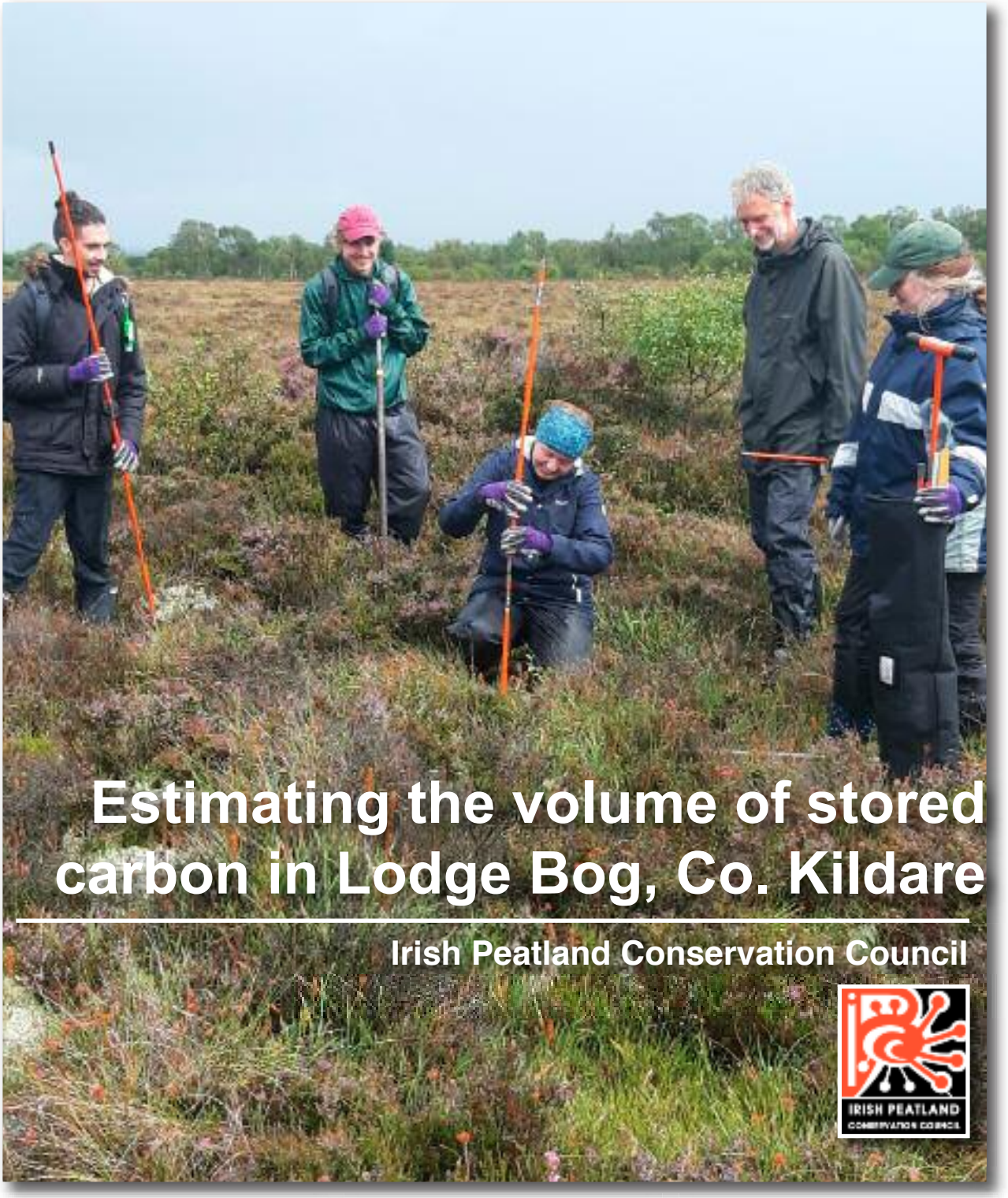

Estimating the volume of stored carbon in Lodge Bog, Co. Kildare

Irish Peatland Conservation Council

Contents

1. Acknowledgements

The Irish Peatland Conservation Council would like to acknowledge and thank our funding partners on this project: The Heritage Council through the Heritage Sector Support Fund 2021, the Community Foundation for Ireland - Biodiversity Fund 2020, the Tides Foundation and the Irish Peatland Conservation Council Friends of the Bog.

IPCC would like to thank all those peatland custodians who volunteered their time to this project including M.Sc. Biodiversity & Conservation Management students Trinity College Dublin, Úna Butler, Elizabeth Cullen, Áine McGirl, Joe Kelly, Mark Reid, Solenn Reeves Long, Cliona Kelliher, Jerome Kelly, Erin McCrudden, Elena Aitova, Dan Sheridan, Mick Barry, Karin Klinkenbergh & Brigita Gindvilyle.

Citation: N. Madigan, P. Farrell & T. Whyte (2021). Estimating the volume of stored carbon in Lodge Bog, Co. Kildare. Irish Peatland Conservation Council, Co. Kildare

Cover Images: Volunteers taking peat depth measurements on Lodge Bog South, summer 2021 & 4,000 pine tree identified within the peat core. Photos: © N. Madigan & Paula Farrell

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2. Executive Summary

Peatlands or bogs are wetlands containing 90% water and 10% dead and decaying plants. Actively growing peatlands accumulate organic mass, and thereby sequester carbon due to excess vegetation production over decay. Carbon is taken in by peatland plants through the process of photosynthesis from carbon dioxide, largely from the atmosphere. A persistently high water table is necessary for carbon storage.

With a growing awareness of the value peatlands offer in terms of carbon storage and the positive impact rewetting peatlands can have on supporting Ireland reach its net zero economy by 2050 this project aimed to estimate the store of carbon on Lodge Bog, Co. Kildare. The project also aimed to share skills with peatland custodians and interested members of the public on the methods used to calculate stored carbon on raised bog habitat in the midlands.

Lodge Bog is one of the last portions of intact raised bog that remains of Lullymore Bog and is the only remnant of this bog that is presently protected. There are two distinct lobes of raised bog habitat known as Lodge Bog North and Lodge Bog South. Three Annex I habitats as defined under the Habitats Directive are present on the site; Active Raised Bog Habitat (7110) covers 36% of the site, Degraded Raised Bog Habitat (7120) covers 52.5% while Bog Woodland Habitat (91DO) makes up the final 11.5%. As 11.5% of the reserve is Bog Woodland this area of the site is not included within the study bringing the total area of peatland included to 30.97 hectares.

191 drain blocks inserted along 5km of internal drains on the reserve aimed to restore water levels on Lodge Bog. Understanding that the hydrology of a peatland affects the carbon storage potential, average water table measurements recorded in 2005 pre drain blocking and 2021 post drain blocking are presented (figure 3 & 4). This data recorded an increase in water levels on the reserve since drain blocking that supports carbon storage however notes that no marginal drains have been blocked on the reserve which will limit the reserves potential to store the maximum store of carbon estimated on the reserve.

To estimate the store of carbon, new research in 2021 determining peat depths at 32 sample points on Lodge Bog South combined with data presented by Kerr, 2011 for Lodge Bog North, a peat stratigraphy, along with average figures for bulk density and percentage carbon for midlands raised bogs presented in Tomlinson, 2005 were used to calculate the minimum, maximum and average estimates for stored carbon on Lodge Bog. Across the 30.97ha reserve it is estimated that the maximum store of carbon is 84,183.16tC, the minimum store of carbon on the reserve is 24,917.79tC while the average store of carbon is estimated at 54,465.31tC.

