places. This complex is differentiated from the poorer quality sub-marginal complex 9/7/6 by its lower cover of *Narthecium ossifragum* while it is differentiated from the sub-central complex 9/7/10 by its lower cover of *Eriophorum vaginatum* and *Sphagna* particularly *S. cuspidatum* and by its higher cover of *Calluna vulgaris*. This complex also supported an area in the east of the middle lobe of the eastern section which had the addition of Pine trees – here the complex was termed 9/7+Pines.

Complex 9/7/4

- **Location**: largely restricted to the northern lobe of the eastern section
- **Ground**: soft
- **Physical indicators**: absent
- ***Calluna* height**: 31-40cm
- ***Cladonia* cover**: 11-25%
- **Macro-topography**: gentle slope
- **Pools**: restricted to former borrow pits
- ***Sphagnum* cover**: 30-40%
- ***Narthecium* cover**: 5-10%
- **Micro- topography**: low hummocks/hollows with occasional lawns and taller hummocks
- **Tussocks**: *Eriophorum vaginatum*
- **Degradation or regeneration evidence**: active growth of *Sphagnum* in places
- **Species cover**: *Calluna vulgaris* (26-33%), *Erica tetralix* (4-10%), *Eriophorum vaginatum* (11-25%), *E. angustifolium* (1-3%), *Rhynchospora alba* (4-10%), *Narthecium ossifragum* (4-10%), *Campylopus introflexus* (<1%), *Cladonia floerkeana* (<1%), *Drosera rotundifolia* (<1%), *Andromeda*

polifolia (<1%); *Trichophorum germanicum* (<1%), *Sphagnum capillifolium* (4-10%), *S. subnitens* (4-10%), *S. papillosum* (1-3%), *S. magellanicum* (11-25%), *S. cuspidatum* (1-3%), *S. austinii* (1-3%), *S. tenellum* (4-10%), *Hypnum jutlandicum* (1-3%).

- **Additional comments**: Variable with ARB-like areas in places with lawns of S. magellanicum, but poorer elsewhere particularly along drain edges where tall Calluna vulgaris dominates. There are also scattered *Pinus sylvestris* trees in this area growing up to 3m in height.

Complex 9/7/6

- **Location**: covered large areas of the sub-marginal ecotope across the site
- **Ground**: soft
- **Physical indicators**: absent
- ***Calluna* height**: 31-40cm
- ***Cladonia* cover**: 4-10%
- **Macro-topography**: gentle slope
- **Pools**: absent
- ***Sphagnum* cover**: 30%
- ***Narthecium* cover**: 10-20%
- **Micro- topography**: low hummocks/hollows and flats
- **Tussocks**: absent
- **Degradation or regeneration evidence**: active growth of *Sphagnum* in places
- **Species cover**: *Calluna vulgaris* (34-50%), *Erica tetralix* (4-10%), *Eriophorum vaginatum* (11-25%), *E. angustifolium* (1-3%), *Rhynchospora alba* (1-3%), *Narthecium ossifragum* (11-25%), *Cladonia uncialis* (<1%), *Drosera rotundifolia* (<1%), *Andromeda polifolia* (<1%), *Trichophorum germanicum* (1-3%), *Sphagnum capillifolium* (11-25%), *S. papillosum* (1-3%), *S. magellanicum* (11-25%), *S. cuspidatum* (1-3%), *S. tenellum* (1-3%), *Hypnum jutlandicum* (1-3%).
- **Additional comments**: This complex varies from poor quality where it grades into marginal ecotope to relatively good quality where it grades into sub-marginal complex 9/7. It is differentiated from the complex 9/7 by its lower cover of *Sphagnum* and its higher cover of *Narthecium ossifragum*. As it grades towards marginal ecotope, the cover of *Eriophorum vaginatum* and *Sphagnum* generally decreases and the cover of *Narthecium ossifragum* increases.

Figure 4 Complex 9/7/6

Marginal Ecotope Complexes

Complex 6/7

- **Location**: occurs mainly in the west of the eastern section (in the area directly east of the old railway track)
- **Ground**: firm
- **Physical indicators**: bare peat (5%)
- ***Calluna* height**: 41-50cm
- ***Cladonia* cover**: 4-10%
- **Macro-topography**: moderate to steep slopes
- **Pools**: absent
- ***Sphagnum* cover**: 10%
- ***Narthecium* cover**: 11-25%
- **Micro- topography**: low hummocks/hollows and flats
- **Tussocks**: *Trichophorum germanicum*
- **Degradation or regeneration evidence**: Although 5% bare peat has been recorded it is expected that this was present since the drains were inserted 20-30 years ago.

