Sunbiggin Tarn, Palaeoenvironmental Assessment Report

March 2022

Westmorland Dales Landscape Partnership

Issue No: 2021-22/2184
NGR: 367833 507930

oxfordarchaeology north

Client Name:	Westmorland Dales Landscape Partnership Scheme
Document Title:	Little Asby Through the Keyhole
Document Type:	Sunbiggin Tarn Palaeoenvironmental Assessment Report
Report No.:	2021-22/2184
Grid Reference:	367833 507930
Site Code:	L11365
Receiving Body:	Westmorland Dales Landscape Partnership Scheme
Issue No:	Final
Date:	March 2022
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Little Asby Through the Keyhole

Sunbiggin Tarn, Palaeoenvironmental Assessment Report

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With illustrations by Anne Stewardson

Contents

List of Figures

Summary

As a part of the first season of 'Little Asby through the Keyhole' community excavations OA North were commissioned by Westmorland Dales Landscape Partnership Scheme to undertake an auger survey at the site of Sunbiggin Tarn, Cumbria. With the help of project volunteers, a short transect of 6 cores was taken through the sediments on the north-eastern edge of the tarn, and the samples dated using carbon 14 techniques.

Despite a relatively poor pollen count from many of the samples it has been possible, in combination with a previous but undated pollen core, to use the available data to interpret a broad outline of palaeoenvironmental changes at Sunbiggin Tarn, in the period from the early Mesolithic to the early Roman or early medieval periods.

The pollen assemblage from the base of the core indicated an environment of abundant mixed woodland vegetation, both locally and regionally during the early Mesolithic period (7310-7060 cal BC), occurring prior to the rise in alder pollen, which elsewhere in Cumbria has been dated to around 6460-5890 cal BC. The data indicates the area around Sunbiggin Tarn at this time was dominated by hazel-type, oak, elm, birch, pine and finally alder, comprising major woodland-forming trees both locally and regionally.

From the early Mesolithic onwards the presence of microcharcoal particles may be interpreted to suggest that humans were using fire deliberately during this period, and there is evidence in the presence of certain species of fungal spores to infer grazing animals at or near the site.

Subsequently an apparent decrease in the presence of Elm pollen in combination with a slight rise in grass and cereal type pollens may be aligned with the wider Elm decline event, regionally dated to the early Neolithic and traditionally taken as evidence for the introduction of crop farming. Similarly, a subsequent decline in pine pollen from later in the core sequence, may be aligned with a national trend that can be broadly dated to the early Bronze Age or later.

Following this the cores upper interval demonstrates a sparsity of tree and shrub pollen, suggesting regional woodland clearance had occurred. At this time only pollen of heather appears to increase in numbers, suggesting the spread of acid moorland, probably both adjacent to and beyond the site. Again a slight increase in cereal type pollen, the occurrence of ribwort plantain and the presence of particular forms of fungal spores infer possible arable as well as pastoral land use activity at this time.

Despite an uncertainty in the dating of the upper half of the core the pollen infers a largely open environment of sedge moorland, with perhaps isolated

stands of oak, ash and pine with some alder and possibly hazel scrub also present regionally. The drier land may have been used for low-scale arable cultivation, as indicated from occurrence of cereal-type pollen, and the land adjacent to the tarn was likely used for pastoral activity.

The results of the survey therefore provide an insight into how the landscape has changed over the past 9000 years and which, in part, was a result of human activity.

Acknowledgements

Oxford Archaeology would like to thank Westmorland Dales Landscape Partnership Scheme for commissioning this project, and in particular to Hannah Kingsbury, for her support. Thanks, is also due to the Friends of the Lake District and to the Asby Commoners Association for granting consents to carry out the work and to the National Lottery Heritage Fund for funding the project.

The project was managed for Oxford Archaeology North (OA North) by Jamie Quartermaine. The auger fieldwork was directed by Mairead Rutherford, who was supported by John Hastwell and James Morrison (volunteers). Katie Sanderson (OA North) surveyed in the Russian core location point and Anne Stewardson (OA North) produced the illustrations. OA North is grateful to the University of Aberdeen Geosciences Laboratory staff for processing the soil samples for pollen assessment.

1 INTRODUCTION

1.1 Scope of work

1.1.1 Oxford Archaeology North (OA North) was commissioned by Westmorland Dales Landscape Partnership Scheme (WDLPS) to undertake a palaeoenvironmental auger survey and to collect a core from an area adjacent to Sunbiggin Tarn, for palaeoenvironmental (pollen) assessment and radiocarbon dating. This is part of a community excavation on Little Asby Common which is being undertaken by the WDLPS.

1.1.2 The work was undertaken as part of the Little Asby Through the Keyhole community project, with a view to engaging volunteers in the process of field auger survey work and how the interpretation of the resultant core data, including pollen work, can be applied to reconstruct the past vegetational sequence and, potentially, to determine human impact at the site and its environs.

1.2 Location, topography and geology

1.2.1 The area of Sunbiggin Tarn is located to the south-west of Little Asby (Fig 1), and was the focus of an archaeological evaluation, where an extensive area of field systems, unenclosed roundhouse settlements, stock enclosures and a small cairnfield, has been recorded by landscape survey (OA North 2004; 2009; 2018). The tarn lies at an elevation of approximately 255m and has an area of four hectares, and a maximum depth of 10m; the tarn perimeter area is approximately 1km (Maberley *et al* 2020).

1.2.2 Little Asby is part of the Sunbiggin Tarn and Moors and Little Asby SSSI, Cumbria. The area contains limestone pavement, of which the Orton-Asby pavements are at the highest elevation and are the most extensive of the Carboniferous limestone outcrops fringing the eastern edges of the Lake District (Goldie 1996). Sunbiggin Tarn is a small marl lake on the Orton Fells, in a karst (limestone) landscape dominated by the limestone and sandstone of the Great Scar Limestone Group of the Carboniferous, overlain by superficial deposits of glacial till and alluvium (Natural England 2013). As this is a karst environment, underground water feeds the tarn *via* springs, as well as surface water from the catchment area and several small shallow streams, resulting in a complicated hydrogeology (Maberley *et al* 2020).

1.3 Previous Palaeoenvironmental Work

1.3.1 Human impact on the Orton-Asby escarpment extends across the prehistoric, Romano-British, and medieval periods. Indicators of settlement include round houses, cairns, cairnfields, enclosures and wall foundations, several of which have utilised parts of the limestone pavement (eg clints) in their construction (Goldie 1996; OA North 2008). It is likely that vegetation was cleared to aid settlement, resulting in a changed landscape with only isolated trees acting as remnant reminders of a more wooded past.

1.3.1 Many of the Lake District tarns have been cored and subjected to pollen analysis, following the work of Pennington (1964; 1969; 1970). Within the limestone area of the Yorkshire Dales National Park, but further south than Orton, in the Craven area and around the Ingleborough Massif, several studies of vegetational history (derived from pollen analysis) have been completed, including those of Swales (1987), Bartley *et al* (1990), Oybak (1993) and Rushworth (2010). To the north of Sunbiggin Tarn, Skinner (2000) analysed pollen from sites from eastern Cumbria, including from the uplands of Cross Fell as well as the lowlands of the River Eden and one site (Bank Moor) from a limestone area to the south, adjacent to the River Lyvennet. At two of the sites analysed by Skinner (2000), the stratigraphic profile was found to be truncated during the early Neolithic period (*c* 4300 BC). At the southernmost site, the pollen record from the late Mesolithic (*c* 4500 BC) through to the Bronze Age/Iron Age (*c* 2200 BC- c 43 AD), was inferred to imply largely open grassland with small stands of birch-dominated woodland. High levels of microcharcoal, attributed to probable woodland burning (dating to *c* 5900 cal BC), were interpreted as possibly deriving from a regional source. Further evidence of burning, based on microcharcoal, was interpreted during the late Neolithic (*c* 2500 BC). The first cereal-types occurred at Bank Moor during the Bronze Age (*c* 1950 cal BC). The openness of the landscape around this site, throughout prehistory, is quite unlike other sites, and Skinner (2000) suggested that thin soils could possibly have restricted woodland growth.