While the estimate of carbon stored highlights the value of peatlands as a carbon store further efforts to improve the hydrology of Lodge Bog is recommended as marginal drains are not blocked on the reserve and therefore this report does not suggest the maximum store of carbon is being stored on Lodge Bog. Depending on how we manage our peatland resources they can strongly contribute to the climate crisis or they can support climate mitigation plans and international biodiversity targets (O'Connell, et al., 2021).

3. Introduction

3.1 Peatlands, Carbon & Climate Change

Peatlands or bogs are wetlands containing 90% water and 10% dead and decaying plants. They are acidic in nature (pH3.7-5.2). Healthy peatlands have a water table within 20cm of the surface throughout the year. Peat is the result of the accumulation of partially decayed plants over thousands of years (Madigan & O'Connell, 2020).

Peat consists of *Sphagnum* moss along with the roots, leaves, flowers and seeds of heathers, grasses and sedges. Actively growing peatlands accumulate organic mass, and thereby sequester carbon due to excess vegetation production over decay. Carbon is taken in by peatland plants through the process of photosynthesis from carbon dioxide, largely from the atmosphere. However peatlands also release carbon as a direct result of decay processes. Most of the vegetation decay takes place aerobically in the surface horizons (the acrotelm). However, anaerobic decay also continues, albeit at a much slower rate, at depth in cold, anaerobic horizons (the catotelm), releasing methane.

A persistently high water table is necessary for this function. As this process has been going on for many thousands of years peatlands are a significant carbon store. Peatlands store more carbon than any other terrestrial ecosystem but once drained, that carbon store is released and that is very damaging to the environment. In a natural peatland system, the movement of greenhouse gases (e.g. methane and carbon dioxide) between the peatland and air and water is complex. Although peatlands accumulate carbon over the long term, they both fix and emit carbon dioxide and release considerable amounts of methane, a by-product of anaerobic decomposition. Drainage of a peatland upsets the accumulation process and leads to a vast increase in the amount of CO_2 released to the atmosphere from the peatland, a by-product of aerobic decomposition (O'Connell et al., 2021).

It is estimated that Irish peatlands contain 64% of Ireland's soil organic carbon (Madigan & O'Connell, 2020). Depending on how we manage our peatland resources they can strongly contribute to the climate crisis or they can support climate mitigation plans and international biodiversity targets (O'Connell, et al., 2021).

Image: The Irish Peatland Conservation Council are a national charity with a mission to conserve a representative portion of Irish peatlands for people to enjoy today and in the future. The work of the Irish Peatland Conservation Council (IPCC) is guided by a series of Conservation Action Plans. In 2021 the IPCC published the 7th Action Plan since its foundation in 1982, Peatlands and Climate Change Action Plan 2030. To learn more about the ecosystem service peatlands offer to us all in climate mitigation please visit our website www.ipcc.ie.

3.2 Lodge Bog

Lodge Bog (grid ref: N714 260) lies in Lullymore Bog in the most Easterly part of the Bog of Allen, the largest complex of raised bog in Ireland. The Bog of Allen covers 115,080 hectares (ha) and spans nine counties across the midlands of Ireland. Lullymore Bog is the largest single raised bog within the Bog of Allen covering 6,575ha (Irish Peat Enquiry Committee 1900).

Lodge Bog is one of the last portions of intact raised bog that remains of Lullymore Bog and is the only remnant of this bog that is presently protected. It is found in the Eastern part of Lullymore Bog and is directly adjacent to Lullymore Island, 220ha of mineral soil which is surrounded on all sides by peatland.

Lodge Bog is located approximately 5 kilometres (km) from the town of Allenwood in Co. Kildare and 9 km from the town of Rathangan and is found along the R414 road which connects the two towns.

The R414 road marks the northern boundary of the site. To the East of the site rewet cutover bog owned by Bord na Móna while to the West the site abuts the mineral soil of Lullymore Island.

At present, the Irish Peatland Conservation Council (IPCC) own 35 hectares of Lodge Bog. The remainder is privately owned (see Figure 1). The portion of Lodge bog owned by the IPCC is divided into two distinct lobes referred to within this report as Lodge Bog North and Lodge Bog South.

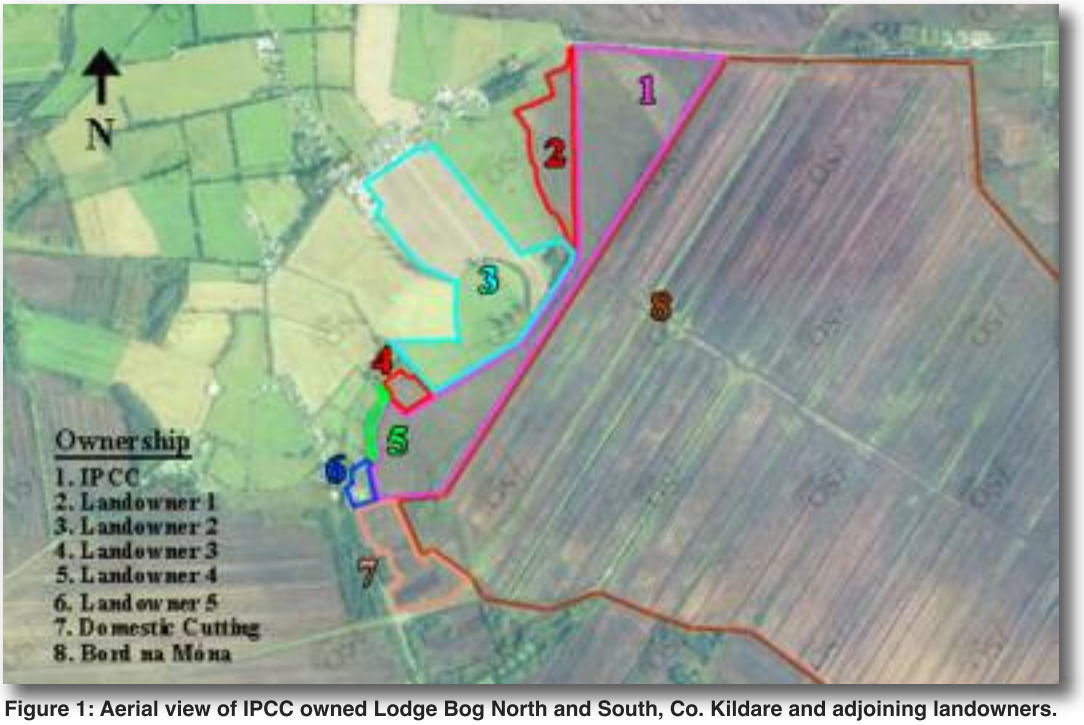

Figure 1: Aerial view of IPCC owned Lodge Bog North and South, Co. Kildare and adjoining landowners. © Google Maps, 2021

The two distinct lobes of raised bog habitat are separated by a 364 metre section of bog woodland. A further area of bog woodland habitat occurs along the south western margin of Lodge Bog South.

