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Natural Resources Wales

Sorbus diversity in the Wye Valley Woodlands SAC, Wales

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Report No 332

www.naturalresourceswales.gov.uk

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Report series:	NRW Evidence Report
Report number:	332
Publication date:	February 2019
Contractor:	T. C. G. Rich
Contract Managers:	J. Woodman & R. Bacon
Title:	*Sorbus* diversity in the Wye Valley Woodlands SAC, Wales
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Distribution List (core)

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Recommended citation for this volume:

Rich TCG, Houston L, Tillotson AC. 2019. *Sorbus* diversity in the Wye Valley Woodlands SAC, Wales. NRW [Report Series] Report No: 332,102pp, Natural Resources Wales, Cardiff.

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2. Executive Summary

The Wye Valley Woodlands Special Area of Conservation (SAC) comprises 16 Sites of Special Scientific Interest (SSSI) on the border of Wales and England. Rare whitebeams are cited as a feature of the SAC, and they are also listed as features of the Blackcliff/Wyndcliff SSSI, Pierce, Alcove & Piercefield Woods SSSI and the Upper Wye Gorge SSSI.

In 2017-2018 Natural Resources Wales (NRW) commissioned projects to provide information on rare and important *Sorbus* trees for their conservation in the SAC. The work included:

- A review of the historical records of *Sorbus* species.
- Field surveys (including rope access surveys at Wynd Cliff) to establish the locations and population sizes of the *Sorbus* trees.
- Marking the rarest species in situ using phenomarkers to enable relocation.
- Production of a '*Sorbus* Management Plan', highlighting Species of Conservation Concern and suitable management to promote their longevity.

Historical *Sorbus* records were compiled from a range of sources including literature, herbaria, databases and personal records; 180 records were traced representing 10 species, 2 hybrids and 1 possible new species. Some historical records were rejected and others were revised.

Field surveys were carried out in 2017 and 2018 by targeting known sites with rare taxa and recording other trees as noted in passing; 513 records were compiled. Many new interesting records were made.

Of the three sites not previously surveyed, Apostles' Rocks had reasonable frequencies of *S. anglica, S. aria* and *S. torminalis.* Alcove Wood and Black Cliff were poor.

Rope access surveys on Wynd Cliff found mostly *S. aria* with a few *S. porrigentiformis* and one possible *S. eminens* plant. *Sorbus anglica* was not refound on the main cliffs. Wyndcliff Quarry had a higher concentration of species than the main cliffs, including *S. anglica, S. eminens* and *S. porrigentiformis.*

32 rare trees were marked using phenomarkers to enable relocation.

The rare taxa of conservation interest were distributed as follows:

- *S. anglica* - Lover's Leap, Piercefield cliffs, Apostles' Rocks, Wyndcliff Quarry.
- *S. eminens* - Alcove Wood, Black Cliff, Lady Park Wood, Lover's Leap, Piercefield cliffs, Wynd Cliff area, Wyndcliff Quarry.
- *S. eminentiformis* - Lady Park Wood.
- *S. porrigentiformis* – Wynd Cliff, Wyndcliff Quarry, Lady Park Wood (not surveyed).
- *S. rupicola* - Highmeadow Woods (extinct).
- *S. saxicola* - Highmeadow Woods, Lady Park Wood (not surveyed).
- *S.* x *tomentella* - Lady Park Wood, Lover's Leap, Wynd Cliff.
- *S.* new species 'Wyndcliff' - Wyndcliff Quarry.

Of the other taxa *S.* x *thuringiaca* is extinct, *S. aria, S. aucuparia* and *S. torminalis* are common and widespread species and *S. croceocarpa* is an

introduced species of no conservation importance. Distribution maps of the species are presented.

The most important *Sorbus* sites are Lady Park Wood and Highmeadow Wood, the Piercefield Park complex (Lover's Leap, Apostles' Rocks, Piercefield NE cliffs), Wynd Cliff and Wyndcliff Quarry. Alcove Wood, Black Cliff, Lower Wyndcliff Wood and Lower Martridge Wood are not considered to hold significant populations of *Sorbus* taxa.

Overall, the Lower Wye Valley is the second most diverse site for *Sorbus* in the British Isles with 19 taxa, second only to the Avon Gorge which hosts about 23 taxa.

The key factor for maintaining the diversity is the presence of extensive areas of open or partly shaded limestone rocks and cliffs with little disturbance or grazing; some dynamic management opening up the canopy for the whitebeams along the cliff edges may be desirable.

A process-based species action plan for *Sorbus* in the Wye Valley is presented, which includes a description of the baseline situation, definition of desired outcomes, an 'intervention plan' to achieve the outcomes with defined indicators of success and proposals for monitoring.

3. Introduction

The Wye Valley Woodlands SAC comprises 16 Sites of Special Scientific Interest (SSSI) on the border of Wales and England. Eight of the SSSIs are located in Wales, seven in England and the Upper Wye Gorge SSSI is shared.

The JNCC description of the '9180 *Tilio-Acerion* forests of slopes, screes and ravines' feature of the Wye Valley Woodlands SAC states:

> *'The woods of the lower Wye Valley on the border of south Wales and England form one of the most important areas for woodland conservation in the UK and provide the most extensive examples of Tilio-Acerion forest in the west of its range. A wide range of ecological variation is associated with slope, aspect and landform. The woodland occurs here as a mosaic with other types, including beech Fagus sylvatica and pedunculate oak Quercus robur stands. Uncommon trees, including large-leaved lime Tilia platyphyllos and rare whitebeams such as Sorbus porrigentiformis and S. rupicola are found here, as well as locally uncommon herbs, including wood barley Hordelymus europaeus, stinking hellebore Helleborus foetidus, narrow-leaved bitter-cress Cardamine impatiens and wood fescue Festuca altissima.'*

Of the component SSSIs, three have *Sorbus* trees listed as features of special scientific interest as follows:

- Blackcliff/Wyndcliff SSSI – *Sorbus anglica* is listed as part of the Assemblage feature of Red Data Book (RDB) and/or Nationally Scarce vascular plants.
- Pierce, Alcove & Piercefield Woods SSSI – *Sorbus anglica* is listed as an Independent Plant feature.
- Upper Wye Gorge SSSI – *Sorbus porrigentiformis* is listed as part of the Assemblage feature of Red Data Book (RDB) and/or Nationally Scarce vascular plants.

In 2017-2018 Natural Resources Wales (NRW) commissioned 3 projects to provide accurate grid references for the locations of rare and important *Sorbus* trees to enable their conservation, to ensure avoidance of damage when undertaking future woodland management operations and to enable effective location of specimens for future identification purposes. The projects were:

1. A review of the existing records of *Sorbus* species combined with limited field work in February and March 2017 to collate information (completed and reported by Rich 2017).
2. A field survey to confirm the identification of known species, new field surveys of Piercefield Park and Black Cliff, marking in situ of the rarest species of *Sorbus* using phenomarkers and production of a '*Sorbus* Management Plan', highlighting Species of Conservation Concern and suitable management to promote their longevity (undertaken by Tim Rich in 2018).
3. A rope access survey of the cliffs at Wynd Cliff and Wyndcliff Quarry (undertaken by Angus Tillotson and Libby Houston of Rope Works in 2018).

In this report, these three projects are integrated and summarised.

3.1. *Sorbus* species recorded in Wye Valley Woodlands SAC

The *Sorbus* taxa recorded in the Welsh part of the Wye Valley Woodlands SAC are listed in Table 1. Taxonomy and nomenclature follow the *Sorbus* handbook for ease of reference (Rich *et al.* 2010); the recent splits of European *Sorbus* into 5 genera with new genera for the hybrids (Sennikov & Kurrto 2017), or the recent lumping of *Sorbus* into *Pyrus* (Christenhusz *et al.* 2018) are equally valid taxonomic alternatives but are not used to minimise confusion. Typical leaf shapes of the taxa recorded are given in Appendix 1.

Table 1. *Sorbus* taxa recorded in the Wye Valley Woodlands SAC with their British and IUCN threat status. Note that 'sensu lato' means in the broad sense (i.e. groups of related taxa) and 'sensu stricto' means in the narrow specific sense.

Latin name	Common name	Status	IUCN threat status
S. anglica	English whitebeam	British and Irish endemic	Near Threatened.
S. aria	Common whitebeam	Widespread	Least Concern
S. aucuparia	Rowan	Widespread	Least Concern.
S. croceocarpa	Orange-fruited whitebeam	Introduced	Least Concern
S. eminens sensu stricto*1	Round-leaved whitebeam	British endemic	Vulnerable
S. eminentiformis	Doward whitebeam	British endemic	Endangered.
S. porrigentiformis sensu stricto*2	Grey-leaved whitebeam	British endemic	Vulnerable
S. rupicola	Rock whitebeam	Widespread in N Europe	Least Concern
S. saxicola	Symonds Yat whitebeam	British endemic	Critically Endangered
S. torminalis	Wild service tree	Widespread	Least Concern
S. x *thuringiaca* (*S. aria* x *aucuparia*)	Hybrid rowan	Widespread hybrid	Endangered
S. x *tomentella* (*S. aria* x *torminalis*)*3	Wye whitebeam	Widespread hybrid	Vulnerable.
S. new species 'Wyndcliff' *4	Wynd Cliff clone	Welsh endemic	Critically Endangered

*1. *Sorbus eminens* was treated in a broad sense by Warburg (1957) who included trees from the lower Wye Valley (type locality Tidenham, opposite Wynd Cliff) with rounded leaf-bases and trees from the north end of the Wye Valley with wedge-shaped leaves (these are now separated as *S. eminentiformis*). Any old records without verified voucher specimens or supported by poor material could be either *S. eminens* or *S. eminentiformis* so are treated as *S. eminens* sensu lato.

Sell & Murrell (2014) have a different interpretation of the holotype of Warburg's *Sorbus eminens* which they allocate to Warburg's northern form, i.e. *S. eminentiformis* T. Rich, and consequently they differ in nomenclature for this group; their treatment is not recommended. T. Rich no longer accepts records of *S. eminentiformis* from the southern Wynd Cliff areas of the Wye Valley and regards it as restricted to the Lady Park-Doward-Symonds Yat area.

*2. *Sorbus porrigentiformis* was treated in a broad sense by Warburg (1957) and it has now been split into numerous taxa (including the Wye Valley *S. evansii,*

S. porrigentiformis sensu stricto, *S. saxicola* and *S. whiteana*, as well as other taxa). Any old records without verified voucher specimens or supported by poor material are treated as *S. porrigentiformis* sensu lato, and it also includes a number of unverified potentially new taxa such as Wynd Cliff clone and the triploid tree recorded at Lancaut opposite Piercefield (cf. Pellicer *et al.* 2012).

*3. The correct name for the *S. aria* x *torminalis* hybrid is now *S.* x *decipiens* (Bechst.) Petz & G. Kirchn (not to be confused with *S. decipiens* (Bechst.) Irmisch in Rich *et al.* 2010), not *S.* x *tomentella* (Rich *et al.* 2014). One tree of *S.* x *tomentella* with very narrow leaves was provisionally thought to be a new clone and was provisionally nicknamed '365 steps' from its location at the bottom of the steps (Rich 2017); this was found to be diploid by flow cytometry in 2018 so is simply *S.* x *tomentella.*

*4. A tetraploid *S. porrigentiformis* segregate, which may merit description as a new species, was found at Wyndcliff Quarry where 16 trees occurred on 2 rock shelves (D. Green, pers. comm. 2017; Green has incorrectly used the name 'Black Rock quarry' for this site). This is referred to as S. new species 'Wyndcliff'. The leaves are distinctive in being broadly elliptic, blunt at the apex but with deep lobes and with few veins (Appendix 1).

4. Methods

4.1. Historical information

Existing *Sorbus* records for the Upper Wye Gorge SSSI (Welsh side), and the vicinity of Piercefield, Black Cliff and Wynd Cliff were compiled from the sources below and reviewed. Many of the records are duplicated between different sources, so they were combined retaining the maximum amount of information when merging the records. Some species records have been re-identified so the current name is used with the original name in the notes section.

A provisional record of *Sorbus whiteana* for Lady Park Wood (Houston *et al.* 2003; Evans 2007) is now referred to *Sorbus saxicola*.

The data are presented in a separate Excel spreadsheet. The structure of the spreadsheets is set out in Appendix 2, with a summary of the data in Appendix 3. The detail of the grid references varies from 2-figure (10-km square) for old records to 10-figure for recent GPS records.

1989 Vicky Morgan surveys

Although the Morgan (1989) records are widely cited, her identifications of *Sorbus anglica* trees at Lover's Leap and on Wynd Cliff steps are not accepted (these are suspected to be lobed forms of *S. aria*, abundant in both places; Rich 2017), and there is not enough information to assess if her *S. eminens* record at Lady Park Wood is correct.

Survey of Wye Valley Woods for *Sorbus* species report

A brief report by Rogers & Williams (1997) simply lists locations for *Sorbus* in the Piercefield and Wynd Cliff areas, but without confirmed identifications (it is clear the authors do not really know the *Sorbus* species). The main use for this report was to see where additional trees might be located in areas not covered by other surveys.

Houston *et al.* 2003 Lady Park Wood survey

This survey was carried out over 2 days in September 2003 for Natural England by Colin Charles, Libby Houston and Angus Tillotson. A series of rope survey drops were carried out along the edge of the cliffs as time allowed and vouchers were collected (held in National Museum of Wales herbarium, NMW); a few identifications have been updated in light of the extensive additional research carried out since 2003 but in general the data are sound. GPS grid references for the records were derived during the 2017/2018 field work using their excellent hand-drawn map (Houston *et al*. 2003).

Floras of Monmouthshire

The *Flora of Monmouthshire* (Evans 2007) contained a summary of the records available up to 2006; these have been extracted and updated. The previous *Flora of Monmouthshire* by Wade (1970) has nothing additional.

Monmouthshire Rare Plant Register

Some data were extracted from the Monmouthshire Rare Plant Register (Evans 2009, 2/11/2009 version). The Rare Plant Register was updated but no additional *Sorbus* records have been added to date (Elsa Wood and Stephanie Tyler, pers. comms., Jan 2017). Most of the records duplicate those in Evans's *Flora* (Evans 2007).

Note that the northern form of *S. eminens* in the register has been redetermined as *S. aria*, and the *S. porrigentiformis* record should be treated as *S. porrigentiformis* sensu lato.

Tim Rich personal records 1982-2017

Tim Rich has visited these areas many times since September 1982 often looking specifically for *Sorbus* or *Hieracium*; records not otherwise covered by the other sources are added.

Specimens in National Museum of Wales (NMW)

Data from all the relevant *Sorbus* specimens in NMW were extracted as these give the verifiable reference source of identification; these are mainly specimens collected by Trevor Evans, Libby Houston and Tim Rich, with some older specimens.

Data compiled for maps for Rich *et al.* (2010) BSBI *Sorbus* handbook

The maps in Rich *et al.* (2010) were compiled from many sources and the data were extracted and checked against the other records incorporating corrections.

D. Green's personal data

Dave Green has spent significant amount of time searching for *Sorbus* in Wynd Cliff area between 2012 and 2016 and kindly summarised the more important of his records, with some vouchers which were rechecked including two *S. eminens* records and a possible *S. croceocarpa*.

S. Bosanquet 2016 data

Sam Bosanquet plotted GPS locations of many *S. aria* trees in 2016 at Wynd Cliff with Rob Bacon and Karen Wilkinson whilst looking for invertebrates associated with *Sorbus*. The identifications of *S. porrigentiformis* and *S. eminens* were not confirmed in 2018 and are not accepted.

Other on-line sources

The NBN Gateway and Aderyn (the Welsh Local Records Centre portal) were checked for additional records of the more interesting species (both hold records of the common taxa *S. aria, S. aucuparia* and *S. torminalis*). Some duplicate records were found on Herbaria@home. No other significant records were found using search engines.

BSBI Big Database

Once the main data had been compiled, the records were checked against the BSBI Big database for additional records and records corrected and verified.

4.2. Field surveys 2017 and 2018

The *Sorbus* surveys carried out in the Wye Valley SAC are listed in Table 2 and the areas searched are shown in Figure 1a-e.

Table 2. Wye Valley SAC *Sorbus* surveys carried out in 2017 and 2018.

Site	Survey dates	Recorders
Alcove Wood	7 September 2018	Tim Rich & Julian Woodman
Black Cliff	4 & 5 September 2018	Tim Rich
Highmeadow Woods	4 September 2018	Tim Rich & Julian Woodman
Highmeadow Woods and Lady Park	28 February 2017	Tim Rich, Joe Atkinson, Rob Bacon, Rosalind Watkins
Lady Park Wood	4 September 2018	Tim Rich & Julian Woodman
Lady Park Wood	6 March 2017	Tim Rich, Rob Bacon, Bob Silverwood and Katy Stephen
Piercefield & Lover's Leap	17 February 2017	Tim Rich, Rob Bacon
Piercefield & Lover's Leap	7 September 2018	Tim Rich & Julian Woodman
Piercefield, Apostles' Rocks only	10 September 2018	Tim Rich
Wynd Cliff area	5 September 2018	Tim Rich
Wynd Cliff area	16 & 17 February 2017	Tim Rich, Rob Bacon and Julian Woodman
Wynd Cliff rope access survey (including quarry)	5, 6, 7, 10 and 14 September 2018	Libby Houston & Angus Tillotson
Wyndcliff Quarry	17 February 2017	Tim Rich, Rob Bacon
Wyndcliff Quarry	19 July 2017	Tim Rich, Dave Green

The searches were carried out by targeting the known sites with rare taxa and recording other trees present in passing. Long-handled 5 m loppers were used to collect samples from the canopy in September 2018, but it was not possible to collect leaves of taller trees. No abseiling, climbing or scrambling was undertaken for these walkover surveys (see rope access below).

Three woods not previously surveyed were selected for detailed survey in 2018; these were Black Cliff, Apostles' Rocks (Piercefield) and Alcove Wood; the details of the sites are given in Appendix 4.

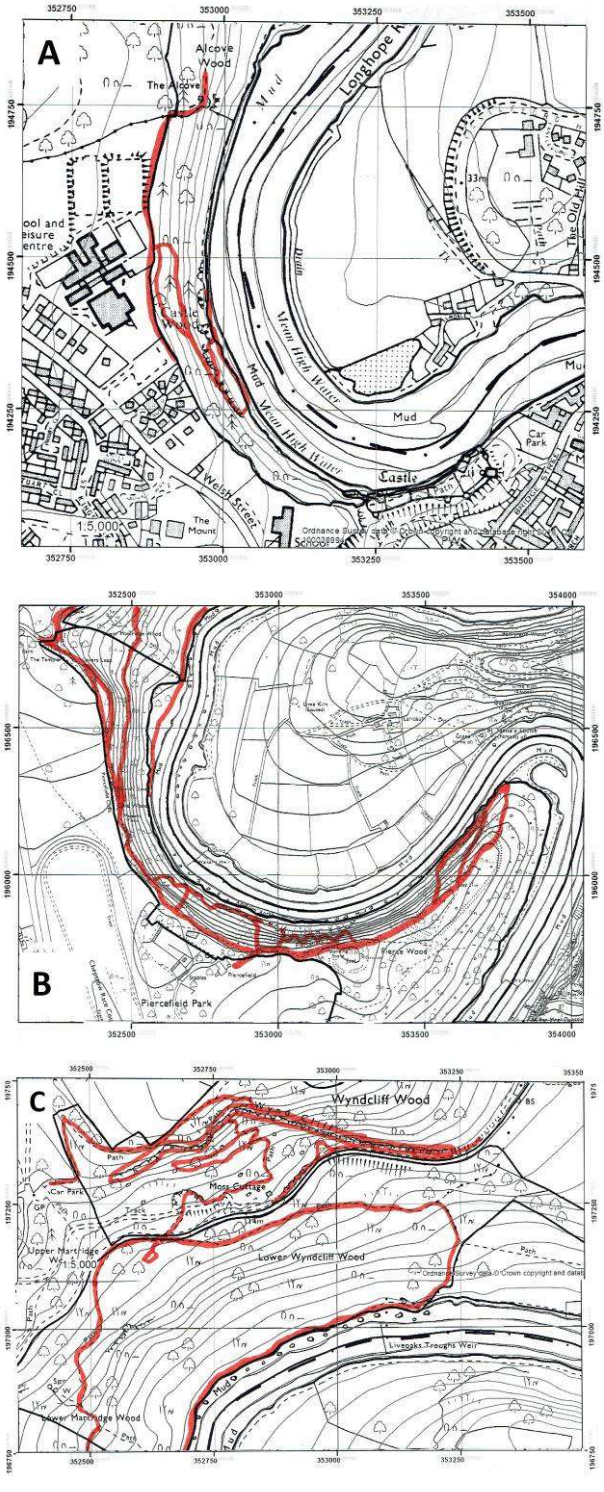
Some trees which could not be accessed were recorded as *Sorbus* sp. and some others which were probably *S. aria* were recorded as *S. aria* sensu lato.

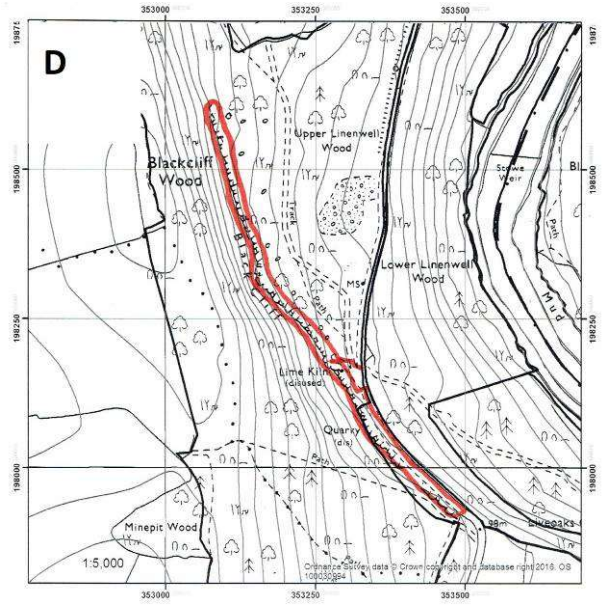
In February and March 2017, it proved relatively easy to find and spot trees from the fallen leaves accumulated underneath which had persisted through the autumn, the white undersides being distinctive. Trees could often be positively identified from these leaves alone, especially *S. aria*, but it was worthwhile checking the identity of the rare ones during the autumn when leaves were present on the tree. Sometimes leaves were found on the ground but the parent tree was not (leaves may be blown 100 m or more). Some trees identified in winter required verification (listed in Rich 2017), so these were targeted in 2018 and the identification verified or corrected.

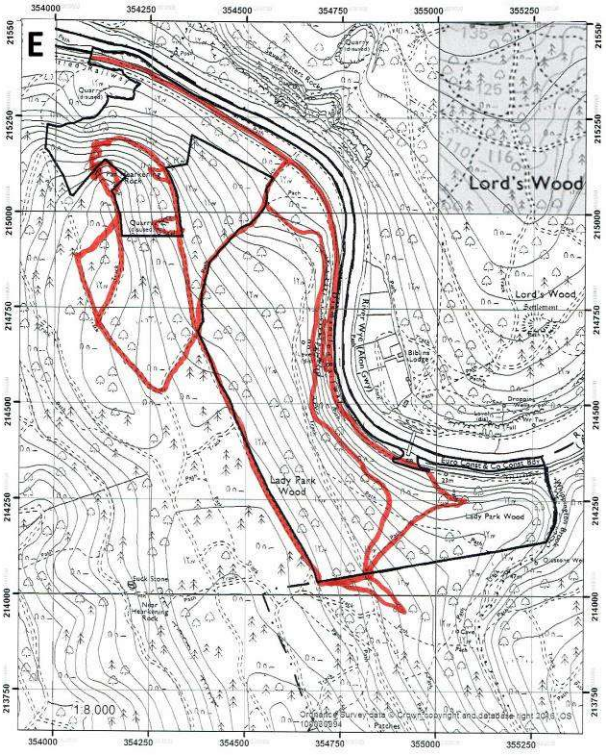
Voucher specimens from both the field surveys and rope access surveys were collected and checked by Tim Rich and have been deposited in the Welsh National Herbarium (NMW).

The field records were compiled into a second Excel spreadsheet similar to that used for the existing records (see Appendices).