1.3.2 A 5.6m deep core taken through the lake deposits at Sunbiggin Tarn was subject to analysis as part of a PhD study (Webster 1969 (re-drawn for this report Fig 4)). The precise location of this core is unknown, but a relatively detailed pollen diagram was produced. The interpretation of this diagram is hampered, however, because the organic deposits or any of the identified clearance events have not been radiocarbon dated. It is therefore not possible to tell whether the identified pastoral and/or arable cultivation (interpreted from the pollen diagram) is linked to late Mesolithic or Neolithic activity in the area or to later local settlements of Bronze Age / Iron Age or Romano-British age.

1.3.3 Two other short cores were collected, one from an area adjacent to the tarn (*c* 1.80m deep – Chinn 1989, Fig 2) and the other, shorter, core from nearby Spear Pots (0.70m) (Chinn 1989). There are no radiocarbon dates available for either core. The pollen diagram closer to the tarn edge (re-drawn for this report; Fig 3) contains an earlier woodland assemblage with common to abundant pollen of pine, followed by lower, but roughly equal, amounts of oak, hazel-type, elm and birch pollen but without alder, suggesting a probable pre-alder rise age. The rise in pollen of alder is a regional event, tracking northwards as the climate warmed; the start of the alder rise is dated from Scaleby Moss, Cumbria, to between 6460-5890 cal BC (7362±146 BP, Q-167; Godwin and Willis 1959). Pine pollen is generally present in pollen assemblages since the early Holocene (*c* 10,000 years ago) and thought to have reached its maximum extent in the British Isles during the Neolithic period (c4300 BC -c2200 BC) and then to have declined in values around the early Bronze Age period, although the timing of the decline in pine, is asynchronous (Gear and Huntley 1991; Bennett 1994; Manning *et al* 2010).

1.3.4 The pollen assemblages succeeding the woodland assemblage in Chinn's diagram (Fig 3) are quite different in character, being dominated by heather heath pollen, grasses, sedges and much reduced tree pollen. The abruptness of the change between local assemblage zone ST-b and ST-c may suggest an hiatus or break in sedimentation.

1.3.5 A Durham University e-thesis (Anderson 1974) is also available for pollen analysis of peats in the vicinity of Sunbiggin Tarn. Two small sites west of the tarn and south of the tarn recorded minerogenic deposits with thin peat layers. A third site, on moorland west of the tarn (Ingmoor Moor), permitted recovery of a core, using a Russian-type corer, that was approximately 3m deep. The core contained evidence of palaeoenvironments stretching back from the Late-glacial period to the Mesolithic/Neolithic and possibly later, but no dating was available for the core. The stratigraphic succession was interpreted as freshwater sediments overlain by fen, wood and moss peats.

1.3.6 The most comprehensive dataset is that of Webster (1969) and the results of that work are summarised below. The pollen diagram (Fig 4) is thought to commence within the later Mesolithic period, the first major impact observed is interpreted from the pollen curves as representing the Elm Decline. This event has been attributed to a probable combination of potential causes, including human activity (clearance of woodland), disease (elm bark beetle) and climate (onset of wetter conditions; Parker *et al* 2002). On Webster's pollen diagram, the Elm Decline is accompanied by the appearance of lime and ash, suggesting colonisation of these trees resulting from the opening up of the forest. Pennington (1964; 1969; 1970) found that at some of the Lake District tarns (eg Blea Water and Goats Water), ash appears to have acted as a pioneer species on limestone, in areas of reduced elm forest. At the same time as elm pollen declined, a rise is observed in pollen of herb taxa such as grasses (Poaceae), ribwort plantain (*Plantago lanceolata*), devil's bit scabious (*Succisa pratensis*), the pink family (Caryophyllaceae) and bracken (*Pteridium aquilinum*). This first peak in declining levels of elm pollen in Webster's core from Sunbiggin Tarn is noted at 5.12-5.04m with a second decline between 4.64-4.40m, with the first phase of cereal-type pollen grains identified between 4.40m-4.24m.

1.3.7 Regionally, there are several dates available for the onset of the Elm Decline, from the limestone area in the south of the Yorkshire Dales, including from Sniddle Moss (3960-3710 cal BC; 5050±50 BP), Arks 1 (3960-3660 cal BC; 5030±50 BP), Allotment Shooting Box (4220-3790 cal BC; 5160±60 BP) (Oybak 1993) as well as Eshton Tarn (4050-3530 cal BC; 5010±110 BP) and White Moss (4050-3640 cal BC; 5058±100 BP; Bartley *et al* 1990).

1.3.8 Between 4.40m and 3.68m, the curve for grass pollen (Gramineae, on Webster's diagram) steadily increases, along with a range of other herbs and heath (*Ericales*-type) pollen, as well as bracken spores. These assemblages are interpreted as the spread of grassland in some areas, whereas heath was beginning to develop in other areas with bracken also starting to spread.

1.3.9 There is evidence for secondary forest re-growth after this time, followed by a reduction in forest and short-lived expansion of grassland with cereal-type pollen (at

3.28m). This has been interpreted as a clear second phase of cereal growing within the vicinity of the tarn (Webster 1969, 147). Following this clearance episode, re-colonisation by birch and oak appear to take place, with declining values of oak after 2.88m, followed by the spread grassland and particularly, of acid heath. Cereal-type pollen is present sporadically and in low numbers, to the top of the diagram.

1.3.10 The aim of the current study is to use pollen assessment data from a Russian-type auger core (SBT-1) collected with volunteers during September 2021, to try to correlate the new data with that produced by Webster (1969). It is hoped that the spacing of samples will allow identification of the clearance events identified by Webster's (1969) work and will provide dating control for the onset and cessation of organic sediments at the tarn.

2 PALAEOENVIRONMENTAL AIMS AND METHODOLOGY

2.1 Aims

2.1.1 The project aims and objectives were as follows:

i. To encourage volunteers to gain an understanding of the landscape history of the fells through palaeoenvironmental sampling.
ii. To explain how to use and set out a gouge-auger transect in order to determine the sub-surface stratigraphy and to learn how to interpret that stratigraphy in order to choose the best location for the collection of a peat core.
iii. To use a Russian-type auger to collect intact and uncontaminated sediments for palaeoenvironmental work.
iv. To select sub-samples from the collected core for pollen processing and assessment.
v. To select sub-samples from the collected core for radiocarbon dating.
vi. To assess the processed sub-samples for pollen and to provide a general interpretation of the results, referencing the potential vegetational and cultural history of the area.
vii. If possible, to broadly correlate the assessed data with previously analysed but undated pollen diagrams (unpublished) from the area of Sunbiggin Tarn.

2.2 Methodology

2.2.1 ***Lithostratigraphy and Radiocarbon Dating:*** a short north-west / south-east transect of six gouge cores was undertaken at the north-eastern end of the tarn, at a time when the lake levels were relatively low following a dry summer (Fig 2). The deposits revealed shell marl overlying banded probable lake sediments and overlain by peat and clay deposits. Details of the transect (Fig 2) and descriptions of the sediments obtained from the gouge cores are appended (Appendix B).

2.2.2 In total, 44 sub-samples was taken from the collected 5m-deep Russian-type core (SBT-1), which were distributed regularly at intervals of 0.16m, but at higher resolution (0.08m intervals) between 2.52-4.52m. Two sub-samples, from the top and from the bottom of the organic deposits, were taken for AMS (humin and humic acid fractions) radiocarbon dating.