- **Species cover**: *Calluna vulgaris* (26-33%), *Erica tetralix* (4-10%), *Eriophorum vaginatum* (4-10%), *E. angustifolium* (1-3%), *Rhynchospora alba* (1-3%; higher in places), *Narthecium ossifragum* (11-25%), *Drosera rotundifolia* (<1%), *Andromeda polifolia* (<1%), *Trichophorum germanicum* (1-3%), *Sphagnum capillifolium* (4-10%), *S. papillosum* (1-3%), *S. cuspidatum* (<1%), *S. subnitens* (1-3%), *S. tenellum* (<1%).
- **Additional comments**: where *Rhynchospora alba* or *Trichophorum germanicum* is more abundant but all other species covers remain similar, this complex is termed Complex 6/7/4 (occurring in the north of the western section and the north-west of the eastern section) or 6/7/2 (occurring in the north of the western section and the south of the eastern section) respectively. The complex grades into sub-marginal complex 9/7/6 in places and is differentiated from it by its lower cover of *Eriophorum vaginatum* and *Sphagnum* and by its higher cover of *Narthecium ossifragum*. This complex also supported an area in the mid-east of the eastern section which had the addition of Pine trees – here the complex was termed 6/7+Pines.

Complex 7/6/4

- **Location**: occurs mainly in the west of the eastern section
- **Ground**: firm
- **Physical indicators**: bare peat (5-10%)
- ***Calluna* height**: 41-50cm
- ***Cladonia* cover**: 4-10%
- **Macro-topography**: moderate to steep slopes
- **Pools**: absent
- ***Sphagnum* cover**: 10%
- ***Narthecium* cover**: 5-10%
- **Micro- topography**: low hummocks/hollows and flats; Rhynchospora alba dominated depressions devoid of *Sphagnum*
- **Tussocks**: *Trichophorum germanicum*
- **Degradation or regeneration evidence**: none
- **Species cover**: *Calluna vulgaris* (76-90%), *Erica tetralix* (<1%), *Eriophorum vaginatum* (1-3%), *E. angustifolium* (1-3%), *Rhynchospora alba* (4-10%), *Narthecium ossifragum* (4-10%), *Trichophorum germanicum* (1-3%), *Sphagnum capillifolium* (4-10%), *S. subnitens* (4-10%), *S. tenellum* (<1%), *Hypnum jutlandicum* (11-25%).
- **Additional comments**: parts of this complex occur in areas that appear to be slightly elevated above the surrounding high bog and support scattered pine and birch to 3-4m.

Figure 5 Complex 7/6/4

Complex 7/4/2

- **Location**: occurs mainly in the west of the eastern section
- **Ground**: firm
- **Physical indicators**: bare peat (5-10%)
- ***Calluna* height**: 41-50cm
- ***Cladonia* cover**: 4-10%
- **Macro-topography**: moderate to steep slopes
- **Pools**: absent
- ***Sphagnum* cover**: 10%
- ***Narthecium* cover**: 5-10%
- **Micro- topography**: low hummocks/hollows and flats; Rhynchospora alba dominated depressions devoid of *Sphagnum*
- **Tussocks**: *Trichophorum germanicum*
- **Degradation or regeneration evidence**: none
- **Species cover**: *Calluna vulgaris* (76-90%), *Erica tetralix* (<1%), *Eriophorum vaginatum* (1-3%), *E. angustifolium* (1-3%), *Rhynchospora alba* (4-10%), *Narthecium ossifragum* (4-10%),

Trichophorum germanicum (1-3%), *Sphagnum capillifolium* (4-10%), *S. subnitens* (4-10%), *S. tenellum* (<1%), *Hypnum jutlandicum* (11-25%).

- **Additional comments**: parts of this complex occur in areas that appear to be slightly elevated and support scattered pine and birch to 3-4m.

Complex 7/9

- **Location**: occurs towards the high bog edge particularly in the eastern section
- **Ground**: firm
- **Physical indicators**: absent
- ***Calluna* height**: 31-40cm
- ***Cladonia* cover**: 51-75%
- **Macro-topography**: steep slopes
- **Pools**: absent
- ***Sphagnum* cover**: 10%
- ***Narthecium* cover**: <1%
- **Micro- topography**: low hummocks/hollows
- **Tussocks**: *Trichophorum germanicum* and *Eriophorum vaginatum*
- **Degradation or regeneration evidence**: none
- **Species cover**: *Calluna vulgaris* (34-50%), *Erica tetralix* (11-25%), *Eriophorum vaginatum* (26-33%), *E. angustifolium* (<1%), *Rhynchospora alba* (<1%), *Narthecium ossifragum* (<1%), *Trichophorum germanicum* (1-3%), *Andromeda polifolia* (<1%), *Sphagnum capillifolium* (4-10%), *S. papillosum* (1-3%).
- **Additional comments**: scattered pine in places, where they become abundant complex described as Complex 7/9+Pines