Figure 1. Routes searched in 2017 and 2018. A, Alcove Wood. B, Piercefield. C, Wynd Cliff area. D, Black Cliff. E, Lady Park Wood and Highmeadow Woods. The area searched by rope access at Wynd Cliff is shown in more detail in Figure 2.







Rope access survey of Wynd Cliff 2018

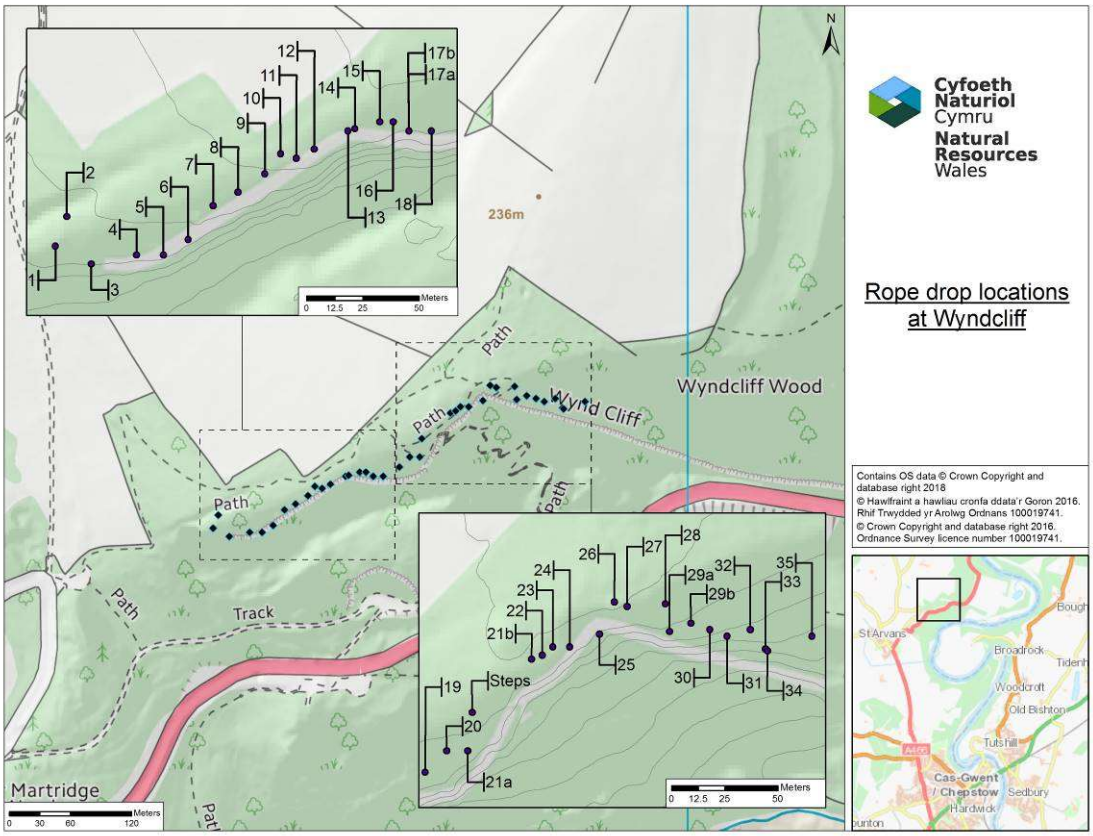
Rope access surveys were undertaken by Libby Houston and Angus Tillotson of Rope Works on the 5, 6, 7, 10 and 14 September 2018 along the cliffs at Wynd Cliff and Wyndcliff Quarry. The cliffs had many loose rocks where they had not previously been climbed and made safe. As there were so few whitebeams on the faces at Wyndcliff Quarry, this was mainly surveyed from the edge above without using ropes.

Table 3 lists the 39 drops made on Wynd Cliff and Figure 2 shows the locations. The Lower Wye Valley Climber's Club Guide (Willson 2007) describes the cliffs relative to the central 365 steps as left-hand crags (here west crags) and right-hand crags (here east crags).

Table 3. Rope access drops at Wynd Cliff in September 2018. The abseilers are indicated by initials: AT Angus Tillotson, LH Libby Houston.

Drop	GPS of top	Species present	Abseiler	Notes
West crags				
01	ST5253497319	-	LH	no *Sorbus* on this drop
02	ST5253997332	-	AT	no *Sorbus* on this drop, one *S. aria* at top
03	ST5255097311	*S. aria*	AT	passes 2-stem beech near crest of face
04	ST5257097315	*S. aria*	LH	from yew
05	ST5258297315	*S. aria, S. porrigentiformis*	AT	from large yew with big very coppiced beech below
06	ST5259397322	*S. aria*	LH	no details of anchor
07	ST5260497337	*S. aria*	AT	from 2 oak stems below yew, deviating W of gnarly beech on crest
08	ST5261597343	*S. aria, S. porrigentiformis*	AT	from 2-stem ash (yew with caught rocks on crest below)
09	ST5262797351	*S. aria*	AT	large yew at W end of more open area
10	ST5263497360	*S. aria*	LH	from hazel above open top, end of holly understorey
11	ST5264197358	*S. aria*, *S.* taxon 1	LH	from coppiced ash with 3 main stems
12	ST5264997362	*S. aria*	AT	from oak
13	ST5266497370	*S. aria*	AT	3-stem coppice ash
14	ST5266797371	*S. aria, S. torminalis*	LH	6m E of drop 13 from big 3-stem coppice ash
15	ST5267897374	*S. aria*	AT	ash with large & small stems
16	ST5268497374	*S. aria*	LH	from slim holly, group of ash and holly
17a	ST5269197370	*S. aria*	AT	large yew with field maple below
17b	ST5269197370	*S. aria*	LH	large yew with field maple below
18	ST5270197370	*S. aria*	AT	hazel below tall maiden oak
19	ST5271797379	*S. aria*	AT	yew
20	ST5272797389	*S. aria*	LH	4-stem ash c.15 m north-east of Drop 19; cliff-edge here more gradual and open
21a	ST5273797389	*S. aria*	LH	from large *Sorbus aria*, 10 m E of Drop 20, c.15 m W of Steps
Steps	ST5273997407	*S. aria*	LH	365 steps
21b	ST5276797432	*S. aria*	AT	large leaning oak above steepening slope
East crags				
22	ST5277297434	*S. aria*	AT	from 2-stem field maple
23	ST5277797438	*S. aria*	LH	from big dead ?oak
24	ST5278597438	*S. aria*	LH	young maiden ash
25	ST5279997444	*S. aria*	AT	spur below large oak
26	ST5280697459	*S. aria*	AT	ash between corner with fallen trees and Eagle's Nest viewpoint
27	ST5281297457	*S. aria*	LH	beech on slope west of Eagle's Nest
28	ST5283097458	*S. aria*	AT	immediately to east of Eagle's Nest at start of wooded slope
29a	ST5283297445	*S. aria*	LH	from yew on rock, E side of gully
29b	ST5284297449	*S. aria*	AT	from yew
30	ST5285197446	*S. aria*	AT	from yew below 2 large beech trees on slope
31	ST5285997443	*S. aria*	LH	from yew above big 3-stem oak
32	ST5287097446	*S. aria*	AT	from yew just west of big ?dead hollow yew
33	ST5287797437	*S.* taxon 2	AT	yew on steepening slope 15 m E of Drop 32
34	ST5287897436	*S. aria*	LH	from yew
35	ST5289997443	*S. aria, S.* taxon 2	AT	from western yew of 3 in a line

Figure 2. Location of drops for rope access survey at Wynd Cliff.



4.3. Marking of rare trees

26 rare trees were marked using phenomarkers supplied by NRW to enable relocation in the future (Appendix 5). The phenomarkers were as far as possible located where they would remain conspicuous but some may inevitably be covered in leaf litter with time. Photographs were taken of the phenomarker in situ with GPS references to help with their relocation.

5. Results

5.1. Historical information

180 historical *Sorbus* records were traced for the SSSIs representing ten species and two hybrids (updated from Rich 2017). The records are summarised in Table 4 and Table 5; the main use of these data were to indicate which species had been recorded at which sites to help direct the field surveys. As they had largely been collected in an *ad hoc*, unplanned fashion they do not indicate either the relative frequency of the *Sorbus* species or relative diversity of the sites.

Table 4. Historical locations and number of records for each *Sorbus* taxon.

Species	**Locations**	**No. records**
S. anglica	Lover's Leap, Piercefield cliffs, Wynd Cliff (a record for Lady Park Wood is rejected).	27
S. aria	Widespread	73
S. aria sensu lato	Widespread	2
S. aucuparia	Wynd Cliff	1
S. croceocarpa	Lower Wyndcliff Wood	1
S. eminens sensu lato	Lady Park Wood, Piercefield cliffs, Wynd Cliff	5
S. eminens sensu stricto	Lady Park Wood, Piercefield cliffs, Wynd Cliff	10
S. eminentiformis	Lady Park Wood	6
S. porrigentiformis sensu lato	Lady Park Wood and Wyndcliff Quarry	7
S. rupicola	Highmeadow Woods	2
S. saxicola	Highmeadow Woods, Lady Park Wood	2
S. new species 'Wyndcliff'	Wyndcliff Quarry	4
S. torminalis	Widespread	20
S. x *thuringiaca*	Piercefield cliffs	2
S. x *tomentella*	Lady Park Wood, Piercefield cliffs (including Lover's Leap), Wynd Cliff	18
	Grand Total	**180**

Table 5. Historical number of *Sorbus* taxa recorded at each site and number of records.

Locality	**Species present**	**No. records**
Black Cliff	*S. aria*	2
Highmeadow Woods	*S. aria, S. rupicola, S. saxicola*	3
Lady Park Wood	*S. aria, S. eminens, S. eminentiformis, S. porrigentiformis, S, saxicola, S. torminalis, S.* x *tomentella.*	72
Lover's Leap	*S. anglica, S. aria, S.* x *tomentella*	14
Lower Wynd Cliff Wood	*S. croceocarpa*	1
Piercefield Park	*S. anglica, S. aria, S. eminens, S. torminalis, S.* x *thuringiaca, S.* x *tomentella*	31

Wynd Cliff	*S. anglica, S. aria, S. aucuparia, S. eminens,* (*S. porrigentiformis*?), *S. torminalis, S.* x *tomentella*	52
Wyndcliff Quarry	*S. aria, S. porrigentiformis, S.* new species 'Wyndcliff'	6
	Total	**180**

5.2. Field surveys 2017 and 2018

Within the SSSIs, 358 records of *Sorbus* were made during the general surveys (excluding the rope access survey; see below). The data are presented with the rope access survey data in an Excel spreadsheet with a similar structure to the historical records (Appendix 2). Note that there may be minor duplication of records of *S. aria* on the edge of Wynd Cliff collected in February 2017 and during the rope access survey.

Of the three sites not previously surveyed, Alcove Wood was very poor with tall woodland and limited places for even *S. aria* to grow, though one *S. eminens* was found near the viewpoint suggesting there could be more scattered in the woodlands (Appendix 4). This wood is not considered worth further survey.

Black Cliff is a long, very steep scar with many levels and is again difficult to survey (Appendix 4). Whilst *S. aria* was relatively frequent, there were only two *S. eminens* and two *S. aucuparia.* It is probably not worth further survey.

Apostles' Rocks was the best of the three new sites. It proved challenging to survey due to the very steep rocks and slopes, and some rocks were shaded with tall woodland and thus unsuitable for *Sorbus*. *Sorbus aria* was the most frequent species with a few *S. torminalis* and *S. anglica* scattered on the more open rocks (Appendix 4). In general, the *Sorbus* composition is similar to the adjacent rocks at the NE end of Piercefield Park, with which this site is contiguous. No doubt there are more individuals of all species present on vertical open rocks which require survey by rope access; the data collected indicate the best places to start climbing if rope access surveys are carried out.

Rope access survey of Wynd Cliff 2018

Most of the cliffs at Wynd Cliff were surveyed, with the exception of a section about 200 m between the east crags and the quarry due to lack of time (Figure 2).

In total 152 records of *Sorbus* were made along the cliffs and quarry (including 2 recently dead trees), mostly of *S. aria*. Three plants of *S. porrigentiformis* were confirmed with another possible plant, and two plants of *S. eminens* with one possible plant. *Sorbus anglica* was not refound on the main cliffs where previously recorded but a coppiced plant was found in Wyndcliff Quarry. Previous records for taxa such as *S. eminens* and *S. porrigentiformis* were probably a result of confusion with the very variable *S. aria* which is widespread on the site, though *S. anglica* has certainly gone.

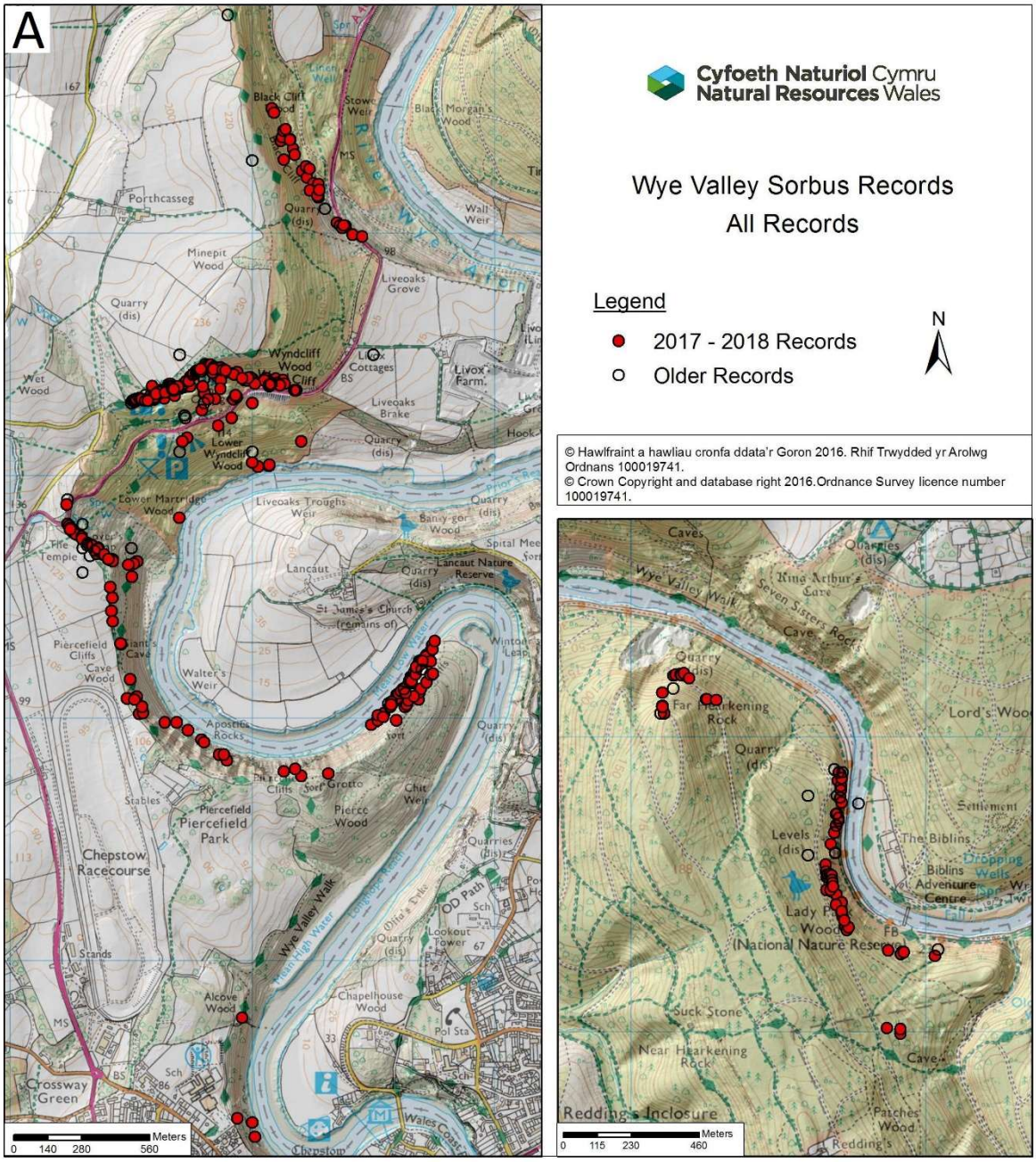
Some trees which could not be clearly ascribed to species, but which looked worthy of potential future investigation were labelled as Taxon 1 (one tree), Taxon 2 (two trees) and Taxon 3 (one tree). However, given the very small numbers of individuals, these are unlikely to be named as species.

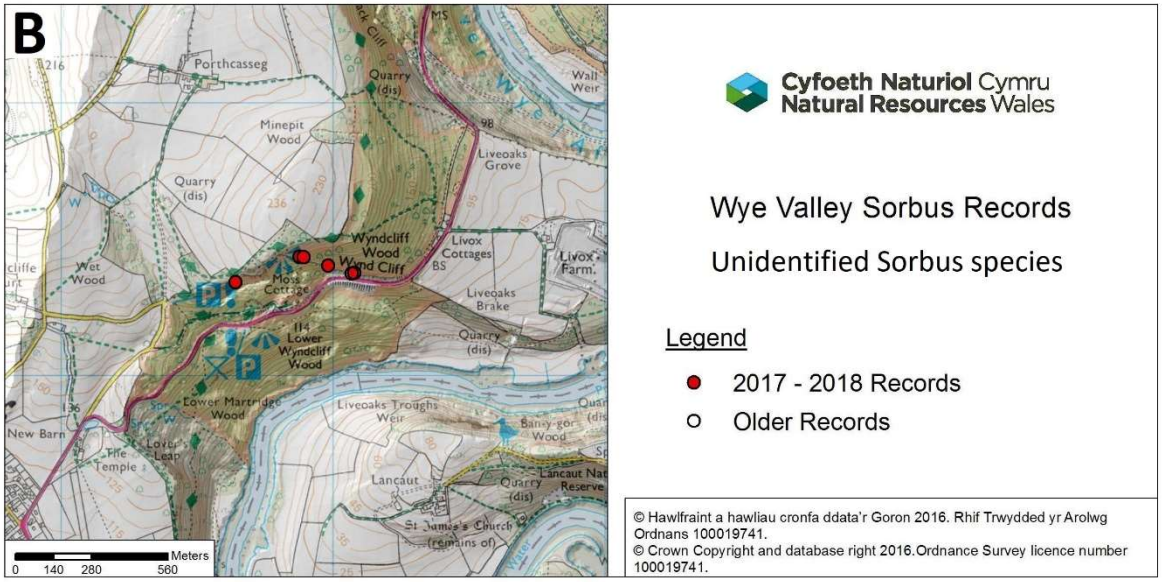
Wyndcliff Quarry had a higher concentration of species than the main cliffs and supported the remaining small population of the new species. The quarry benches had more species and more individuals than the top, lightly wooded edge, which was surprisingly poor.

5.3. Occurrence of *Sorbus* species in Welsh Wye Valley SAC

All the *Sorbus* records combined are shown in Figure 3a. This indicates the overall frequency of *Sorbus* recorded in the different areas, bearing in mind the routes surveyed (Figures 1 and 2). The locations of old records are taken as given in the original record, so some locations are best treated as indicative rather than actual.

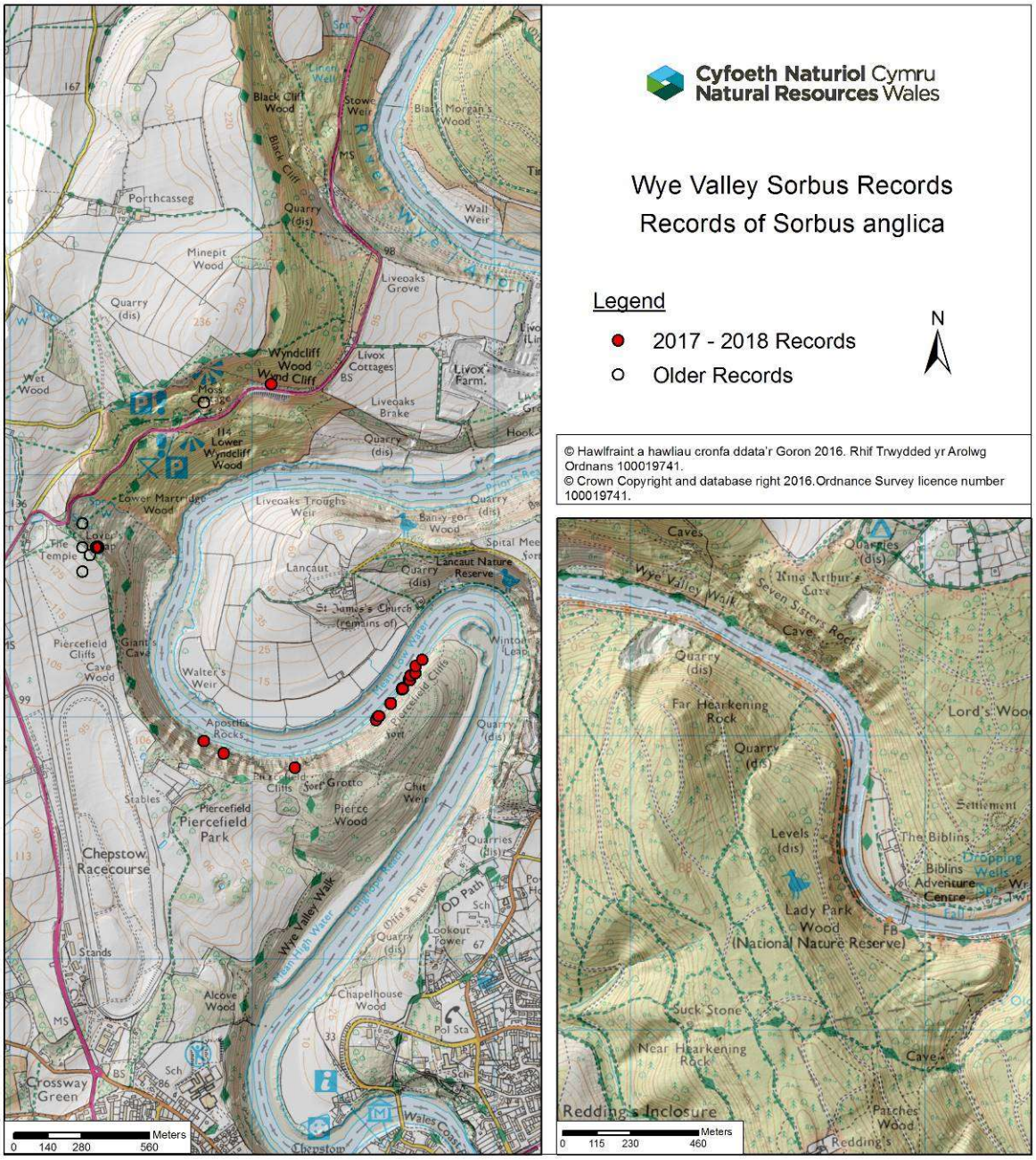
Figure 3. A, All records. B, Records not determined to species. ● 2017-2018. ○ pre-2017.




B
Porthcasseg
Quarry (dis)
Minepit Wood
Quarry (dis)
Wall Weir
Liveoaks Grove
Wyndcliff Wood
Wynd Cliff
Livox Cottages
Livox Farm
Wet Wood
Moss Cottage
Liveoaks Brake
114 Lower Wyndcliff Wood
Quarry (dis)
Lower Martridge Wood
Liveoaks Troughs Weir
New Barn
Lover's Leap
The Temple
Lancaut
Lancaut Nat Reserve
Quarry (dis)
St James's Church (remains of)
Meters
0 140 280 560
Cyfoeth Naturiol Cymru
Natural Resources Wales
Wye Valley Sorbus Records
Unidentified Sorbus species
Legend
2017 - 2018 Records
Older Records
© Hawlfraint a hawliau cronfa ddata'r Goron 2016. Rhif Trwydded yr Arolwg Ordnans 100019741.
© Crown Copyright and database right 2016.Ordnance Survey licence number 100019741.