2.2.3 ***Pollen Methodology:*** the Russian core (SBT-1) samples were cleaned and the lithologies described prior to sub-sampling for pollen assessment. Volumetric samples were taken from 44 sub-samples and the samples were prepared at the Geosciences Lab at Aberdeen University, using a standard chemical procedure (method B of Berglund and Ralska-Jasiewiczowa 1986), using HCl, NaOH sieving, HF and Erdman's acetolysis to remove carbonates, humic acids, particles >170 microns, silicates and cellulose, respectively. The samples were then stained with safranin, dehydrated in tertiary butyl alcohol and the residues mounted in 2000cs silicone oil. Slides were examined at a magnification of x400 by ten equally spaced traverses across at least two slides to reduce the possible effects of differential dispersal on the slides (Brooks and Thomas 1967), or at least until 100 pollen grains were counted. Pollen identification was made following the keys of Moore *et al* (1991), Faegri and Iversen (1989) and a small modern reference collection. Plant nomenclature follows Stace (2010) and that for non-pollen palynomorphs (NPP) follows van Geel (1978). The preservation of the pollen was noted and an assessment was made of the potential for further analysis.

3 RESULTS

3.1 Introduction and Presentation of Results

3.1.1 The results of the assessment are presented below, and include a description of the stratigraphy of the auger holes transect. The full lithological details of all augers and depths of all deposits can be found in Appendix B. A summary of the lithostratigraphy is followed by presentation of the radiocarbon data and then the assessed pollen data.

3.2 General Soils and Ground Conditions

3.2.1 Ground conditions throughout the auger fieldwork were very good, as collection of the Russian-type core followed a period of very dry summer weather. Therefore, it may have been possible to access an area of the Tarn that otherwise may have been submerged during wetter periods.

3.3 Lithology

3.3.1 Details of the stratigraphy of a short transect across the north-eastern edge of the tarn are presented in Appendix B. The deepest sediments comprise a green/cream silty marl which is overlain by a banded brown/cream marl (Figs 5 and 6; 4.5-5m core photo). This is overlain by peat deposits with snail shells and woody debris (Figs 5 and 6; 3.5-4m), grading to fibrous peat with woody fragments (Figs 5 and 6; 2-2.5m). A clayey peaty deposit overlies the peat which is overlain by organic mud/clay at 0.5m (Fig 6; 0.5-1m).

3.4 Radiocarbon Dating

3.4.1 Humic and humin fractions of the peat were dated separately at two levels, outlined in the table below (Appendix E). The lower dates from both humin and humic fractions provide confidence in the early Mesolithic age assignment. There is a discrepancy, however, between the humic and humin fractions dated from the upper level at 0.35-0.36m. It is thought that this could be due to migration of clay particles within the organic deposits and therefore the date at 0.35-0.36m is of either early Roman or early medieval age.

3.4.2 Where radiocarbon dates in years before present (BP) have been quoted in the text from various publications, these dates have been calibrated to cal years BC, using the program, IntCal20 from OxCal 4.4.

SUERC	GU	DEPTH	FRACTION	DATE (BP)	DATE (AD/BC)
102077	59534	0.35-0.36	Humic	1515±24	cal AD 440-640
102081	59535	0.35-0.36	Humin	1993±22	40cal BC – cal AD 110
102082	59536	4.47-4.48	Humic	8152±19	7310-7060 cal BC
102083	59537	4.47-4.48	Humin	8151±23	7310-7060 cal BC

Table 1: AMS radiocarbon dates (Appendix E)

3.5 Pollen assessment

3.5.1 The data are initially described and then interpreted. All of the 44 sub-samples contained some pollen, however, fewer than half contained sufficient pollen (ie 100 total land pollen taxa (trees, shrubs and herbs)) at assessment, despite considerable efforts to count more than ten slide traverses, as outlined in the standard methodology above. This is thought to reflect the considerable quantities of organic matter within the sample residues, effectively diluting the pollen component, as well as varying levels of clay mineral content in the peat deposit. Nevertheless, it has been possible to use the available data to interpret a broad outline of palaeoenvironmental changes at Sunbiggin Tarn, in the period from the early Mesolithic to the early Roman or early medieval periods.

3.5.2 The deepest samples (4.80-4.44m; Fig 5), from an organic marl deposit and from the bottom of the overlying peat (with molluscs) deposit, contain abundant tree and shrub pollen, dominated by hazel-type (*Corylus avellana*-type), birch (*Betula*), oak (*Quercus*), pine (*Pinus*) and elm (*Ulmus*). Pollen of willow (*Salix*) is recorded along with a low frequency of grains of heather (*Calluna*) and juniper (*Juniperus*). Pollen of herbs includes occurrences of grasses (Poaceae), sedges (Cyperaceae), docks/sorrels (*Rumex*-type) and meadowsweet (*Filipendula*). A variety of fern spores, some associated with marshes and fens (*Thelypteris*), and others associated with woodlands, for example, buckler ferns (*Dryopteris*), bracken (*Pteridium aquilinum*) and monolete ferns (Pteropsida), are present. Pollen from aquatic plants is also recorded, including in particular, pondweed (*Potamogeton*), duckweed (*Lemna*) and bogbean (*Menyanthes trifoliata*). Fungal spores are present, especially *Coniochaeta xylariispora* (HdV-6) as well as *Kretzschmaria deusta* (HdV-44), *Sordaria* (HdV-55A/B) and microfossil type HdV-128. The bottom of the peat has been dated at 4.47-4.48m, to 7310-7060 cal BC (Table 1), which is the early Mesolithic period.

3.5.3 Between 4.36m – 3.16m, two main changes are observed within the pollen profiles (Fig 5). The first is that pollen of alder (*Alnus*) appears to be represented for the first time, at 4.36m, and thereafter occurs more or less continuously. The second is an apparent decrease in elm pollen between 4.04m and 3.88m, which may represent the Elm Decline. Between these depths, the pollen curves for grasses and sedges appear to increase slightly; there is also a record of pollen of ribwort plantain (*Plantago lanceolata*) at 4.20m, pollen of the carrot family (Apiaceae, a large group including plants such as water dropwort, fool's parsley and marshworts) at 3.88m, 4.04m, 4.28m and 4.36m) and mugworts (*Artemisia*) at 4.04m. Cereal-type pollen is present at depths above this, at 3.40m and 3.16m. However, cereal-type pollen is difficult to distinguish from some varieties of wild grasses, for example, *Glyceria* spp (sweet-grasses), which are known to grow in or by water (Andersen 1979; Stace 2010). Pollen of aquatic plants, including white water-lilies (*Nymphaea alba*) and arrowheads (*Sagittaria*), are also recorded. Fungal spores include occurrences of *Podospora* (HdV-368), *Glomus* (HdV-207), *Sordaria* (HdV-55A/B), *Kretzschmaria deusta* (HdV-44) and *Gelasinospora* (HdV-1). Small quantities of microcharcoal are consistently recorded.

3.5.4 Between 3.08m – 2.08m, pollen recovery is generally poor, with only two levels producing counts of approximately 100 grains (trees, shrubs, herbs). The top two levels, at 2.24m and 2.08m, produced reliable counts that show substantial quantities of tree pollen of hazel-type, oak, birch, alder and elm still present but with much reduced frequency of pine. Sedges and grasses are the dominant herbs but there are sporadic records for pollen of the pink family (Caryophyllaceae, including plants such as mouse-ears, campions and water chickweeds), daisy family (Asteraceae, including for example, burdocks, saw-worts and hawkbits) and meadowsweet. There is a continuous curve for fern spores of marsh ferns, probably *Thelypteris palustris*, a native fern that is usually shaded among taller herbs or shrubs in marshes and fens. Fungal spores of *Glomus* (HdV-207), *Sordaria* (HdV-55A/B) and *Coniochaeta xylariispora* (HdV-6) are recorded. Microcharcoal particles are present consistently but in relatively low quantity throughout this interval.