Three Annex I habitats as defined under the Habitats Directive are present on the site; Active Raised Bog Habitat (7110) covers 36% of the site, Degraded Raised Bog Habitat (7120) covers 52.5% while the Bog Woodland Habitat (91DO) makes up the final 11.5%.

To date there have been 200 floral species and 188 faunal species recorded on Lodge Bog (Ó Corcora, 2011).

Image: Bog Rosemary (*Andromeda polifolia*) on Lodge Bog. © N. Madigan

Lodge Bog was affected by historic drainage. The Irish Peatland Conservation Council identified over 5km of internal drains on the site. Between 2006 and 2009 a programme of drain profiling and dam installation was carried out on Lodge Bog. Overall 191 drain blocks were constructed across the network of drains on Lodge Bog. Three different types of dam were used; Geoflex plastic dams, natural peat dams and composite dams. Composite dams are a combination of the previous two comprising of a layer of peat wedged between two plastic dams. These are used in wider drains where there is a large volume of water as they are capable of withstanding the pressure that comes under these conditions. Between September 22nd and October 12th 2010 a dam survey was carried out across the entire site in order to assess the integrity of the dams and identify those dams that needed reinforcement. In total only 7 dams were deemed in need of repair. In all cases the issue was with water escaping around the side of the dam. This was halted through reinforcement with as many sheets of Geoflex as were necessary (Ó Corcora, 2011). It should be noted that due to the R414 and adjacent private land, the Irish Peatland Conservation Council have only blocked internal drains on Lodge Bog and no marginal drains were blocked. Water level monitoring has allowed the Irish Peatland Conservation Council to analyse changes in the hydrology since drain blocking was undertaken on the reserve. For the purposes of this project the most central transects on both Lodge North and Lodge South will be presented sharing data recorded prior to and post drain blocking (Figure 3 & 4).

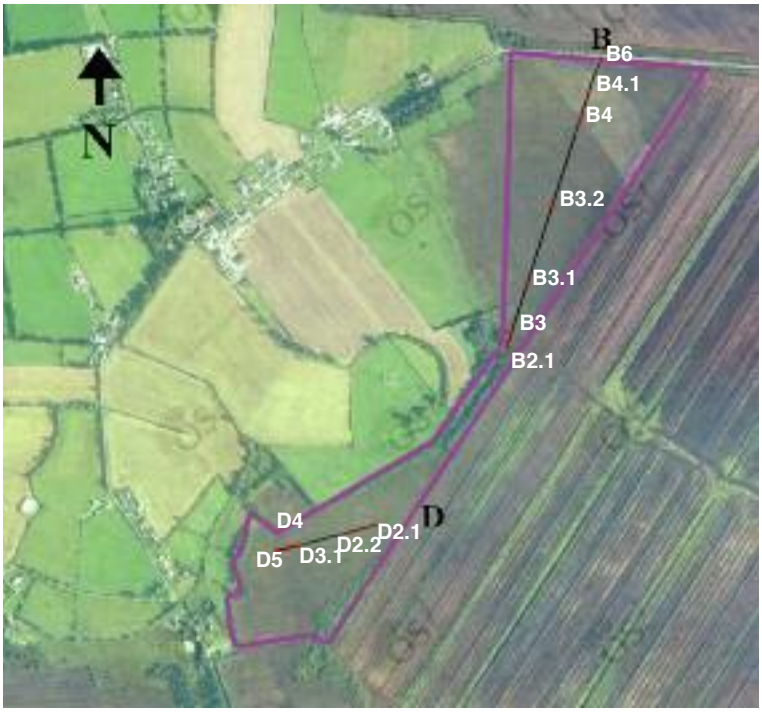

Figure 2: Location of the most central piezometers used to monitor water levels on Lodge Bog. Transect B is located on Lodge Bog North and Transect D located on Lodge Bog South.

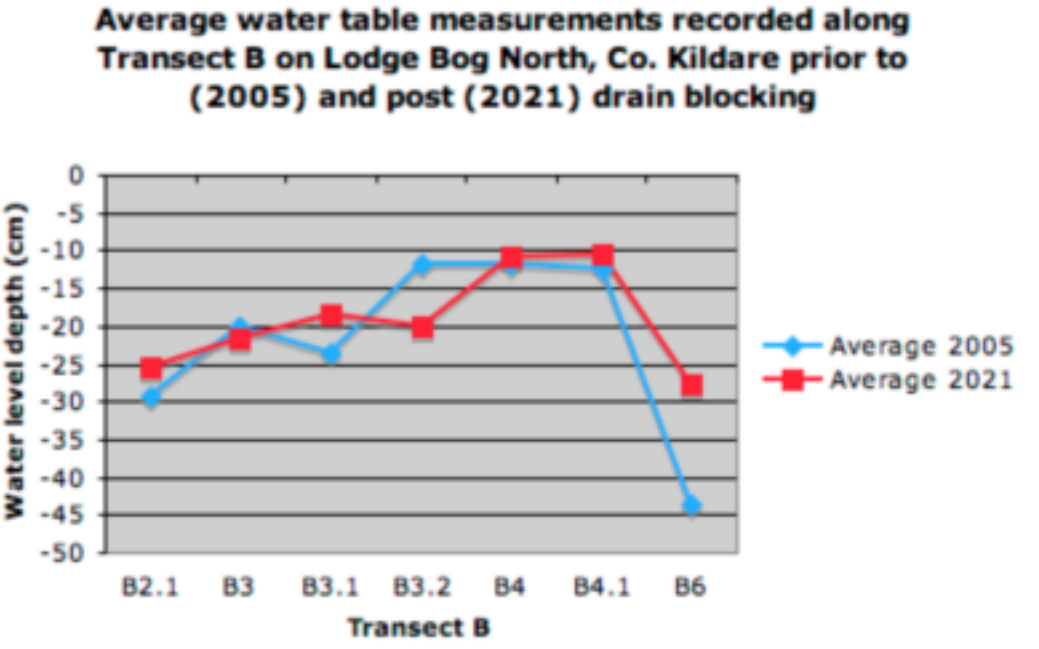

Figure 3: A healthy peatland has a water table within 20 cm of the surface. Prior to drain blocking commencing on Lodge Bog North in 2005, data gathered from 4 of the 7 piezometers monitored recorded average water levels below this ideal water table. The lowest water table was recorded in B6 with a water table measurement in excess of -40cm with B2.1 recording a water table close to -30cm below the surface. In 2021 average water levels have increased along the transect which highlights the positive impact drain blocking can have on a peatland. With the exception of B3.2 all piezometers monitored show an improvement in water table levels post drain blocking. It is not clear from the data why B3.2 has recorded a drop in water table. This piezometer is located centrally along the transect and a possible explanation may be the surface drain blocking has affected water movement below the surface unseen to the human eye. New techniques in drain blocking known as bunding work to manage both the flow of water on the surface and beneath the peat. Further analysis of water data should be undertaken to investigate the lower water table recorded in B3.2 but this is outside the scope of this project. Overall the average water table measurements recorded post drain blocking are showing increasing water levels which support carbon storage on Lodge Bog North.