Complex 7/9+Pines

- **Location**: largely restricted to the south-west of the eastern section
- **Ground**: firm
- **Physical indicators**: bare peat (5%)
- ***Calluna* height**: 41-50cm
- ***Cladonia* cover**: 1-3%
- **Macro-topography**: gentle to moderate
- **Pools**: absent
- ***Sphagnum* cover**: 10%

- ***Narthecium* cover**: 2%
- **Micro- topography**: hummocks
- **Tussocks**: *Trichophorum germanicum* and *Eriophorum vaginatum*
- **Degradation or regeneration evidence**: none
- **Species cover**: *Calluna vulgaris* (76-90%), *Erica tetralix* (1-3%), *Eriophorum vaginatum* (4-10%), *E. angustifolium* (1-3%), *Pinus sylvestris* (4-10%), *Vaccinium oxycoccos* (<1%), *Andromeda polifolia* (<1%), *Sphagnum capillifolium* (4-10%), *Dicranum scoparium* (<1%), *Cladonia uncialis* (<1%), *Hypnum jutlandicum* (4-10%).
- **Additional comments**: Abundant *Pinus sylvestris* up to 5m in height.

Inactive Flush

- **Location**: along eastern margin of the north and middle lobes of the eastern section of high bog
- **Ground**: firm
- **Physical indicators**: absent
- ***Calluna* height**: 31-40cm
- ***Cladonia* cover**: absent
- **Macro-topography**: steep slope
- **Pools**: absent
- ***Sphagnum* cover**: 11-25%
- ***Narthecium* cover**: absent
- **Micro- topography**: low hummocks and tussocks
- **Tussocks**: *Trichophorum germanicum* and *Eriophorum vaginatum*
- **Degradation or regeneration evidence**: none
- **Species cover**: *Myrica gale* (51-75%), *Calluna vulgaris* (26-33%), *Erica tetralix* (4-10%), *Eriophorum vaginatum* (4-10%), *Trichophorum germanicum* (1-3%), *Vaccinium oxycoccos* (<1%), *Andromeda polifolia* (<1%), *Sphagnum capillifolium* (11-25%), *S. magellanicum* (1-3%).
- **Additional comments**: Abundant *Pinus sylvestris* up to 5m in height. This flush is solely defined by the abundance of *Myrica gale* and much of it corresponds to the length of high bog that has remained unchanged since the 1840s. It transitions into woodland on the cutover where Smith and Crowley (2019) mapped a mixture of bog woodland (some of which was Annex I quality) and wet woodland. These were adjudged to correspond largely with WL3F (*Salix cinerea – Phalaris arundinacea* woodland), WL4C (*Betula pubescens – Sphagnum palustre* woodland) and WL4E (*Betula pubescens – Salix cinerea* woodland) communities as defined by the Irish Vegetation Classification.

APPENDIX V 2020 Vegetation quadrats

Date	09/07/2020	08/07/2020	08/07/2020
Ecotope	Sub-central	Sub-central	Sub-central
Complex	4/10	9/10	9/10
Quadrat	**Qsc1**	**Qsc3**	**Qsc4**
X	643426.90	643932.70	643993.58
Y	682639.18	682374.74	682135.69
Firmness	Very soft	Soft	Soft
Bare_Peat	0	0	0
High_Hummo	Absent	Absent	Absent
Low_Hummoc	34-50	51-75	51-75
Hollows	34-50	26-33	26-33
Lawns	Absent	Absent	Absent
Flats	4-10	Absent	4-10
Pools	Absent	Absent	Absent
Total_Spha	76-90	76-90	51-75
S_austinii	Active	Absent	Absent
S_beothuk	Absent	Absent	Absent
S_magellan	4-10	34-50	11-25
S_papillos	4-10	4-10	<4 (many)
S_cuspidat	11-25	<4 (many)	<4 (many)
S_denticul	Absent	Absent	Absent
S_capillif	34-50	11-25	26-33
Ssubnitens	Absent	Absent	Absent
S_tenellum	1-3 (many indiv)	4-10	4-10
Calluna	26-33	34-50	34-50
Erica	4-10	4-10	4-10
Evaginatum	4-10	34-50	4-10
E_angustif	<4 (many)	Absent	<4 (few)
R_alba	11-25	Absent	<4 (several)
Narthecium	4-10	Absent	4-10
Carex_pani	Absent	Absent	Absent
Trichophor	Absent	Absent	Absent
Cladonia_p	1-3 (many indiv)	<4 (many)	<4 (several)
Campylopus	Absent	Absent	Absent
Menyanthes	Absent	Absent	Absent
Drosera_an	Present	Absent	Absent
Comment	Cladonia uncialis	Quadrat more/less defined at 3 of 4 corners by 1m tall Betula and pine.	*Vaccinium oxycoccos, Polytrichum alpestre* & *Odontoschisma sphagni* present
Comment2		*Vaccinium oxycoccos* abundant	
Comment3		*Odontoschisma* super abundant	