3.5.5 Between 1.92m and 0.16m, pollen recovery is again variable but is good at the top of the profile. No elm pollen is present above 2.08m; tree and shrub pollen is much reduced with obvious declines in hazel-type, birch, pine, oak and alder but with expansion of heather (*Calluna*). Pollen of sedges and grasses dominate the assemblages; several herbs are continuously recorded, including, for example, ribwort plantain, dandelion-type (*Taraxacum*), daisy-type, buttercup-type (*Ranunculus*) as well as rare occurrence of cereal-type pollen. Fern spores are represented by common polypody (*Polypodium vulgare*), monolete ferns and, in particular, bracken. *Sphagnum* moss spores are recorded throughout, as well as pollen from aquatic plants, including arrowheads, pondweed, white waterlilies and water plantains (*Alisma*). Freshwater algae are sporadically recorded, including for example, *Pediastrum* (HdV-760) and *Botryococcus* (HdV-766). Fungal spores record rare occurrence of *Gelasinospora* (HdV-1), with abundant recovery of *Glomus* (HdV-207) and continuous records of *Sordaria* (HdV-55A/B) and *Sporomiella* (HdV-113). Microcharcoal is recorded in relatively low amounts. The top of the section has been dated and is either of early Roman or early medieval age (Section 3.4 above).

4 Discussion

4.1 Pollen interpretation

4.1.1 Pollen that ranges in age from the early Mesolithic to at least early Roman (or perhaps early medieval) times is present in Russian-type core SBT-1. The pollen assemblages may, in part, be correlated with pollen records from a deep core collected from the tarn (Webster 1969) and similarities are also possible with the work of Chinn (1989). However, it must be remembered that assessment work from SBT-1 is based on limited pollen counts (*c* 100 grains per level) and is therefore not as accurate as analysed data, for which counts of 300-500 grains would be needed.

4.1.2 The earliest date for the bottom of the peat in SBT-1 (immediately above the lake marl deposits) is of early Mesolithic age (7310-7060 cal BC; Table 1) and supports the pollen assemblage which is indicative of abundant mixed woodland vegetation locally and regionally during this time. The pollen data from SBT-1, pre-date Webster's (1969) work, as they represent pre-alder rise pollen assemblages, whereas alder is already present in the deepest sub-samples from Webster's pollen diagram. The rise in pollen of alder is dated from Scaleby Moss, Cumbria, to between 6460-5890 cal BC (7362±146 BP, Q-167; Godwin and Willis 1959). The pollen data for the area around Sunbiggin Tarn at this time suggests that hazel-type, oak, elm, birch, pine and finally alder, comprised major woodland-forming trees both locally and regionally. Willow may have grown adjacent to the tarn edge, along with other plants of wetter soils, including for example, sedges, grasses, docks/sorrels and meadowsweet. Fern spores present in the pollen assemblage were probably derived from woodland trees, where they may have grown as epiphytes on the trees or perhaps at the woodland edge. Not surprisingly, there is also evidence for aquatic plants, including, for example, pondweed and white waterlilies.

4.1.3 Whilst some herb taxa reflect local conditions of growth (ie mints and meadowsweet) growing in damp areas, other pollen types suggest disturbance to the natural vegetation, including for example, ribwort plantain and mugworts. Such disturbance could be due to natural vegetation changes or animals trampling or through disturbance to the vegetation through human impact.

4.1.4 Prior to the current study, there were no data available for the presence or otherwise of microcharcoal particles or of non-pollen palynomorphs (including freshwater algae and fungal spores). Assessment of sub-samples from SBT-1 from the early Mesolithic onwards, may be interpreted to suggest that fire may have been used deliberately during this period (although the possibility of microcharcoal particles being derived from wildfires cannot be ruled out). The occurrence of rare fungal spores of *Gelasinospora* (HdV-1) supports the presence of charred vegetation (van Geel 1978). Fungal spores of *Sordaria* (HdV-55A/B), *Podospora* (HdV-368) and *Sporomiella* (HdV-113) are mainly coprophilous (although *Sordaria* may also occur on rotten wood), and may be used to infer grazing animals at or near the site. Fungal spores of *Coniochaeta xylariispora* (HdV-6) occur on dead and decaying plant matter (van Geel 1978). The presence of decaying wood is also evidenced from identification of the fungal spore

Kretzschmaria deusta (HdV-44), which has been linked to moribund trees and a correlation with livestock grazing intensity is possible (Innes *et al* 2006).

4.1.5 A significant event traditionally accepted as occurring around the Mesolithic/Neolithic boundary (*c* 4000 BC), is the Elm Decline, where values in elm pollen decline from robust numbers to quite low numbers or absence. Regionally, the Elm Decline is dated to the early Neolithic period (Section 1.3.8 above). The pollen diagram produced by Webster (1969) for Sunbiggin Tarn, shows two phases of declining elm pollen, of which the upper one is associated with the occurrence of cereal-type pollen, but both are associated with the expansion of the pollen curve for grasses and near continuous records for pollen of ribwort plantain (Fig 4). The assessed pollen diagram (SBT-1; Fig 5) from the north-eastern part of the tarn, may show a probable decline in elm pollen at 3.88m, with rare cereal-type pollen occurring above this, at 3.40m. The early Mesolithic date at the bottom of core SBT-1 coupled with the subsequent rise of alder (dated regionally) and then a probable elm decline (dated regionally), permit recognition of the expected trends in woodland vegetation during the Mesolithic to Neolithic periods. The decline in pine pollen, visible in more productive sub-samples, at 2.24m and 2.08m, may be indicative of a broad early Bronze Age (*c* 2200 BC) or later date (Section 1.3.3). Furthermore, the data may be interpreted to permit a probable correlation with Webster's (1969) pollen diagram, for which solid evidence of cereal-types coincides with immediate post-Elm Decline assemblages.

4.1.6 The upper interval assessed in SBT-1 (1.92m – 0.16m), is characterised by an expansion of sedge pollen, perhaps reflecting local ecological conditions adjacent to the tarn, and perhaps also indicative of raised water table levels. Tree and shrub pollen is relatively rare, suggesting regional woodland clearance had occurred. Only pollen of heather appears to increase in numbers, suggesting the spread of acid moorland, probably both adjacent to and beyond the site. Within this interval, cereal-type pollen is again recorded in low numbers and the curve for ribwort plantain is largely continuous, suggesting possible arable as well as pastoral land use activity. The potential presence of herbivores grazing the land may be inferred from relatively robust counts for fungal spores of *Sporomiella* (HdV-113) at 1.60m and 1.28m; abundant *Glomus* (HdV-1) may also infer disturbance to soils, potentially caused, for example, as a result of animal trampling.

4.1.7 Pollen from the upper half of Russian-type core SBT-1 is broadly dated from possibly the Neolithic/Bronze Age to either the early Roman (*c* 43 AD) or early medieval period (*c* 410 BC). Although robust pollen counts are not available for all levels assessed, those that did produce sufficient pollen are interpreted to suggest that a largely open, sedge-dominated fen/marsh existed on the edges of the tarn, with development regionally of acid moorland, supporting heather. Woodland trees probably existed as isolated or mixed stands of oak, ash and pine with some alder and possibly hazel scrub also present regionally. The drier land may have been used for low-scale arable cultivation, as indicated from occurrence of cereal-type pollen, and the land adjacent to the tarn was likely used for pastoral activity. The assessment data show no major changes, at least from 1.60m towards the top of the core, the predominant signal being one of post-clearance vegetation. The unpublished pollen diagrams of Webster (1969) and

Chinn (1989), though undated, show good agreement with the data from SBT-1; the upper sections of these diagrams, with cereal-type relatively consistently recorded albeit in low numbers, could range in age from the Neolithic/Bronze Age (*c* 4300 BC - *c* 800 BC) periods to at least early Roman (*c* 43 AD). The implication from Webster's diagram, is that the area was subject to possibly fairly continuous low scale arable as well as pastoral activity during the period represented by the diagram.

4.1.8 Similar pollen profiles have been obtained from pollen work through mires and tarns on the limestone areas within the southern Yorkshire Dales (Thwaite Tarn, Smarsett Tarn, Attermire Moss and Rough Haw; Rushworth 2010). Although hiatuses are thought to exist in some of the cores analysed, the data appear to reveal major ecological changes during and after the mid-later Neolithic period (*c* 3000 BC), with tree pollen values decreasing, as values for sedges and grasses increase along with occurrences of ruderal pollen types (for example, dandelion-type and plantains). It has been suggested that such environments may have promoted grazing activity. The presence of cereal-types within these sequences has been used to infer arable activity close to the sites (Rushworth 2010).