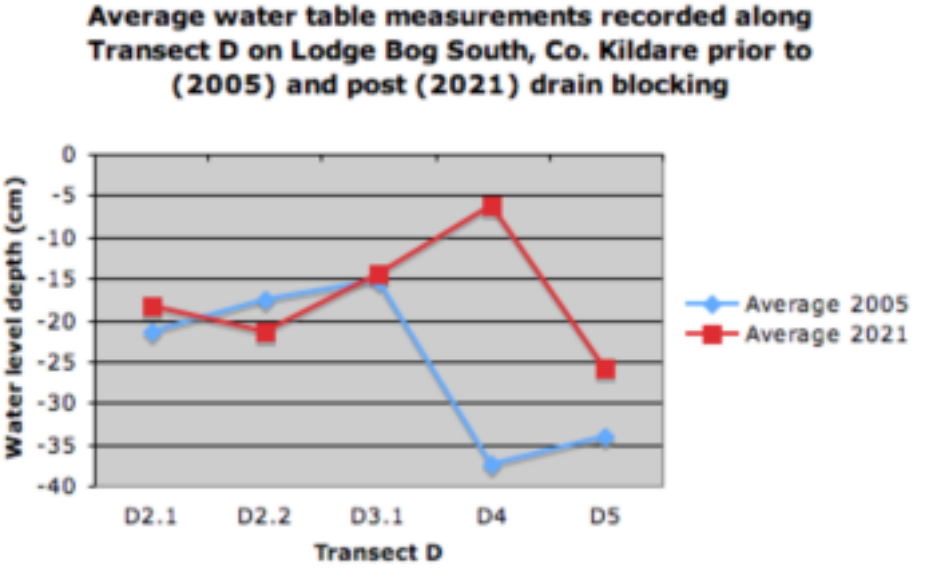

Figure 4: Transect D located on Lodge Bog South once again shows the positive impact drain blocking has had on the water levels. Similar to Transect B an unexplained drop in average water level is recorded in one of the piezometers, D2.2. This piezometer is also located centrally along Transect D and as suggested above this may be as a result of water movement beneath the surface unseen to the human eye. In 2021, 3 of the piezometers recorded show an average water table within the ideal range for peat accumulation with the two remaining piezometers showing improvements and measurements between -26 and -21cm below the surface. Overall the average water table measurements recorded post drain blocking are showing increasing water levels which support carbon storage on Lodge Bog South.

4. Project Aims

With a growing awareness of the value peatlands offer in terms of carbon storage and the positive impact rewetting peatlands can have on supporting Ireland reach its net zero economy by 2050, this project aimed to:

1. Explore the depth of peat on Lodge Bog South and to take a peat core to support the Irish Peatland Conservation Council to estimate the store of carbon on this area of the reserve.

2. In 2011 an undergraduate student Emily Kerr completed a project entitled 'The Long Term Carbon Storage Capacity on Lodge Bog'. This project focused on Lodge Bog North. Using data gathered and reported in the 2011 report combined with that gathered in 2021 on Lodge Bog South, the Irish Peatland Conservation Council will calculate an estimate of the carbon stored across open peatland on Lodge Bog. As 11.5% of the reserve is Bog Woodland this area of the site is not included within the study bringing the total area of peatland included to 30.97 hectares.

3. To share skills with peatland custodians and interested members of the public on the methods used to calculate stored carbon on raised bog habitat in the midlands.

Image: Volunteers take part in a skill sharing day exploring the peat depth on Lodge Bog 2021. © P. Farrell

5. Methods

5.1 Measuring peat depth on Lodge Bog

In 2020 the Irish Peatland Conservation Council completed desktop research on the best practice methods to estimate carbon stored in peatlands (O'Connell, et al., 2020). It was identified during this research that peat depths were required to estimate the store of carbon on a reserve. Peat depths for Lodge Bog North are presented in Kerr, 2011. To determine peat depth on Lodge Bog South four transects were set up as follows across this area of the reserve: A (Northeast-Southwest), B (Northwest-Southeast), C (West-East) and D (North-South) as shown in Figures 5 & 6 and recommended by Agus, et al (2011).

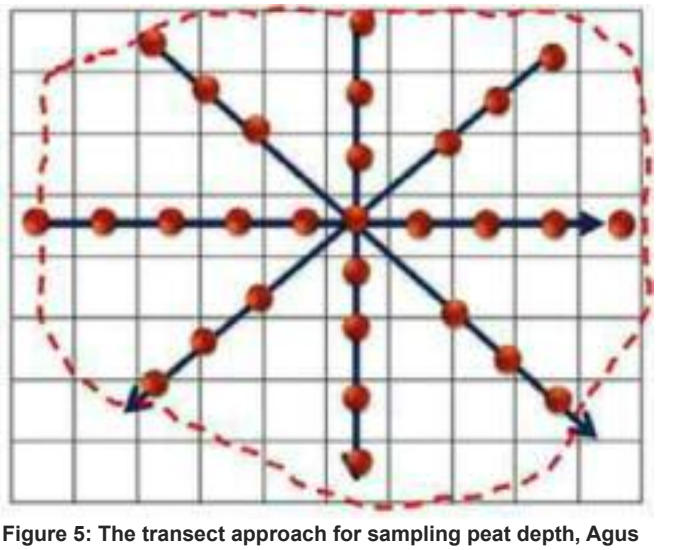

Figure 5: The transect approach for sampling peat depth, Agus et al (2011).

Peat depth sampling points were identified at 50m intervals along the transects. A total of 32 points were sampled across four transects using a Van Walt peat probe. Elevation was recorded at each of the sample points to understand the depth of peat in comparison to the surface of the bog above the height of sea level and changes in same. The area of Lodge Bog included in this study is 88.5% or 30.97Ha of the reserve as the 11.5% of Bog Woodland has been excluded.