Sorbus anglica, English whitebeam

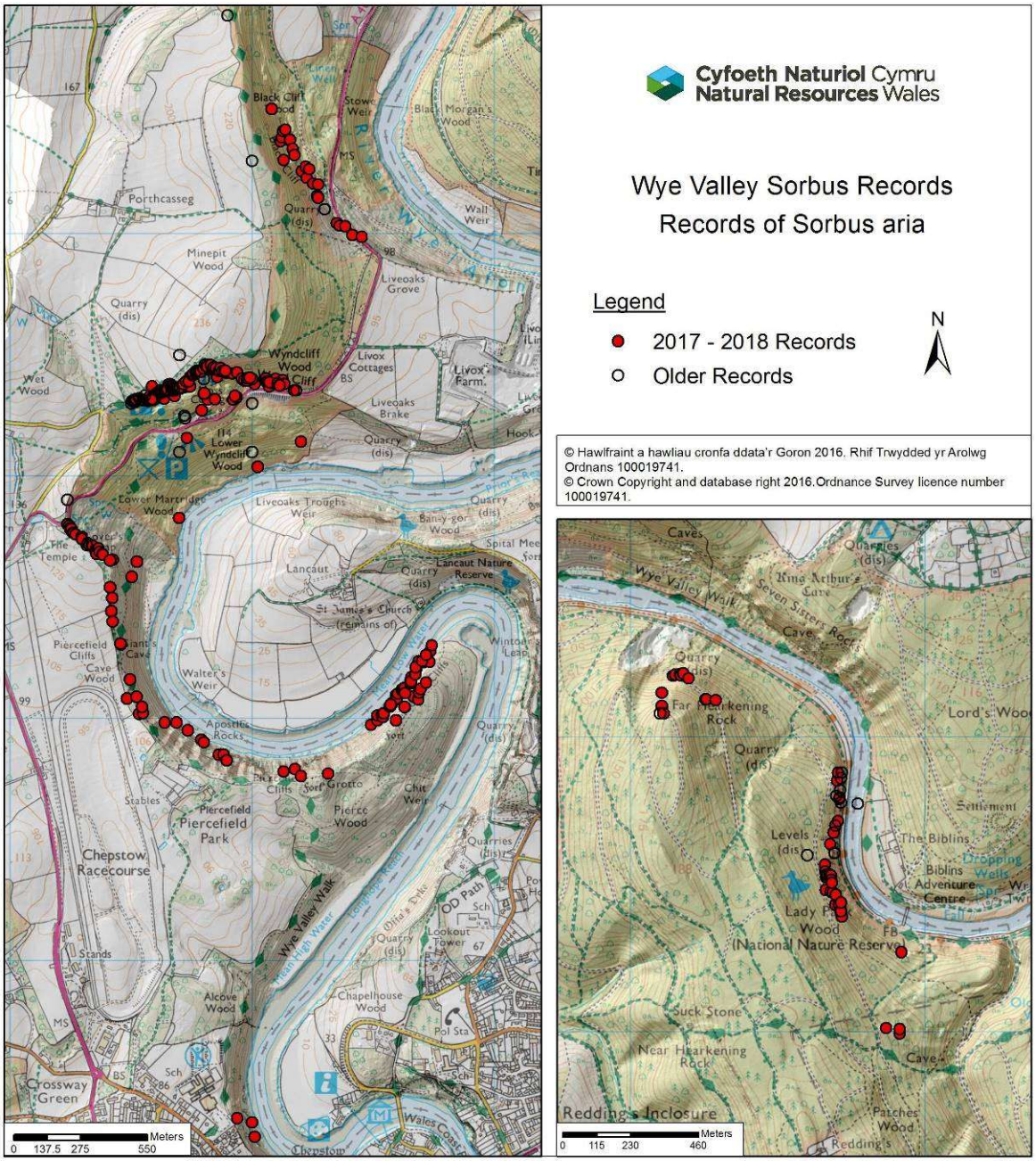
Figure 4. *Sorbus anglica*. ● 2017-2018. ○ pre-2017. The scattered old records around Lover's Leap probably all refer to plants at or near the viewpoint.



This rare tree was previously recorded from Piercefield Cliffs, Lover's Leap and Wynd Cliff. It was refound at Piercefield and Lover's Leap, with new records for Apostles' Rocks and Wyndcliff Quarry, total 20 trees (Figure 4). It could not be refound at Wynd Cliff, where 6 plants were last seen for certain in 1995; there is no obvious reason for this loss.

Sorbus aria, Common whitebeam

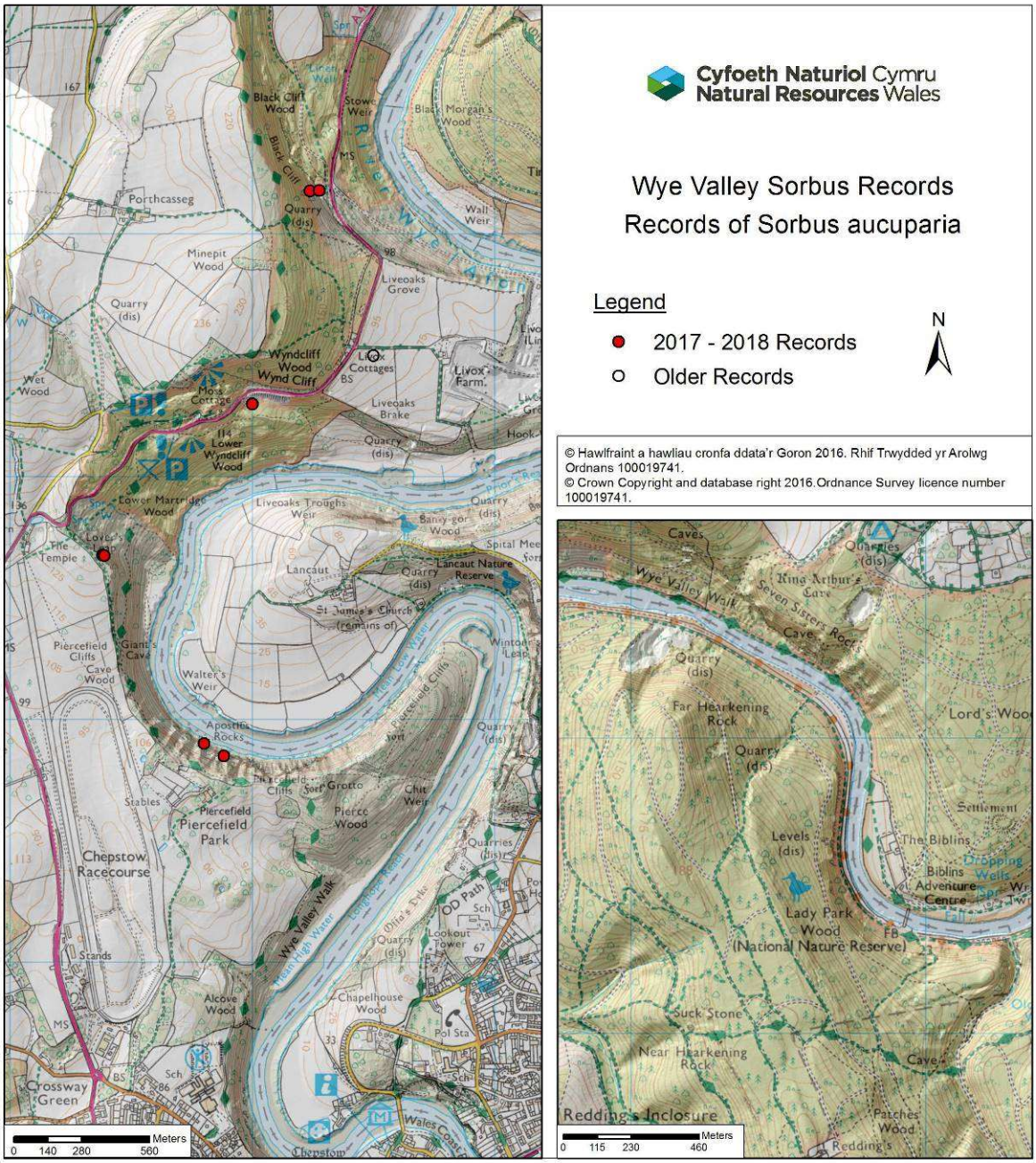
Figure 5. *Sorbus aria*. ● 2017-2018. ○ pre-2017.



This is a very morphologically variable, widespread tree which is common and frequent, with numerous older and recent records (Figure 5). It is the most abundant species in all sites, especially in the shorter, open woods associated with cliffs, or more rarely in taller woodland.

Sorbus aucuparia, Rowan

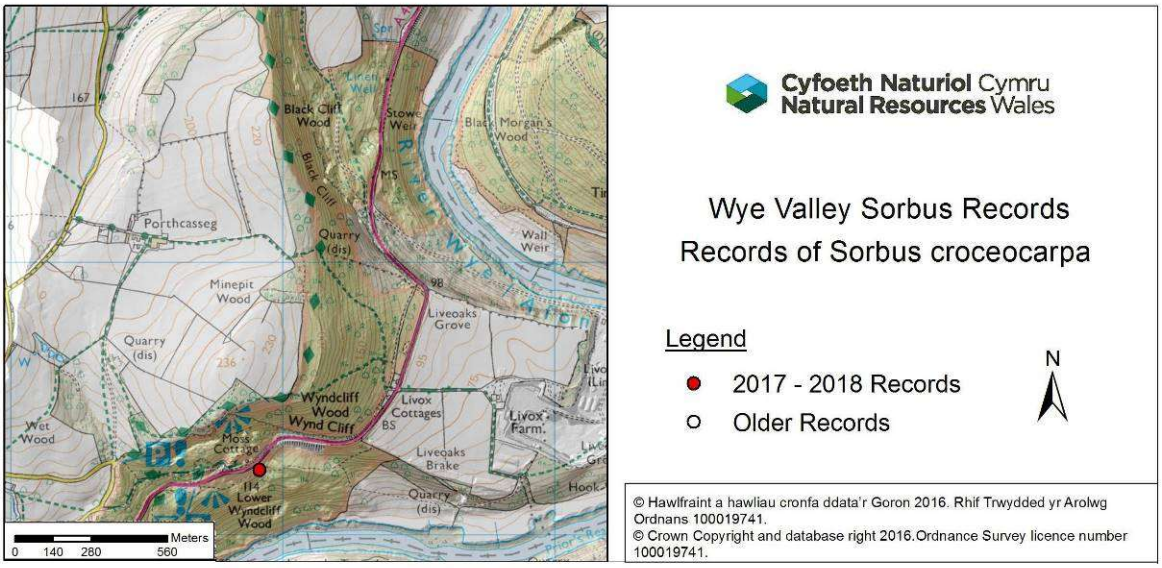
Figure 6. *Sorbus aucuparia*. ● 2017-2018. ○ pre-2017.



This is relatively widespread and common in Monmouthshire, though less so on the limestones than elsewhere and it was surprisingly rare in our surveys (Figure 6). It was noted in small quantity in 4 sites but was not recorded at Wynd Cliff itself (though present in the quarry) - the previous record may not have been from the areas we looked at and its absence is not of concern.

Sorbus croceocarpa, Orange-fruited whitebeam

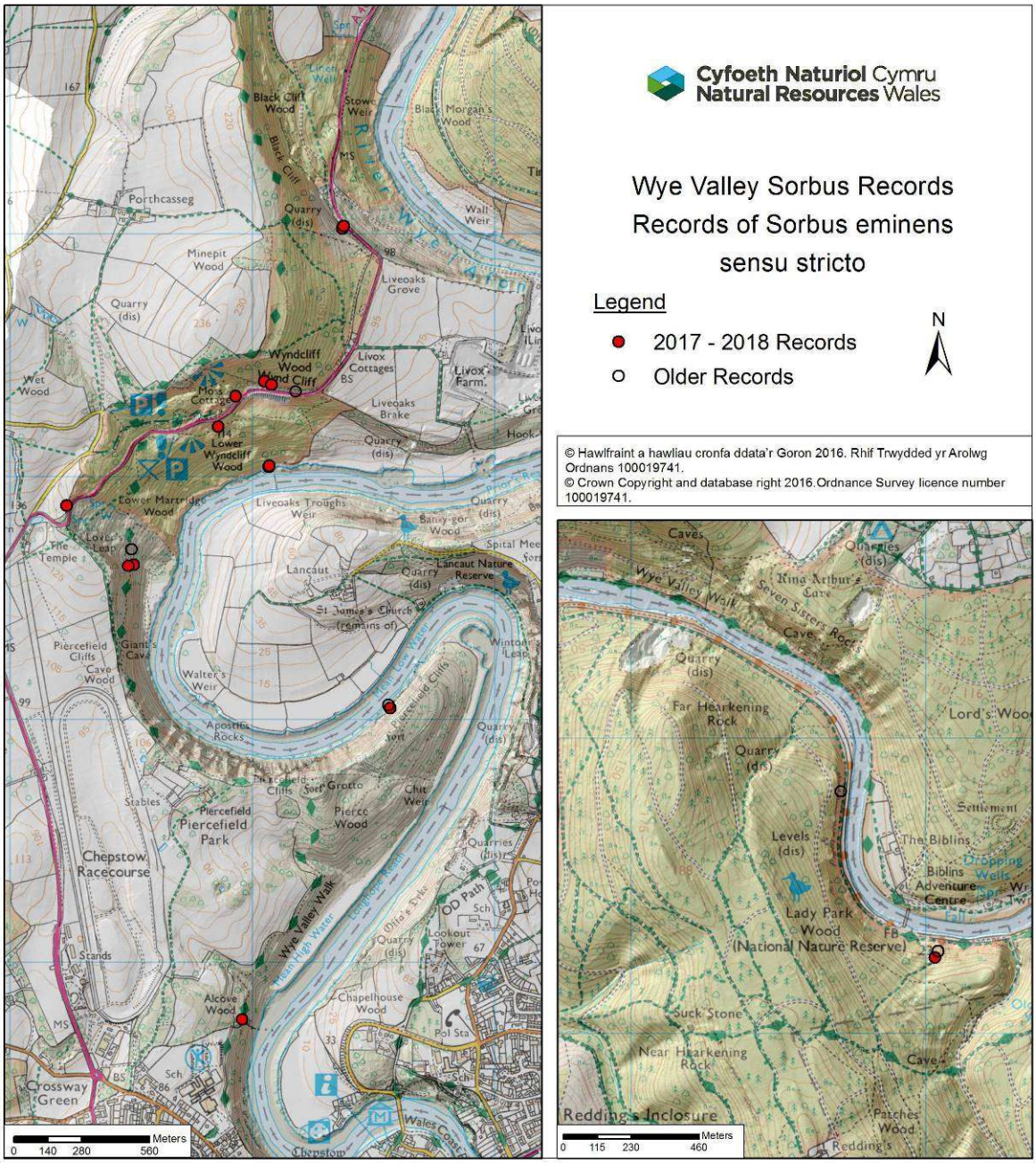
Figure 7. *Sorbus croceocarpa*. ● 2017-2018. ○ pre-2017.



There is one occurrence of this introduced species in Lower Wyndcliff Wood (Figure 4). There is a historic record from Piercefield Park where it was presumably planted and from where it may have spread.

Sorbus eminens sensu stricto, Round-leaved whitebeam

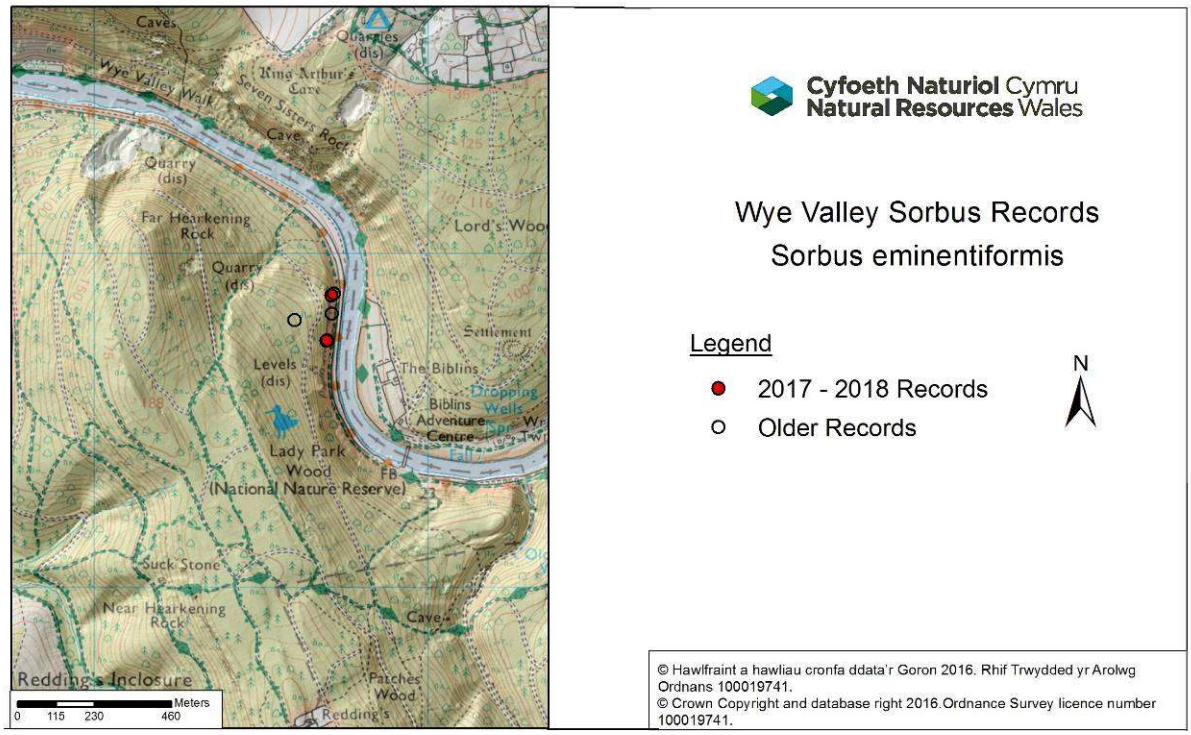
Figure 8. *Sorbus eminens* sensu stricto. ● 2017-2018. ○ pre-2017.



This rare endemic tree has previously been recorded at Lady Park Wood, Lover's Leap, Wynd Cliff area and Piercefield and small populations are still present in these sites, and new populations were found at Alcove Wood (1 sapling) and Black Cliff (2 trees) (Figure 8). It was found more frequently than expected scattered around Wynd Cliff and Piercefield areas, often as single trees in woodland (total 12 trees).

Sorbus eminentiformis, Doward whitebeam

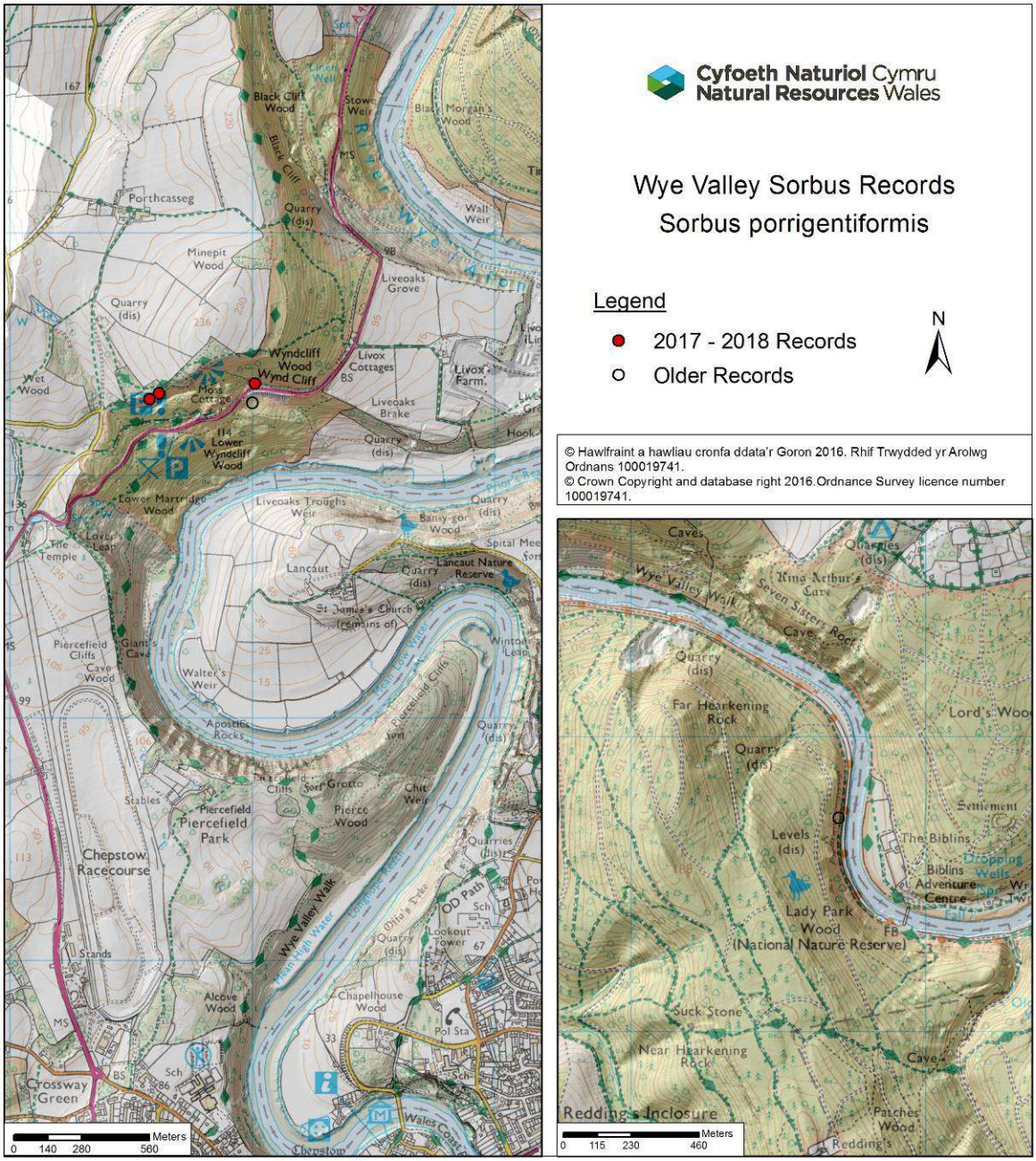
Figure 9. *Sorbus eminentiformis*. ● 2017-2018. ○ pre-2017.



This nationally very rare endemic tree occurs on both sides of the Wye at the Doward and Lady Park Wood. The 5 trees previously on the cliffs at Lady Park Wood require a rope access survey to confirm they are still present, but the tree previously recorded at LPW10 (Houston *et al.* 2003) was still present with another newly confirmed tree nearby (Figure 9). Records from Wynd Cliff-Ban-y-gor area (cf. Rich *et al.* 2009) have been reassessed and none confirmed.

Sorbus porrigentiformis sensu stricto, Grey-leaved whitebeam

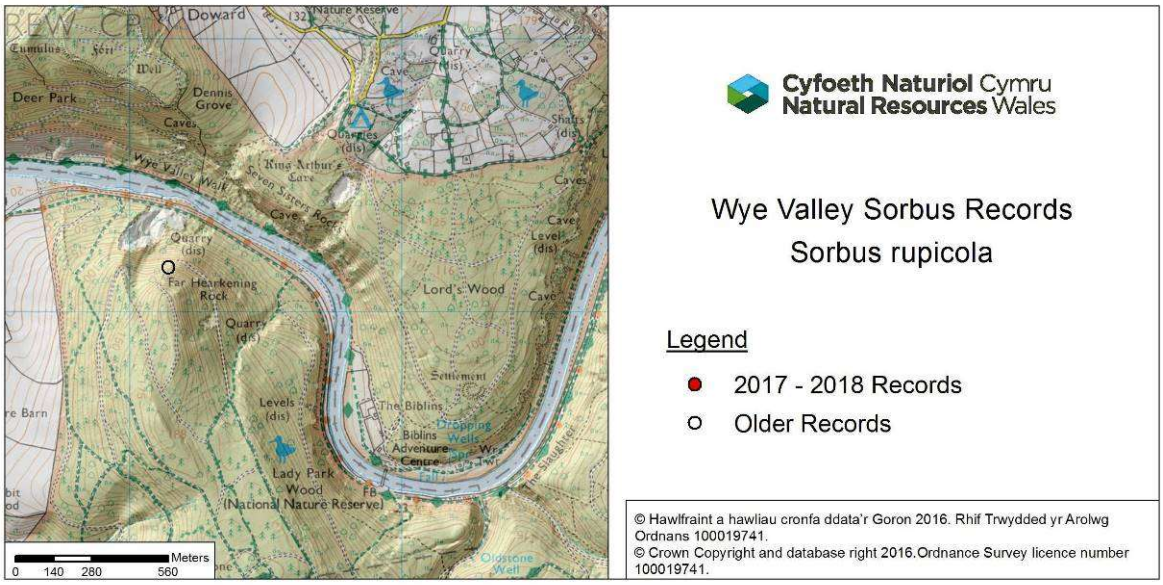
Figure 10. *Sorbus porrigentiformis*. ● 2017-2018. ○ pre-2017.