4.2 Conclusions and Recommendations

4.2.1 Previously undated sediments at Sunbiggin Tarn have been confirmed as ranging in age from at least early Mesolithic to post-Roman periods. It is likely that the pollen sequences in Webster's core date from a little later in the Mesolithic than those from SBT-1, and by correlation with the upper part of SBT-1, are considered likely to range to the post-Roman period, although this cannot be proven.

4.2.2 The new core provides confirmation of the presence of cereal-type pollen coincident with probable post-Elm Decline times and later (Neolithic to early Roman or early medieval), which correlates well with analysed samples from Webster's core in which the record of cereal-type is recorded in two main pulses within the period covering the Elm Decline and is almost consistently recorded in the post-Elm Decline section.

4.2.3 ***Recommendations:*** work could be undertaken to analyse more productive levels from SBT-1 in full, in particular those horizons where cereal-type pollen was present, and to obtain radiocarbon dates to confirm the age of arable activity and elm decline. It is likely that cereal-type occurrences in the deeper samples probably date to a post-Elm Decline, early or post-early Neolithic period (*c* 4000 BC), and cereal-types in the upper deposits are likely to be considerably later than that and could be as recent as post-Roman or post-medieval. It might prove difficult to date the upper levels accurately, however, due to clay particles within the peat, which may cause anomalous results from humic and humin acid fractions.

4.2.4 It would also be possible to further analyse productive levels between 1.60m and 1.28m, in order to clarify land-use in this post-woodland, potentially cleared environment. Pollen assessment has provided clear fungal spore evidence to suggest probable grazing activity during this period. Dating of these sediments would be crucial for potential correlation with excavation work at Little Asby.

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APPENDIX B BOREHOLE LOGS

OXFORD ARCHAEOLOGY				
BOREHOLE RECORDING SHEET				
SUMMARY DETAILS				
Site code	L11365	Sunbiggin Tarn Gouge Auger Transect		
Borehole No.	BH01	Collected BH01 from this location with Russian-type auger, for palaeoenvironmental assessment and radiocarbon dating.		
Easting	367833			
Northing	507930			
GL ELEV (m aOD)	250	Logged by	Mairead Rutherford	
Total depth (m)	4.75	Date	13th September 2021	

COMPOSITE LITHOLOGICAL LOG				
Depth (m)		Keyword	Upper contact	Description
From	To			
0.00	0.5	Soil/Clay		Dark brown to black soft, wet silty peaty soil/clay with abundant rootlets, very fresh
0.5	2	Peat	Gradual	Dark brown/black clayey peat, fibrous, rootlets common (0.5-1m); wood fragments *c* 1.80-2m
2	3.20	Peat	Gradual	Medium brown soft peat, fibrous, with wood fragments
3.20	4.48	Peat	Gradual	Medium brown soft peat, fibrous, with snail shells. Large wood fragment *c* 3.70m
4.48	4.75	Marl	Sharp	Banded brown organic / pale cream/green marl
4.75	5.00	Marl	Sharp	Green banded to cream white silty marl

OXFORD ARCHAEOLOGY				
BOREHOLE RECORDING SHEET				
SUMMARY DETAILS				
Site code	L11365	Sunbiggin Tarn Gouge Auger Transect		
Borehole No.	BH02	Located near a small stream meandering out of / into Tarn; gently rising ground to the east.		
Easting	367859			
Northing	507878			
GL ELEV (m aOD)	250	Logged by	Mairead Rutherford	
Total depth (m)	0.5-	Date	13th September 2021	

COMPOSITE LITHOLOGICAL LOG					
Depth (m)		Keyword	Upper contact	Description	
From	To				
0.00	0.5	Mud on bedrock		Several holes were attempted in the general vicinity but all gave way from mud to rock.	

OXFORD ARCHAEOLOGY				
BOREHOLE RECORDING SHEET				
SUMMARY DETAILS				
Site code	L11365	Sunbiggin Tarn Gouge Auger Transect		
Borehole No.	BH03	BH03 Located near a small stream meandering out of / into Tarn		
Easting	367855			
Northing	507888			
GL ELEV (m aOD)	250	Logged by	Mairead Rutherford	
Total depth (m)	3	Date	13th September 2021	
COMPOSITE LITHOLOGICAL LOG				
Depth (m)		Keyword	Upper contact	Description
From	To			
0.00	1.75	Peat		Silty peat; peat at surface
1.75	2.4	Marl	Sharp	Grey/green soft silty marl
2.4	2.5	Sand	Sharp	Green, medium-fine, soft sand
2.5	2.6	Marl	Sharp	Pale yellow silty marl
2.6	3	Marl	Sharp	Grey/green banded/laminated clay marl

OXFORD ARCHAEOLOGY			
BOREHOLE RECORDING SHEET			
SUMMARY DETAILS			
Site code	L11365	Sunbiggin Tarn Gouge Auger Transect	
Borehole No.	BH04		
Easting	367848		
Northing	507899		
GL ELEV (m aOD)	250	Logged by	Mairead Rutherford
Total depth (m)	2.5	Date	13th September 2021
COMPOSITE LITHOLOGICAL LOG			

Depth (m)		Keyword	Upper contact	Description
From	To			
0.00	0.5	Soil		Soil, mud becoming peaty with depth
0.5	1.25	Peaty clay	Gradual	Medium brown peaty organic clay
1.25	2	Peat	Gradual	Medium brown peat, woody, fibrous
2	2.5	Marl	Sharp	Pale yellow silty marl

OXFORD ARCHAEOLOGY			
BOREHOLE RECORDING SHEET			
SUMMARY DETAILS			
Site code	L11365	Sunbiggin Tarn Gouge Auger Transect	
Borehole No.	BH05		
Easting	367842		
Northing	507910		
GL ELEV (m aOD)	250	Logged by	Mairead Rutherford
Total depth (m)	3	Date	13th September 2021
COMPOSITE LITHOLOGICAL LOG			

Depth (m)		Keyword	Upper contact	Description
From	To			
0.00	0.5	Soil		Soil, muddy clay
0.5	1.5	Peat	Gradual	Medium brown, very fibrous peat
1.5	2.5	Peat	Gradual	Medium brown peat, woody, fibrous
2.5	2.7	Peat	Gradual	Medium brown peat, with clay, becoming wet
2.7	3	Marl	Sharp	Pale yellow silty marl

OXFORD ARCHAEOLOGY			
BOREHOLE RECORDING SHEET			
SUMMARY DETAILS			
Site code	L11365	Sunbiggin Tarn Gouge Auger Transect	
Borehole No.	BH06		
Easting	367837		
Northing	507920		
GL ELEV (m aOD)	250	Logged by	Mairead Rutherford
Total depth (m)	3	Date	13th September 2021

COMPOSITE LITHOLOGICAL LOG						
Depth (m)		**Keyword**	**Upper contact**	**Description**		
From	**To**					
0.00	1	No recovery		Auger came out wet with no recovery		
1	1.10	Clay		Light brown sloppy silty clay mud		
1.10	2.7	Peat	Gradual	Medium brown peat, soft, fibrous		
2.7	3	Marl	Sharp	Pale yellow silty marl		

APPENDIX C POLLEN TABLES OF RAW POLLEN COUNTS

Table of raw pollen counts for Russian core SBT-1

Sunbiggin Tarn SBT-1													
Preservation		Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Potential		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**YES**	**NO**	**YES**	**NO**	**NO**
Depth (m)		0.16	0.32	0.48	0.64	0.80	0.96	1.12	1.28	1.44	1.60	1.76	1.92
Trees/Shrubs													
Betula	Birch	2			1	1							
Alnus	Alder		3	2	4			1	1	1	1		2
Calluna	Heather	2	3	5	6		1		1	1	1		
Corylus avellana-type	Hazel-type	1	8	5	5		3	1	4		3	2	1
Fraxinus	Ash	1											
Ligustrum-type	Wild privet	1											
Pinus	Pine	1	2	2	1	1					2	1	1
Quercus	Oak	4	2	7	3		3		2			2	5
Crops	Cereal-type / large grasses			1	1								
Herbs													
Asteraceae	Daisy family		1	1									
Caryophyllaceae	Pink family								1			1	
Cyperaceae	Sedges	69	64	66	51		33	14	62	3	79	4	13
Mentha-type	Mints		1										
Plantago lanceolata	Ribwort plantain	2	5	4	3				3		1		
Poaceae	Grasses	17	9	11	24		4	16	16	1	13	1	4
Ranunculus-type	Buttercup-type		1		1				1	1			
Rubiaceae	Bedstraws	1											