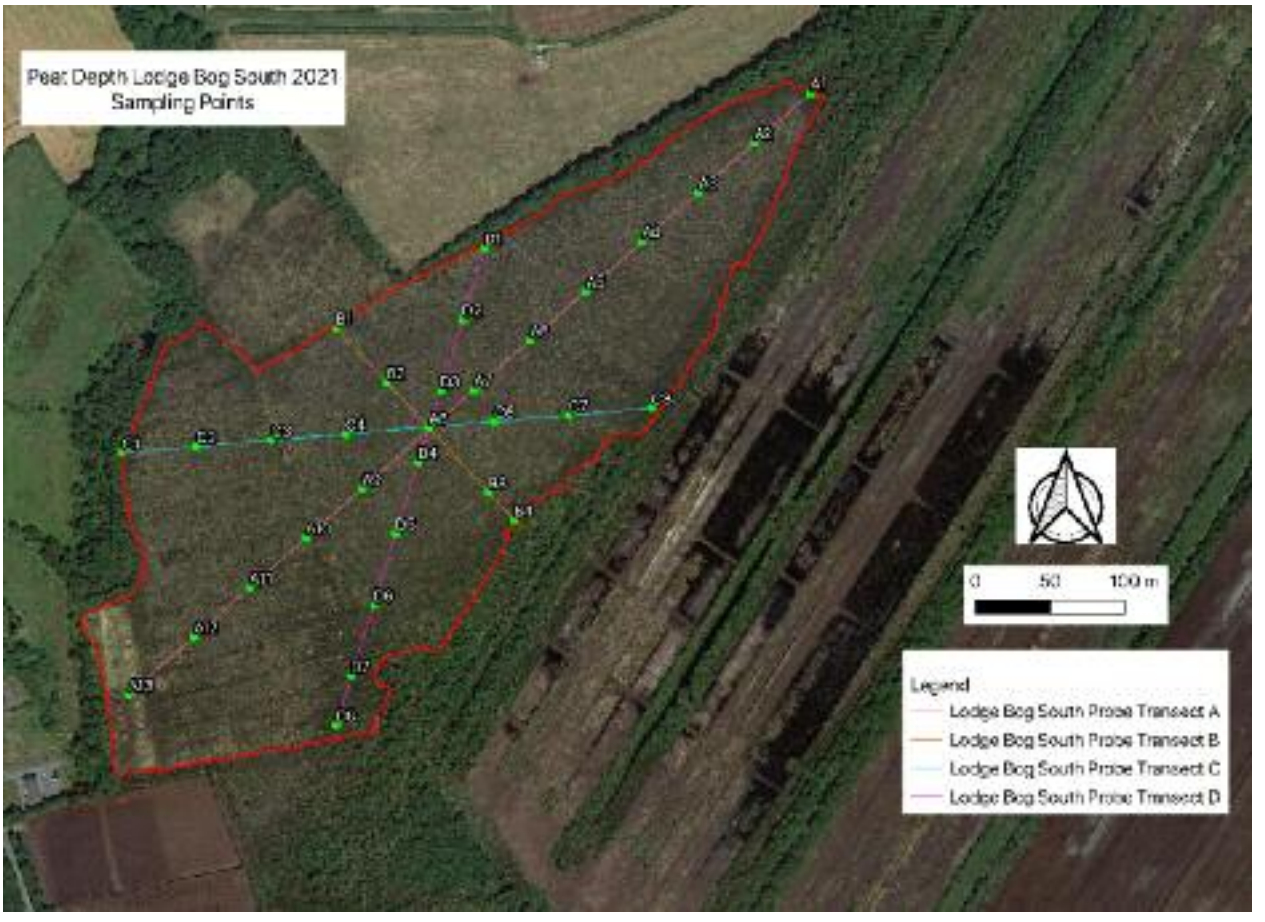

Figure 6: Map identifying the Transect Method for determining peat depth and the location of the 32 sample points along four transects A, B, C and D on Lodge Bog South, Co. Kildare. © Created using QGIS and Google Satellite Maps, 2021.

Figure 7: Map identifying the 17 sampling points Kerr, 2011 used to determine peat depth on Lodge Bog North. It should be noted that Agus et al. (2011) sampling method was not available to Kerr at the time of sampling. As a result Kerr used a different approach by measuring peat depths at sample points at 250m intervals around the perimeter of the reserve and along Transect B through the centre of the reserve.

5.2 Estimating Carbon Store on Lodge Bog

To estimate carbon stored, desktop research in 2020 identified a scientific paper Tomlinson, 2005, and taking advice from Dr. David Wilson in 2020 it was determined that a peat stratigraphy was required. Kerr, 2011 presents a peat stratigraphy for Lodge Bog North. Therefore for this project only one core was required from Lodge Bog South. A Peat Auger was used to extract a peat core sample. The analysis of the stratigraphy of the extracted sample was supported by the Soil Key of Cutover and Cutaway Raised Bogs (O'Connell, 2000) (see Appendix 1).

To calculate carbon stored within the reserve peat bulk density (BD) and percentage carbon (% C) figures are required. Tomlinson, 2005 presents average figures for bulk density and percentage carbon for midlands raised bogs. His figures were calculated using over 600 records from Davidson, 2003 in Northern Ireland and Hammond, 1989. Analysing the peat core using the Soil Key for Cutover and Cutaway Raised Bogs (O'Connell, 2000) combined with the figures from Tomlinson, 2005, the soil carbon stock measured in tonnes can be calculated for an area of peatland provided that the average depth is known.

32 sample points were identified along four transects labelled A, B, C and D to measure peat depth on Lodge Bog South while Kerr, 2011 recorded 17 sample points at 250m intervals around the perimeter of the Lodge Bog North and along Transect B an established transect used to measure the water table (see figure 2).

6. Results

6.1 Peat Depth Lodge Bog North

Date:	2011	**Recorder:**	Emily Kerr	
Transect	**Latitude**	**Longitude**	**Elevation (m)**	**Peat depth (m)**
1	53.28167	-6.9244	80	2.26
2	53.27993	-6.92625	81	2.44
3	53.27808	-6.92835	80	3.54
4	53.27622	-6.93047	82	2.43
5	53.27592	-6.93078	87	0.81
6	53.27687	-6.93087	83	1.88
7	53.27893	-6.93232	86	1.45
8	53.28043	-6.93332	83	2.72
9	53.2808	-6.93182	84	1.81
10	53.28212	-6.93103	84	2.33
11	53.28193	-6.92685	82	2.84
12	53.28197	-6.92723	89	2.84
13	53.28033	-6.92817	85	2.83
14	53.2792	-6.92872	89	4.82
15	53.2784	-6.92928	88	6.10
16	53.2771	-6.92998	82	4.71
17	53.27885	-6.93017	84	5.70

Table 1: Peat depth recorded at 17 sample points using the Van Walt peat probe during the field work in 2011 at Lodge Bog North Co. Kildare.

6. 2 Peat Depth Lodge Bog South

Date:	14th July, 5th & 11th August 2021	**Recorders:**	Paula Farrell, Nuala Madigan, Tristram Whyte and volunteers.	
Transect	**Latitude**	**Longitude**	**Elevation (m)**	**Peat depth (m)**
A1	53.27333553	-6.933741171	84.8	3.675
A2	53.27304364	-6.934311042	86.3	4.685
A3	53.27275175	-6.934880905	82.9	4.39
A4	53.27245985	-6.935450761	81.9	5.195
A5	53.27216796	-6.936020608	81.4	6.465
A6	53.27187606	-6.936590448	80.3	6.3
A7	53.27158416	-6.93716028	80.9	7.415
A8	53.27136022	-6.937620117	81.7	7.205
A9	53.27100034	-6.938299921	74.5	5.815
A10	53.27070843	-6.93886973	81.3	5.455
A11	53.27041652	-6.939439531	77.5	5.905
A12	53.27012461	-6.940009325	80.7	4.75
A13	53.2697843	-6.940673555	78.5	3.17
B1	53.27196984	-6.938535568	79.9	4.4
B2	53.27163564	-6.938034544	81	6.605
B3	53.27096725	-6.93703252	80	7.2
B4	53.27079678	-6.936776967	79.9	5.7
C1	53.27123586	-6.940698963	81	4.63
C2	53.2712671	-6.939951239	81	4.95
C3	53.27129834	-6.939203515	80	5.83
C4	53.27132957	-6.938455789	81	4.86
C6	53.27139203	-6.936960335	80	6.915
C7	53.27142325	-6.936212606	79	7.235
C8	53.27145794	-6.935381489	75.4	3.695
D1	53.2724341	-6.937032591	81.4	6.04
D2	53.2720072	-6.93726643	83.3	5.905
D3	53.2715803	-6.937500264	80.9	6.715
D4	53.2711534	-6.937734094	83.4	6.9
D5	53.2707265	-6.937967919	79.8	7.775
D6	53.2702996	-6.938201739	72.8	6.815
D7	53.2698727	-6.938435554	77.3	5.585
D8	53.2695821	-6.938594714	82.2	5.765

Table 2: Peat depth recorded at 32 sample points using the Van Walt peat probe during the field work in July and August 2021 at Lodge Bog South Co. Kildare. Note elevation points at B2 and B3 have been altered from those recorded in the field. In the field B2 and B3 recorded elevations of 58.2 and 48.7m these recordings were significantly different to all those other elevations recorded on the reserve. A check on Irish Grid Finder presented elevations more in keeping with those recorded results in the field and human error is suggested for the significant difference.