There are few specific records of the restricted form of this species from the Wye Valley, though it was originally described from Tidenham. There is one acceptable specimen previously collected from Lady Park Wood (though a chromosome count is required to separate it from the triploid *S. evansii* and a rope access survey to confirm it is still present). There is one plant at Wyndcliff Quarry and at least two plants in the middle of the cliffs on Wynd Cliff in a location not previously surveyed (Figure 10).

Sorbus rupicola, Rock whitebeam

Figure 11. *Sorbus rupicola*. ○ pre-2017.



This species is very uncommon in the Wye Valley with only a few small, scattered populations. It was recorded below Far Hearkening Rock in 2005; this tree was found to have blown over and died by 2017 (Figure 11). It was still present in 2018 on Seven Sisters Rocks, England opposite Lady Park Wood, though one of the trees had been cut down during 'conservation' work.

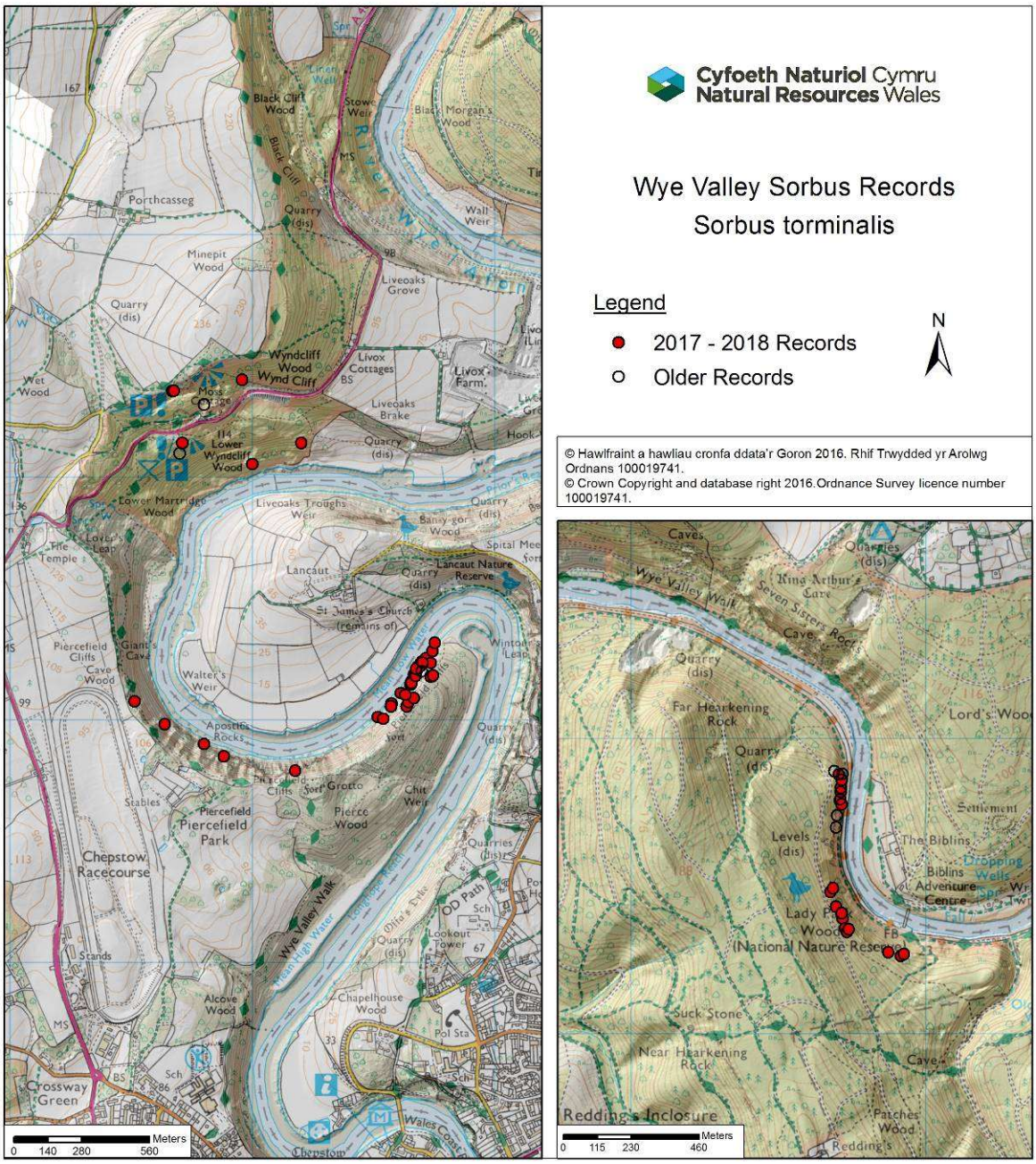
Sorbus saxicola, Symonds Yat whitebeam

Figure 12. *Sorbus saxicola*. ● 2017-2018. ○ pre-2017.

This rare endemic is confined to the Symonds Yat – Lady Park Wood area. It has been recorded on the cliffs at Lady Park Wood (requires rope access survey to confirm still present), and one tree is still present at Far Hearkening Rock (Figure 12).

Sorbus torminalis, Wild Service tree

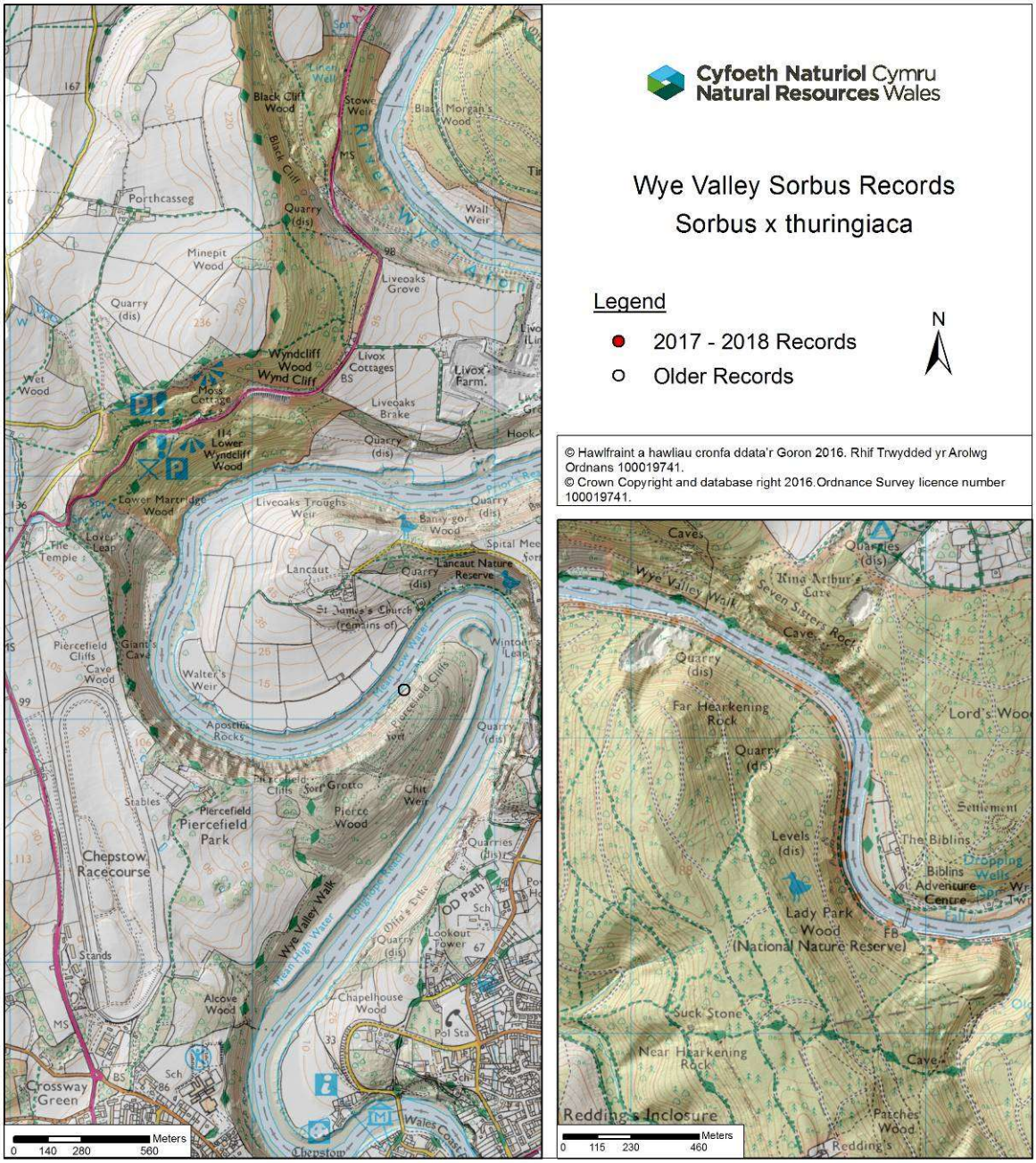
Figure 13. *Sorbus torminalis*. ● 2017-2018. ○ pre-2017.



This tree grows occasionally in all three SSSIs, including both large trees and smaller suckers on open rocks. During the 2017-2018 field surveys, it was found scattered rarely at Wynd Cliff, but frequent along the lower edge of Piercefield cliffs and Apostles' Rocks and occasional in the woodland above, and along the main cliff in Lady Park Wood with occasional patches to the south (Figure 13). It can spread by rhizomes/suckers as well as by seed.

Sorbus x *thuringiaca* (*S. aria* x *aucuparia*), Bastard mountain ash, Hybrid rowan

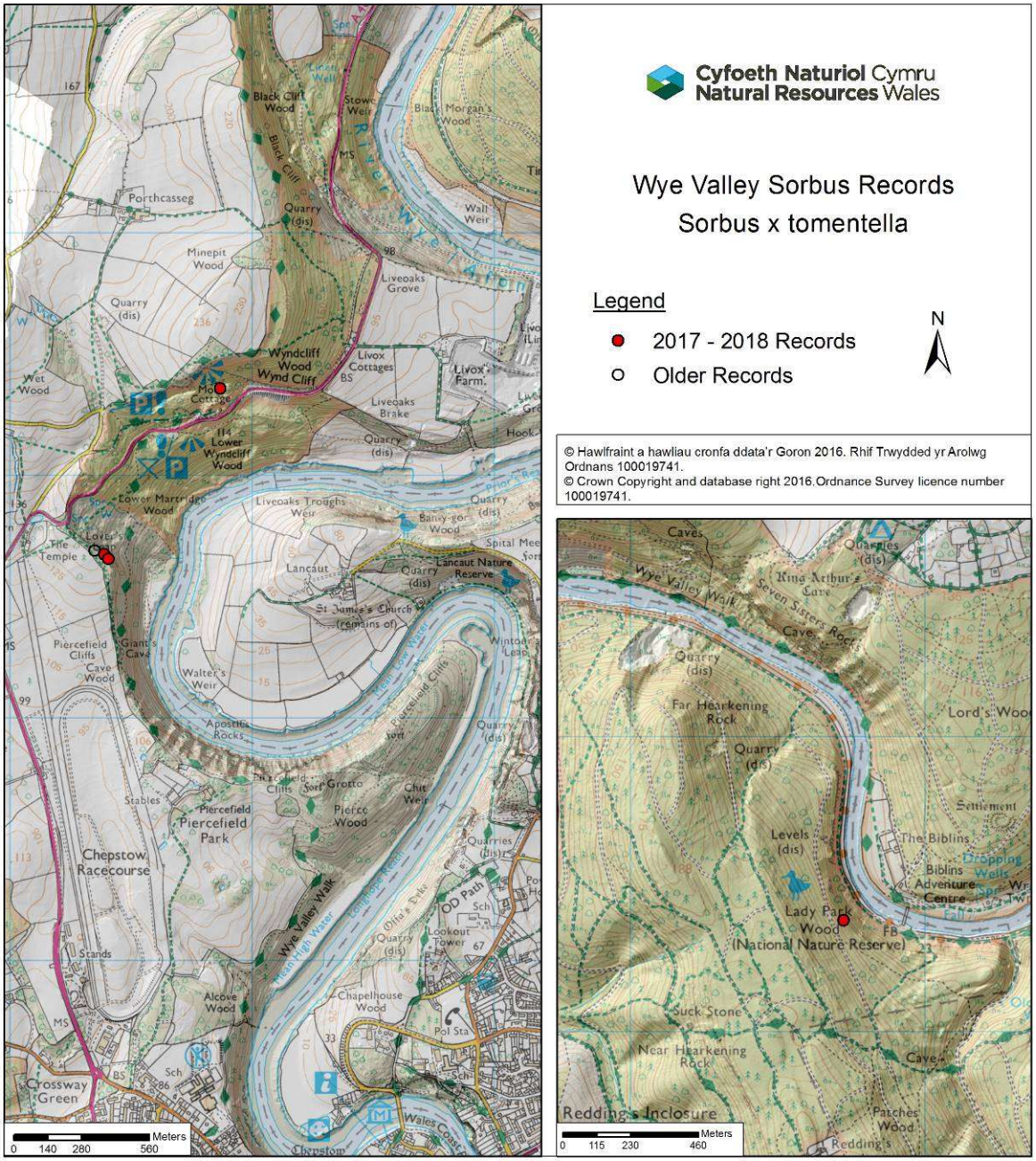
Figure 14. *Sorbus x thuringiaca*. ● 2017-2018. ○ pre-2017.



This variable spontaneous hybrid has been recorded only at the east end of Piercefield cliffs, where it was first found by T. G. Evans (Figure 14). The one tree had been knocked over by a fallen beech tree the last time it was seen in 2005; it was searched for but not refound during the 2017-2018 field surveys.

Sorbus x *tomentella* (*S. aria* x *torminalis*), Wye whitebeam

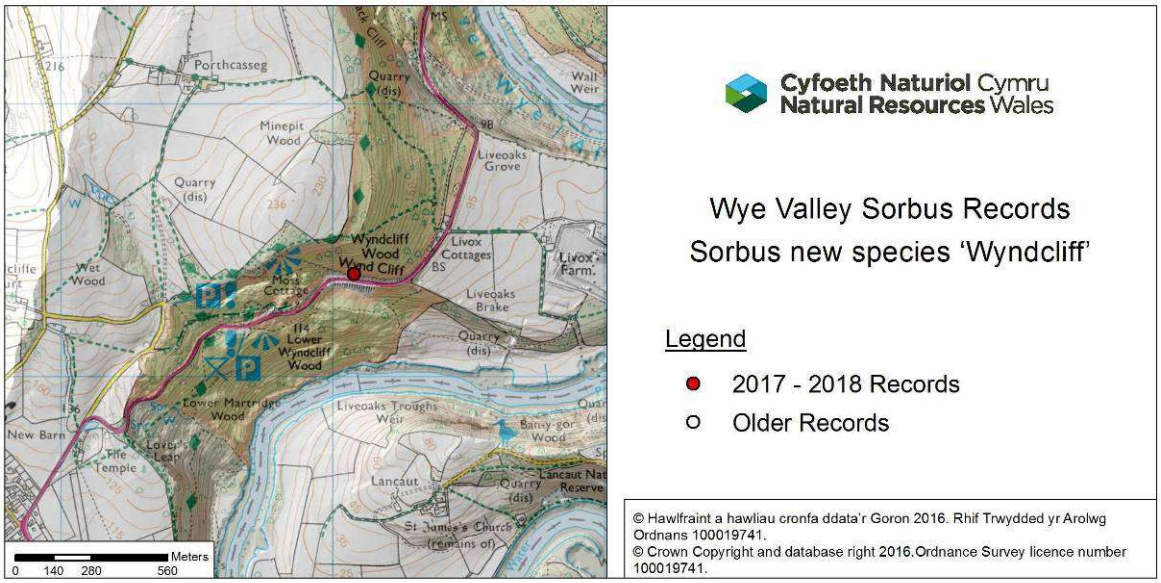
Figure 15. *Sorbus x tomentella*. ● 2017-2018. ○ pre-2017.



This variable spontaneous hybrid is quite rare nationally, with the Wye Valley providing the largest concentration, possibly as a consequence of both parents growing together relatively frequently on the open limestone cliffs (Price & Rich 2007). The hybrid has been recorded from Lover's Leap, Wynd Cliff and Lady Park Wood (Figure 15) and is still present in all sites (4 trees).

Sorbus new species ‘Wyndcliff’ clone (S. *porrigentiformis* group)

Figure 16. *Sorbus* new species 'Wyndcliff'. ● 2017-2018. ○ pre-2017.



D. Green originally found 16 trees in Wyndcliff Quarry. In July 2017, only 9 trees were found all of which had been cut to facilitate access for climbers (6 had been cut recently and 3 previously). No trees were found on Wynd Cliff, though 200 m remain to be searched. This is thus the only site for this new, un-named species.

5.4. Marking of rare trees

32 rare trees marked using phenomarkers supplied by NRW to enable relocation in the future are listed in Table 6 with full details in Appendix 5.

Table 6. Location of trees marked with phenomarkers. More than one individual was noted at some phenomarker locations.

Rare species	**Location**	**GPS**
S. anglica	Lover's Leap	ST5235196700
S. anglica	Lover's Leap	ST5236696701
S. anglica	Piercefield, NE cliffs	ST5370396237
S. anglica	Piercefield, NE cliffs	ST5370396237
S. anglica	Piercefield, NE cliffs	ST5367796211
S. anglica x3	Piercefield, NE cliffs	ST5365796153
S. anglica x3	Piercefield, NE cliffs	ST5363196104
S. anglica	Piercefield, NE cliffs	ST5357396044
S. anglica x2	Piercefield, NE cliffs	ST5352196003
S. anglica	Piercefield, NE cliffs	ST5351295988
S. eminens	Piercefield, NE cliffs	ST5357396044
S. eminens	Lady Park Wood, S of Biblins bridge	ST5503214258
S. eminens	Lower Wyndcliff Wood	ST5286597208
S. eminens	Lower Wyndcliff Wood	ST5306997045
S. eminens	Piercefield	ST5248896632
S. eminens	A466	ST5223396883
S. eminens	Alcove Wood	ST5295994765
S. eminens	Wynd Cliff A466 roadworks	ST5293597323
S. eminens x2	Black Cliff	ST5337298032
S. sapling (*eminens/ eminentiformis* leaves)	Lady Park Wood	SO5471514409
S. eminentiformis	Lady Park Wood:	SO5471114874
S. eminentiformis	Lady Park Wood	ST5469614738
S. saxicola	Far Hearkening Rock	ST5410714103
S. x *tomentella*	Lady Park Wood	ST5472514378
S. x *tomentella*	Lover's Leap	ST5239096675
S. x *tomentella*	Lover's Leap	ST5240696656

6. Discussion

6.1. Occurrence of *Sorbus* species in Welsh Wye Valley SAC

The occurrence of the *Sorbus* taxa within the SSSIs is summarised in Table 7; for the wider Monmouthshire context, see Evans (2007) and Rich *et al.* (2010). The commonest species by far was *S. aria* followed by *S. torminalis*. Of the rarer taxa, *S. eminens* and *S. anglica* were the most frequent, with very few *S. eminentiformis, S. porrigentiformis, S. saxicola* and *S.* x *tomentella*. The single trees of *Sorbus rupicola* and *S.* x *thuringiaca* had died.

Table 7. Summary of occurrence of *Sorbus* taxa within the Wye Valley SAC in Wales. Sites not surveyed in 2017-2018 are shown in brackets.

***Sorbus* species**	**2017-2018 Locations**	**Previous records not refound**
S. anglica	Lover's Leap, Piercefield cliffs, Apostles' Rocks, Wyndcliff Quarry	Wynd Cliff
S. aria	Widespread	-
S. aucuparia	Apostles' Rocks, Black Cliff, Lover's Leap	Wynd Cliff
S. croceocarpa	Lower Wyndcliff Wood	-
S. eminens	Alcove Wood, Black Cliff, Lady Park Wood, Lover's Leap, Piercefield cliffs, Wynd Cliff area, Wyndcliff Quarry	-
S. eminentiformis	Lady Park Wood	-
S. porrigentiformis	(Lady Park Wood?), Wynd Cliff, Wyndcliff Quarry	-
S. rupicola	-	Highmeadow Woods
S. saxicola	Highmeadow Woods (Lady Park Wood?)	-
S. torminalis	Widespread	-
S. x *thuringiaca*	-	Piercefield cliffs
S. x *tomentella*	Lady Park Wood, Lover's Leap, Wynd Cliff	-
S. new species 'Wyndcliff'	Wyndcliff Quarry	-

6.2. *Sorbus* diversity in the Wye Valley Woodlands SAC

Table 8 lists the *Sorbus* taxa present in 2017-2018 at various Welsh subsites within the Wye Valley SAC and indicates which species have been lost.

The most important *Sorbus* sites are Lady Park Wood and Highmeadow Wood, the Piercefield Park complex (Lover's Leap, Apostles' Rocks, Piercefield NE cliffs), Wynd Cliff and Wyndcliff Quarry. Alcove Wood, Black Cliff, Lower Wyndcliff Wood and Lower Martridge Wood are not considered to hold significant populations of *Sorbus* taxa.

Table 8. *Sorbus* taxa present at various Welsh Wye Valley SAC sites in 2017-2018. Species in brackets require confirmation of continued presence.

Locality	**Species present 2017-2018**	**No longer present**
Alcove Wood *2	*S. aria, S eminens*	-
Apostles' Rocks *2	*S. anglica, S. aria, S. aucuparia, S. torminalis*	-
Black Cliff *1	*S. aria, S. aucuparia, S. eminens*	-
Highmeadow Woods *3	*S. aria, S. saxicola*	*S. rupicola*
Lady Park Wood *3	*S. aria, S. eminens, S. eminentiformis,* (*S. porrigentiformis*?), *(S. saxicola?), S. torminalis, S.* x *tomentella*	-
Lover's Leap *2	*S. anglica, S. aria, S. aucuparia, S. eminens, S.* x *tomentella*	-
Lower Wyndcliff Wood and Lower Martridge Wood *1	*S. aria, S. eminens, S. croceocarpa, S. torminalis*	-
Piercefield NE cliffs *2	*S. anglica, S. aria, S. eminens, S. torminalis*	*S.* x *thuringiaca*
Wynd Cliff *1	*S. aria, S. aucuparia, S. eminens, S. porrigentiformis, S. torminalis, S.* x *tomentella*	*S. anglica*
Wyndcliff Quarry *1	*S. anglica, S. aria, S. eminens, S. porrigentiformis, S.* new species 'Wyndcliff'	-

*1 Part of Blackcliff/Wyndcliff SSSI.

*2 Part of Pierce, Alcove & Piercefield Woods SSSI.

*3 Part of Upper Wye Gorge SSSI.

The loss of some trees is inevitable and under normal conditions is expected, as *Sorbus* may be relatively short-lived trees; Rich *et al.* (2012) showed that the estimated annual mortality of *S. aria* trees in the Avon Gorge was 3.4%.

The loss of the only *S. rupicola* at Highmeadow Woods is significant within the Welsh portion of the SSSIs as it was the only individual present, but it could be seen as part of the wider Great Doward area population. It may have died from too much shading by the large beech trees above (a similar fate could affect the *S. saxicola* tree still at the site). The loss of *S. anglica* from near the top of 365 steps at Wynd Cliff is puzzling as there is no apparent reason for their loss unless they were cut and cleared for the viewpoint at the top of the 365 steps.

The loss of the sterile diploid hybrid *S.* x *thuringiaca* was due to a natural event and is not significant.