Rumex-type	Docks/Sorrels										2		
Urtica-type	Nettles		1										
Taraxacum-type	Dandelions		1	4	1		3		8		8		
Fern spores													
Polypodium vulgare	Common polypody				3		1	1	1		1		1
Pteridium aquilinum	Bracken	1	1		2		3	2	4		7		1
Pteropsida	Monolete ferns	5		1	1		2				1	4	
Selaginella	Lesser Clubmosses				1						1		
Thelypteris	Marsh ferns											4	1
	Total land pollen	**107**	**102**	**109**	**108**	**2**	**53**	**35**	**104**	**7**	**120**	**19**	**29**
	Number of traverses	10	7	5	10	10	10	12	10	10	7	10	10
Aquatics													
Alisma-type	Water plantains						3						
Nymphaea alba	White water-lilies						1						
Potamogeton	Pondweed	1			1								
Sagittaria-t	Arrowhead			1									
Rotifers													
cf *Polyarthra dolichoptera*	XXX-25			1									
Conochilus natans-type	XXX-21				1								
Dicrocelium -type					2								
Mosses													
Sphagnum	Moss spores	1	1	3	1				2		2		
Microscopic charcoal		7	1	4	7		5	2	19	3	15	12	9
NPP*													

Botryococcus HdV-766							1						
Byssothecium circinans HdV-16C										1			
Clasterosporium caricinum HdV-25		1											
Closterium HdV-60			1									1	
Copepoda HdV-28									1				
Coniochaeta xylariispora HdV-6		1		2			1						
Gelasinospora HdV-1									2				
Glomus HdV-207				3	4	5	12	2	16	8	6	1	
Pediastrum HdV-760		1										1	
Podospora HdV-368					1				1		2	2	1
Rivularia HdV-170		2	4				1		3		2		
Sordaria HdV-55A/B		2	5	4	4				3	1	6	2	2
Sporomiella HdV-113				2	1				8		15		
HdV-4							1			1			
HdV-18									1			1	
HdV-85									1			1	1
HdV-128								9	3		1		
Fungal hyphae		1			1								

Fungal spores (indeterminate)									2		3	5	
Broken grains		1	1		1			2	1		5		
Concealed grains			2	1				1	1	1	1		
Crumpled grains			1		1			2	5		4		

Sunbiggin Tarn SBT-1													
Preservation		Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Potential		**YES**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Depth (m)		2.08	2.24	2.40	2.52	2.60	2.68	2.76	2.84	2.92	3.00	3.08	3.16
Trees/Shrubs													
Betula	Birch	14	15							3		2	
Alnus	Alder	4	6			1		1		1			1
Calluna	Heather												
Corylus avellana-type	Hazel-type	12	8	4	1	1		1	1	2	2	1	1
Ericales-type	Heaths				1								
Pinus	Pine	2	3	1	2	1			1	3			3
Quercus	Oak	15	17	2					1	4	1		3
Rosaceae	Rose family									1			
Salix	Willow						1						
Ulmus	Elm	5	12	2		1			2	3			
Crops	Cereal-type / large grasses												1
Herbs													
Asteraceae	Daisy family	1	1		1					1			
Caryophyllaceae	Pink family	1	1							1			
Cyperaceae	Sedges	24	27	9	2	2	1		3	15	28	4	13
Filipendula	Meadowsweets	1	2			1							
Persicaria amphibia	Amphibious bistort		1										

Plantago spp.	Plantains	1											
Poaceae	Grasses	10	9		2	1	2			2	2	3	3
Ranunculus-type	Buttercup-type		2		1								
Taraxacum-type	Dandelions								1				
	Indeterminate herbs	4	4						1			1	
Fern spores													
Dryopteris	Buckler-ferns	1	3			1			1				
Ophioglossum	Adder's tongues	1											
Polypodium vulgare	Common polypody									1			
Pteridium aquilinum	Bracken	1									2	1	1
Pteropsida	Monolete ferns		3	1	1		1			6	1		1
Thelypteris	Marsh ferns	3	2	3	1				2	2			
	Total land pollen	**100**	**116**	**22**	**12**	**9**	**5**	**2**	**13**	**45**	**36**	**12**	**27**
	Number of traverses	30	16	12	10	10	10	10	10	10	10	10	10
Aquatics													
Nymphaea alba	White water-lilies		1										
Stratiotes	Water soldier	1											
Rotifers													
Undifferentiated		1											
Testate amoebae													
Undifferentiated							1						
Mosses													
Sphagnum	Moss spores									1			
Microscopic charcoal		10	5	14	6	6	7	1	6	6	17	5	11
NPP*													

Byssothecium circinans HdV-16C		1			1								1
Coniochaeta xylariispora HdV-6		1	6	1		2	1		4			1	6
Diporotheca HdV-143		1											
Glomus HdV-207		2		1	1		4		1	1	3		
Podospora HdV-368				1			1				2		1
Sordaria HdV-55A/B		1	3	3	1	1	6			2		1	4
Xylomyces KIU-163			1										
HdV-18					1								
HdV-85													2
HdV-128		1		1	1		2	1					1
Fungal spores (indeterminate)		2				2				2		1	4
Broken grains		1	2	1	2					3		1	1
Concealed grains			2							2	1		
Crumpled grains		2	1	1			1		1	5	1	1	4

Sunbiggin Tarn SBT-1													
Preservation		Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Potential		**Possible**	**NO**	**Possible**	**NO**	**NO**	**NO**	**NO**	**NO**	**YES**	**NO**	**YES**	**Possible**
Depth (m)		3.24	3.32	3.40	3.48	3.56	3.64	3.72	3.80	3.88	3.96	4.04	4.12
Trees/Shrubs													
Betula	Birch	1	1	6	1		2	4	3	13	3	14	8
Alnus	Alder	2		1		1	2			1		3	3

Calluna	Heather						1			1			
Corylus avellana-type	Hazel-type	6	3	24	4	5	7	6	5	40	8	34	33
Ericales-type	Heaths	1		1									
Hedera	Ivy					1							1
Juniperus	Juniper												1
Pinus	Pine	14	4	11	2	1	3	4	4	17	5	24	15
Prunus-type	Cherries												
Quercus	Oak	4	2	12	2	1	6	4	4	8	3	12	9
Salix	Willow			1	1		1		2				
Ulmus	Elm	2	2	4	1		2			2	2	7	3
Crops	Cereal-type / large grasses			1									
Herbs													
Apiaceae	Carrot family									1		1	
Artemisia	Mugworts											1	
Caryophyllaceae	Pink family								1				
Cyperaceae	Sedges	11	1	19	3	6	2	3	15	14	1	3	8
Fabaceae	Pea family	1		4									
Filipendula	Meadowsweets	1		1	1							1	
Geum-type	Avens							1					
Lysimachia-type	Loosestrifes									1			
Mentha-type	Mints								1				
Persicaria amphibia	Amphibious bistort									1	1		
Poaceae	Grasses	9	3	7	4	3	2		3	6	1	7	4
Rumex-type	Docks/Sorrels					3							
Succisa pratensis	Devil's Bit Scabious												1
Taraxacum-type	Dandelions					1							
	Indeterminate herbs	1				1		1					
Fern spores													
Dryopteris	Buckler-ferns			3		4			1	2			1