The maximum peat depth recorded on Lodge Bog North was 610cm at sample point 15 located at coordinates 53.2784, -6.92928. The minimum peat depth recorded on Lodge Bog North was 81cm at sample point 5 located at coordinates 53.27592, -6.93078. Using the 17 sample points recorded on Lodge Bog North the average depth of peat was calculated at 303cm.

The maximum peat depth recorded on Lodge Bog South was 775cm at sample point D5 located at coordinates 53.2707265, -6.937967919. The minimum peat depth recorded during the study was 317cm at sample point A13 at location 53.2697843, -6.940673555. The average peat depth on Lodge Bog South was 575cm.

The two different approaches to determining the peat depth sample points on Lodge Bog North and Lodge Bog South have had a significant difference on the depths recorded on each lobe of the reserve. By Kerr sampling 12 of the 17 peat depths recorded on Lodge Bog North at the perimeter of the reserve at 250m intervals, it is not unexpected that Lodge Bog North recorded the lowest peat depth across the reserve and has a lower average peat depth when compared to Lodge Bog South. These 12 peat depth sample points are located adjacent to the R414, industrial peatland managed by Bord na Móna and agricultural land. Drains cause shrinkage of peat. Those sample points adjacent to the R414 and the industrial peatland are still affected by drainage as the Irish Peatland Conservation Council have only blocked internal drains. The sample points adjacent to the agricultural land are located at the edge of the reserve where peat depth would always be expected to be lower. It should be noted that the best practice method of sampling peat depths presented in Agus et al. (2011) was not available to Kerr when choosing the sample points for Lodge Bog North as Kerr completed the research element of her project in 2010. Using the Agus et al. (2011) method for choosing sample points and choosing a shorter distance between sample points, more peat probes were recorded on Lodge Bog South which presents a greater representative sample of peat depth across this area of the reserve.

Elevation was recorded at each of the sample points to understand and visually present the depth of peat in comparison to the surface of the bog above the height of sea level. Elevations ranged from 72.8-86.3m on Lodge Bog South and 80-89m on Lodge Bog North. The elevation data presented will be useful for future researchers however for the purposes of this project only peat depth is required to estimate carbon stored.

Image: E. Kerr, Mr. Kerr, M. Lawless and T. Ó Corcora taking a peat core from Lodge Bog North in 2010 as research undertaken as part of a project entitled 'The Long Term Carbon Storage Capacity of Lodge Bog, Co. Kildare'. © C. O'Connell

6.3 Peat Core

Using bulk density figures presented in Tomlinson 2005, to estimate carbon stored in a peatland reserve a peat stratigraphy is required. In 2010 Kerr extracted and described a peat core on Lodge Bog North. Eight different segments were described measuring to a depth of 600cm.

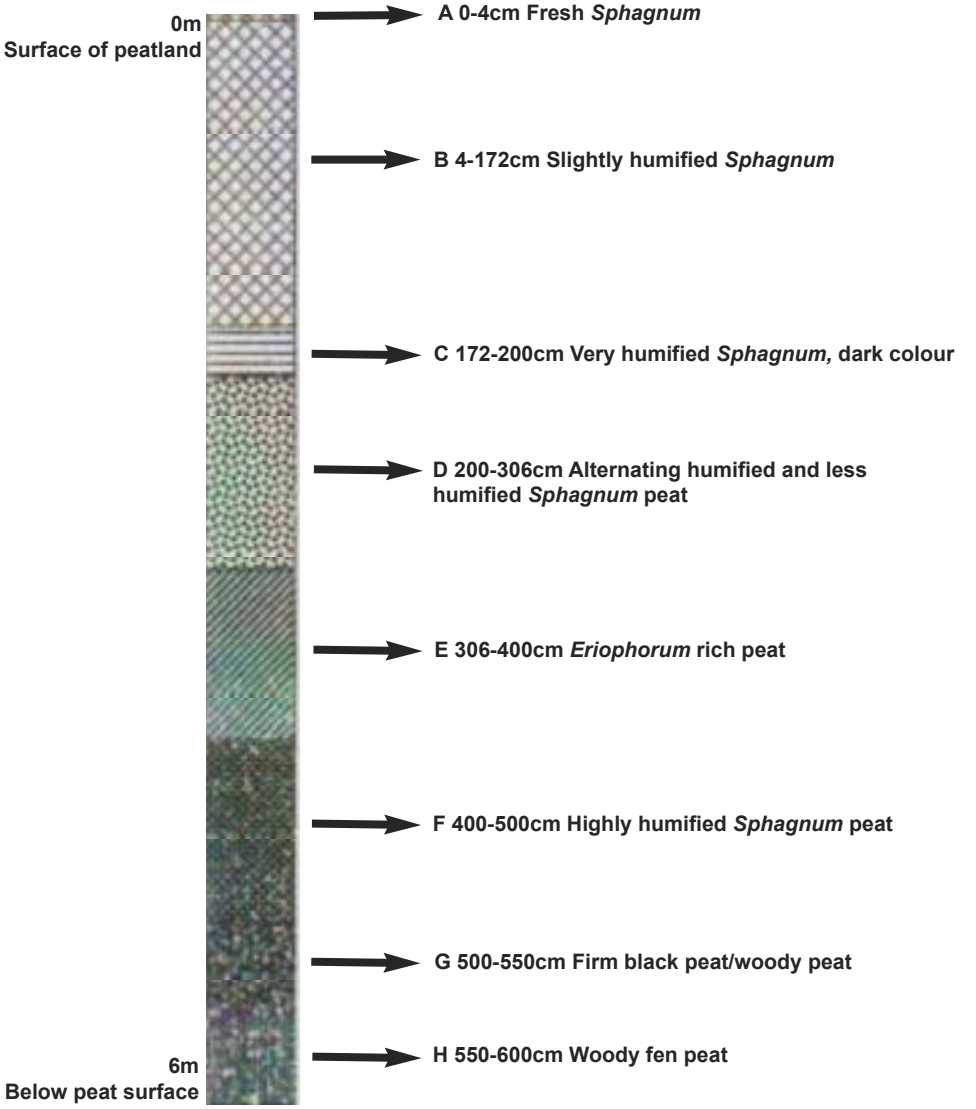

Figure 8: Peat stratigraphy described by Kerr, 2011.

Prior to this project no peat core had been described for Lodge Bog South. The Irish Peatland Conservation Council only had access to a core that would extract a sample of peat to a depth of 3m. To determine if the peat present on Lodge Bog North was similar to that on Lodge Bog South a 300cm core was extracted and described. This core was taken at sample point A13 at coordinates 53.2697843, -6.940673555 on Lodge Bog South.

Image: Volunteers take a peat core at sample point A13 and describe the peat stratigraphy on Lodge Bog South, July 2021. © N. Madigan

Layer	Peat Depth (cm)	Description
A	0m-100cm	Older *Sphagnum* peat
B	100-186cm	Older *Sphagnum* peat
C	186cm-221cm	Darker peat with wood and bog bean seeds identified
D	221cm-300cm	Woody fen peat

Table 3: Peat stratigraphy describing the peat layers taken from a 3m core sample on Lodge Bog South at sample point A13 on the 14th of July 2021.