Three SSSIs have *Sorbus* species listed as features of special scientific interest, and this work confirms that two SSSIs retain their *Sorbus* species:

- Blackcliff/Wyndcliff SSSI – *Sorbus anglica* was confirmed as still present but only as one plant in a very vulnerable location.
- Pierce, Alcove & Piercefield Woods SSSI – *Sorbus anglica* is confirmed as still present in Piercefield Woods with a reasonable population of at least 2 plants at Lover's Leap, 3 plants at Apostles' Rocks and 14 plants on the cliffs at the NE end of Piercefield Park.
- Upper Wye Gorge SSSI – rope access surveys at Lady Park Wood are needed to confirm the occurrence of *Sorbus porrigentiformis* on the Welsh side of the SSSI (if indeed it occurs there rather than a closely related species); it is still present on the English side.

The SSSI descriptions need to be updated to reflect the increased knowledge of *Sorbus* and their rarity. It is suggested that these could be amended to include all the rare species as follows:

- Blackcliff/Wyndcliff SSSI: *Sorbus anglica, S. eminens* and *S. porrigentiformis* and possibly the new 'Wyndcliff' species if it is described.
- Pierce, Alcove & Piercefield Woods SSSI: *Sorbus anglica, S. eminens.*
- Upper Wye Gorge SSSI: *S. eminens, S. eminentiformis, S. porrigentiformis, S. saxicola.*

The key factor for the diversity is the presence of extensive areas of open or partly shaded limestone rocks and cliffs with little disturbance or grazing. These open rocks provide ideal habitat for members of the *S. aria* group such as *S. rupicola* and *S. porrigentiformis* which are short, light-demanding trees and shrubs.

Historically the Wye Valley woodlands were probably managed to the cliff edges by piecemeal coppicing or as high forest timber, as shown in some old photographs. Some areas may have been managed as wood pasture, the grazing probably limiting the regeneration except on the cliffs. This dynamic, small-scale forestry may have provided conditions for colonisation and recolonisation along the cliff edges by both *Sorbus* and *Hieracium* (Sawtschuk & Rich 2008; Peterken 2008; Rich *et al.* 2009).

In many places the cliff edges are now overgrown, forcing normally small whitebeams, such as *S. saxicola* to grow tall to keep their leaves in sunlight. For example, Far Hearkening Rock must once have been open as it was reportedly used as a look-out for centuries by the Dobunni, Romans, gamekeepers and Royalist troops, but is now relatively shaded with the whitebeams struggling to survive. As these cliff edges become more shaded by taller trees such as beech and the evergreen yews, the whitebeams will become more restricted to the open cliff faces and may no longer have a regeneration niche, hence some dynamic management opening up the canopy for the whitebeams along the cliff edges may be desirable. As the *Sorbus* species are light demanding, probably relatively short-lived trees, a degree of dynamic management is required by

selective felling/crown thinning of shading trees without opening up the canopy too much and causing wind-throw. At Lady Park Wood, where the non-intervention woodland management policy would not facilitate active management for *Sorbus*, some *Sorbus* saplings are taking advantage of natural gaps created on the cliff edge.

It is important to manage for the common whitebeams (*S. aria, S. aucuparia* and *S. torminalis*) as well as the rare ones, as these provide the pollen to enable fruit formation to occur in the rare species (though the pollen does not contribute to the genetic make-up of the trees, see Rich *et al.* 2010). In such places, many endemics have evolved locally through hybridisation between these apomictic polyploids and sexual diploids, creating further diversity (Rich *et al.* 2010).

6.3. The importance of *Sorbus* diversity

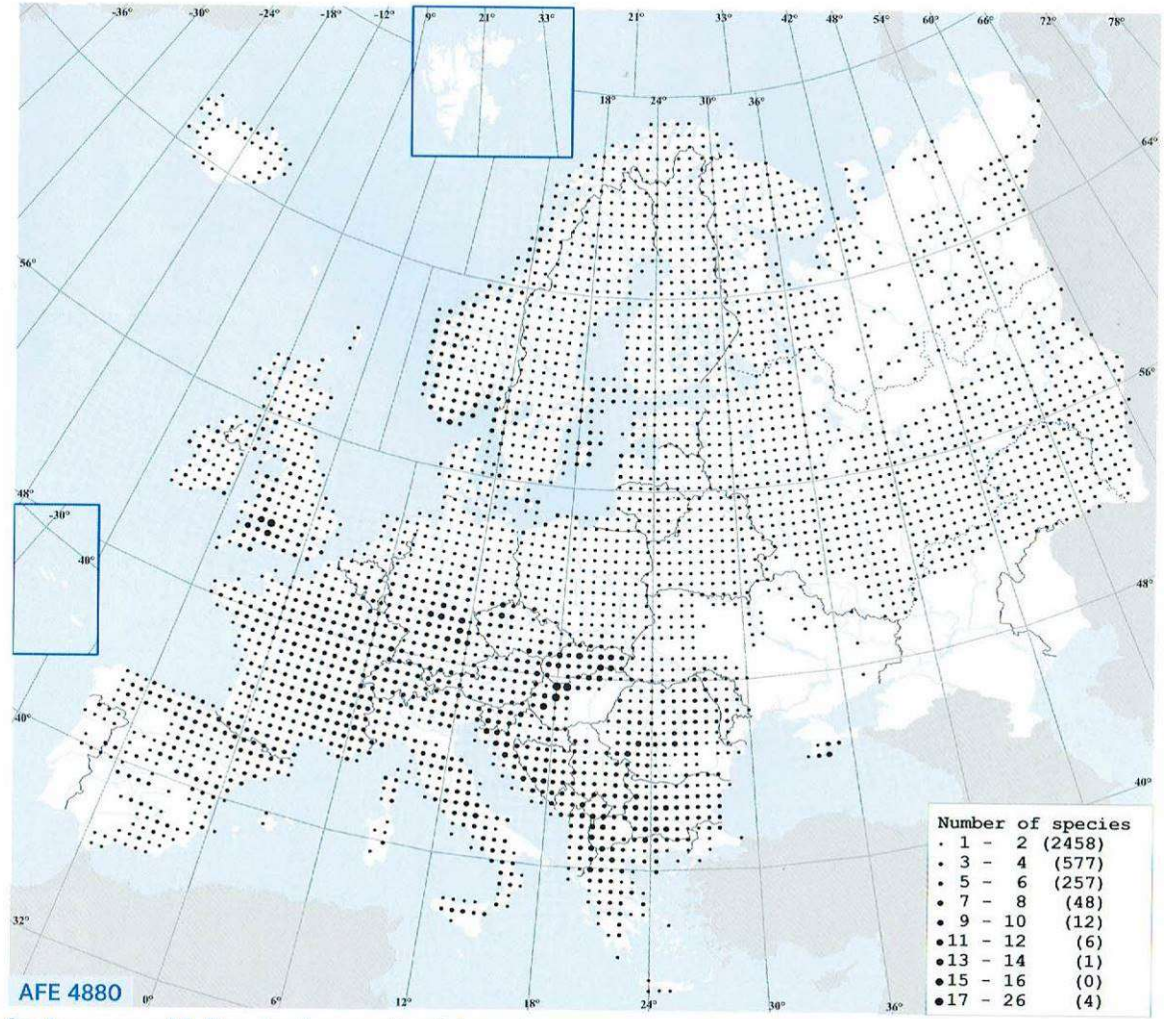
Rich *et al.* (2009) reviewed the diversity of *Sorbus* in the Wye Valley based on surveys carried out between 1999 and 2006, and Rich *et al.* (2014) described some additional taxa. A total of 19 *Sorbus* taxa have been recorded for the Wye Valley, of which six are endemic to the area (*S. eminentiformis*, *S. evansii, S. greenii, S. herefordensis, S. parviloba* and *S. saxicola*) and another three are endemic to Britain (*S. eminens, S. porrigentiformis* and *S. whiteana*). Overall, the Lower Wye Valley is one of the richest *Sorbus* sites in the world as shown by Figure 17; it is the second most diverse site for *Sorbus* in the British Isles, second only to the Avon Gorge which hosts about 23 taxa.

In the Wye Valley, both the northern area around Symonds Yat with the Doward, and the southern end from Chepstow to Shorn Cliff are diverse, but the Welsh side is notably less diverse than the English side due to greater incidence of tall woodland and fewer limestone outcrops. However, as the *Sorbus* populations are dynamic, the areas within different countries cannot be considered in isolation.

Sorbus is an actively evolving group across Europe, with the increase in diversity being driven by complex interactions between hybridisation, apomixis (reproducing by direct clonal copies of the mother), polyploidy (having more than 2 sets of chromosomes) and pseudogamy (the need for fertilisation of the endosperm to ensure seed set) (Robertson *et al.* 2009; Rich *et al.* 2010; Ludwig *et al.* 2013).

The Wye Valley endemics have evolved since the last glaciation from the meeting of the 3 widespread European sexual diploid species (*S. aria, S aucuparia* and *S. torminalis*) with a few apomictic polyploids such as *S. porrigentiformis* and *S. rupicola* (Rich *et al.* 2010). Hybridisation between them has resulted in the diversity in the Symonds Yat – Doward area, with the sexual diploid *S. aria* playing a prominent role. As much of the diversity is generated in sequence (one species giving rise to another, which gives rise to another, and so on), it is important to maintain the diversity in the long term and allow adaptation to climate change and other environmental change.

Figure 17. Native *Sorbus* richness across Europe (AFE 4880 from *Atlas Florae Europaeae*; Kurrto *et al.* 2018).



Ennos *et al.* (2012) proposed a process-based species action plan for *Sorbus* which concentrated on conserving the processes generating biodiversity, rather than focusing on the preservation of individual species. The process-based species action plan focused on optimising habitat management to ensure the reproduction and regeneration of *Sorbus*, and facilitating hybridisation to ensure the continued generation of diversity.

7. *Sorbus* Management Plan

Ennos *et al.* (2012) process-based species action plan for *Sorbus* comprises four main steps:

Step 1. Description of the baseline situation.

Step 2. Definition of desired outcomes.

Step 3. Creation of an 'intervention plan' to achieve the outcomes, with defined indicators of success.

Step 4. Monitoring to evaluate the success of the conservation action with respect to the indicators and the baseline.

This plan is based on this approach and applies to the Welsh portions of the Wye Valley Woodlands SAC. It needs to be balanced against other conservation priorities and policies; for example, the non-intervention policy at Lady Park Wood is of wider importance. It should also be seen in context with the other populations of these species in the English parts of the Wye Valley Woodlands SAC as they are all part of the wider metapopulations.

7.1. Baseline situation

Overview of the system

This plan is designed around the taxonomically-complex *Sorbus* diversity hotspot in the Wye Valley, one of the two most diverse *Sorbus* sites in the British Isles and probably in the world. A total of 19 *Sorbus* taxa have been recorded for the Wye Valley, of which six are endemic and it is an important site for evolution of *Sorbus*.

Most of the *Sorbus* taxa occur on the steep sides and open rocks in two areas of old woodlands on limestone in the Wye Valley between Chepstow and Monmouth.

Components of the system

The *Sorbus* taxa are woody trees which are insect-pollinated and whose fruits are dispersed by birds and small mammals. Within the Welsh SSSIs there are 10 *Sorbus* species, 2 hybrids and 1 possible new species, which differ in breeding system and ploidy level; the three diploids are sexual and out-breeding, the seven polyploids are apomictic and pseudogamous, and the two diploid hybrids have low fertility.

The rare taxa of conservation interest are as follows:

- *S. anglica* – a relatively widespread British and Irish endemic which is tetraploid and apomictic. At least 20 trees are present at Lover's Leap, Piercefield cliffs, Apostles' Rocks and Wyndcliff Quarry. It is IUCN threat category 'Near Threatened'.
- *S. eminens* – a moderately widespread British endemic which is tetraploid and apomictic. At least 12 trees are present in Alcove Wood, Black Cliff, Lady Park Wood, Lover's Leap, Piercefield cliffs, Wynd Cliff area and Wyndcliff Quarry. It is IUCN threat category 'Vulnerable'.
- *S. eminentiformis* - a very rare British endemic restricted to the Upper Wye Valley. It is tetraploid and apomictic. 2 trees are present at Lady

Park Wood (with another possible 5 trees which were not surveyed). It is IUCN threat category 'Endangered'.

- *S. porrigentiformis* a relatively widespread British endemic which is tetraploid and apomictic. It is recorded in very small quantity in Wynd Cliff and Wyndcliff Quarry (3 plants) and at Lady Park Wood (not surveyed). This species is found to be the key species driving evolution in the Avon Gorge (Rich *et al.* 2010) and probably also in the Wye Valley. It is IUCN threat category 'Vulnerable'.
- *S. rupicola* – a NW European endemic which is tetraploid and apomictic. It is widespread but very locally-distributed in the Wye Valley. The one plant known in Highmeadow Woods was found dead in 2017. It is IUCN threat category 'Least concern'.
- *S. saxicola* - a very rare British endemic restricted to the Upper Wye Valley. It is triploid and apomictic. One plant was recorded at Highmeadow Woods, with another possible unsurveyed plant at Lady Park Wood. It is IUCN threat category 'Critically Endangered'.
- *S.* x *tomentella* – a relatively uncommon diploid hybrid recorded from Lady Park Wood, Lover's Leap, Wynd Cliff (total 4 trees). Price & Rich (2007) found this was back-crossing with *S. aria* in the Wye Valley generating further diversity. It is IUCN threat category 'Vulnerable'.
- *S.* new species 'Wyndcliff' – a very rare undescribed tetraploid which is probably apomictic. A population of up to 16 trees has been recorded at Wyndcliff Quarry, its only site. It would qualify as IUCN threat category 'Critically Endangered'.

Of the other taxa, *S. aria, S. aucuparia* and *S. torminalis* are common and widespread, sexual, out-breeding, diploid species and *S. croceocarpa* is an introduced species of no conservation importance; all are IUCN threat category 'Least Concern'. *Sorbus* x *thuringiaca*, a ±sterile, diploid hybrid, is extinct.

The most important *Sorbus* sites are Lady Park Wood and Highmeadow Wood, the Piercefield Park complex (Lover's Leap, Apostles' Rocks, Piercefield NE cliffs), Wynd Cliff and Wyndcliff Quarry. Alcove Wood, Black Cliff, Lower Wyndcliff Wood and Lower Martridge Wood are not considered to hold significant populations of *Sorbus* taxa.

Conservation concerns

The primary threats to the process generating the diversity in Wye Valley are:

- Clearance/cutting of rare trees for climbing access (Wyndcliff Quarry), viewpoints (Wynd Cliff and Lover's Leap) and for road safety works (A466). The clearance may either kill the tree or result in coppicing and lack of reproductive output until the boughs are big enough to fruit;
- increase in shade on open rocks due to lack of woodland management, resulting in either shading of the light-demanding *Sorbus* and consequently no flowering or even death, and no recruitment from seed;
- spread of invasive non-native woody plants such as cherry laurel, resulting in dense shade and no recruitment;

- browsing by high levels of deer, resulting in no recruitment except for inaccessible places; and
- soil damage by wild boar resulting in localised disturbance affecting recruitment.

Evolutionary processes generating the observed diversity

The primary mechanism driving speciation is hybridisation between sexual diploids and polyploid apomicts, a process which is probably on-going in the Wye Valley (as it is in the Avon Gorge; Rich *et al.* 2010). The critical components for this process to continue are the presence of the sexual species (*S. aria, S. aucuparia, S. torminalis*) amongst apomictic polyploids, open light conditions to allow flowering and fruiting, the activity of pollinators within pollination distance of the apomictic taxa, and conditions conducive to seedling establishment and growth. Ludwig (2013) showed that in *S. wilmottiana*, a rare endemic species in the Avon Gorge, most mating events occurred between trees less than 11 m apart, and that trees were mainly pollinated by bumblebees and solitary bees. Fortunately many bees have large foraging ranges and can transport pollen hundreds of metres, and as indicated by the high fruit set observed in 2018, pollinators are likely to be in sufficient abundance in the Wye Valley.

7.2. Desired outcomes

The desired outcomes are

1. maintenance or enhancement of populations of *Sorbus* taxa of conservation importance within the Welsh Wye Valley Woodlands SAC

The species of conservation importance are *S. anglica, S. eminens, S. eminentiformis, S. porrigentiformis, S. rupicola, S. saxicola* and *S.* x *tomentella*. Of these the highest priorities are *S. eminentiformis* and *S. saxicola* which are endemic to the Wye Valley and occur nowhere else in the world. To facilitate pollination, conservation of some populations of *S. aria* close to the species of conservation importance will also be required.

2. maintenance of the processes which generate the diversity of *Sorbus.*

The evolutionary interactions should be maintained together with the numbers and diversity of the taxa, and recruitment should be enabled to ensure that this diversity enters the system to give populations which are dynamic in space and time.

7.3. Intervention plan

Further surveys

Three further rope access surveys are required to complete the baseline data:

- Lady Park Wood – to update the 2003 survey with populations on the cliffs not surveyed in 2017-2018 (c. 2 days field work for abseiling team).
- Lover's Leap – to determine species diversity on the cliffs around the viewpoint where rare trees are at risk of routine clearance (c. 1 day field work for abseiling team). Trees out of view over the cliff have never been surveyed.
- Wynd Cliff – complete the surveys with the c. 200 m section not completed due to lack of time in 2018 (c. 2 days field work for abseiling team).

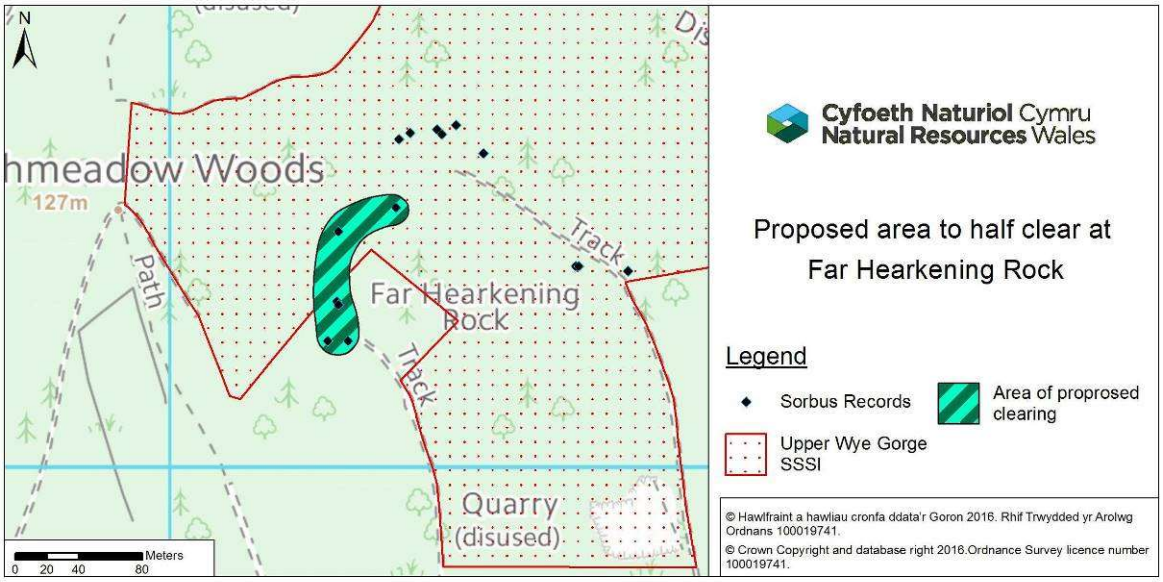
Intervention Sites

Highmeadow/Far Hearkening Rock

The main work at this site is to improve the existing habitat for all *Sorbus* and to enable population reinforcement for *S. saxicola* and reintroduction of *S. rupicola*. A successful outcome will be self-sustaining populations of *S. saxicola* and *S. rupicola.*

- 2019-2025: slowly thin the shading canopy trees around the one remaining *S. saxicola* to open the canopy up gradually to allow the tree to adapt and not to blow over (e.g. 1 m circular increase in gap around tree each year) and to flower and fruit.
- 2019: undertake 50% clearance of all trees (except *Sorbus*) along rocks on ridges at and below Far Hearkening Rock excluding the *S. saxicola* site to increase suitability for all *Sorbus* species and create planting sites for *S. rupicola* and *S. saxicola* saplings (Figure 18).

Figure 18. Area for 50% clearance at Far Hearkening Rock.



- 2019-2022: collect fruit of *S. saxicola* and *S. rupicola* to grow seedlings for population reinforcement (if seed of *S. saxicola* is available collect from Far Hearkening Rock, if not seed of both species can be collected from the Doward in England, subject to landowner consent, which are part of the same metapopulation). Grow seedlings in a horticultural facility with a view to planting them out when they are 2-3 years old but also sow some seeds direct into the rock crevices out of reach of deer to see if seedlings can be established directly from seed in situ.

Lady Park Wood – non-intervention area

This non-intervention nature reserve is already being monitored for long term ecological change so no direct action is required. A successful outcome will be the continued presence of *S. aria, S. eminens, S. eminentiformis, S. porrigentiformis, S. saxicola, S. torminalis* and *S.* x *tomentella.*

- 2019: carry out rope access survey of cliffs as above to assess continued occurrence of previously recorded taxa.

- 2019 onwards: Participate in control of deer populations in Wye Valley to reduce the high browsing pressure and allow for natural regeneration.
- 2019 onwards: Participate in control of wild boar populations in Wye Valley to reduce the damage to woodland soils and allow for natural regeneration.

Lady Park Wood – other areas

The one *S. eminens* tree south of Biblins bridge is outside the area of non-intervention woodland (Figure 8). The surrounding woodland is very tall and the *S. eminens* tree may no longer be in the canopy so is unlikely to flower or fruit.

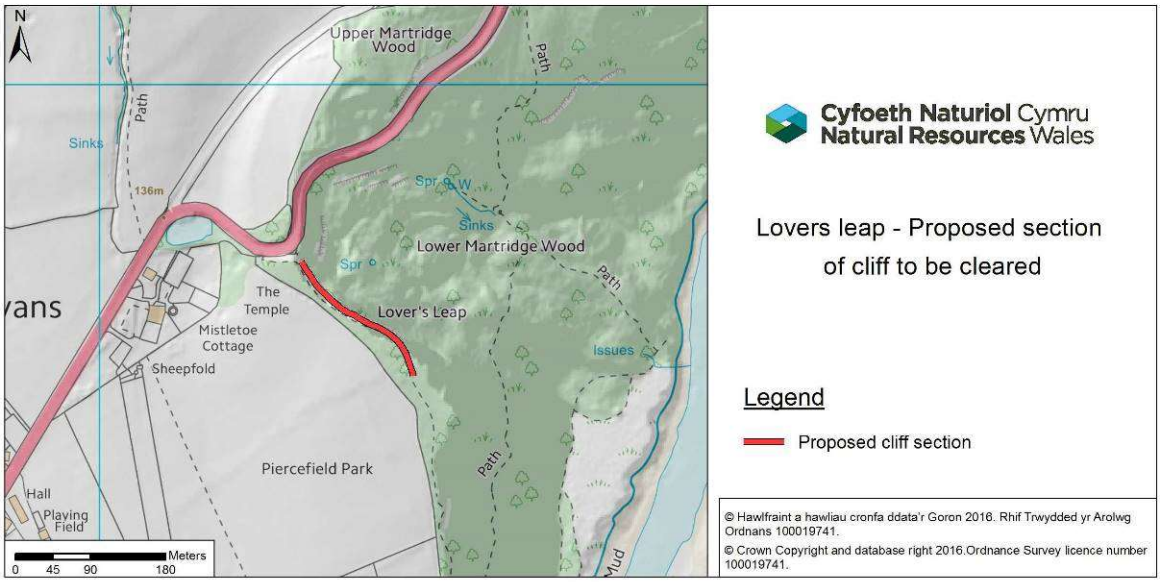
- 2019: assess and consider removing surrounding tree canopy to give 1-2 m gap around *S. eminens* to maximise light without creating too much of a gap in the canopy which could result in wind-throw. Given the height of the woodland this may not be practical and it should be noted that *S. eminens* is frequent along the south-facing Biblins cliffs immediately to the north on the English side of the Wye.
- 2019 onwards: Participate in control of deer populations in Wye Valley to reduce the high browsing pressure and allow for natural regeneration.
- 2019 onwards: Participate in control of wild boar populations in Wye Valley to reduce the damage to woodland soils and allow for natural regeneration.