Polypodium vulgare	Common polypody						1						1
Pteridium aquilinum	Bracken	1		1			1		2	1	1		1
Pteropsida	Monolete ferns	3		1	2		1		3	2		2	1
Thelypteris	Marsh ferns	4	2	2		1	3	3	2			2	
Trilete ferns (undifferentiated)								4	1		1		
	Total land pollen	**61**	**18**	**99**	**21**	**28**	**34**	**30**	**47**	**110**	**26**	**111**	**90**
	Number of traverses	10	10	20	10	10	12	12	12	18	10	5	13
Aquatics													
Nymphaea alba	White water-lilies				2							1	1
Potamogeton	Pond weed		1				1		1	2		1	2
Sagittaria	Arrowheads						1	1					
Testate amoebae													
Undifferentiated				1						1			
Mosses													
Sphagnum	Moss spores		1	2									
Microscopic charcoal		4	11	20	2	4	9	6	0	22	3	9	17
NPP*													
Byssothecium circinans HdV-16C				1			2		1			1	1
Coniochaeta xylariispora HdV-6		2		3	1	1		1		1	1	4	3
Glomus HdV-207		1	1			1	3	1	1			1	
Pediastrum HdV-760				2									

Podospora HdV-368		2	1	1						1			1
Rivularia KIU-171							1						
Savoryella cf lignicola KIU-71												1	
Sordaria HdV-55A/B		3	1	2			3	1	7	2	1	3	2
Spirogyra HdV-130/132						1		1	1	1		2	1
Valsaria HdV-263										1			
Xylomyces KIU-163							1						
HdV-18			1	3			1	1					
HdV-85									1			1	
HdV-128		3		2			2	2	1	1	1	2	2
Fungal spores (indeterminate)				1				1		2	1	1	
Broken grains		1				1							1
Concealed grains		1		1									
Crumpled grains		1											

Sunbiggin Tarn SBT-1													
Preservation		Good	Good	Good	Good	Good	Good	Good	Good				
Potential		**NO**	**YES**	**YES**	**NO**	**YES**	**YES**	**YES**	**YES**				
Depth (m)		4.20	4.28	4.36	4.44	4.52	4.57	4.60	4.74				
Trees/Shrubs													
Betula	Birch	4	11	14	5	30	23	21	32				
Alnus	Alder			5									
Calluna	Heather	1	1	2		1	1						

Corylus avellana-type	Hazel-type	6	32	42	8	42	45	43	77				
Ericales-type	Heaths		1										
Juniperus	Juniper								1				
Pinus	Pine	3	17	6	9	12	10	16	4				
Quercus	Oak	4	7	8	4	6	6	10	5				
Rosaceae	Rose family						1	2	1				
Salix	Willow			1	1	2	5	3					
Ulmus	Elm	2	4	11		7	2	6	6				
Herbs													
Apiaceae	Carrot family		1	1									
Cyperaceae	Sedges	4	5	17	4	3	3	1	7				
Fabaceae	Pea family			1									
Filipendula	Meadowsweets	1			1								
Plantago lanceolata	Ribwort plantain	1											
Poaceae	Grasses		5	2	1	2	3	4	2				
Ranunculus-type	Buttercup-type								1				
Rumex-type	Docks/Sorrels						3						
	Indeterminate herbs		1										
Fern spores													
Dryopteris	Buckler-ferns		1	1	1	2		3	1				
Pteridium aquilinum	Bracken		2			1							
Pteropsida	Monolete ferns		4		1			2					
Thelypteris	Marsh ferns		1	1			1						
Trilete ferns undifferentiated	Ferns							3					
	Total land pollen	**26**	**93**	**112**	**35**	**108**	**103**	**114**	**137**				
	Number of traverses	10	24	6	14	4	5	7	16				
Aquatics													
Lemna spp.	Duckweed							1					
Menyanthes	Bogbean				1								

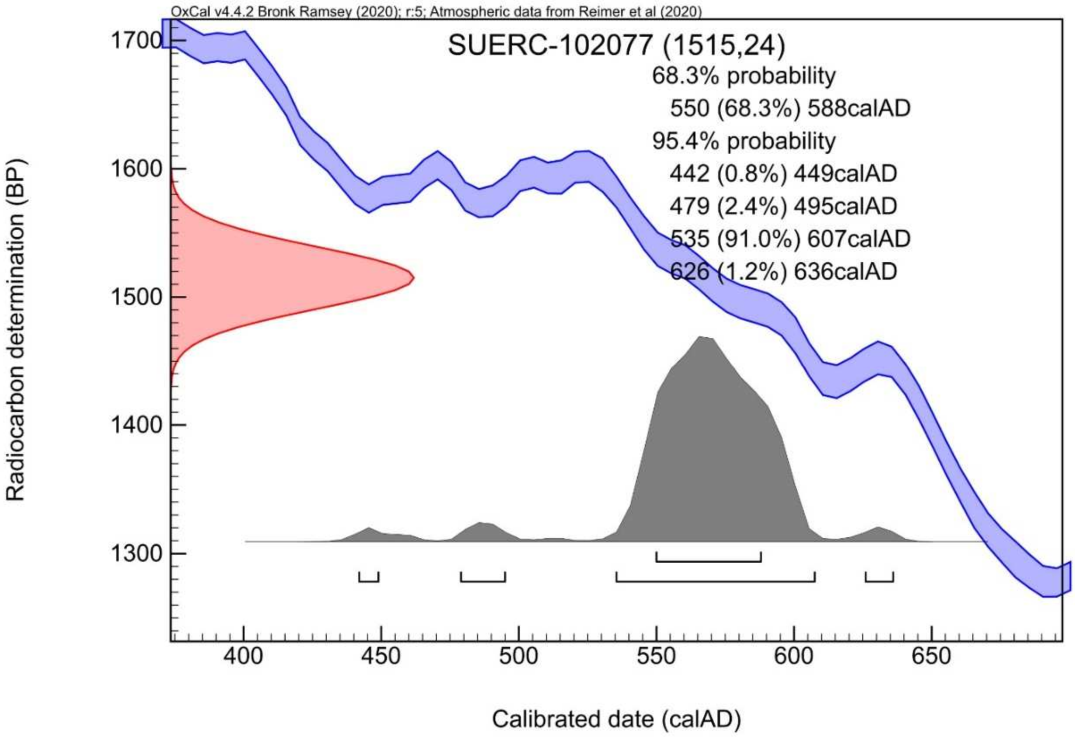
Potamogeton	Pond weed				1			1					
Microscopic charcoal		7	18	8	5	0	6	6	1				
NPP*													
Botryococcus HdV-766				1	1								
Brachysporium HdV-359			1										
Byssothecium circinans HdV-16C		1	3	1									
Coniochaeta cf. *ligniaria*				1									
Coniochaeta xylariispora HdV-6			8	3	2	1	1	3	5				
Gelasinospora HdV-1			1										
Glomus HdV-207		1	5		1								
Kretzschmaria deusta HdV-44			1						1				
Podospora HdV-368		3	6										
Sordaria HdV-55A/B			9		5	1		1	1				
Spirogyra HdV-130/131				1									
Sporomiella HdV-113									1				
HdV-18			3										
HdV-85				1									
HdV-128			5	4	2		3		1				
Fungal spores (indeterminate)		1	9	1	1			1					

Broken grains						1							
Concealed grains			1					2					
Crumpled grains			1			1							