The description of peat layers within the peat cores were described using the Soil Key to Cutover and Cutaway Raised Bog (O'Connell, 2000). Those layers close to the surface of peatland are described as Younger *Sphagnum*. This peat is yellowish in colour and the peat does not disintegrate when squeezed. Below this layer Older Humified *Sphagnum* is found. This peat type is brown with reddish tinges, plant remains are present which is dominated by black twigs of ling heather (the wood has ridges and has pin holes) and hairy bog cotton fibres. The peat sample is quite solid and sticks together during examination. Woody Fen peat is found below Older Humified *Sphagnum*. This peat is black with up to 50% of the remains of pine, oak and birch. This peat falls apart when handled.

Comparing the results of the core from Lodge Bog South described in 2021 with that presented by Kerr, 2011 the lower layers in both core samples were very similar. It is acknowledged that there are differences in the measurements for example the core taken by Kerr, 2011 begins the woody fen peat layer at 500cm below the peat surface while in 2021 the woody fen peat layer is recorded as starting at 486cm (taking into account Kerr, 2011 had a core measurement 3m greater) below the surface. Removing the peat core from the peat auger can cause disturbance to the peat layers (see image page 11). That combined with the fact that the beginning and ending of each of the layers within a peat stratigraphy is a subjective opinion of the recorder can account for these differences in recording where the peat layers begin and end. Acknowledging these differences within the peat stratigraphy, those layers described from 300-600cm below the surface in both peat stratigraphies are similar. As a result the upper layers presented by Kerr, 2011 are deemed acceptable to use for calculating the carbon stored on Lodge Bog South. To keep the calculations standard across the two lobes of the reserve it was decided to use the peat stratigraphy described by Kerr in 2011 across both Lodge Bog North and Lodge Bog South when estimating the store of carbon.

6.4 Calculating Carbon Stored

Knowing peat depth and the peat stratigraphy within a peatland reserve, sufficient data has been gathered to estimate carbon stored. Using Tomlinson, 2005 bulk density and percentage carbon within midland raised bog data, the following equation was applied to the peat core stratigraphy:

To calculate carbon stored using Tomlinson, 2005

bulk density x carbon percentage x peat depth = t/Carbon density/hectare

Peat Layer	Bulk Density (BD)	Percentage Carbon (% C)
Poorly humified *Sphagnum*	0.062	51%
Humified *Sphagnum*	0.082	51%
Woody Peat	0.125	49%
Fen/Reed peat	0.116	36%

Table 4: Average bulk density and percentage carbon figures identified by Tomlinson (2005) using over 600 samples to calculate soil carbon stock within midland raised bogs.

As described earlier Lodge Bog is 35 hectares in size. 11.5% of the reserve is considered Bog Woodland which has been excluded from this study. The following are the areas that will be used to calculate stored carbon. The total area of Lodge Bog is 30.97ha, Lodge Bog South is calculated as covering an area of 9.33ha while Lodge Bog North covers an area of 21.64ha.

Minimum Soil Carbon Stock Lodge Bog North 2011							
Layer cm	**Layer Description**	**Thickness (cm)**	**Bulk Density (BD) - figure from Tomlinson 2005)**	**Percentage Carbon (% C) - figure from Tomlinson, 2005)**	**Carbon density tC per ha (BD X %C X Thickness) as per Tomlinson 2005**	**Area of Lodge Bog North (ha)**	**Soil C Stock tonnes C (carbon density X area)**
81	Woody Peat	81	0.125	49	496.13		
	Total	81			496.13	21.64	**10,736.25**

Table 5: A minimum soil carbon stock is calculated as 10,736.25t for Lodge Bog North. This figure is calculated using the minimum peat depth recorded on the reserve of .81m, the peat stratigraphy described by Kerr, 2011, the area of the reserve measured at 21.64ha and bulk density and percentage carbon figures from Tomlinson, 2005.

Minimum Soil Carbon Stock Lodge Bog South 2021							
Layer (cm)	**Layer Description**	**Thickness (cm)**	**Bulk Density (BD) - figure from Tomlinson 2005)**	**Percentage Carbon (% C) - figure from Tomlinson, 2005)**	**Carbon density tC per ha (BD X %C X Thickness) as per Tomlinson 2005**	**Area of Lodge Bog North (ha)**	**Soil C Stock tonnes C (carbon density X area)**
0-217	Older humified *Sphagnum* peat	217	.082	51	907.49		
217-317	Woody Peat	100	0.125	49	612.50		
	Total	317			1519.99	9.33	**14,181.54**

Table 6: A minimum soil carbon stock is calculated as 14,181.54t for Lodge Bog South. This figure is calculated using the minimum peat depth recorded on the reserve of 317cm, the peat stratigraphy described by Kerr, 2011, the area of the reserve measured at 9.33ha and bulk density and percentage carbon figures from Tomlinson, 2005.

Maximum Soil Carbon Stock Lodge Bog North, 2011							
Layer cm	**Layer Description**	**Thickness (cm)**	**Bulk Density (BD) - figure from Tomlinson 2005**	**Percentage Carbon (% C) - figure from Tomlinson 2005**	**Carbon density tC per ha (BD X %C X thickness) as per Tomlinson 2005**	**Area of Lodge Bog North (ha)**	**Soil C Stock tonnes C (carbon density X area)**
0-183	Younger *Sphagnum* peat	183	0.062	51	578.65		
183-510	Older humified *Sphagnum* peat	327	0.082	51	1367.51		
510-610	Woody peat	100	0.125	49	612.50		
	Total	610			2558.66	21.64	**55,369.40**

Table 7: A maximum soil carbon stock is calculated as 55,369.40t for Lodge Bog North. This figure is calculated using the maximum peat depth recorded on the reserve of 610cm, the peat stratigraphy described by Kerr, 2011, the area of the reserve measured at 21.64ha and bulk density and percentage carbon figures from Tomlinson, 2005.

Maximum Soil Carbon Stock Lodge Bog South, 2021							
Layer cm	**Layer Description**	**Thickness (cm)**	**Bulk Density (BD) - figure from Tomlinson 2005**	**Percentage Carbon (% C) - figure from Tomlinson 2005**	**Carbon density tC per ha (BD X %C X thickness) as per Tomlinson 2005**	**Area of Lodge Bog North (ha)**	**Soil C Stock tonnes C (carbon density X area)**
0-350.5	Younger *Sphagnum* peat	350.5	0.062	51	1108.28		
350.5-677.5	Older humified *Sphagnum* peat	327	0.082	51	1367.51		
677.5-777.5	Woody peat	100	0.125	49	612.50		
	Total	777.5			3088.29	9.33	**28,813.76**

Table 8: A maximum soil carbon stock is calculated as 28,813.76t for Lodge Bog South. This figure is calculated using the maximum peat depth recorded on the reserve of 777.5cm, the peat stratigraphy described by Kerr, 2011, the area of the reserve measured at 9.33ha and bulk density and percentage carbon figures from Tomlinson, 2005.