Lover's Leap

The small English whitebeam population has been reduced by clearance around the viewpoint, so the main action is to stop this happening in the future. A successful outcome will be self-sustaining populations of *S. anglica.*

- 2019: Liaise with those responsible for maintaining the viewpoint to make them aware of *Sorbus* (currently no rare trees are at risk). Install signage with historic background to Piercefield Park and its walks and presence of English whitebeam at viewpoint to explain why it has not been cleared.
- 2019: carry out rope access survey around viewpoint as above to assess other taxa at risk.
- 2019 onwards: Participate in control of deer populations in Wye Valley to reduce the high browsing pressure and allow for natural regeneration.
- Consider implementing experimental sequential clearance every 10 years along 30-50 m sections of cliff edges at Lover's Leap to determine if this favours *Sorbus* regeneration on open cliffs.

Figure 19. Possible area for sequential clearance along cliff edge at Lovers' Leap.



Piercefield cliffs including Apostles' Rocks

No direct management for *Sorbus* is required along the cliffs and cliff edges where the populations already seem quite diverse and are operating in a natural way, and given the very steep topography, management is probably not practical anyway. A successful outcome will be the continued presence of *S. anglica*, *S. aria, S. eminens* and *S. torminalis*.

- 2019 onwards: Continue clearance of invasive cherry laurel and other invasive species to minimise future spread.
- 2019 onwards: Participate in control of deer populations in Wye Valley to reduce the high browsing pressure and allow for natural regeneration.

Wynd Cliff

No direct management for *Sorbus* is required along the cliffs and cliff edges where the populations already seem quite diverse and operating in a natural way. The main action is to minimise the impact of climbing on the *Sorbus* populations, which is probably minimal as only a few areas are suitable for climbing. A successful outcome will be the continued presence of *S. aria, S. eminens, S. porrigentiformis* and *S. torminalis*.

- 2019: complete the surveys of the missing c. 200 m section, as above.
- 2019: Engage with climbing community through signage, climbing guides and through clubs, ensure they are aware of presence of rare trees and do not cut trees or clear vegetation within the SSSI.
- 2019: Liaise with those responsible for maintaining views at 365 steps and Eagle's Nest viewpoint to make them aware of *Sorbus* (currently no rare trees are at risk).
- 2019: Liaise with Monmouthshire Highways Network Management Team to ensure they are aware of *S. eminens* trees adjacent to the A466 which should be taken into account when undertaking road safety works. Unavoidable loss of trees could be mitigated by replacement plantings.

- 2019 onwards: Participate in control of deer populations in Wye Valley to reduce the high browsing pressure and allow for natural regeneration.

Wyndcliff Quarry

This site is the highest priority for action. It is richest site for *Sorbus* in the SAC including one unique (if unnamed) species and is also the one under most pressure from climbers - indeed the *Sorbus* populations have already been significantly damaged by cutting to improve access. A successful outcome will be the continued presence of *S. anglica, S. aria, S. eminens, S. porrigentiformis* and the unnamed new species.

- 2019: Consider climbing options at this site. Either ban climbing completely or organise a user group to ensure site is not further damaged and engage with climbing community through signage, climbing guides and through clubs, ensure they are aware of presence of rare trees and do not cut trees or clear vegetation within the SSSI.
- 2019 onwards: Mark/cordon off rare species using a more visible means and routinely check this. Instigate a 'no climb area' where rare trees are at risk.
- 2019-2022: once the cut trees of the unnamed new species have regrown, collect fruit and deposit in Millennium Seed Bank.

Other sites

No actions are proposed at Alcove Wood, Black Cliff, Lower Wyndcliff Wood and Lower Martridge Wood as the *Sorbus* populations are not significant.

7.4. Monitoring

Highmeadow/Far Hearkening Rock

- 2019-2029: monitor yearly until new *S. saxicola* and *S. rupicola* trees are established.
- 2029 and every 6 years thereafter:
    - Population sizes of *S. aria, S. saxicola* and *S. rupicola.*
    - Routine monitoring of spread of non-native conifers from adjacent plantations and clearance if required.

Lady Park Wood

- 2029 and every 6 years thereafter:
    - Population sizes of *S. aria, S. eminens, S. eminentiformis, S. porrigentiformis, S. saxicola, S. torminalis* and *S.* x *tomentella.*
    - Colonisation of open cliffs created by recent tree falls.

Lover's Leap

- 2019 and 3-yearly thereafter: *Sorbus anglica* population at viewpoint.
- 2029 and every 6 years thereafter:
    - Population sizes of *S. anglica, S. aria, S. eminens* and *S.* x *tomentella.*

Piercefield cliffs including Apostles' Rocks

- 2029 and every 6 years thereafter:
    - Population sizes of *S. anglica, S. aria, S. eminens, S. torminalis*
    - Spread of non-native species (cherry laurel, non-native conifers) and clearance of required.

Wynd Cliff

- 2029 and every 6 years thereafter:
    - Population sizes of *S. aria, S. eminens, S. porrigentiformis, S. torminalis* and *S.* x *tomentella.*

Wyndcliff Quarry

- Twice yearly 2019-2029 until climbing issues are resolved.
- Population sizes of *S. anglica*, *S. aria*, *S. eminens*, *S. porrigentiformis* and *S.* new species 'Wyndcliff'.

8. Acknowledgements

We would like to thank the land owners for access consent, NRW staff for help with field survey (Joe Atkinson, Rob Bacon, Nick Hudson, Ros Watkins and Julian Woodman), Natural England Staff for help with Lady Park Wood (Bob Silverwood and Katey Stephen), and Sam Anstice for preparing the maps, and Rob Bacon and Julian Woodman for their help with the project.

We would also like to thank Dave Green for information on his new species, Jaume Pellicer, Royal Botanic Gardens Kew, for undertaking the four ploidy estimates by flow cytometry, and the BSBI for access to the Big Database.

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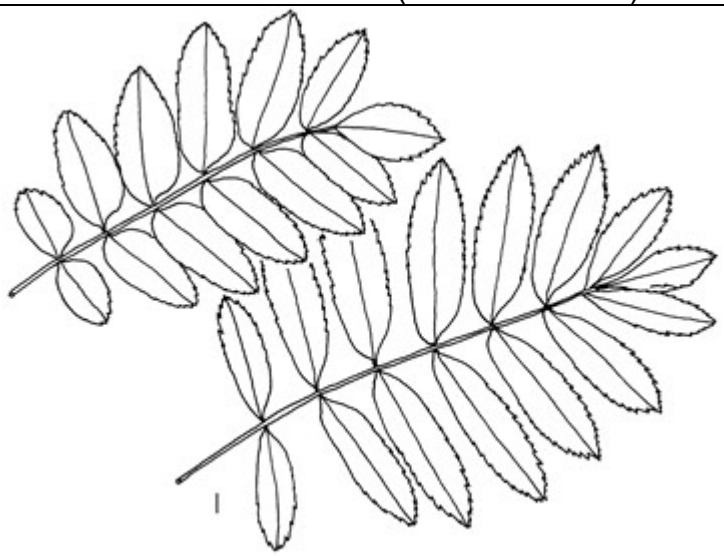
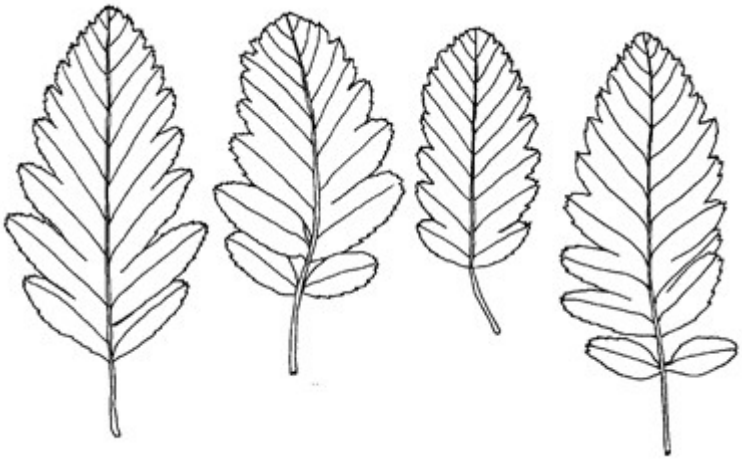
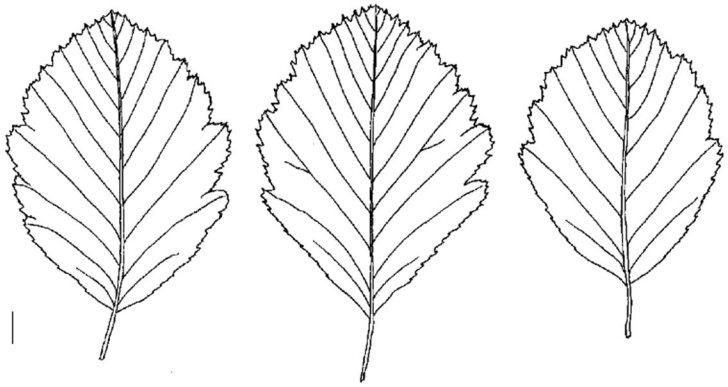
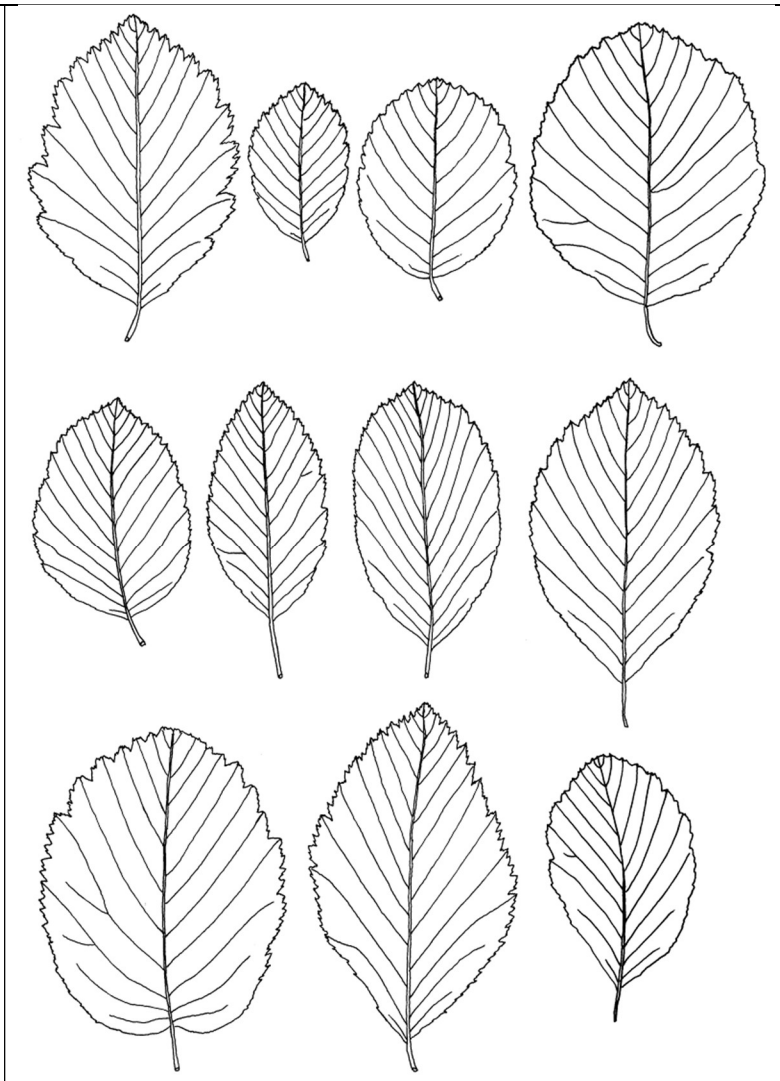
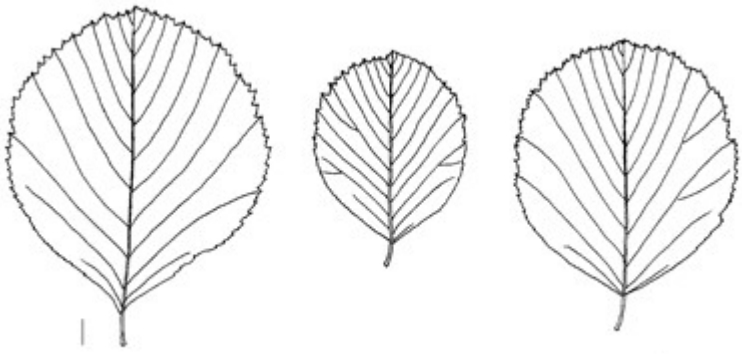
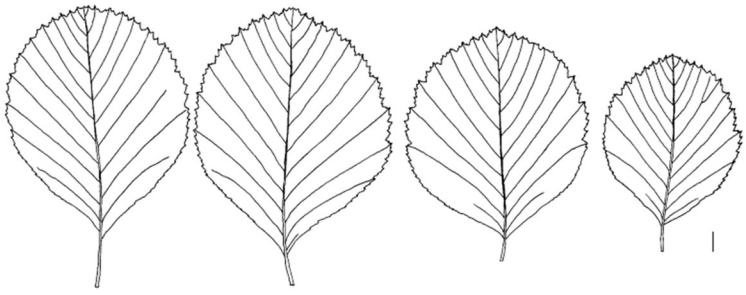
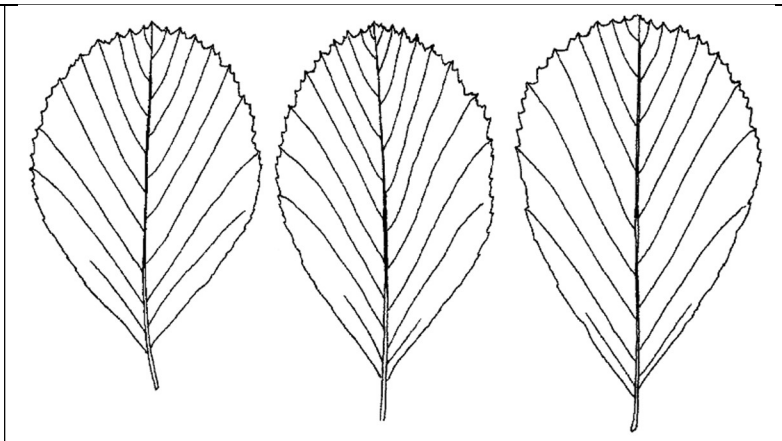
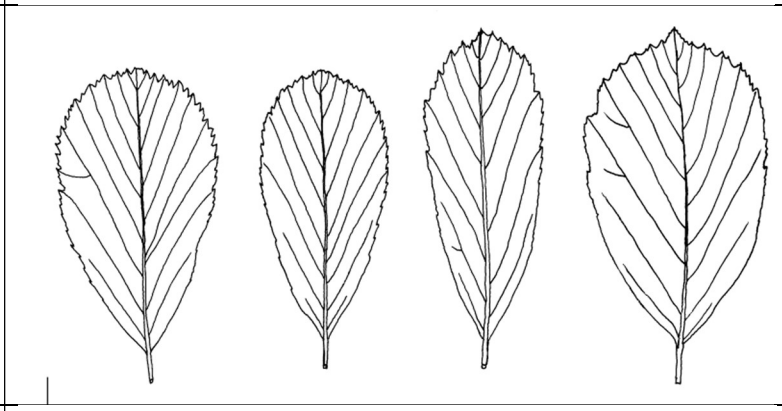
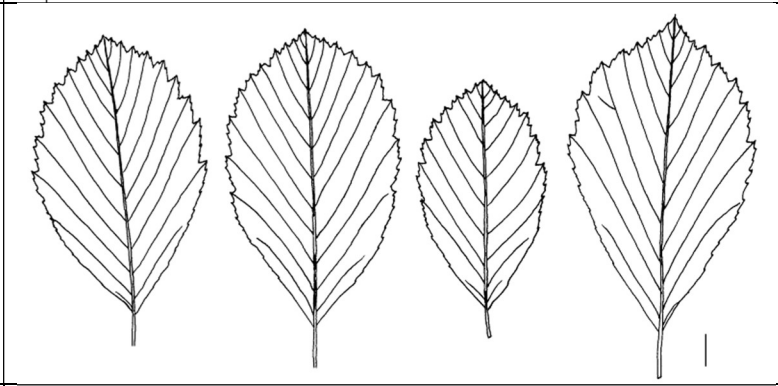
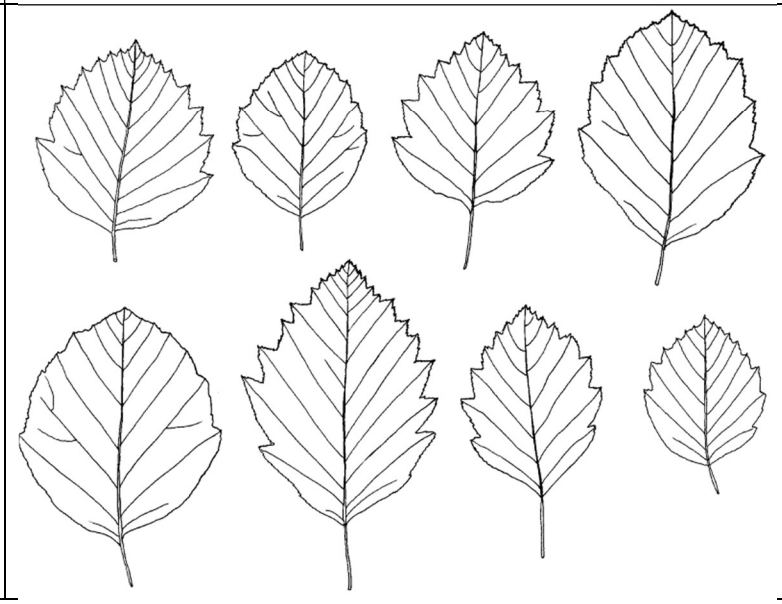
10. Appendices

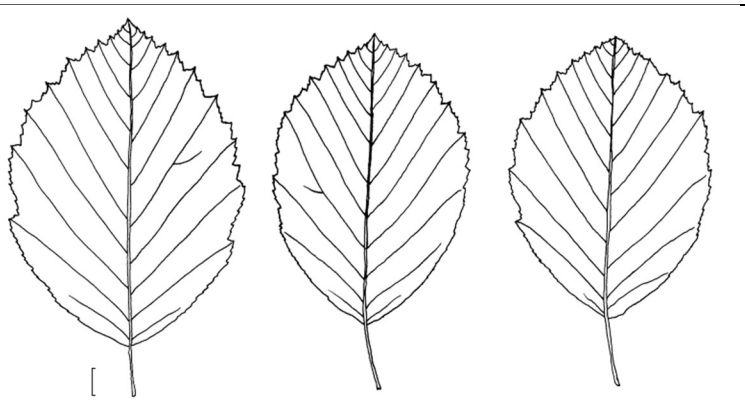
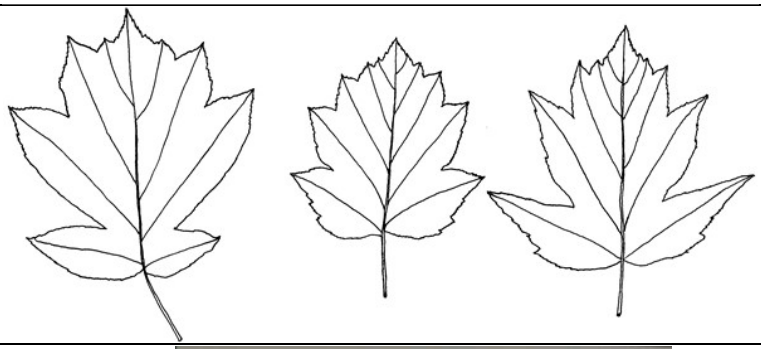
11. Appendix 1. Typical *Sorbus* leaf shapes

Leaf shapes are taken from the *Sorbus* handbook (Rich *et al.* 2010).

Sorbus aucuparia, Rowan	
Sorbus x *thuringiaca* Bastard mountain ash, Hybrid rowan	
Sorbus anglica English whitebeam	

Sorbus aria Common whitebeam	
Sorbus eminens sensu stricto, Round-leaved whitebeam	
Sorbus eminentiformis, Doward whitebeam	

Sorbus porrigentiformis, Grey-leaved whitebeam	
Sorbus rupicola, Rock whitebeam	
Sorbus saxicola, Symonds Yat whitebeam	
Sorbus x *tomentella* Wye whitebeam	

Sorbus croceocarpa, Orange-fruited whitebeam	
Sorbus torminalis, Wild Service tree	
Wynd Cliff clone (new taxon)	

12. Appendix 2. Spreadsheet structure

The spreadsheets of historical and 2017-2018 records are structured as follows:

Latin Name – includes authority. Undescribed taxa are listed as new species, though these may never be formally described. Undetermined species are listed as *Sorbus* sp.

National grid – grid reference at varied scales.

Vice county – Watsonian vice-county = 35 Monmouthshire.

Locality – follows spelling on Ordnance survey maps, rather than as cited by collector.

Collectors – usually listed in alphabetical order.

Collection date – in a few cases these are to year or month only.

Identifier – authority who has determined the record.

Notes

Source/voucher – sources of information or vouchers are cited as follows:

- ABS – Aberystwyth University herbarium
- BEL – Belfast Museum herbarium
- Biological Records Centre (1970-2008) – miscellaneous records held by BRC
- BIRM – Birmingham Museum herbarium
- BRISTM – Bristol City Museum and Art Gallery herbarium
- BSBI Big database
- CGE – Cambridge University herbarium
- D. Green personal records
- E – Royal Botanic Gardens Edinburgh herbarium
- Fl. Mons (Evans 2007) – Evans TG. 2007. *Flora of Monmouthshire*. Chepstow: Chepstow Society.
- GL – Glasgow University herbarium
- herb. D Green – Herbarium of D. E. Green
- Houston et al (2003) – Houston L, Tillotson A, Charles C. 2004. *Wye Valley* Sorbus *project. 4. Wintour's Leap and Lady Park Wood Autumn 2003*. Unpublished contract report to English Nature, Ledbury, March 2004.
- MANCH – Manchester Museum herbarium
- Mons RPR (Evans 2009) – Evans TG. 2009. *Monmouthshire Rare Plant Register*. Unpublished spreadsheet.
- Morgan (1989) – Morgan V. 1989. *Rare Plant surveys of Wales. South Wales Region. Gwent.* Cardiff: Nature Conservancy Contract report.
- Nature Conservation Review vol. 2 page 71
- NMW – National Museum Wales herbarium (specimen accession numbers usually also cited)
- Sell (1989), page 389 – Sell PD. 1989. The *Sorbus latifolia* (Lam.) Pers. aggregate in the British Isles. *Watsonia* 17, 385-399.
- T Rich personal records
- UPS – Uppsala herbarium
- Wigginton, M.J. (1995) – Records compiled for Vascular Plant Red data book by Martin Wigginton

13. Appendix 3. Summary of historical *Sorbus* records

Queried or rejected records are given in red.