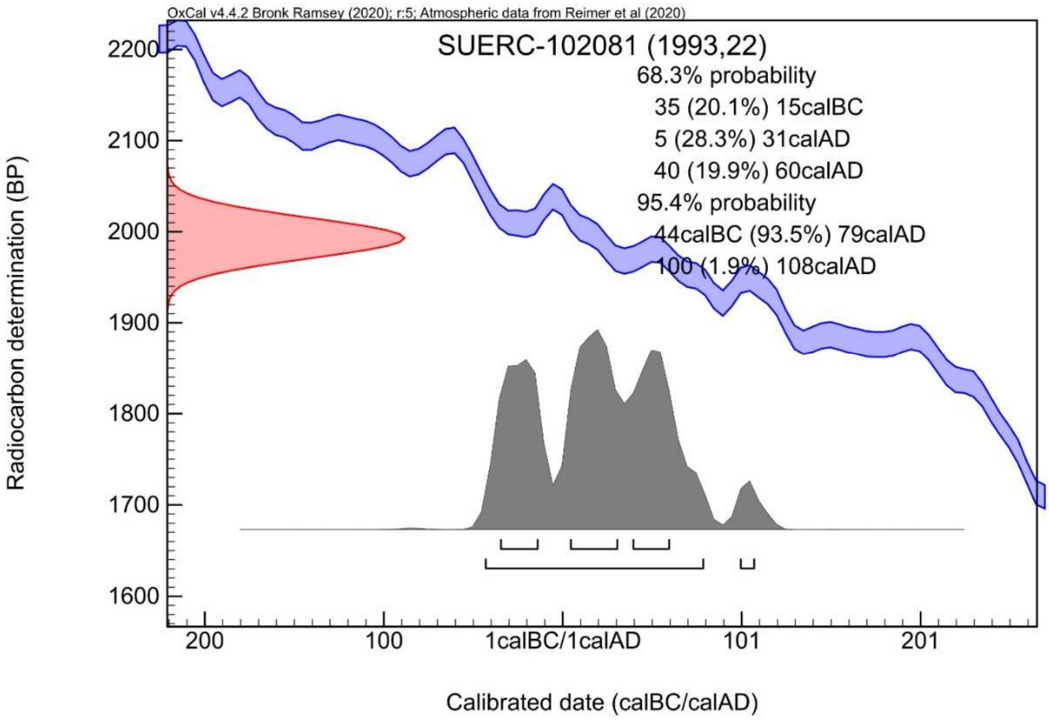
APPENDIX D SITE SUMMARY DETAILS

Site name:	Little Asby Through the Keyhole; Sunbiggin Tarn
Site code:	STB-1
Grid Reference	367833 507930
Type:	Palaeoenvironmental Assessment
Date and duration:	September 2021-March 2022
Area of Site	N/A
Location of archive:	The Russian-type core (SBT-1) and pollen residues are currently held at OA, Mill 3, Moor Lane Mills, Moor Lane, Lancaster, LA1 1QD.
Summary of Results:	To provide palaeoenvironmental input to the community dig 'Little Asby Through the Keyhole', volunteers took part in an auger survey leading to collection of a 5m-deep auger core, from the edge of Sunbiggin Tarn, south-west of the Little Asby excavation sites. Organic sediments within the core provided radiocarbon AMS dates ranging from the early Mesolithic to post-Roman or post-medieval periods. Pollen assessed from the core was interpreted as providing evidence for early Mesolithic plant communities that may have been impacted by fire; a probable decline in elm pollen, traditionally dated to the early Neolithic, and shortly followed by incidence of cereal-type pollen; the expansion of sedge fen at the site and the spread, probably regionally, of acid moorland, with further evidence for possible low-scale arable and pastoral activity. The data have been correlated with a detailed pollen diagram from the tarn itself, dated to 1969, and reproduced in this report.

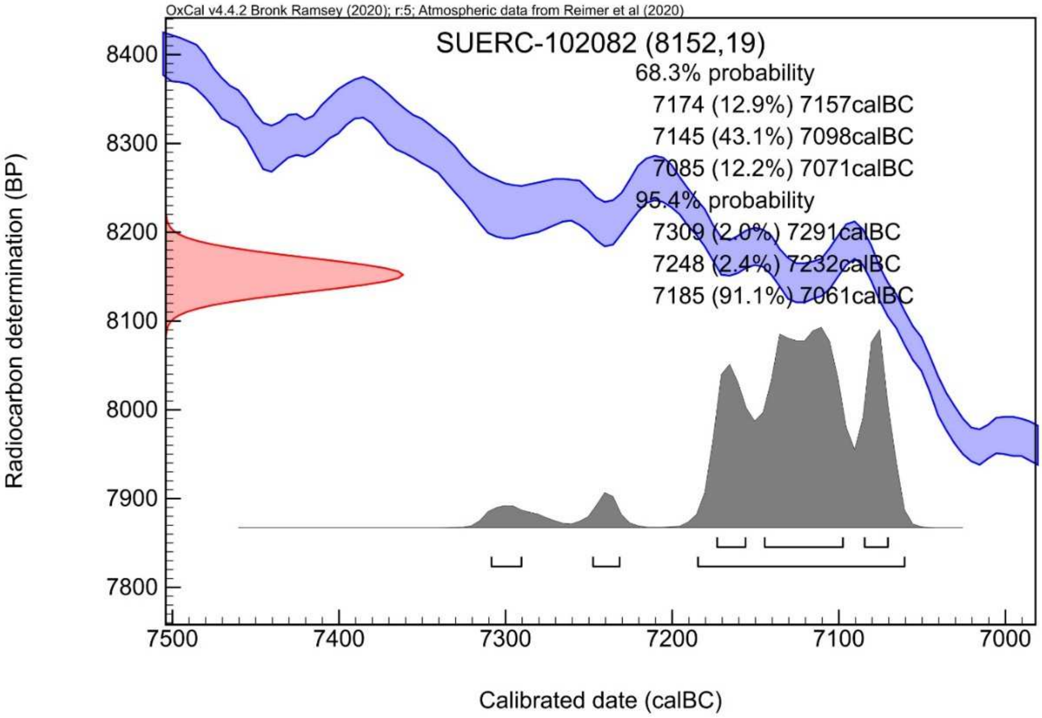
APPENDIX E RADIOCARBON DATING CERTIFICATES



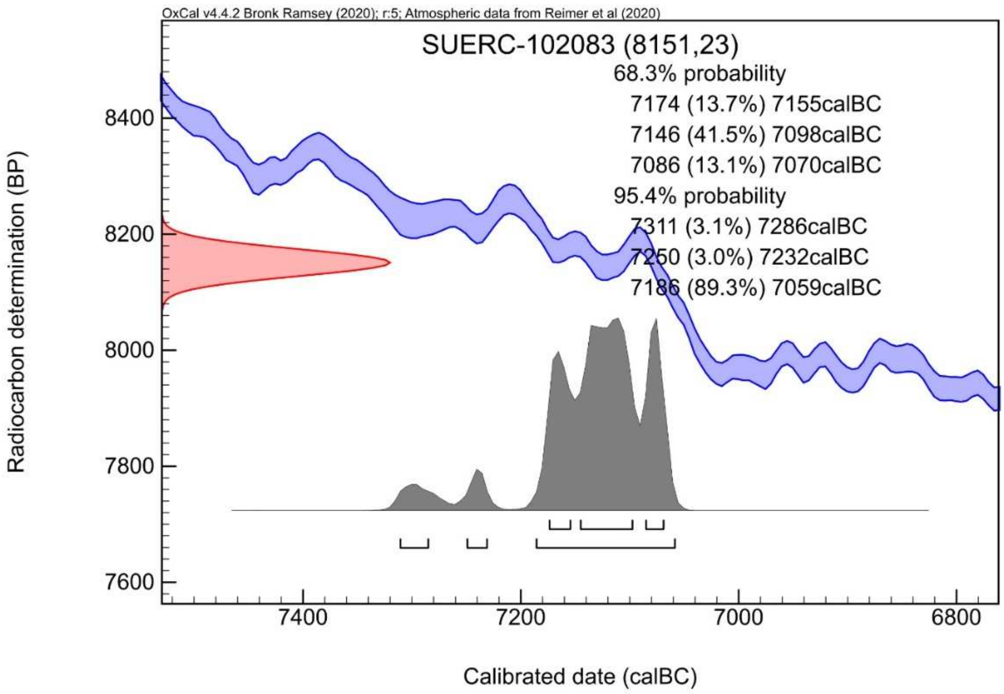
SUERC -102077 0.35-0.36m depth Humic Fraction



SUERC -102081 0.35-0.36m depth Humin Fraction



SUERC -102082 4.47-4.48m depth Humic Fraction



SUERC -102083 4.47-4.48m depth Humin Fraction

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