Average Soil Carbon Stock Lodge Bog North, 2011							
Layer cm	**Layer Description**	**Thickness (cm)**	**Bulk Density (BD) - figure from Tomlinson 2005**	**Percentage Carbon (% C) - figure from Tomlinson 2005**	**Carbon density tC per ha (BD X %C X thickness) as per Tomlinson 2005**	**Area of Lodge Bog North (ha)**	**Soil C Stock tonnes C** (carbon density X area)
0-203	Older humified *Sphagnum* peat	203	0.082	51	848.94		
203-303	Woody peat	100	0.125	49	612.50		
	Total	303			1461.44	21.64	**31,625.56**

Table 9: An average soil carbon stock is calculated as 31,625.56t for Lodge Bog North. This figure is calculated using the average peat depth recorded on the reserve of 303cm, the peat stratigraphy described by Kerr, 2011, the area of the reserve measured at 21.64ha and bulk density and percentage carbon figures from Tomlinson, 2005.

Average Soil Carbon Stock Lodge Bog South, 2021							
Layer cm	**Layer Description**	**Thickness (cm)**	**Bulk Density (BD) - figure from Tomlinson 2005**	**Percentage Carbon (% C) - figure from Tomlinson 2005**	**Carbon density tC per ha (BD X %C X thickness) as per Tomlinson 2005**	**Area of Lodge Bog North (ha)**	**Soil C Stock tonnes C** (carbon density X area)
0-148	Younger *Sphagnum* peat	148	0.062	51	467.98		
148-475	Older humified *Sphagnum* peat	327	0.082	51	1367.51		
475-575	Woody peat	100	0.125	49	612.50		
	Total	575			2447.99	9.33	**22,839.75**

Table 10: An average soil carbon stock is calculated as 22,839.75t for Lodge Bog South. This figure is calculated using the average peat depth recorded on the reserve of 575cm, the peat stratigraphy described by Kerr, 2011, the area of the reserve measured at 9.33ha and bulk density and percentage carbon figures from Tomlinson, 2005.

Summary of Carbon Store on Lodge Bog North & South, Co. Kildare				
Reserve	**Size (ha)**	**Minimum Soil C Stock tC**	**Maximum Soil C Stock tC**	**Average Soil C Stock tC**
Lodge Bog North	21.64	10,736.25	55,369.40	31,625.56
Lodge Bog South	9.33	14,181.54	28,813.76	22,839.75
Total	30.97	24,917.79	84,183.16	54,465.31

Table 11: Summary table of calculations recorded for soil carbon stock on Lodge Bog North and Lodge Bog South, Co. Kildare. Results are taken from tables 5-10.

Table 11 summaries the estimates calculated of stored carbon on Lodge Bog, Co. Kildare. Across the 30.97ha reserve it is estimated that the maximum store of carbon is 84,183.16tC, the minimum store of carbon on the reserve is 24,917.79tC while the average store of carbon is estimated at 54,465.31tC.

While the water table on Lodge Bog has improved since internal drains were blocked (figure 3 & 4) on the reserve, for Lodge Bog to reach its maximum potential of storing 84,183.16tC, further hydrological management of the marginal drains is required as average water data presented is not at the ideal levels to date of publication. Those reading the report should also make a note of the differing methods of peat depth sampling across Lodge Bog North and South. If Kerr, 2011 had access to the best practice peat sampling offered by Agus et al, 2011 peat depth recorded on Lodge Bog North may have provided deeper peat depths across the reserve which would affect the average peat depth presented for Lodge Bog North.

Acknowledging the limitations of the research to put the estimate of stored carbon calculated for Lodge Bog in perspective we can now convert this to Carbon Dioxide (CO_2) within the atmosphere, a Greenhouse gas using the following formula

1 tonne of C = 14/12 = 3.67 tonnes of CO2

Taking the estimate of average tonnes of carbon stored on Lodge Bog, if this was to be released into our atmosphere it would release 199,887.69 tonnes CO_2. The average car in Ireland emits 3 tonnes of CO_2 per year therefore if the average tonnes of carbon stored within the 30.97ha were to be released as CO_2 emissions into our atmosphere it would be, approximately, the same emissions as 66,629 cars on Irish roads each year. Climate Neutral Group suggest that to remove 1 tonne of CO_2 from the atmosphere 50 trees must grow for 1 year, therefore if all of the carbon was to be released from Lodge Bog it would be required that 9,994,384 trees grow for one year to sequester this carbon back out of the atmosphere.

Peatlands are a valuable store of carbon and the method used to calculate stored carbon can be easily replicated by peatland custodians and community groups nationwide. The Irish Peatland Conservation Council identify that depending on how we manage our peatlands they can support with climate mitigation plans or contribute to the climate crisis.

8. References

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Appendix 1

Soil Key to Cutover and Cutaway Raised Bog

13. Soil Key to Cutover and Cutaway Raised Bogs

1.1	Mineral material present e.g. sand, silt, clay or gravel	go to 4
1.2	Organic plant material present i.e. peat	go to 2
2.1	Peat is a yellowish colour. Plant remains are washed-out yellow colour when squeezed between finger and thumb. Peat doesn't disintegrate when squeezed.	Younger *Sphagnum* Peat
2.2	Plant remains are a brown colour when squeezed between finger and thumb	go to 3
3.1	Brown peat with reddish tinges when fresh. Dominant plant remains present are black twigs of ling heather (the wood has ridges and has pin holes), hairy bog cotton fibres. Peat looks like felt with tiny red hairs, the stems of *Sphagnum* moss plants. Peat sample quite solid and sticks together during examination.	Older *Sphagnum* Peat
3.2	Black peat when fresh. Dominant plant remains present are wood of birch, pine and oak. Up to 50% of this peat type is wood. Birch wood has silvery bark. The inside of a freshly broken twig is a deep red colour. Oak and pine wood is yellowish internally. Sometimes the flattened leaves of trees are also present. The peat sample falls apart during examination.	Woody Fen Peat
3.3	Yellowy-brown peat when fresh. Dominant plant remains present are brown mosses and sedges. The mosses look feathery and flat. The moss structure is still visible, but if they are rubbed between finger and thumb, they disintegrate. The orange seeds of bog bean are occasionally found. The peat smells strongly of rotten eggs. The peat sample peels apart like the pages in a book during examination.	Bog Bean Peat
3.4	Black peat when fresh which may have an orange-brown mottled appearance. Dominant visible plant remains present are the deep yellow-brown stems of reeds. These are either flattened horizontally appearing like squashed straws or they have collapsed vertically like a concertina. There may be birch twigs in the sample, but usually no more than 10%. The peat sample is dense and highly decomposed.	Reed Peat
4.1	Creamy white soil with or without tiny snail shells. Crumbles when you dig it.	Lake Marl
4.2	Not as above	go to 5
5.1	Smooth soil. No gritty bits felt when soil is rubbed between finger and thumb	go to 6
5.2	Rough soil. Lots of gritty bits felt when soil is rubbed between finger and thumb	go to 7
6.1	Grey soil	Silt
6.2	Blue soil	Silty Clay
7.1	Soil sample sticks together when sampled. Stones held together in a matrix	go to 8
7.2	Soil sample falls apart when sampled. Loose stones, no matrix	Gravel
8.1	Stones broken down into sand. Soil grey.	Weathered Till
8.2	Stones present in the matrix, not broken down by weathering. Soil grey.	Unweathered Till