Latin name:	National grid:	Locality:	Collection date:
Sorbus anglica?	SO547144	Lady Park Wood	1970, Sep 01
Sorbus anglica	ST523967	Lover's Leap	1993
Sorbus anglica	ST523968	Lover's Leap	1978, May 29
Sorbus anglica?	ST522967	Lover's Leap	1988
Sorbus anglica	ST5296	Lover's Leap	1989, Oct 05
Sorbus anglica	ST523967	Lover's Leap	1995, Dec
Sorbus anglica	ST5236196705	Lover's Leap	2002, Aug 29
Sorbus anglica	ST523968	Lover's Leap	2003
Sorbus anglica	ST52339667	Lover's Leap	2005, Jul 05
Sorbus anglica	ST523966	Lover's Leap	2005, Sep 20
Sorbus anglica	ST5235596701	Lover's Leap	2011, Aug 11
Sorbus anglica	ST5296	Piercefield Cliffs	1894, Sep 14
Sorbus anglica	ST5296	Piercefield Park	1878, Jun 22
Sorbus anglica	ST5296	Piercefield Park	1878, May
Sorbus anglica	ST5296	Piercefield Park	1884, Sep
Sorbus anglica	ST5296	Piercefield Park	1886, Aug
Sorbus anglica	ST5295	Piercefield Park	1889, Jun 14
Sorbus anglica	ST5296	Piercefield Park	1893, May 05
Sorbus anglica	ST5296	Piercefield Park	1894, May 16
Sorbus anglica	ST5295	Piercefield Park	1894, Sep 14
Sorbus anglica	ST5296	Piercefield Park	1903, Jun 18
Sorbus anglica	ST53629612	Piercefield Park	2005, Jul 05
Sorbus anglica	ST528973	Wynd Cliff	1970
Sorbus anglica	ST528973	Wynd Cliff	1977
Sorbus anglica?	ST527974	Wynd Cliff	1988
Sorbus anglica	ST5297	Wynd Cliff	1878, Jun 23
Sorbus anglica	ST528973	Wynd Cliff	1995, Aug 30
Sorbus aria	ST533981	Black Cliff	2014
Sorbus aria	ST530983	Black Cliff	2017, Jan 05
Sorbus aria	ST529989	Black Cliff, fort	2017, Jan 05
Sorbus aria	ST5318297353	Wyndcliff Quarry (as Black Rock)	2014, Sep 15
Sorbus aria	ST530973	Wyndcliff Quarry (as Black Rock quarry, above)	2014
Sorbus aria	SO54101508	Highmeadow Woods	2005, Oct 06
Sorbus aria	SO5414	Lady Park Wood	2001, Aug 21
Sorbus aria	SO5414	Lady Park Wood	2001, Aug 21
Sorbus aria	SO5414	Lady Park Wood	2001, Aug 21
Sorbus aria	SO5414	Lady Park Wood	2001, Aug 21
Sorbus aria	SO547148	Lady Park Wood	2003, Sep 11
Sorbus aria	SO5470614878	Lady Park Wood	2003, Sep 11
Sorbus aria	SO5470614878	Lady Park Wood	2003, Sep 11
Sorbus aria	SO5471814880	Lady Park Wood	2003, Sep 11

Latin name:	National grid:	Locality:	Collection date:
Sorbus aria	SO5471514860	Lady Park Wood	2003, Sep 11
Sorbus aria	SO5471214819	Lady Park Wood	2003, Sep 11
Sorbus aria	SO5471214819	Lady Park Wood	2003, Sep 11
Sorbus aria	SO5470514715	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5470514715	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5470514715	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5470514715	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5470514715	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469614700	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469614700	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469014676	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469014676	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469014676	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469014676	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469014676	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469014676	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469014676	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469014676	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469014676	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5467914636	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5467914636	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5467914636	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469314607	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469314607	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5469314605	Lady Park Wood	2003, Sep 12
Sorbus aria	SO546146	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5471014792	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5471014792	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5471114794	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5471614778	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5471614778	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5477214774	Lady Park Wood	2003, Sep 12
Sorbus aria	SO5477214774	Lady Park Wood	2003, Sep 12
Sorbus aria	SO546146	Lady Park Wood	2012, Jul 22
Sorbus aria	ST5296	Lover's Leap	2005, Sep 20
Sorbus aria	ST5231796715	Lover's Leap	2011, Aug 11
Sorbus aria	ST5296	Piercefield Cliffs	2002, Aug 29
Sorbus aria	ST5296	Piercefield Cliffs	2002, Aug 29
Sorbus aria	ST5223896902	Piercefield House, opposite	2014, Sep 15
Sorbus aria	ST5069196209	Piercefield Park	2005, Jul 05
Sorbus aria	ST5297	Wynd Cliff	1895, Jun 27
Sorbus aria	ST527975	Wynd Cliff	1962, Jul 23
Sorbus aria	ST5297	Wynd Cliff	1989, Jul 19
Sorbus aria	ST5297	Wynd Cliff	1989, Jul 19

Latin name:	National grid:	Locality:	Collection date:
Sorbus aria	ST5297	Wynd Cliff	1989, Jul 19
Sorbus aria	ST52689733	Wynd Cliff	2001, Jul 19
Sorbus aria	ST530971	Wynd Cliff	2012, Jul 07
Sorbus aria	ST5251997312	Wynd Cliff	2014, Sep 16
Sorbus aria	ST525973	Wynd Cliff	2016, Oct 22
Sorbus aria	ST5296	Wynd Cliff	2016, Sep 16
Sorbus aria	ST5251697305	Wynd Cliff	2016, Sep 30
Sorbus aria	ST5251997310	Wynd Cliff	2016, Sep 30
Sorbus aria	ST5255897332	Wynd Cliff	2016, Sep 30
Sorbus aria	ST5262497354	Wynd Cliff	2016, Sep 30
Sorbus aria	ST5267197371	Wynd Cliff	2016, Sep 30
Sorbus aria	ST5271997248	Wynd Cliff	2016, Sep 30
Sorbus aria	ST5272397239	Wynd Cliff	2016, Sep 30
Sorbus aria	ST5273897389	Wynd Cliff	2016, Sep 30
Sorbus aria	ST5267797351	Wynd Cliff	2016, Sep 30
Sorbus aria	ST5258897317	Wynd Cliff	2016, Sep 30
Sorbus aria	ST528974	Wynd Cliff	2017, Jan 05
Sorbus aria	ST527971	Wynd Cliff, viewpoint	2014
Sorbus aucuparia	ST5397	Wynd Cliff	2012, Apr 24
Sorbus croceocarpa	ST53039723	Lower Wynd Cliff Wood	2014, Sep 23
Sorbus eminens	SO5471814880	Lady Park Wood	2003, Sep 11
Sorbus eminens	SO5469914740	Lady Park Wood	2003, Sep 12
Sorbus eminens	ST59	Piercefield Park	1903
Sorbus eminens	ST528974	Wynd Cliff	2001, Jul 19
Sorbus eminens	SO5414	Lady Park Wood	1943, Jun
Sorbus eminens	SO550142	Lady Park Wood	1980, Aug
Sorbus eminens	SO550142	Lady Park Wood	1994, Jul 13
Sorbus eminens	SO5504214280	Lady Park Wood	2001, Aug 21
Sorbus eminens	SO550142	Lady Park Wood	2003, Sep 01
Sorbus eminens	SO5471214819	Lady Park Wood	2003, Sep 11
Sorbus eminens	ST525967	Wynd Cliff	2001, Sep 09
Sorbus eminens	ST53189735	Wynd Cliff	2014, Sep 15
Sorbus eminens	ST5223396883	Wynd Cliff	2014, Sep 15
Sorbus eminens sensu lato?	SO547146	Lady Park Wood	1988, Aug 10
Sorbus eminentiformis	SO5471814880	Lady Park Wood	2003, Sep 11
Sorbus eminentiformis	SO5471814880	Lady Park Wood	2003, Sep 11
Sorbus eminentiformis	SO5471214819	Lady Park Wood	2003, Sep 11
Sorbus eminentiformis	SO5471214819	Lady Park Wood	2003, Sep 11
Sorbus eminentiformis	SO546148	Lady Park Wood	2003, Sep 11
Sorbus eminentiformis	SO5469914740	Lady Park Wood	2003, Sep 12
Sorbus eminentiformis	ST5356296060	Piercefield Cliffs	2012, Sep 12
Sorbus porrigentiformis	SO5470514725	Lady Park Wood	2003, Sep 12
Sorbus porrigentiformis	ST530973	Wyndcliff Quarry (as Black Rock quarry), above	2014

Latin name:	National grid:	Locality:	Collection date:
Sorbus porrigentiformis?	ST59	Blackcliff-Wyndcliff-Pierce Woods	
Sorbus porrigentiformis	SO5470514725	Lady Park Wood	2003, Sep 12
Sorbus porrigentiformis?	ST59	Wynd Cliff	1894, Jun 25
Sorbus porrigentiformis?	ST5269197366	Wynd Cliff	2016, Sep 30
Sorbus porrigentiformis?	ST527971	Wynd Cliff, viewpoint	2014
Sorbus rupicola?	ST59	Blackcliff-Wyndcliff-Pierce Woods	
Sorbus rupicola	SO5414315164	Highmeadow Woods	2005, Oct 06
Sorbus saxicola	SO54101508	Highmeadow Woods	2005, Oct 06
Sorbus saxicola	SO5471314834	Lady Park Wood	2003, Sep 11
Sorbus aria sensu lato	ST5297	Wynd Cliff	1989, Jul 19
Sorbus aria sensu lato	ST59	Wynd Cliff	1989, Oct 05
Sorbus new sp. 'Wyndcliff'	ST5307797377	Wyndcliff Quarry (as Black Rock quarry)	2012
Sorbus new sp. 'Wyndcliff'	ST5307797377	Wyndcliff Quarry (as Black Rock quarry)	2013, May 18
Sorbus new sp. 'Wyndcliff'	ST5307797377	Wyndcliff Quarry (as Black Rock quarry)	2013, Oct 07
Sorbus new sp. 'Wyndcliff'	ST5306997376	Wynd Cliff	2012, Sep 12
Sorbus torminalis	SO5414	Lady Park Wood	2001, Aug 21
Sorbus torminalis	SO5470614878	Lady Park Wood	2003, Sep 11
Sorbus torminalis	SO5471814880	Lady Park Wood	2003, Sep 11
Sorbus torminalis	SO5471514860	Lady Park Wood	2003, Sep 11
Sorbus torminalis	SO5471214819	Lady Park Wood	2003, Sep 11
Sorbus torminalis	SO5469914740	Lady Park Wood	2003, Sep 12
Sorbus torminalis	SO5469614700	Lady Park Wood	2003, Sep 12
Sorbus torminalis	SO5471114794	Lady Park Wood	2003, Sep 12
Sorbus torminalis	SO5471614778	Lady Park Wood	2003, Sep 12
Sorbus torminalis	SO54691489	Lady Park Wood	2012, Jul 22
Sorbus torminalis	ST5395	Piercefield Cliffs	1957
Sorbus torminalis	ST5395	Piercefield Cliffs	1987
Sorbus torminalis	ST537962	Piercefield Cliffs	1997, May
Sorbus torminalis	ST508962	Piercefield Park	2005, Jul 05
Sorbus torminalis	ST59	Wynd Cliff	1871, May
Sorbus torminalis	ST5297	Wynd Cliff	1957
Sorbus torminalis	ST5297	Wynd Cliff	1987
Sorbus torminalis	ST528973	Wynd Cliff	2001, Jul 19
Sorbus torminalis	ST526971	Wynd Cliff	2017, Jan 05
Sorbus torminalis	ST527971	Wynd Cliff, viewpoint	2014
Sorbus x thuringiaca	ST535960	Piercefield Cliffs	1972, Aug 29
Sorbus x thuringiaca	ST5362696122	Piercefield Park	2005, Jul 05
Sorbus x tomentella	ST528973	Wynd Cliff	2016, Sep 16
Sorbus x tomentella	ST528973	Wynd Cliff	2017, Jan
Sorbus x tomentella	SO5414	Lady Park Wood	1943, Sep 15
Sorbus x tomentella	SO547144	Lady Park Wood	1983, Sep 18
Sorbus x tomentella	SO546144	Lady Park Wood	2003, Sep 12
Sorbus x tomentella	SO5469414390	Lady Park Wood	2005, Oct 06

Latin name:	National grid:	Locality:	Collection date:
Sorbus x tomentella	ST522967	Lover's Leap	1986
Sorbus x tomentella	ST52359669	Lover's Leap	1970s
Sorbus x tomentella	ST5296	Piercefield Park	1878, Jun 22
Sorbus x tomentella	ST5296	Piercefield Park	1894, May 16
Sorbus x tomentella	ST5296	Piercefield Park	1932, Jun 22
Sorbus x tomentella	ST5296	Piercefield Park	1933, Sep 18
Sorbus x tomentella	ST52359669	Piercefield Park	2005, Jul 05
Sorbus x tomentella	ST5297	Wynd Cliff	1873, Jun 23
Sorbus x tomentella	ST5297	Wynd Cliff	1878, Jun 09
Sorbus x tomentella	ST5297	Wynd Cliff	1894, Jun 25
Sorbus x tomentella	ST5297	Wynd Cliff	1903, Aug 20
Sorbus x tomentella	ST5297	Wynd Cliff	1935, Sep

14. Appendix 4. Descriptions of Apostles' Rocks, Black Cliff and Alcove Wood

14.1. Apostles' Rocks, Piercefield

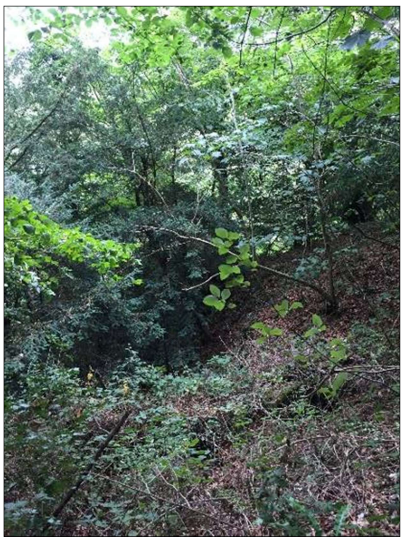
Apostles' Rocks are a series of north-facing limestone cliffs and bluffs in the middle of the Piercefield cirque above the River Wye. The slopes are large (up to c. 100 m), very steep and largely wooded, with occasional rock outcrops and cliffs only the biggest of which are open with potential habitat for whitebeams. The biggest cliffs are about 50 m high. The woodland is tall to 30 m, with a canopy of mixed *Tilia cordata*, *Fagus silvatica, Acer pseudoplatanus, Fraxinus excelsior* (lots of ash die-back), *Ulmus glabra* (especially at base) with occasional *Sorbus aria, Carpinus betulus* and *Castanea sativa,* a scattered understorey of *Taxus baccata* and *Ilex aquifolium*, and occasional *Prunus laurocerasus*. There are numerous fallen trees, and the woods are unmanaged. Deer browsing is heavy throughout.

The cliffs were worked on 7 September 2018 with help from Julian Woodman and on 10 September 2018, by dropping down from the top path as moving along the crags is not possible (interestingly there are occasional indications of old contour paths, perhaps associated with Piercefield Park walks). Access is very difficult and occasionally dangerous with loose rocks, steep slopes and cliffs directly into the Wye, and a full survey would require rope access and take a significant amount of time. No phenomarkers were installed.

The rocks investigated are listed below from west to east. Photos do little to convey the size of cliffs due to the small angles available and the strong contrast between shade and open:

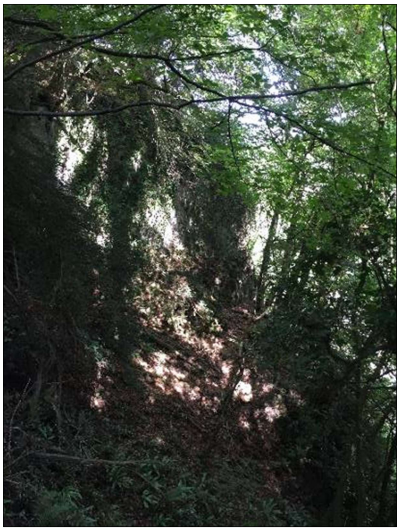
ST52546.96057 (AP6)

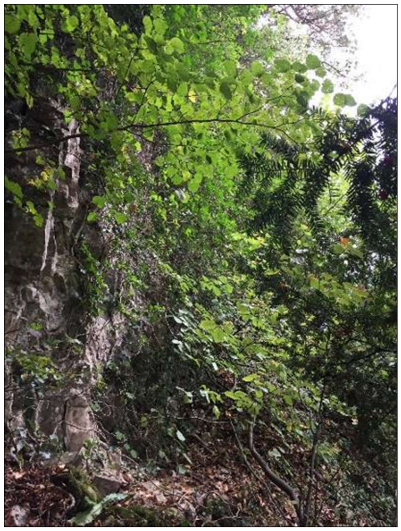
A small rocky 'nose' 30 m below top path, shaded, no *Sorbus*.

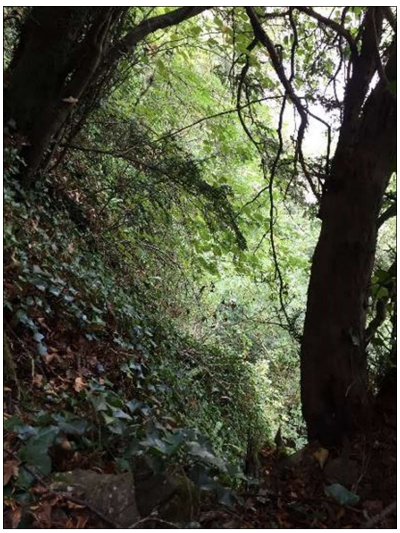


ST52639.95984 (AP1)

50 m crag, middle and base of cliff accessed from east side, with *S. aria* on face. No obvious access to top edges.

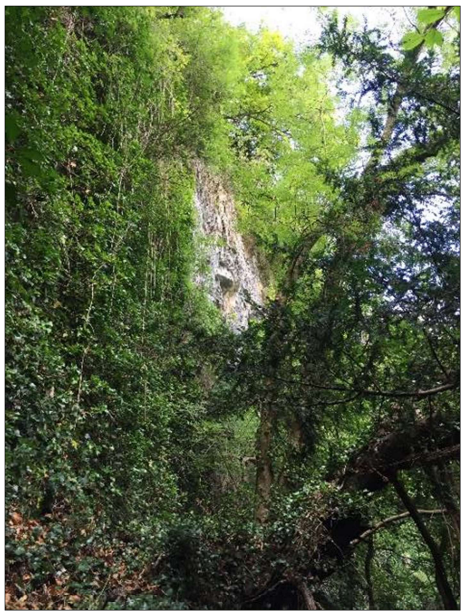


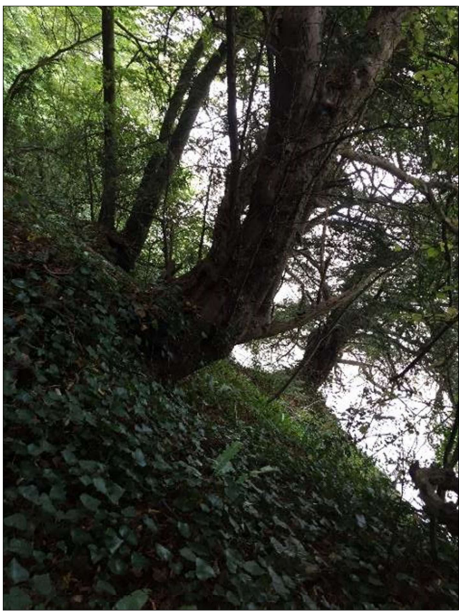




ST52687.95983 (AP2)

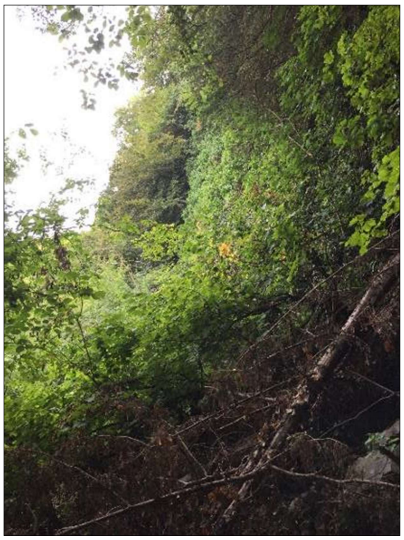
Large crag 50 m tall looked at from base by Wye, a few *S. aria*

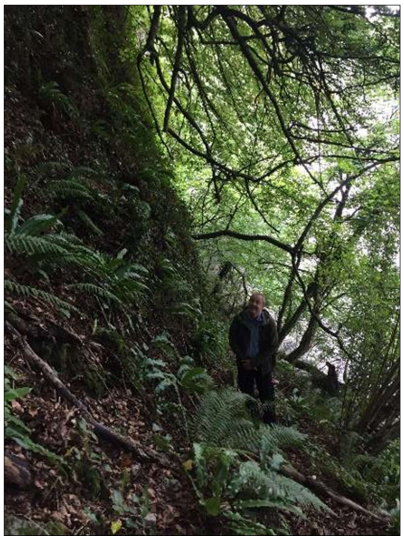




ST52734.95951 (AP3)

Cliff straight up from Wye, base covered with ivy, a few *S. aria* visible.





ST52788.95878 (AP7)

Hint of cliff c. 30 m below top path, too shaded for whitebeams – see AP4 for base.

ST52789.95912 (AP4)

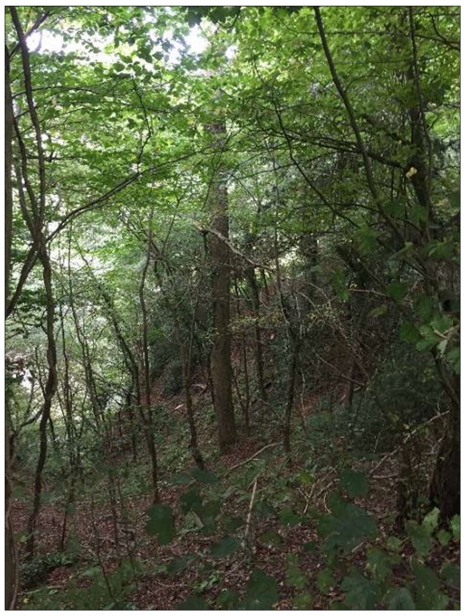
Open cliff and ledge c 30 m up from river, open, and associated cliff edge above with *S. anglica, S. aria, S. torminalis* and *S. aucuparia*. This might be worth further survey with ropes.

ST52883.95851 (AP8)

Small cliff 'nose' with *S. anglica, S. aria, S. torminalis* and *S. aucuparia*. This might be worth further survey with ropes.

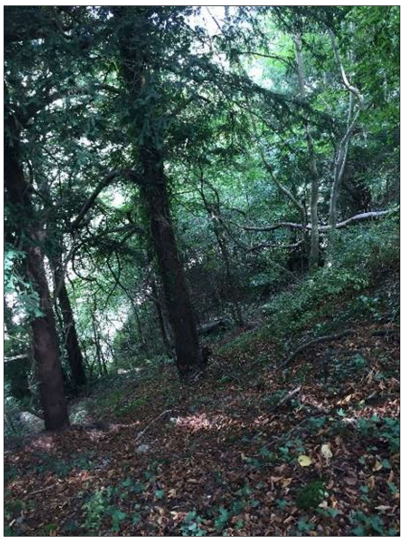
ST53131.95781 (AP5)

Long wooded edge to big cliff, only *S. aria* seen.



ST53178.95791 (AP9)

Small promontory with *S. anglica, S. aria* and *S. torminalis.* This might be worth further survey with ropes.



ST53202.95763 (AP10)

Small open section at top of big cliff, possibly open from tree fall

ST53247.95845 (AP11)

Small cliffy 'nose' too shaded

ST53267.95800 (AP12)

Small cliffy 'nose', too shaded

Beyond here to the east the cliffs seem to become too shaded as they drop down to the Wye and become contiguous with the NE cliffs at river level.

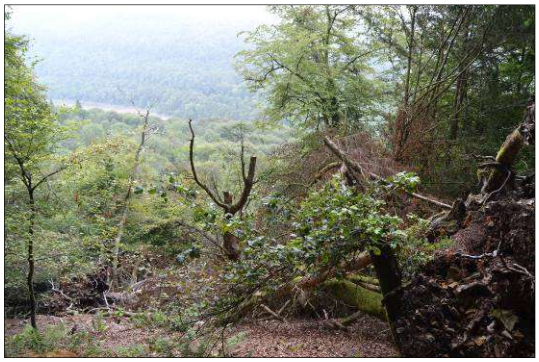
14.2. Black Cliff, Tintern

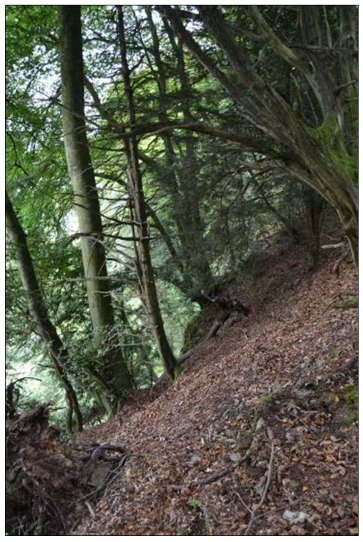
Black Cliff has not been investigated for *Sorbus* before.

Black Cliff is a c. 500 m long north-east facing cliff from the A466 to c. ST53206.9862 where it peters out. The cliffs are quite large, 20-40 m high, and vertical though often stepped and with increasingly steep slopes down from above, and block scree below. They have a fairly dense tree cover of *Fagus, Fraxinus, Tilia cordata* and *Ulmus glabra* with *Taxus* and *Corylus* along their length, with many fallen trees. There is a lot of ivy on the cliffs, with relatively few open rocks. The eastern end of Black Cliff by the A466 has a small quarry associated with the lime kiln, but other than that the cliff seems fairly natural. The roadside stepped cliff along the A466 is man-made, to about 10 m tall and has recently been cleared for road safety works.

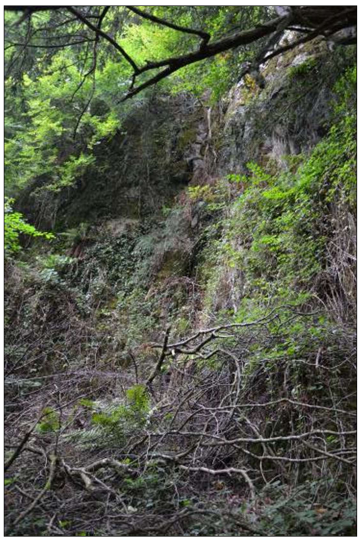
Black Cliff was surveyed on 4 September 2018 by going along the top cliff edge and back along the base. Binoculars were used to look at living trees on the cliffs and fallen leaves were examined on the floor; no abseiling or climbing was undertaken. The top edge is difficult to see over from above as the cliffs get increasingly steep, and some access is blocked by fallen trees with scrub and bramble. From below some parts are also blocked by dense brambles and fallen trees, and there are often so many trees on the cliffs that it is difficult to see the open areas. Nonetheless, about 80% of the cliff was accessed from both above and below over c. 4.5 hours survey.

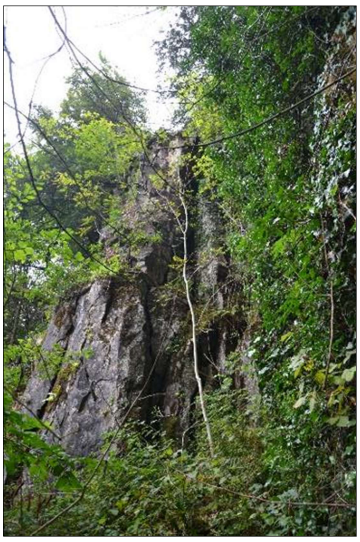
Whitebeams were scattered along the cliff in the open places and occasionally in the woodlands above. Other than two *S. eminens* at the south-east end, all trees were *S. aria* with a very few *S. aucuparia*. It is not a rich *Sorbus* site.



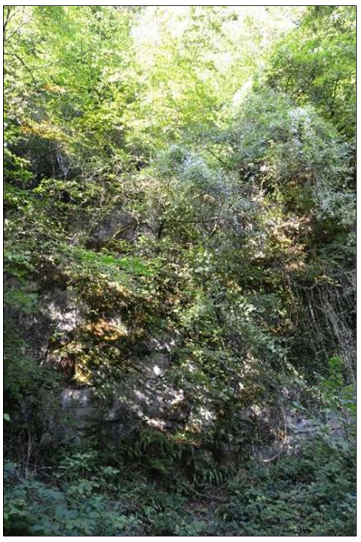


Some views along the top of Black Cliff showing the tall woodland and steep drop of the edge, sometimes with fallen trees




Open crags below Black Cliff



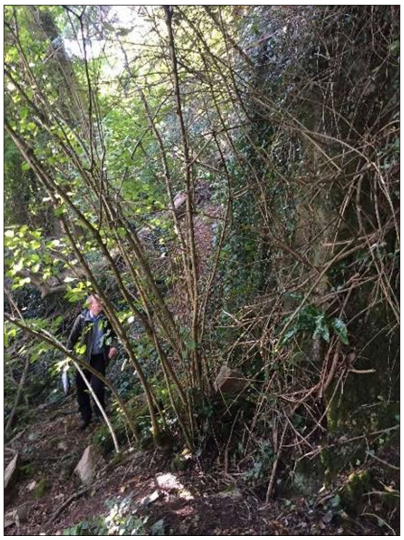
Wooded cliff above lime kiln

A466 roadside cliff, recently cleared.

14.3. Alcove Wood

Alcove Wood, which has some east-facing cliffs shown on maps, has not previously been investigated for *Sorbus*. It was visited on 7 September 2018 with Julian Woodman.

The slopes are up to c. 70 m, very steep and heavily wooded with *Tilia, Fagus, Acer* and *Fraxinus*. At the southern end (c. ST5293.9432) there were only a few open cliffs to 10 m or so at the base of the slope, with only an occasional *Sorbus aria*. There was no path along the bottom despite what is shown on Ordnance Survey maps.



At the north end, one *S. eminens* sapling was found just north of the castle viewpoint at ST5295.9476:

It is not a rich wood and no further surveys for whitebeams are recommended.

15. Appendix 5. Location of marked rare trees

15.1. *Sorbus anglica*, Lover's Leap

2017 GPS: ST52362.96699 in front of railings

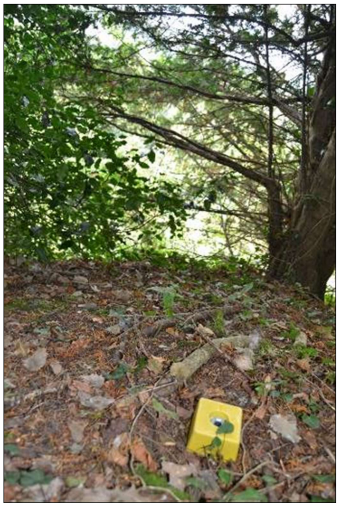
GPS with Garmin 60CX in 2018: ST52351.96700

The phenomarker was placed over the railings immediately above the first *anglica* tree.

15.2. *Sorbus anglica*, Lover's Leap

2017 GPS: ST5236696701

This second tree (*anglica* 2) leans out over the cliff and is located 3 m east of the end of the railings, c. 7 m east of the first *anglica* in the middle of the viewpoint.



15.3. *Sorbus anglica*, Piercefield, NE cliffs

Phenomarker PP4 ST53703.96237, 1 m above large *torminalis*, *anglica* 4 m below and over edge

4th promontory from NE tip, *S. anglica* 3 m fruiting tree hanging over cliff

looking c. NW

looking approx. NE

15.4. *Sorbus anglica*, Piercefield, NE cliffs

Phenomarker PP5 ST53703.96237

5th promontory from NE tip. Just off west side of tip, *S. anglica* 3 m down over edge, 3 m tall coppice with fruit

looking north

looking NW

Looking N

15.5. *Sorbus anglica*, Piercefield, NE cliffs

Phenomarker PP6 ST53677.96211 located about 1 m above ‘triple’ trunked oak 6th promontory from NE tip on west side, 4 m long *S. anglica* growing along ground, very shaded, hardly alive, no fruit

looking north

15.6. *Sorbus anglica*, Piercefield, NE cliffs

Phenomarker PP7 ST53657.96153 placed on ‘path’.

7th promontory from NE tip, 3 *S. anglica* trees.

S. anglica ST53654.96172, over edge and dangling down, 4 m tall, fruiting, east side

S. anglica ST53648.96153 4 m tall, fruiting

S. anglica ST53651.96154, over tip, 4 m down, 3 m tall, fruiting

15.7. *Sorbus anglica*, Piercefield, NE cliffs

Phenomarker PP8 ST53631.96104 in middle of ‘path’

8th promontory from NE tip

S. anglica x 2 ST53623.96117, either side of oak tree

Tree to east of oak 3 m tall, no fruit

Tree to west side 4 m tall, sparse fruit

S. anglica ST53618.96116 tree 4 m tall, fruiting

15.8. *Sorbus anglica*, Piercefield, NE cliffs

Phenomarker PP9 ST53573.96044 below ‘path’ between 2 large trees 9th promontory from NE tip

S. anglica in middle of bluff, 4 m tall, no fruit, maiden ST53572.96056

looking NE

looking north

15.9. *Sorbus anglica*, Piercefield, NE cliffs

10th promontory from NE tip. No phenomarker as had run out!

3 shaded *S. anglica* ST53521.96003

1; 4 m tall, no fruit

2: 4 m tall, fruit

3: 6m tall, fruit, with big stem dead

15.10. *Sorbus anglica*, Piercefield, NE cliffs

ST53512.95988 11th promontory from NE tip. No phenomarker as had run out!

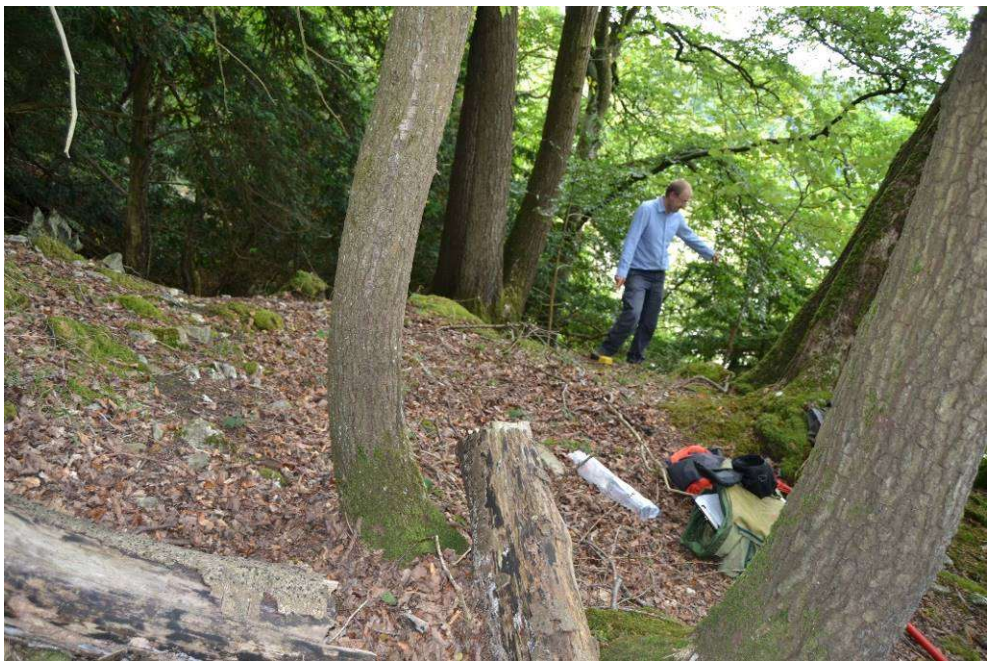
S. anglica 5 m tall, fruit, 5 m over edge

15.11. *Sorbus eminens*, Piercefield, NE cliffs

Phenomarker PP9 ST53573.96044 below 'path' between 2 large trees

9th promontory from NE tip, quite a big high bluff

S. eminens, 6 m tall coppice, fruit broader than long (6 seeds in 5 fruit)



15.12. *Sorbus eminens*, Lady Park Wood, S of Biblins bridge

2017 GPS: SO5504214280

GPS with Garmin 60CX in 2018: ST55032.14258

The large multi-stemmed tree near the path up the east side of Lady Park Wood was marked with a marker 1 m from the tree to the west along the slope.

looking east

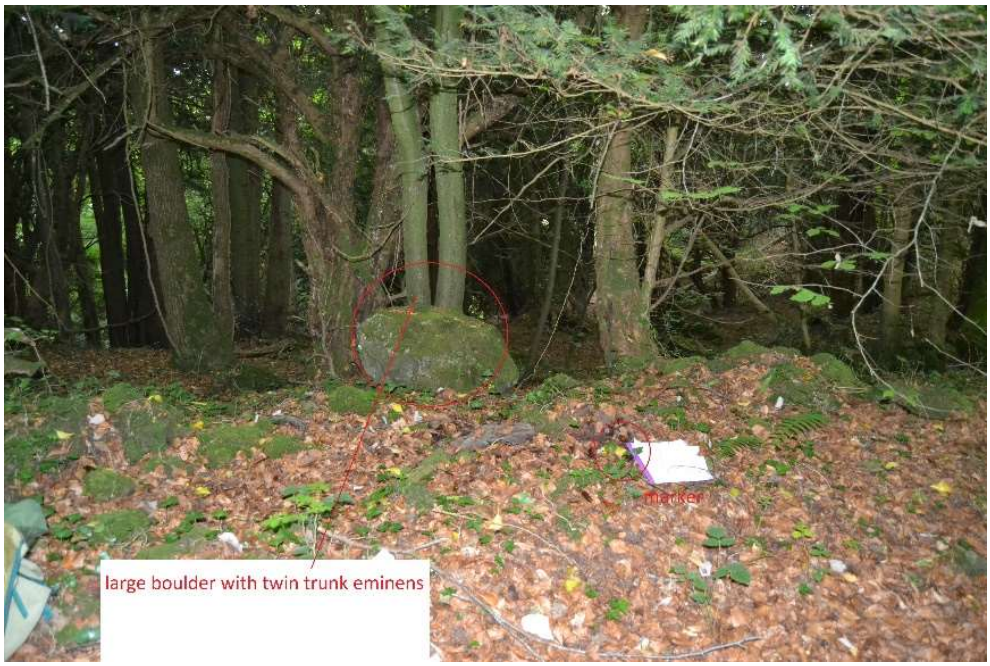
looking west

15.13. *Sorbus eminens*, Lower Wyndcliff Wood

2017 GPS: ST52859.97207

GPS with Garmin 60CX in 2018: ST52865.97208

The marker for this twin-trunked tree was placed 1 m in from the track and 3 m from the tree; this location may get covered with leaf litter in future years but is easily found by the distinct large boulder immediately in front of the tree. The tree was far too tall (25m+) to get any leaves or fruit to confirm for certain that it is *S. eminens,* but it seems to fit from what can be seen of leaf shape with binoculars.



Note marker to left of clip board

looking south to location by rucksack beside path

Note the large boulder in front of the twin trunks

15.14. *Sorbus eminens*, Lower Wyndcliff Wood

2017 GPS: ST53067.97042

GPS with Garmin 60CX in 2018: ST53069.97045

This tree is leaning out over the River Wye and is rooted just over the edge of the low cliff. It has a lot of ivy on the trunk. I was unable to get any sun leaves or fruit but the sucker leaves at the back in shade confirm to *S. eminens*. There is a *S. aria* growing beside it.

The phenomarker is located about 3 m above the base of the tree where it should remain conspicuous.

Tree leaning out over mud (far side of oak)

looking south with lopper pole pointing to tree on edge of small river cliff

looking north

15.15. *Sorbus eminens*, Piercefield

2017 GPS: ST5251096638, path below Lover's Leap

GPS with Garmin 60CX in 2018: ST52488.96632

Phenomarker installed 3 m up from path immediately below trunk, above obvious rocky 'steps' on main path by bluff. Tree had one large trunk fallen and cut but other 2 trunks ok. Plant fruiting well, but fruits about as long as wide, not obviously wider than long.

The second adjacent *S. eminens* tree at ST5250496642 in 2017 was confirmed as dead in 2018 so was not marked.

15.16. *Sorbus eminens*, A466

2017 GPS: ST5223396883

This tree, found by Dave Green from fallen leaves, occurs on the A466 west bank near the entrance to Piercefield Park Lover's Leap, in a dangerous location on the bends. No leaves or fruit could be reached in 2018.

The phenomarker was located directly below the tree about 1 m up from the road in open bramble and loose leaf within road mowing zone.

looking south

looking north

15.17. *Sorbus eminens*, Alcove Wood

GPS with Garmin 60CX in 2018 ST52959.94765

10 m north of viewpoint on west side of path, small coppiced shrub c 2 m high. Ploidy level tetraploid determined by RBG Kew in 2018.

looking NW away from viewpoint

15.18. *Sorbus eminens,* Wynd Cliff A466 roadworks

2017 GPS: ST52931.97332 road

GPS with Garmin 60CX in 2018: ST52935.97323

This tree was coppiced during road safety works and is now re-growing on the rocks above the road. The phenomarker was placed on the NW side of the coppice stool c 1 m away but this is likely to get hidden under brambles and Buddleja. The ground here feels quite unstable when hammering in the phenomarker, so the rocks may require more stability work.

[An adjacent tree in the woodland edge 10 m to NW at ST52934.97334 has leaves somewhat similar to *S. eminens* but has fruits longer than wide and is *S. aria*.]

looking south-east to coppiced tree above cliff

15.19. *Sorbus eminens*, Black Cliff

GPS with Garmin 60CX in 2018: ST53372.98032

Two *S. eminens* trees at SE end of Black Cliff above road, newly discovered in 2018, were marked here with one phenomarker.

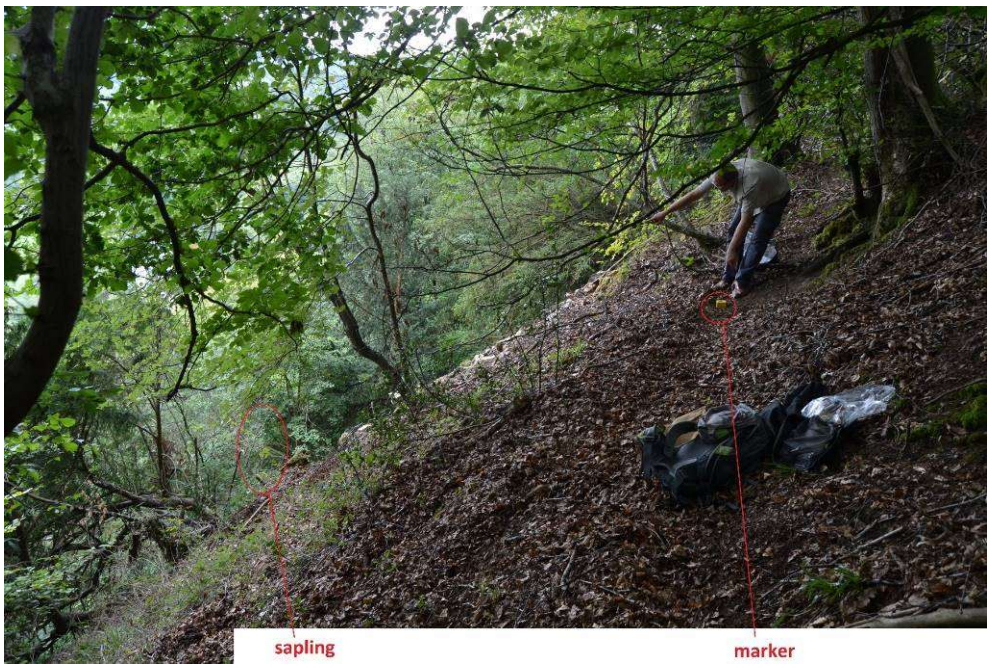
The first tree (maiden, c. 10 m tall leaning towards road) is located about 1.5 m directly downslope of the marker, which was placed on a slightly raised mound to try to prevent it being covered with leaf litter.

The second tree is located about 8 m up slope and is a big 4-stemmed coppiced tree in the woodland about 12 m from the cliff edge:

15.20. *Sorbus* sapling (*eminentiformis*/*eminens* leaves), Lady Park Wood

2017 GPS: GPS with Garmin 60CX in 2018: SO54715.14409

A young sapling newly seen 2018 (or perhaps an old tree, densely shaded for years but now in the open as a result of a tree falling from cliff, which has put up an new slender shoot) with *eminens* or *eminentiformis* type leaves, phenomarker 10 up hill



looking south along cliff edge

Julian on cliff edge pointing to sapling

15.21. *Sorbus eminentiformis*, Lady Park Wood

GPS with Garmin 60CX in 2018: SO54711.14874

2 stem coppice c. 10 m in from cliff edge, 6 m tall, by *S. torminalis*, no fruit

looking north-ish

looking east-ish

15.22. *Sorbus eminentiformis*, Lady Park Wood

2017 GPS: SO5469914740

GPS with Garmin 60CX in 2018: SO54696.14738

Very tall tree with leaves in canopy (one leaf on ground looks correct). Phenomarker 1 m to NW along slope.

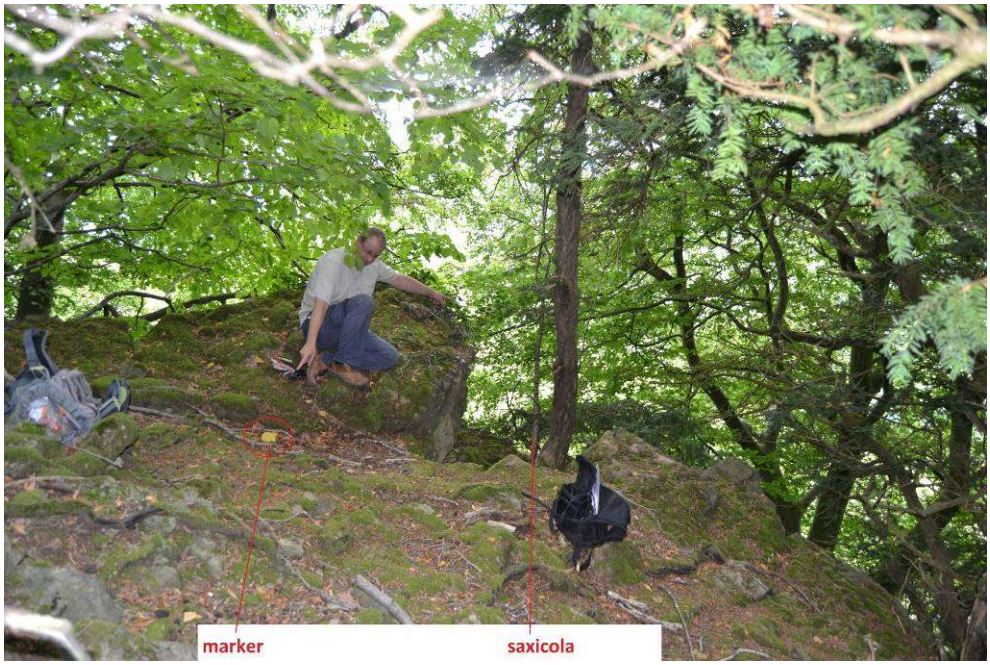
15.23. *Sorbus saxicola*, Far Hearkening Rock

2017 GPS: SO5410915083

GPS with Garmin 60CX in 2018: ST54107.14103

This is the top rock in the series of outcrops which are called Far Hearkening Rock, it is not clear exactly which outcrop this name refers to! Marker 3 m east of tree on edge of cliff in crevice.

Tree is very shaded and unrecognisable from shade leaves (original 2005 collection had good leaves when not so shaded); needs careful opening up of canopy.



15.24. *Sorbus* x *tomentella*, Lady Park Wood

2017 GPS: SO5469414390

GPS with Garmin 60CX in 2018: ST54725.14378

The marker was placed 1 m to the north of the trunk along the slope beside the minor path. This tree was confirmed as diploid in 2018 by flow cytometry.

looking south

looking north (marker behind tree)

15.25. *Sorbus* x *tomentella*, Lover's Leap

2017 GPS: Lover's Leap ST5239096676

GPS with Garmin 60CX in 2018: ST52390.96675

Marker 2 m south of huge trunk close to path. This very large tree to 25 m has lots of suckers (mostly c. 30 cm tall and deer-browsed) and at least one sapling 3 m tall 7 m south of marker. Some suckers occurred up to 10 m from this tree.

looking northwest to cliff edge

Looking west along cliff edge

15.26. *Sorbus* x *tomentella*, Lover's Leap

2017 GPS: Lover's Leap ST5240696656

Looking north-east along cliff from marker to second large *tomentella* (see also photo below)

Julian pointing to the second large *tomentella* on cliff edge

The adjacent sapling in a hollow below the cliff edge (2017 GPS: Lover's Leap ST5241396653) is *S. aria* and the leaves found associated with it in February 2017 were thought to be blown from the nearby large tree.

Data Archive Appendix

Data outputs associated with this project are archived on server–based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] An Excel table with all the Sorbus records.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue https://libcat.naturalresources.wales (English Version) and https://catllyfr.cyfoethnaturiol.cymru (Welsh Version) by searching 'Dataset Titles'. The metadata is held as record no

Published by:
Natural Resources Wales
Cambria House
29 Newport Road
Cardiff
CF24 0TP

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